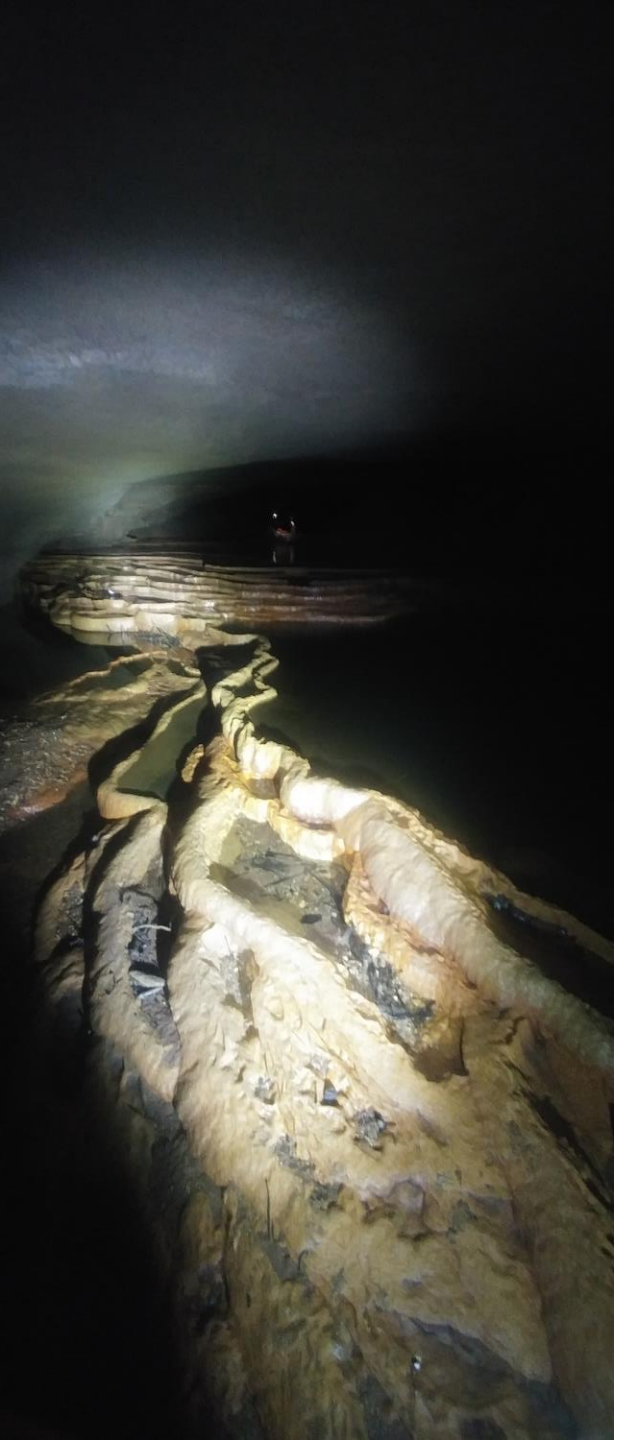
Joint Controls on Cave Formation and Morphology: Snail Shell Cave, Tennessee

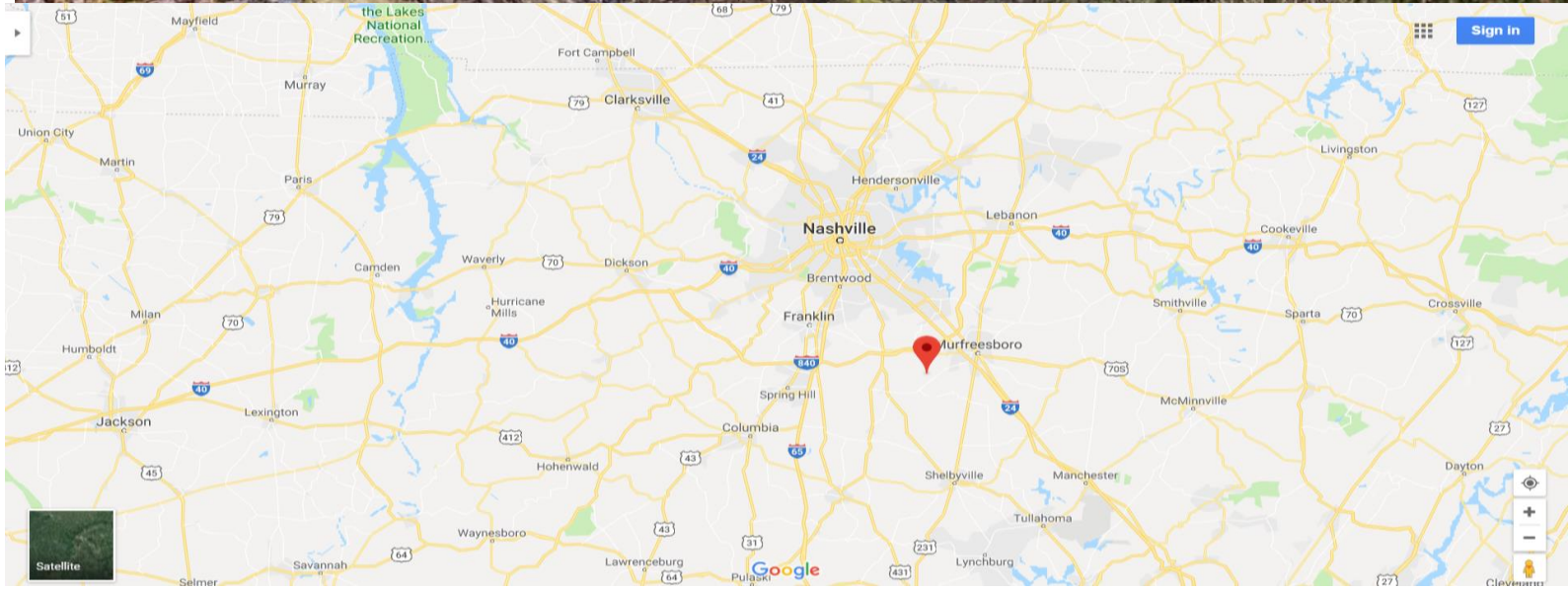


Purpose

- To determine the effect fracture strike in the Ridely Limestone on Passage orientation in Snail Shell Cave
- Mapping of surface and subsurface fractures
- Determine possible surface contamination points
- Locate undiscovered cave passages.

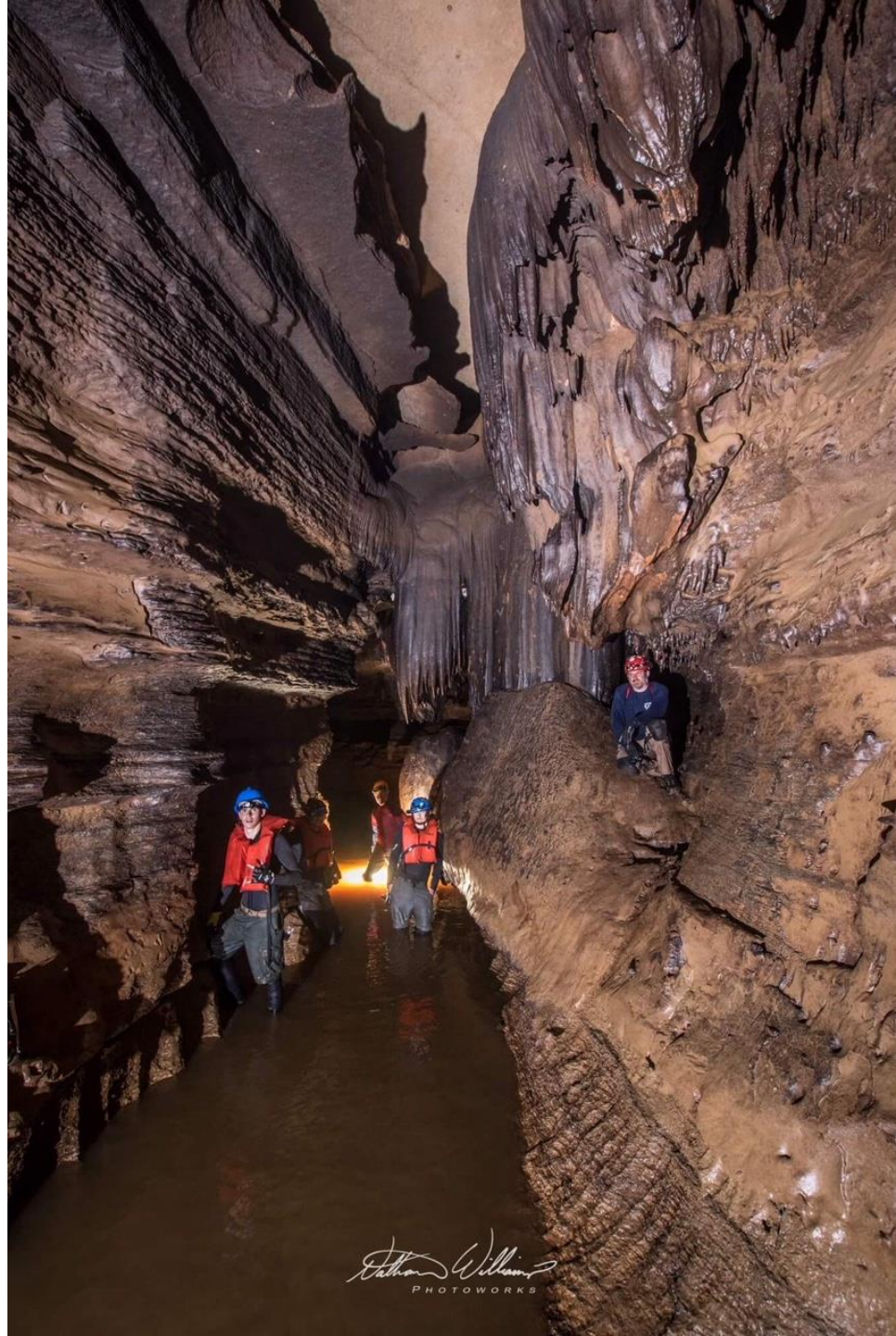
Snail Shell Cave Location

- Southeast of Murfreesboro
- Rockvale, Rutherford County, TN
- Entrance owned by the Southeastern Cave Conservancy



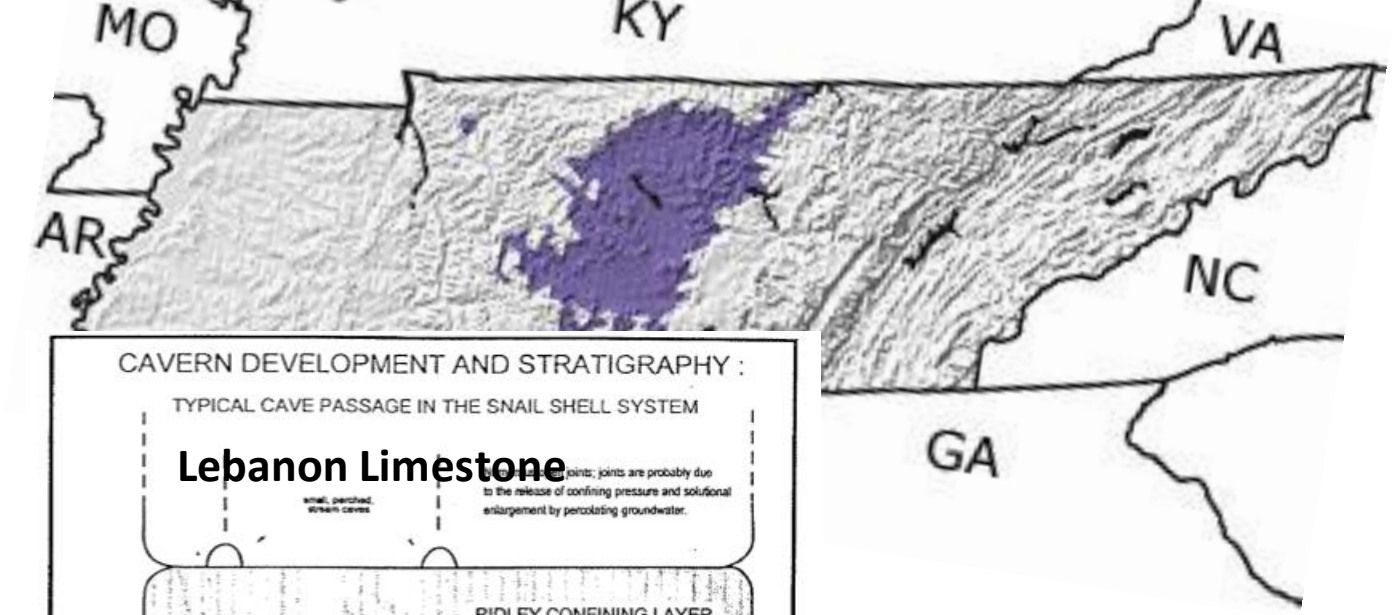
Snail Shell Cave Significance

- Very shallow cave, 20m under surface,
- Ideal to study surface effects the cave system
- Covers an 80km basin and have around 160km of passage
- Most of the cave has not been explored because it is flooded
- Provides water for local communities
- Proximity to Murfreesboro makes it a possible location for contamination of water
- Has several rare species of fish and lizard



General Geology

- In stone river group
  - Lebanon Limestone
  - Ridley Limestone
  - Pierce Formation
- Devonian and Ordovician Carbonates
- Cave is located in Nashville Dome
- Central Basin Aquifer.
- Cave Contained in Ridley Limestone



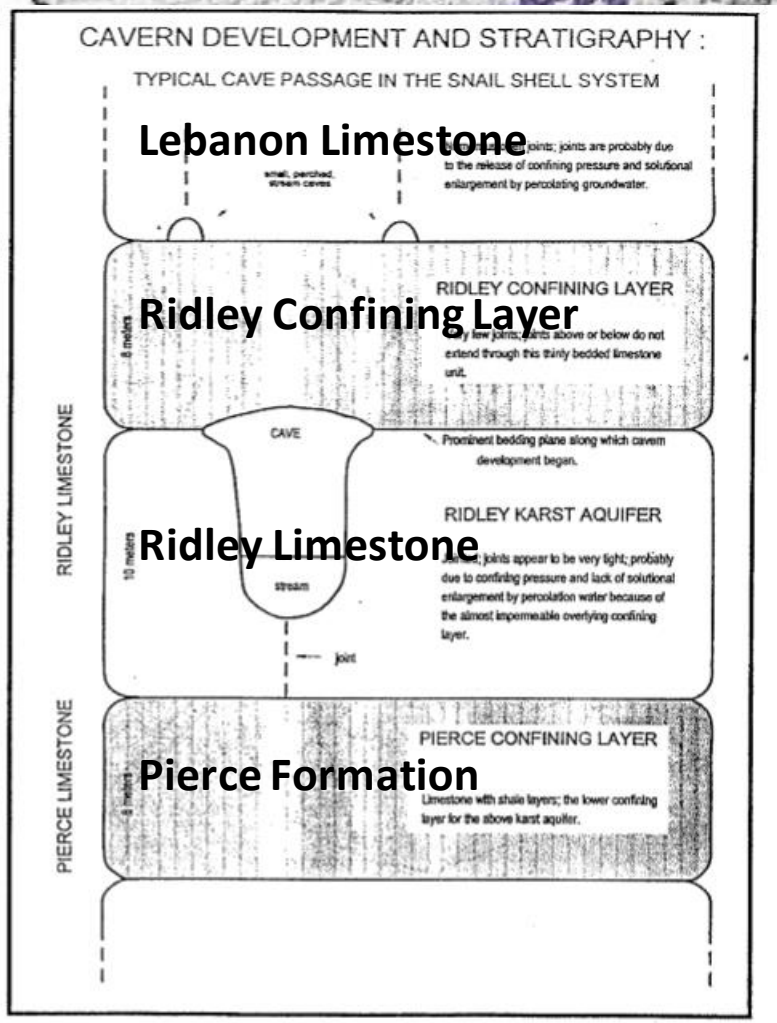
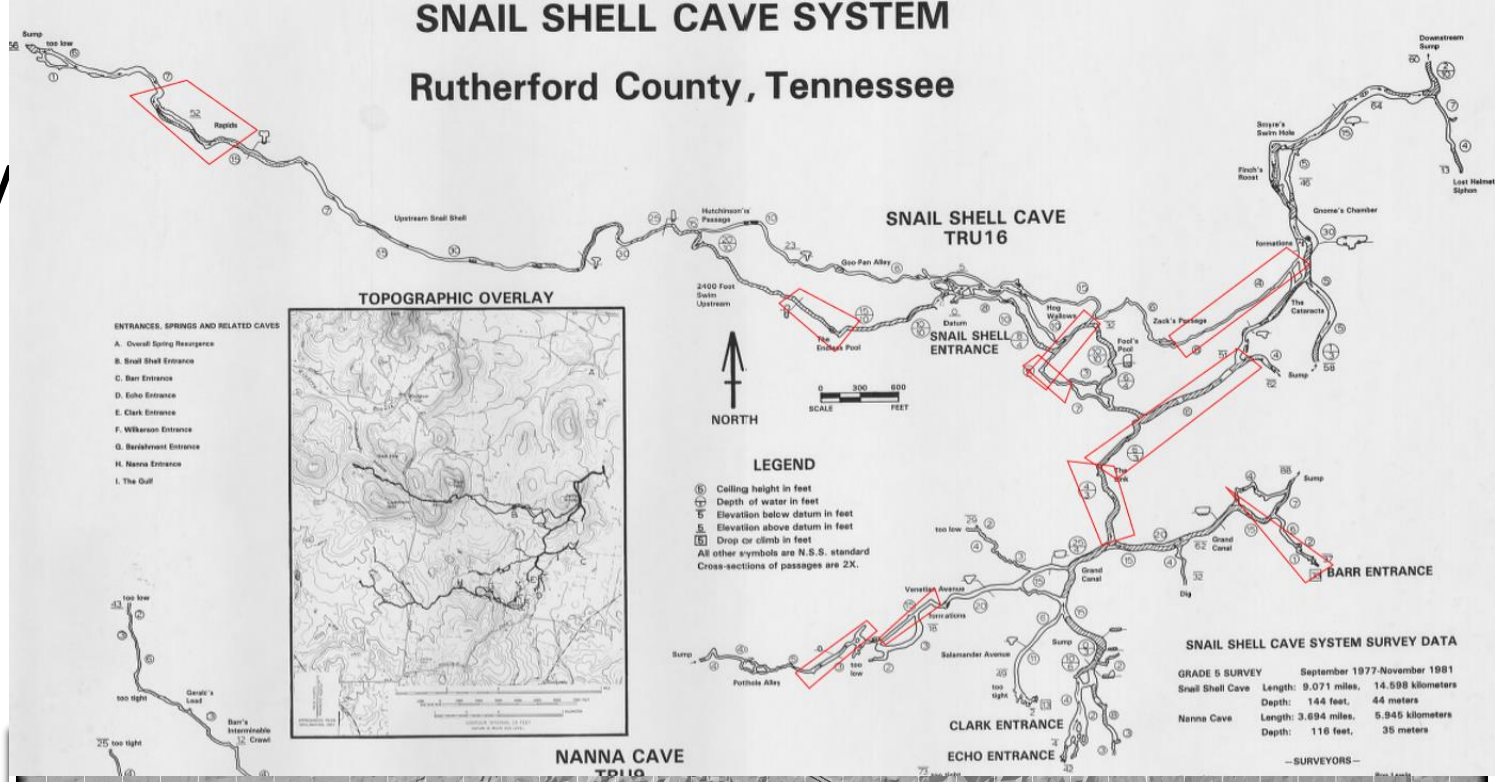
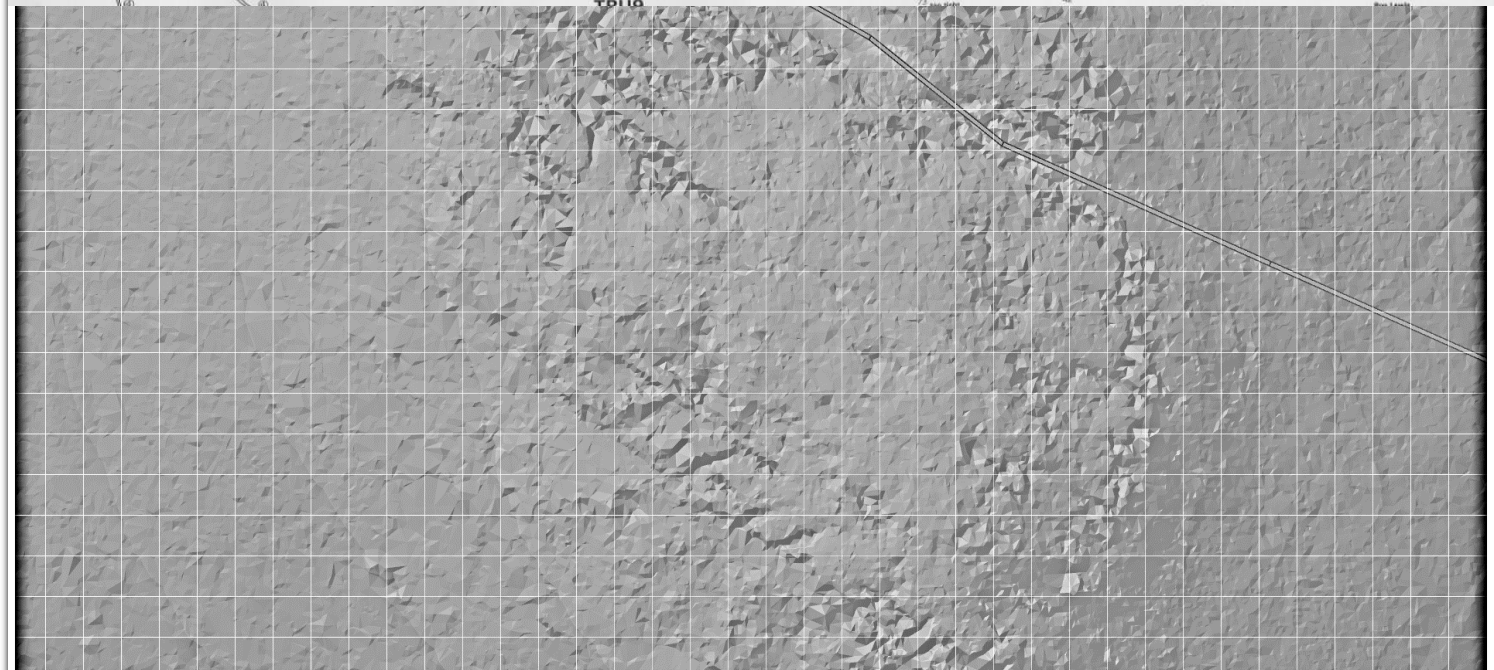


Figure 3. Stratigraphic section of the lower Ridley Limestone and Pierce Confining Layer (from Crawford, 1998).

Two Methods of Study

- Sub-Surface Fracture mapping
  - This was limited because the full extent of most fractures was not visible in cave passages
- Surface LIDAR Fissure mapping
  - This was the only method used to collect surface data because of lack of access to entire study area and large amounts of vegetation



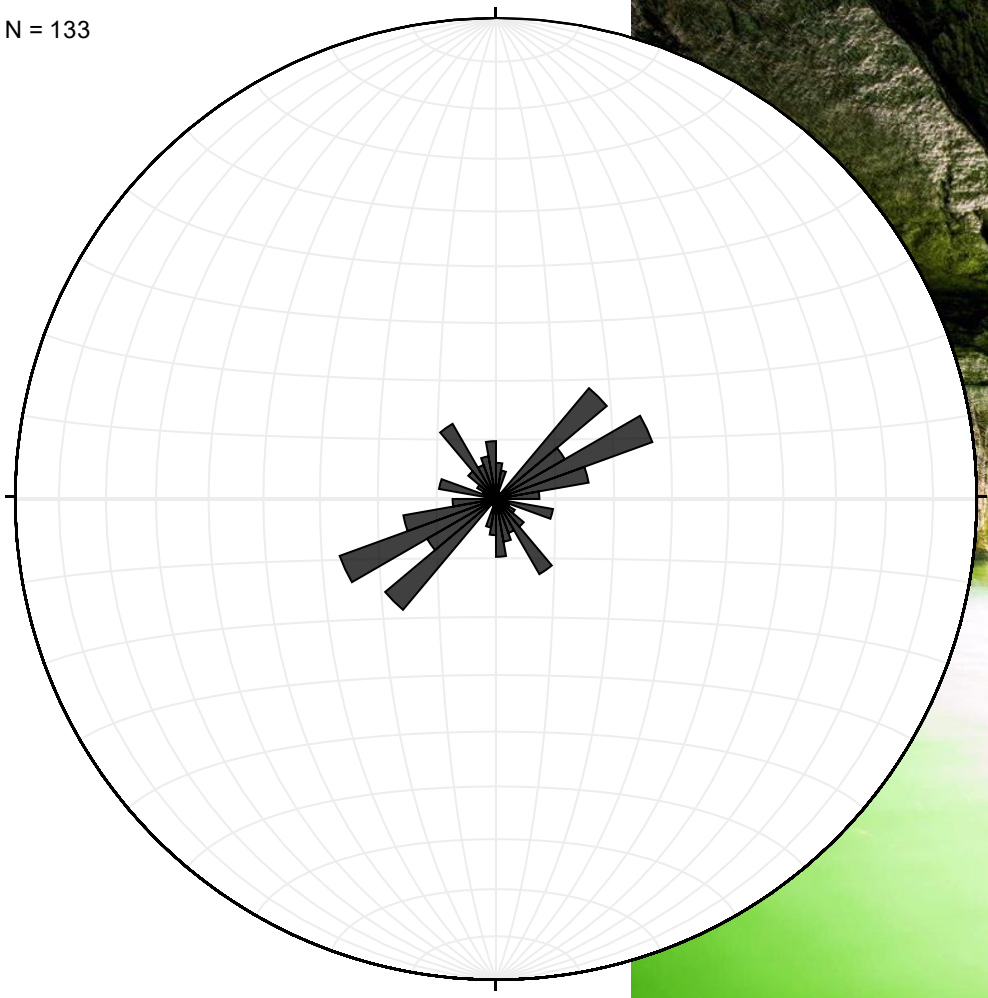


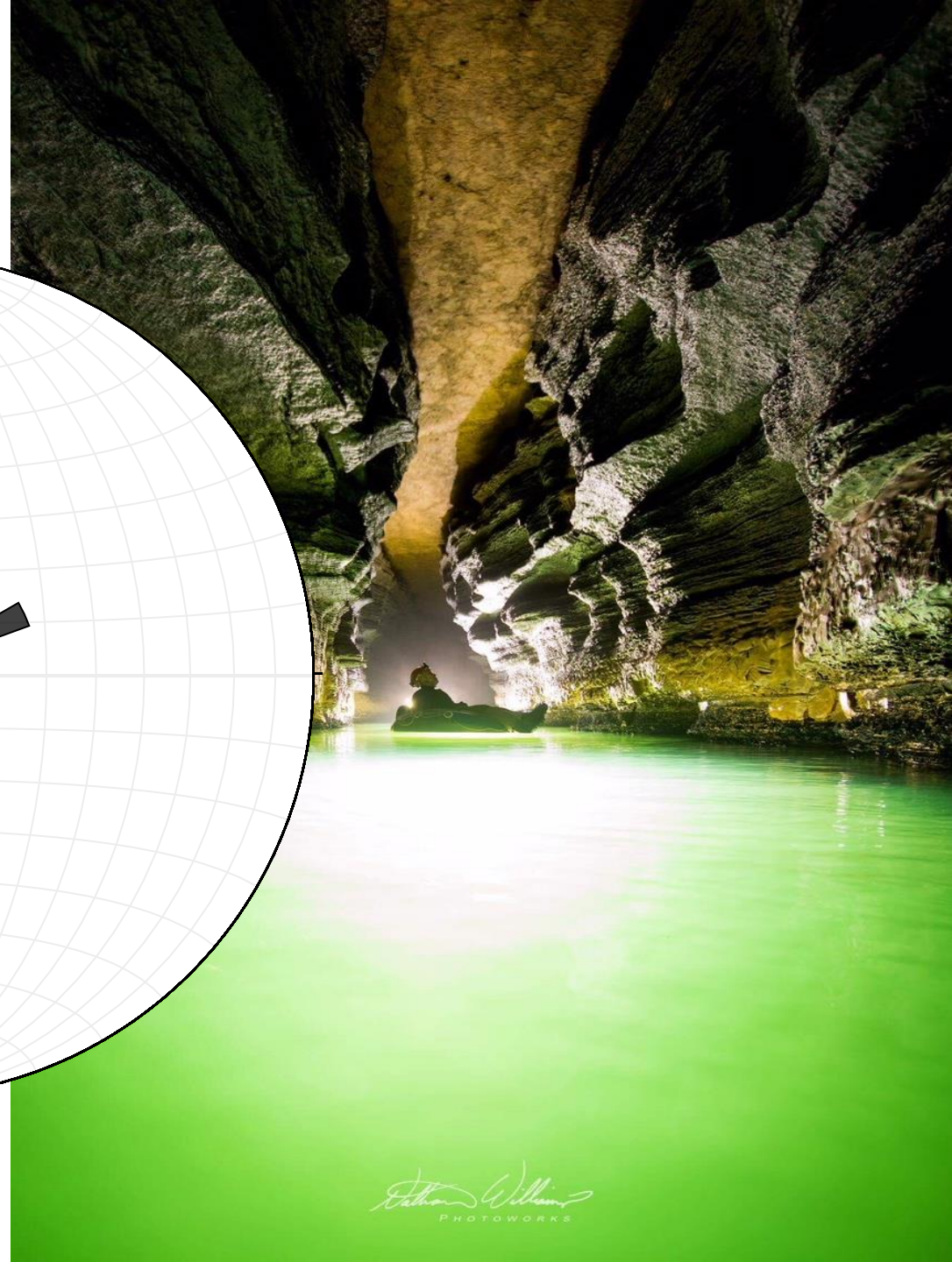
Sub-Surface Fracture Collection

- Three survey trips lasting two days took place
- Strike and density was collected
- Fracture had zero slope, due to geology of area
- Fracture length could not be collected due to intersection with passage walls
- Fracture location was recorded on a map

Sub-Surface Fracture Analysis

- Collection was difficult due to water levels
- Data was used to create a rose diagram
- Dominant fracture Strike was 145 and 045 degrees
- **Fracture strike Followed major Passage orientations**





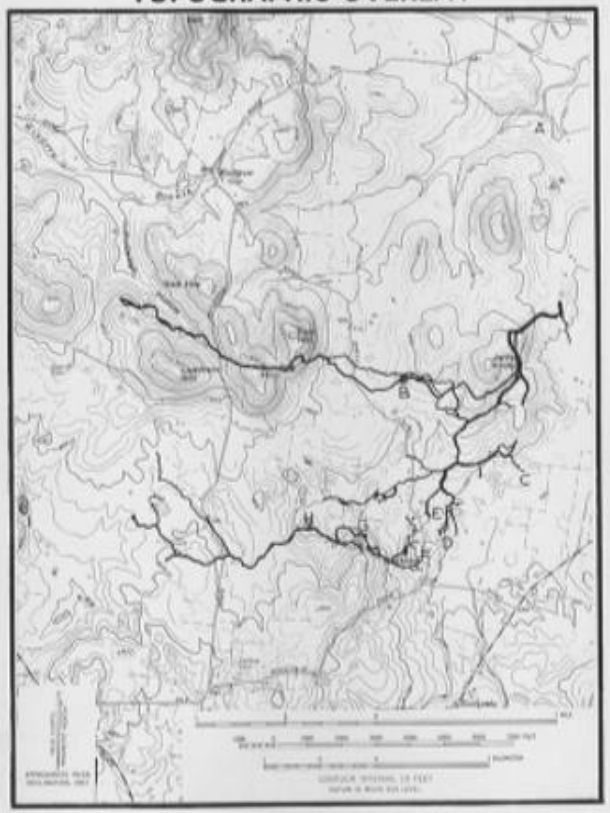
SNAIL SHELL CAVE SYSTEM

Rutherford County, Tennessee

SNAIL SHELL CAVE
TRU16

NANNA CAVE
TRU9

TOPOGRAPHIC OVERLAY



ENTRANCES, SPRINGS AND RELATED CAVES

A. Overall Spring Resurgence
B. Snail Shell Entrance
C. Barr Entrance
D. Echo Entrance
E. Clark Entrance
F. Wilkerson Entrance
G. Banishment Entrance
H. Nanna Entrance
I. The Gulf

NORTH

SCALE 0 300 600 FEET

LEGEND

- (5) Ceiling height in feet
- +5 Depth of water in feet
- 5 Elevation below datum in feet
- 5 Elevation above datum in feet
- [5] Drop or climb in feet

All other symbols are N.S.S. standard
Cross-sections of passages are 2X.

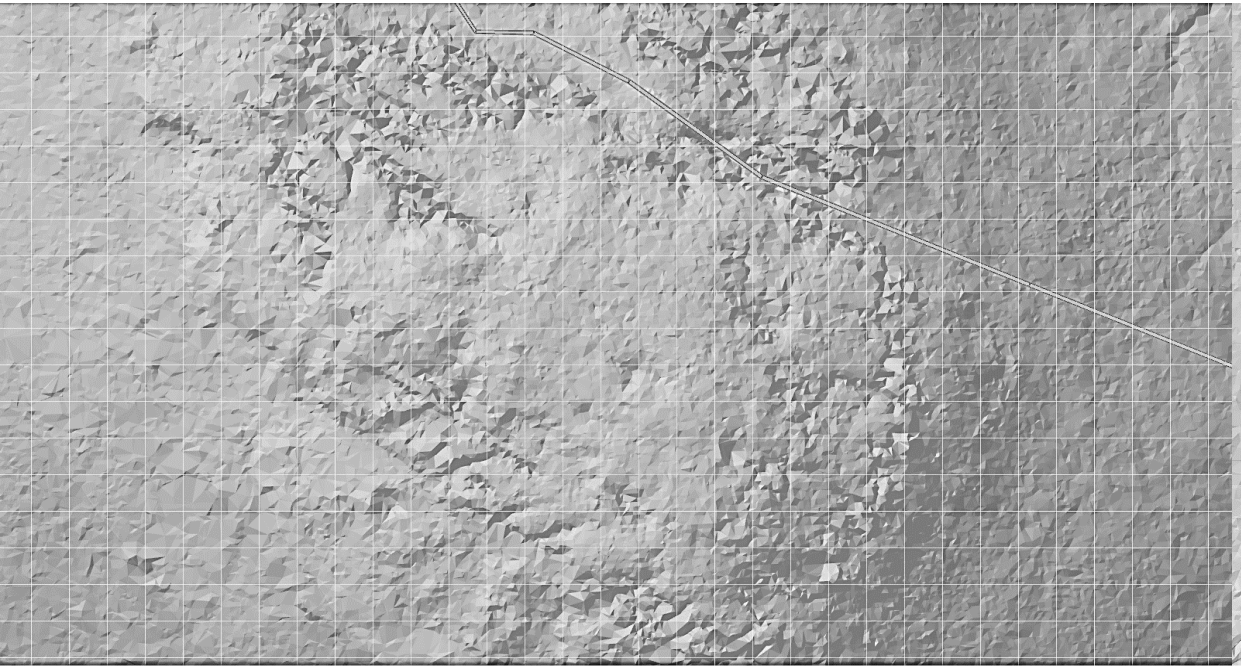
SNAIL SHELL CAVE SYSTEM SURVEY DATA

GRADE 5 SURVEY		September 1977-November 1981	
Snail Shell Cave	Length:	9.071 miles,	14.598 kilometers
	Depth:	144 feet,	44 meters
Nanna Cave	Length:	3.694 miles,	5.945 kilometers
	Depth:	116 feet,	35 meters

—SURVEYORS—

Surface Data collection using LIDAR

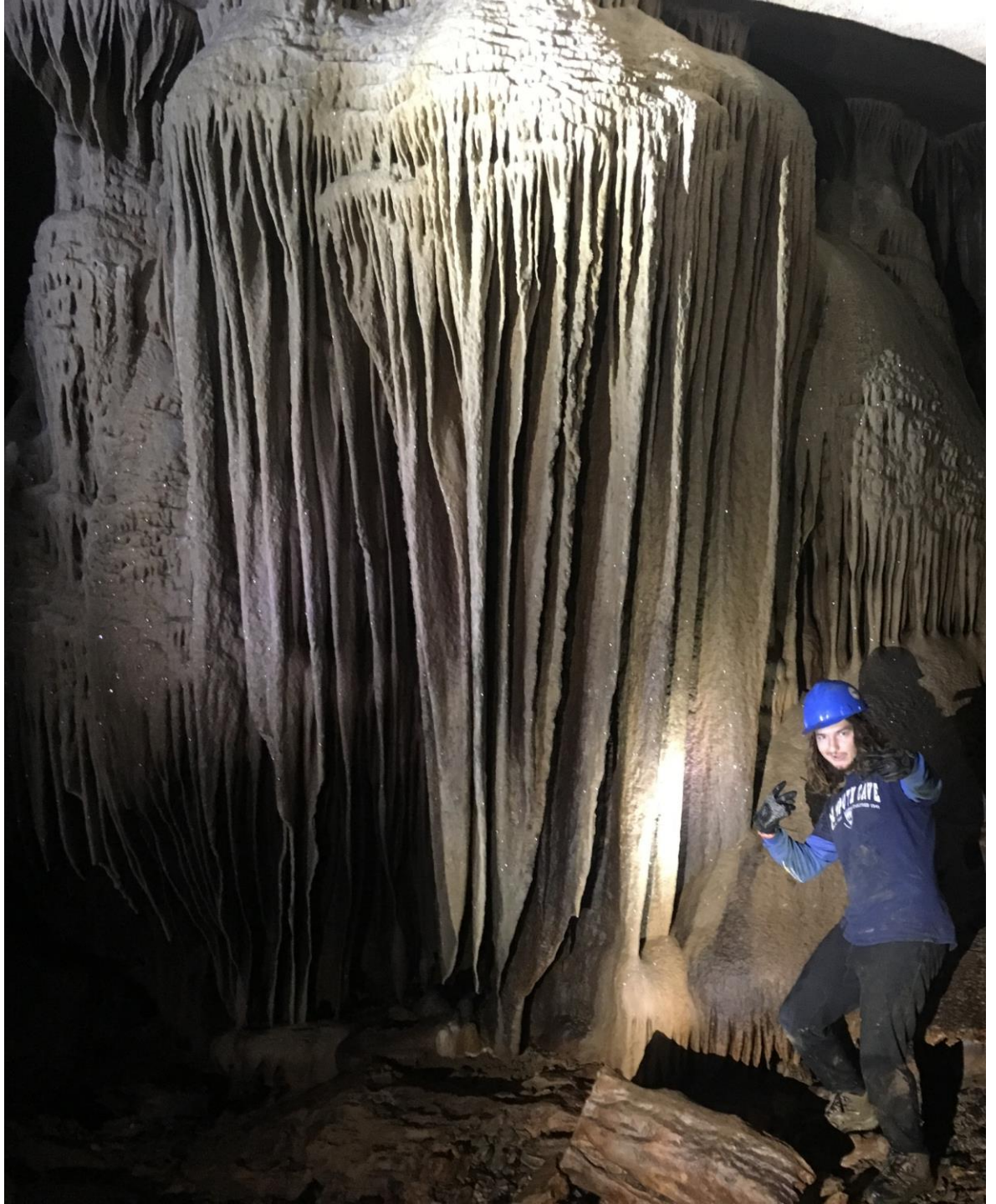
- Surface field study Impossible
  - Heavy Vegetation
  - Lack of Access to land
- Large karst fissures following fractures allowed data to be collected using LIDAR data provided by Rutherford County
- Surface fractures and cave map were traced onto ArcGIS




Red Hill
Hollow
WINDROW
SNAIL
Cem
Fain
Hill
BM
771
SHEL
Dyer
Cem
Leathers
Hill
Rowling
Hill
Jarrett
Knob
CAVE
Cem
660
Rockvale
Ch.
ROAD
ROAD
THOMPSON
850
800
750
700
650
730
690

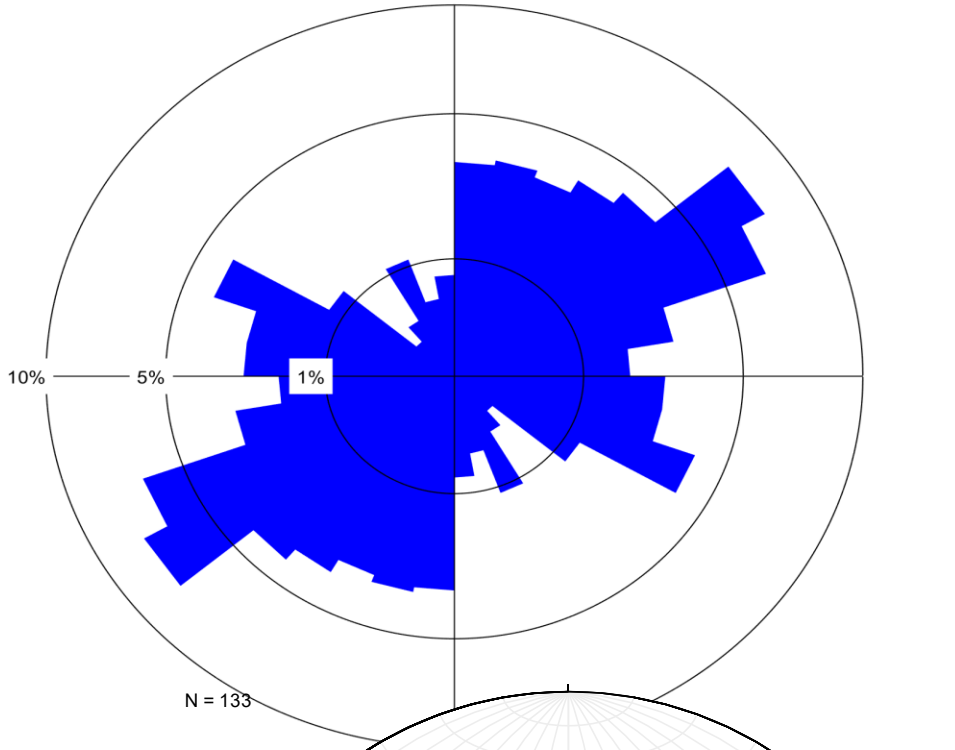
Data Analysis

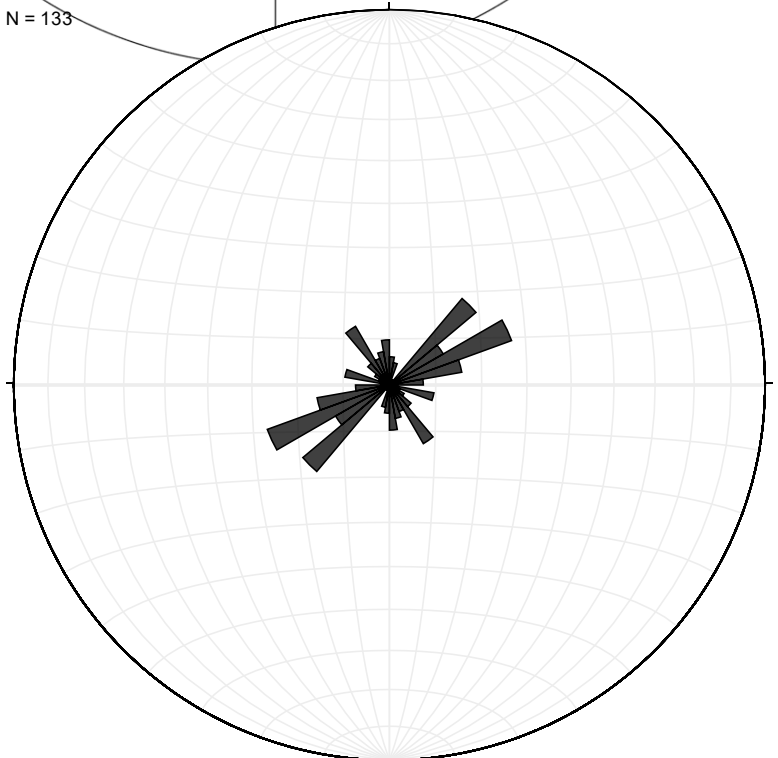
- Fracture trace was then entered into the MatLab suite FracPaQ
- This suite designed by Dr. Dave Healy analys's fracture traces to create a number of different statistics
- It was used to create
  - Fracture strike rose diagram
  - Fracture trace intensity diagram



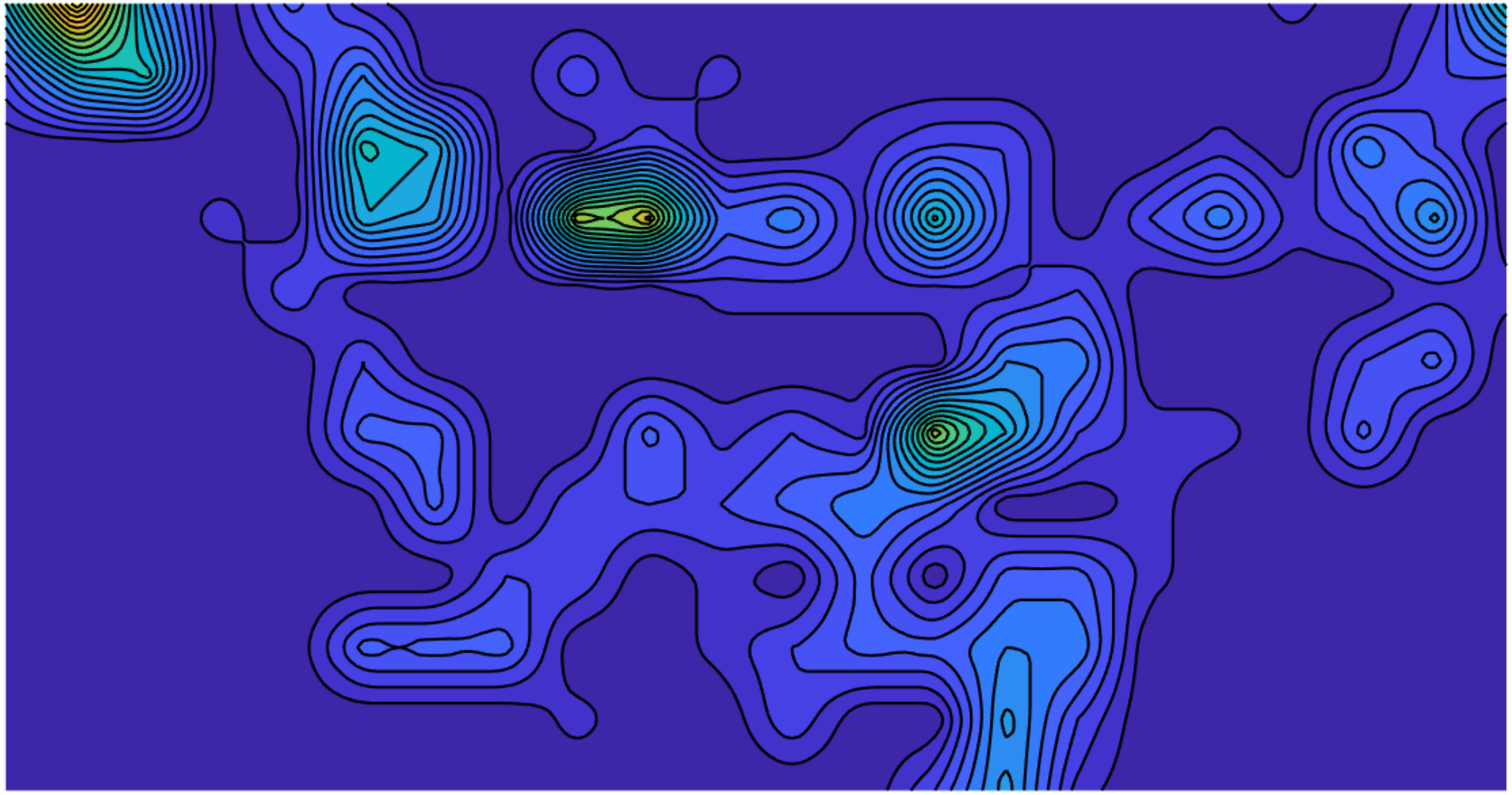
Rose Diagrams

- The sub-surface and Surface Rose diagrams lined up well with the dominant fracture direction in 145 and 045 degrees
- The fracture on the surface are the same fractures population seen in the cave
- They act as a source of recharge for the cave system

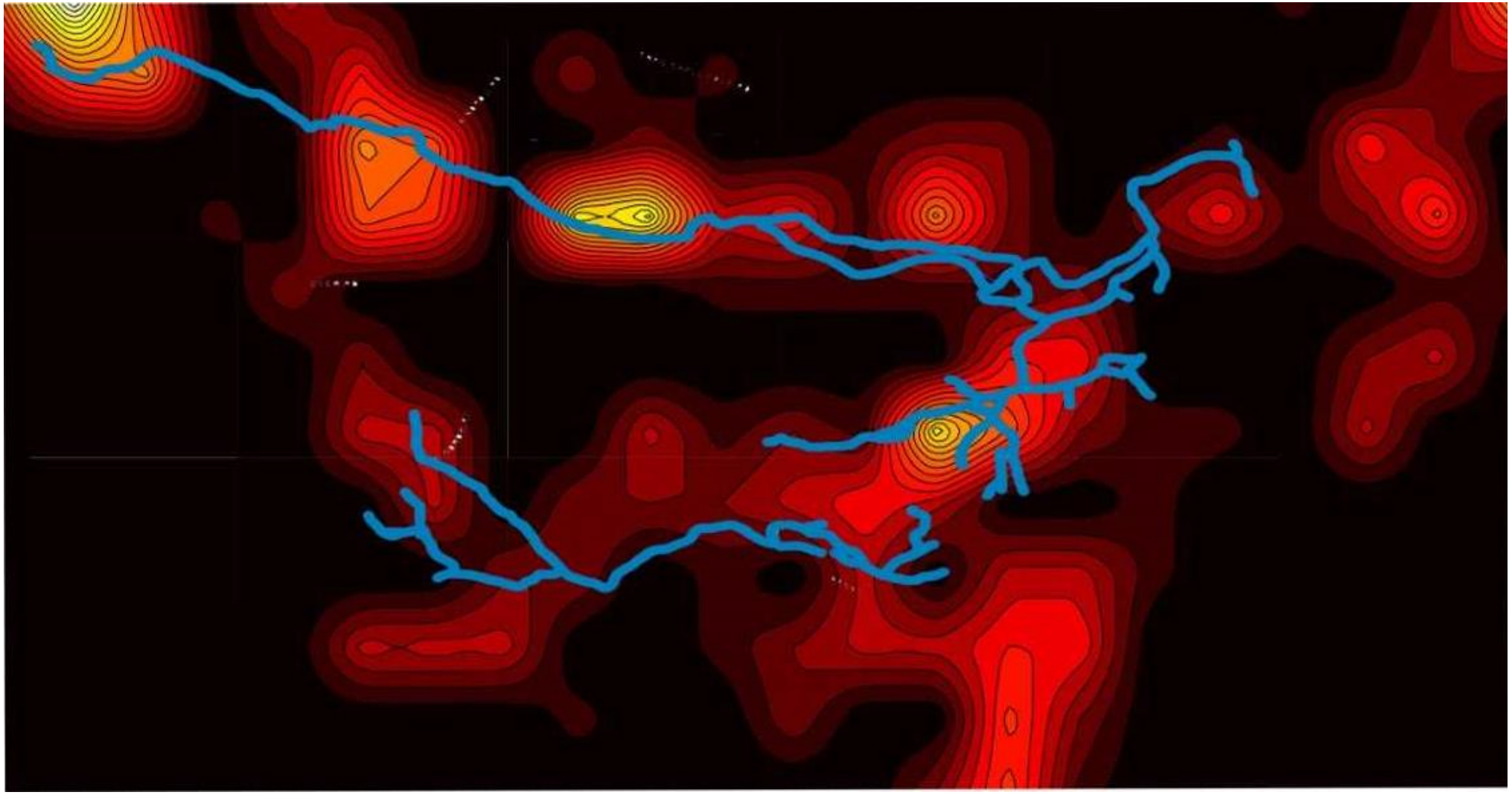




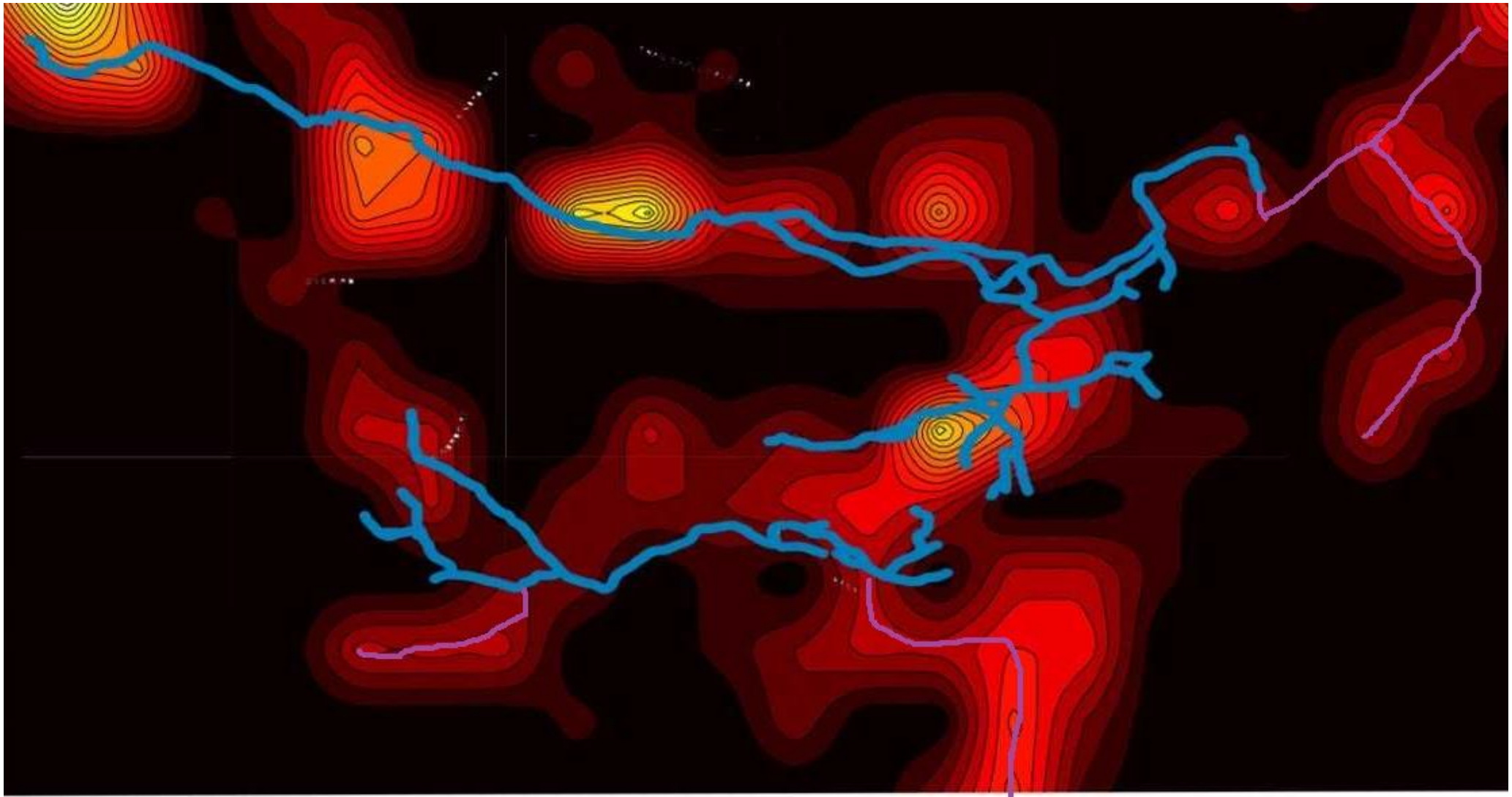
Fracture Intensity Diagram



Fracture Intensity closely matched the cave passages location



From looking at Intensity you can estimate where undiscovered passages might be



Conclusion

- Fracture Strike in the cave closely matched fracture Strike on the surface, suggesting the same fracture population
- Fracture intensity map closely simulated cave passage shape
- Fracture Intensity on the surface could be used in shallow caves to assume the possible location of undiscovered cave passages, correct errors in cave maps, and find contamination points
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Future research

- This study could easily be tested for effectiveness by duplication by
  - Placing other cave maps in GIS
  - Using LIDAR to map surface Fracture patterns
  - Using MatLab FracPaQ to create fracture intensity maps
  - Then see if the cave map and intensity map match up
  - This could be done on several shallow caves to possibly locate new passages
- Further exploration of Snail Shell will most likely involve diving

Acknowledgments

- Southeastern Cave Conservancy
  - Bob Biddix
  - Robert Handford
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