

stRat stat manual – January 2020 – v1.0

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stRat stat is an R-based application that allows for users to discretize a graphical/visual stratigraphic section in to a numerical format. Users import an image of a stratigraphic section, then hand pick different makers on the image to provide the location of bed boundaries, grain size divisions, sedimentary structures, facies, and two levels of stratigraphic hierarchy (i.e., elements and element sets). The output of the discretization process is a single .csv file that communicates the different recorded parameters (e.g., grain size, occurrence of sedimentary structures, and facies) as a function of thickness. After a stratigraphic section is discretized users can import and pair both discrete measurements (e.g., core measurements) and/or continuous measurements (e.g., petrophysical logs) to the section and summarize these data by bed, facies, element, or element set. Lastly, multiple discretized stratigraphic sections can be joined together to form a large stratigraphic dataset that can be visualized easily in R or other platforms (e.g., Excel, python, a GIS etc.).

The output table is optimized for calculation of summary statistics (e.g., proportion of facies within an architectural element) in R but can easily imported into other platforms. The statistics that are calculated on beds, facies, elements, and element sets are statistics commonly used in reservoir characterization, but merely form a foundation for other statistics that could calculated based on user needs. The current statistics are:

Beds: Bed thickness, average grain size, maximum grain size

Facies: Facies thickness, average grain size, net:gross

Elements: element thickness, average grain size, net:gross

Element sets: element set thickness, average grain size, net:gross

More specific statistics (e.g., proportion of sedimentary structures within facies or the proportion of facies within an element) can be programmed in by users on a case by case basis, likely on a local copy of stRat stat.

If you have any suggestions or questions, please contact D.Coutts at dannycoutts@gmail.com or interact via GitHub.

Digitizing stratigraphic sections in stRat stat

The opening panel of stRat stat hosts save and load options. If creating new data, click the “Digitize stratigraphic data” drop down (1) and navigate to “2. Digitize beds and grain sizes”.

If saving digitized data (2), click “Save Data” to compile all currently picked markers into a save file, and then click “Download saved section data” to download it.

If loading a previously saved file (3), browse to the location the click “Load data”.

The second panel, “2. Digitize beds and grain sizes”, is where the majority of digitization is done. First upload a stratigraphic section in .png, or .jpg format (4) by browsing to the file location and selecting the file. For stRat stat to work effectively file sizes should be <1mb for the image. This will hopefully be improved in future versions and more high-resolution images can be imported. The thickness at the top and bottom are input numerically (5). This must be in thickness and not in depth. The grain size division present in the stratigraphic section are selected in a checkbox list (6).

(7) Four types of markers are digitized on this panel: 1) top and bottom locations of the section, 2) grain sizes division along the bottom or top of the section, 3) the location of bed tops, and 4) the grain size profile of the section. Check the bottom box to turn on the ability to digitize markers on the right-hand image.

Bottom and top of the section – these markers are used to demarcate the bottom and top of the stratigraphic section. The marker of this kind that is placed represents the bottom of the stratigraphic section. The second represents the top. Only two can be placed.

Grain size divisions – these markers provide the x-axis and are interpolated to get grain size information. Click markers on the location of grain size division that are present on the stratigraphic section (traditionally along top or bottom of the stratigraphic section). These markers are added in the direction of increasing grain size (either left or right). **Note: the number of grain size markers on the image must equal the number of checked boxes on the left-hand side of the app window.**

Bed tops – bed tops markers appear as red, horizontal, dashed lines. No bed tops are required for the bottom of the first bed in the stratigraphic section, or the top of the last bed in the stratigraphic section.

Grain Size profiles – these markers appear as green circles and are used to provide the grain size information for individual beds. Multiple markers can be used to give beds realistic coarsening or fining profiles.

(8) The left-hand plot is used to zoom and navigate the view of the right-hand image. To zoom drag a box on the portion of the stratigraphic section you would like to view. Click on the right-hand image to place markers on the image (9).

To speed up digitization, the right-hand plot will only updated when the window selected on the left-hand plot is changed, or when the “Update” button is clicked.

When picking grain size markers:

If zero markers are picked between bed boundaries, the interval will be treated as there is no data/covered interval/lost core.

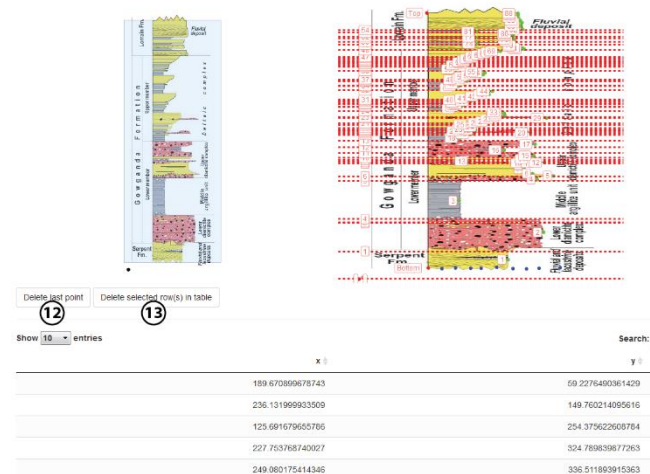
If a single grain size marker is picked between bed boundaries, there will be a uniform/single grain size populated for the bed.

If two or more grain size markers are picked between bed boundaries (11), the markers will be interpolated, and uniform grain sizes will be populated below the first marker in the bed and above the last marker in the bed.

Drag window to zoom on LEFT plot. Digitize points on the RIGHT plot.



Drag window to zoom on LEFT plot. Digitize points on the RIGHT plot.

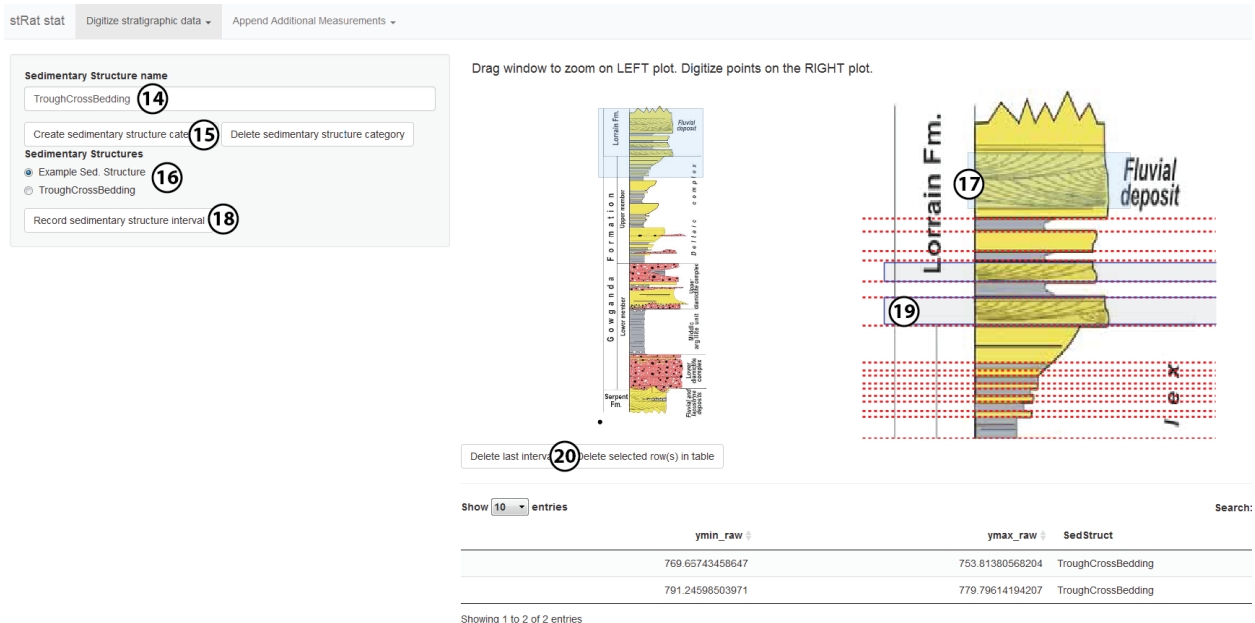
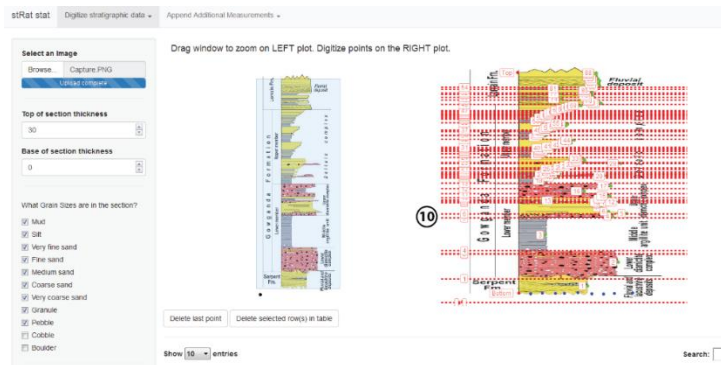


Logged markers of each type will appear in a table below the plots of the sedimentary section, when the type of marker is selected on the left (7). To delete logged markers, the last marker logged can be deleted by selecting the button (12).

To delete multiple markers, multiple rows can be selected in the table then deleted (13).

Markers or intervals that are logged are numbered or labeled.

When all four data types are digitized on the image it may appear very busy (10); however, by zooming in on the right-hand image, markers can be picked easily. For later steps (e.g., sedimentary structures, and facies) only the required digitized data will be displayed.



To log sedimentary structures, navigate to the “3. Digitize sedimentary structures and features” page. To create a sedimentary structure to log in an interval, type the name (e.g., TroughCrossBedding) in the field (14) and click “Create sedimentary structure” (15). After creating the structure, it will appear in the list (16). They can be deleted by clicking “Delete sedimentary structure category” button. To log the interval of the sedimentary structure, select the interval on the right-hand plot (17) and click “Record sedimentary structure interval (18). Once it is logged, it will appear as a blue box on the right-hand section (19). Options to delete (20) are the same as on the previous page, either deleting the last logged interval, or deleting row(s) from the table.

Facies name

AmalgamatedSand

Create facies category Delete facies category

Facies

Example Facies

AmalgamatedSSConglomerate

Record facies interval

☒ Clip facies boundaries to closest beds?

Drag window to zoom on LEFT plot. Digitize points on the RIGHT plot.

g and a member

nit diamicite complex

Delete last interval

Delete selected row(s) in table

21

22

23

24

Show 10 entries

Search:

ymin_raw	ymax_raw	FaciName
382.488491480291	320.705694393109	AmalgamatedSSConglomerate

Showing 1 to 1 of 1 entries

To log the facies, elements, and element sets (on separate pages), categories can be created, deleted, and selected similar to sedimentary structures (21). A feature for facies, elements, and element sets is clipping the selected interval to the nearest bed boundaries (22). If this check box is selected/checked, the interval selected (23) will be modified to have the same position as the nearest bed boundaries. If this check box is not selected/un-checked. The interval that is selected (23) will be logged exactly as it is on the right-hand plot. Recorded facies can be deleted as previously described (24).

After markers and intervals are logged into stRat stat, there are options to provide user-specific numerical settings on the “Numerical settings” page.

The numerical values of each grain size division can be set to user-specific values (27). These values are the values that are at each logged marker. If some grain size check boxes are un-checked (6), their sizes do not need to be changed.

Key reservoir grain size cutoffs (28) can be changed to case-specific values.

Lastly, the increment that the data/stratigraphic is discretized at can be modified (29). The increment should be half to one third of the thickness of the thinnest bed that is to be resolved.

stRat stat Digitize stratigraphic data Append Additional

Mud/Clay Size
0.001

Silt Size
0.0332

Very Fine Sand Size
0.09375

Fine Sand Size
0.1875

Medium Sand Size
0.35

Coarse Sand Size
0.75

Very Coarse Sand Size
1.5

Granule Size
3

Pebble Size
34

Cobble Size
160

Boulder Size
256

Reservoir Grain Size Cutoff
0.063475

Increment to discretize data at
0.01

The last inputs on “8. Process digitized data” name (30) and location of the data to be input (31).

The UTM of the section can be input (32) to allow for spatial analysis of multiple stRat stat sections outside of stRat stat.

Inputs 30-32 are not required inputs.

Optional statistics can be run on the different hierarchical levels (thickness, mean grain size, net:gross). To include these statistics when discretizing the data, select the desired checkbox (33)

If all inputs are correct the then the process can be run (34). **NOTE: logged data should be saved (2) prior to running the discretization process.**

Once run, the data can be downloaded and saved to a local environment (35).

stRat stat Digitize stratigraphic data Append Additional Measurements

Section name location options

Section/Core Name
30

Section/Core Location
31

UTM Easting
32

UTM Northing

Which statistics do you want to compute?

☐ Compute bed-scale statistics 33

☐ Compute facies-scale statistics

☐ Compute element-scale statistics

☐ Compute element-set/strat. interval statistics

34 Process selected points 35 Download processed section data

Adding additional data to previously digitized stratigraphic sections

Once a stratigraphic section is discretized it can be paired to additional data. Both discrete data (e.g., core plugs/analysis) or continuous data (e.g., borehole petrophysical logs) can be imported and paired to the data.

First, navigate to the “Import discrete data” or “Import continuous data” under “Append additional measurements” (1).

The process of joining either discrete or continuous data to a processed stratigraphic section is similar. Select the digitized and downloaded stratigraphic section data .csv file (2) and a .csv file of the measurement data that is to be joined (3).

The measurement data (discrete or continuous) will appear to the right of the sidebar panel (4).

Indicate whether the measurement data has a header or not (5) and which column hosts the thickness data (6).

The measurement data can be summarized by bed, facies, element, and element set (7). If selected, the minimum, mean, max, and standard deviation of each measurement will be calculated intervals of the selected stratigraphic hierarchy.

Once the inputs are correct the process can be run (8) and then downloaded (9).

The resulting .csv will consist of the original processed stratigraphic section data, with additional columns that provide the measurements, as well as any calculated summary statistics.

The screenshot shows the 'stRat stat' web application. The top navigation bar includes 'stRat stat', 'Digitize stratigraphic data', and 'Append Additional Measurements'. The sidebar on the left contains instructions and numbered steps (1-9) for the workflow. The main panel displays a table of measurement data with columns for 'Element1' and 'DiscreteMeasurement2'. The table contains 20 rows of data. A dropdown menu is open under 'Append Additional Measurements', showing options: 'Import discrete data' (highlighted with a red circle 1), 'Import continuous data', and 'Create Stratigraphic Data Library'. A red circle 2 is next to the 'Browse...' button for the stratigraphic section data. A red circle 3 is next to the 'Browse...' button for the measurement data. A red circle 4 is next to the 'Upload complete' button. A red circle 5 is next to the 'Header in additional measurement data?' checkbox. A red circle 6 is next to the 'Which column is depth/thickness' dropdown menu. A red circle 7 is next to the 'Summarize continuous data by:' checkboxes. A red circle 8 is next to the 'Join measurements to section data' button. A red circle 9 is next to the 'Download merged data' button.

Import discrete measurement data
This page will append discrete measurement data (e.g., proosity/permeability samples, fracture orientations/dimensions) to a already created digitized file. If summarized, all imported measurements will be summarized.

Choose DIGITIZED STRATIGRAPHIC SECTION data .csv file of data to add additional measurements too

Browse... ExampleData_Proces Upload complete

Choose .csv file of MEASUREMENT data to append to digitized stratigraphic section data

Browse... ExampleData_Discret Upload complete

☒ Header in additional measurement data?

Which column is depth/thickness

1

Summarize continuous data by:

☐ Bed
☐ Facies
☐ Element
☐ Element set/interval

Join measurements to section data

Download merged data

	Element1	DiscreteMeasurement2
	0.95	NA
1.01	0.95	1.43
1.72	1.07	2.17
2.58	0.99	5.67
2.99	0.40	0.59
3.67	0.65	1.82
5.08	1.05	1.90
5.22	0.38	0.52
5.29	0.70	123.67
6.21	0.50	0.97
7.66	0.56	0.95
9.06	0.87	1.17
10.70	0.43	1.14
11.16	0.65	0.84
11.94	0.51	0.75
12.38	0.91	0.99
12.78	0.96	1.04
12.87	0.87	1.31
13.10	0.48	0.72
13.10	0.45	0.74
13.68	0.07	0.08
18.22	0.48	3.38
21.37	0.56	5.07
21.72	0.30	0.32
23.86	0.08	0.11
24.10	0.23	0.31
24.23	0.80	0.93
24.78	0.13	0.21
24.89	0.23	0.46

Creating a large stratigraphic dataset for visualization

The final functions that stRat stat has is to create a large stratigraphic set that consists of multiple stRat stat files. This is accomplished in the on the “Create Stratigraphic Data Library”. This page allows for multiple processed stratigraphic sections to be appended together.

To create a stratigraphic dataset, select a processed stratigraphic section .csv in the file browser (1) and click “Import selected file” (2). The names and number of rows of imported files will appear in a table to the right (3). If the wrong file is imported, it can be deleted using the “Delete last uploaded file” button (4). Once all desired files are imported, the stratigraphic dataset can be downloaded by clicking the “Download merged data” button (5). The appended datafile will have all columns of the input files and can be further manipulated/explored in multiple programs (e.g., R, Python, Excel, etc.) depending on the user’s preferences.

stRat stat Digitize stratigraphic data Append Additional Measurements

Choose pre-digitized stratigraphic .csv file

1 Browse... ValidationData_Proces...
Upload complete

2 Import selected file

4 Delete last uploaded file

5 Download merged data

FileName	NumRows
ExampleData_ProcessedData.csv	5050.00
ValidationData_ProcessedData.csv	700.00

3