

# Developing a Database for the Fragile Geologic Features at Trona Pinnacles National Monument

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## Abstract

- Fragile geologic features (FGFs) can be used to constrain ground motions where appropriate measuring instruments aren't available (Brune, 1996).
- Trona Pinnacles National Monument has several FGFs that were impacted by the 2019 Ridgecrest Earthquake Sequence.**
- Several days after the M7.1 mainshock of the Ridgecrest Earthquake Sequence in 2019, a team from USC went out and photographed several of the spires, both those that were damaged and those that were undamaged.
- We propose to create a database that aggregates data relating to these features and the damage they sustained (if applicable to that particular feature).
- We are creating a framework to aggregate data relating to the spires.**
- this database will be similar in form to the SCEC precariously balanced rock (PBR) database
- the final database will include a numbered ID for each spire, its coordinates, strength measurements, and other data if available.**
- This database can be used in the future in order to compare the damage caused by the Ridgecrest to the next large earthquake that impacts the Trona Pinnacles National Monument area.

## Data Collection

Our data that will be used for the final products include the following.

- Geotagged field photographs taken post-Ridgecrest, with related EXIF data extracted from said photographs,
- Several point clouds of the focus area in Trona Pinnacles.
- Tensile strength data on a subset of spires
- Pre-Ridgecrest photographs from the web.

## Aggregation Methodology

Our data aggregation methodology includes the following steps.

- Developing a framework using MATLAB to collect data and aggregate it in a database that includes images of each spire taken soon after Ridgecrest, precise coordinates and elevation for each spire, as well as tensile strength measurements and links to pre-Ridgecrest images.
- Assigning identification numbers to each spire based on photographs.
- Populating a spreadsheet with data about the features, using visual recognition from field photographs as well as the point cloud sent in.
- Cataloging pre-event photographs of the spires.
- The database will be delivered via web tools.

- FGFs can be used to constrain ground motion from large earthquakes in places where recording instruments are not available.
- This database will be made available to researchers working on ground motion estimates and serve as a reference to monitor future damage.



**Figure 1.** Screenshot of the point cloud sent in by the JPL Caltech team, imaged using unmanned aerial vehicles. This was used along with the field photographs in order to assign numbers to and identify each spire. Trona Pinnacles Monument location shown in inset in relation to the M7.1 rupture (long red line), and the M6.4 rupture (short red line).



**Figure 2.** An image taken post-Ridgecrest showing several of the tufa spires that were surveyed.



**Figure 3.** (left) shows process of assigning numbers to each tufa spire; this image in particular was originally a screenshot from one of the point clouds, that was then labeled based on field photographs of previously identified tufa spires (each number represents its associated tufa spire). This screenshot is helping to identify features that were previously unidentified in several of the field photographs taken by the USC team.

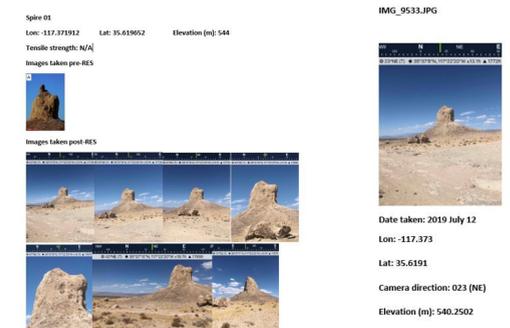
## Database Products

The final products will be the following:

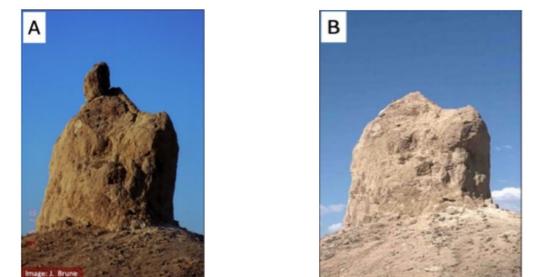
- A populated spreadsheet with data about each photograph.
- A database discoverable via web tools.

file name	compass	clon	lat	elevation	1	2	3	4	5
IMG_8560	184	-117.373	35.6193	538.6118	-999	1	1	-999	-999
IMG_8564	153	-117.373	35.6193	538.0909	-999	-999	1	-999	-999
IMG_8574	132	-117.372	35.6188	539.9874	-999	-999	-999	1	-999
IMG_8584	143	-117.373	35.6187	539.9244	-999	-999	-999	1	-999
IMG_8586	128	-117.373	35.6187	538.7845	-999	-999	-999	1	-999
IMG_8634	71	-117.373	35.6182	542.0214	-999	-999	-999	-999	1
IMG_8744	108	-117.374	35.6158	540.2554	-999	-999	-999	-999	-999
IMG_8746	115	-117.374	35.6158	542.3217	-999	-999	-999	-999	-999
IMG_8748	132	-117.374	35.6157	542.8499	-999	-999	-999	-999	-999
IMG_8750	168	-117.374	35.6158	542.8663	-999	-999	-999	-999	-999
IMG_8752	271	-117.374	35.6157	542.9609	-999	-999	-999	-999	-999
IMG_8754	88	-117.374	35.6157	543.4722	-999	-999	-999	-999	-999
IMG_8756	58	-117.374	35.6157	543.4615	-999	-999	-999	-999	-999
IMG_8758	96	-117.374	35.6157	543.4962	-999	-999	-999	-999	-999
IMG_8760	88	-117.374	35.6154	553.3753	-999	-999	-999	-999	-999
IMG_8762	279	-117.374	35.6153	545.7012	-999	-999	-999	-999	-999
IMG_8764	63	-117.374	35.6153	545.7584	-999	-999	-999	-999	-999

**Figure 4.** Screenshot of development spreadsheet populated with image data and spire information. Each column after the elevation column represents the spire it is associated with (the assigned number is labeled at the top of the column).



**Figure 5.** A preliminary draft for what the final database may look like. Includes longitude and latitude, elevation, direction of camera, tensile strength measurements, and images of each spire before and after the Ridgecrest Earthquake Sequence. Each image also includes its own coordinates, elevation, and the direction that the camera was facing when the photograph was taken.



**Figure 6.** Photographs of spire 01 taken before (A. May 30, 2001) and after (B. July 12, 2019) the Ridgecrest Earthquake Sequence. It can be seen that the feature was damaged after the sequence, causing part of the spire to break off (Brune, 2019).

## References

- Brune, J. N. (1996). Precariously balanced rocks and ground-motion maps for southern California. *Bull. Seism. Soc. Am.*, 86(1), 43-54.  
 Brune, J. (2019) Figure 6 photo from 2001 (pers. comm.)