



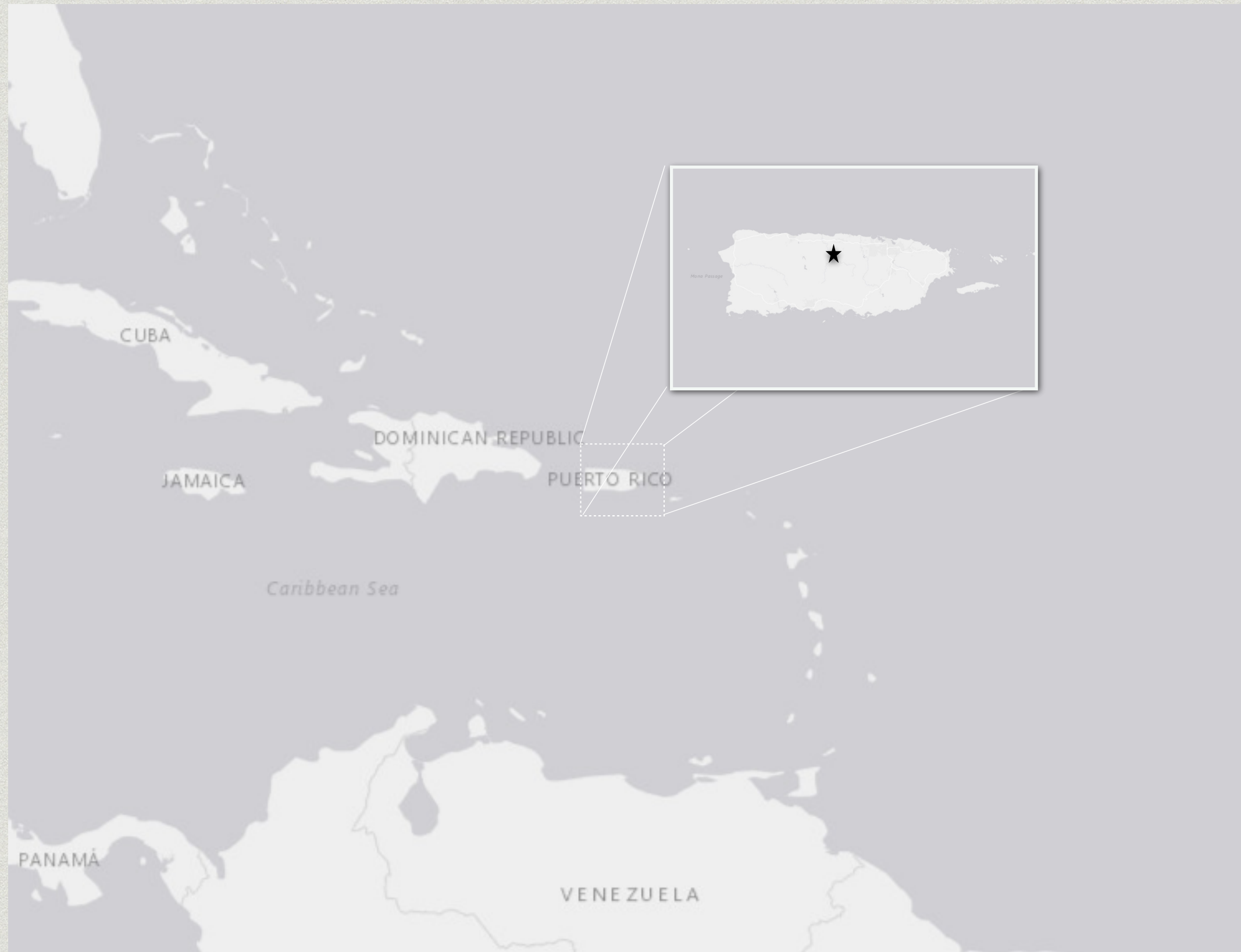
DEPARTAMENTO DE
FÍSICA Y QUÍMICA



GEOMETRICAL CHARACTERIZATION OF THE CABACHUELAS NATURAL RESERVE CAVE SYSTEM

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Location of Cabachuelas Nature Reserve Cave System

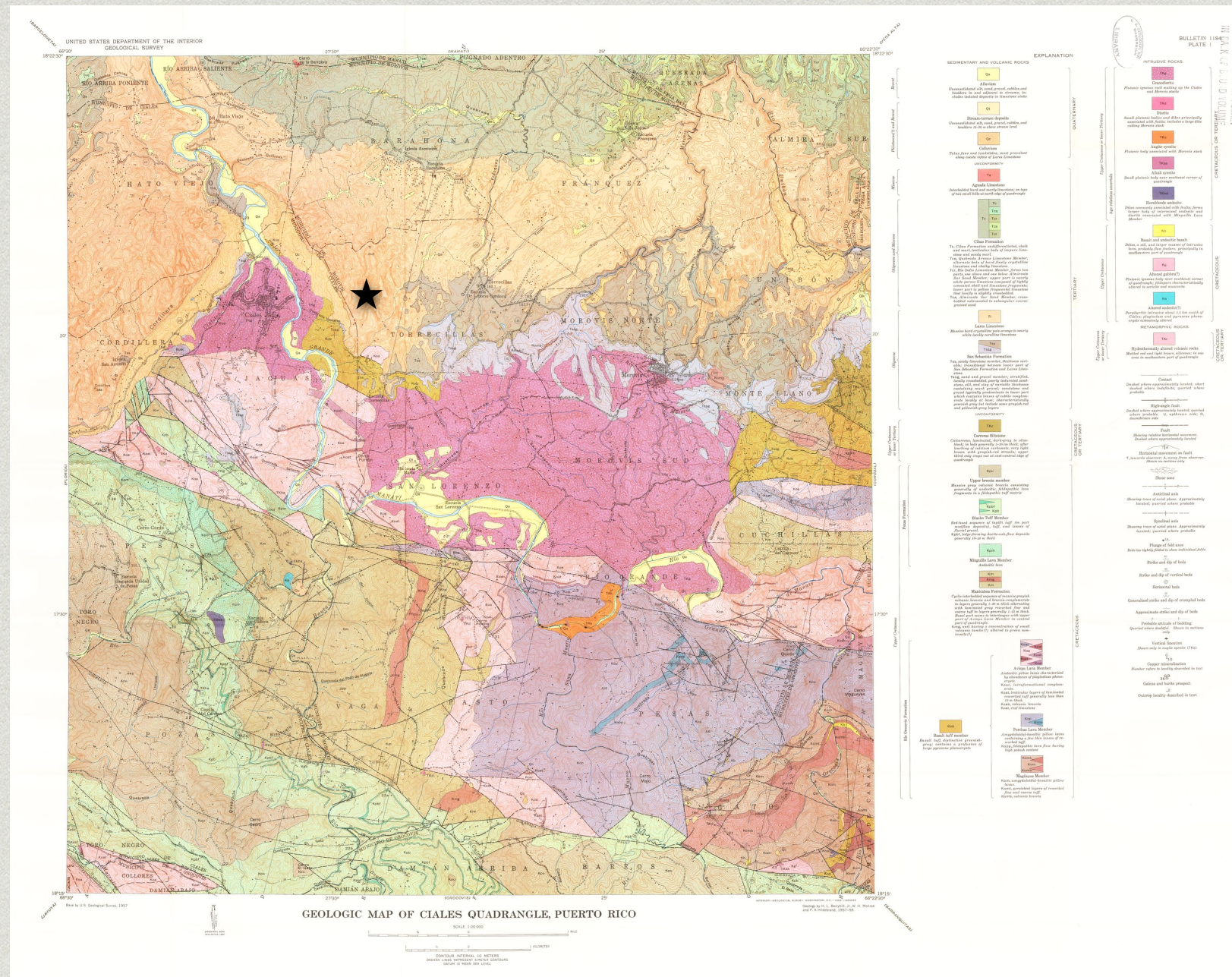


Location of Cabachuelas Nature Reserve Cave System



Las Cabachuelas is located in Morovis and Ciales, PR and was declared as a preserved site in February 2012 due to its natural and historical value. The reserve consists in approximately a cave system of 60 caves.

Location of Cabachuelas Nature Reserve Cave System



Geologically, the reserve is located in the Lares Limestone formation, a massive hard crystalline pale-orange to nearly white locally coralline limestone, and surface and groundwater dissolution processes created the caves.

Cabachuelas Nature Reserve Cave System



Cave found: 2, 3, 4, 6, 9, 11, 14, 18, 21, 22, 39.

Map provided by Carlos Figueroa-Robles, Proyecto Cabachuelas.

Las Cabachuelas Project Objectives

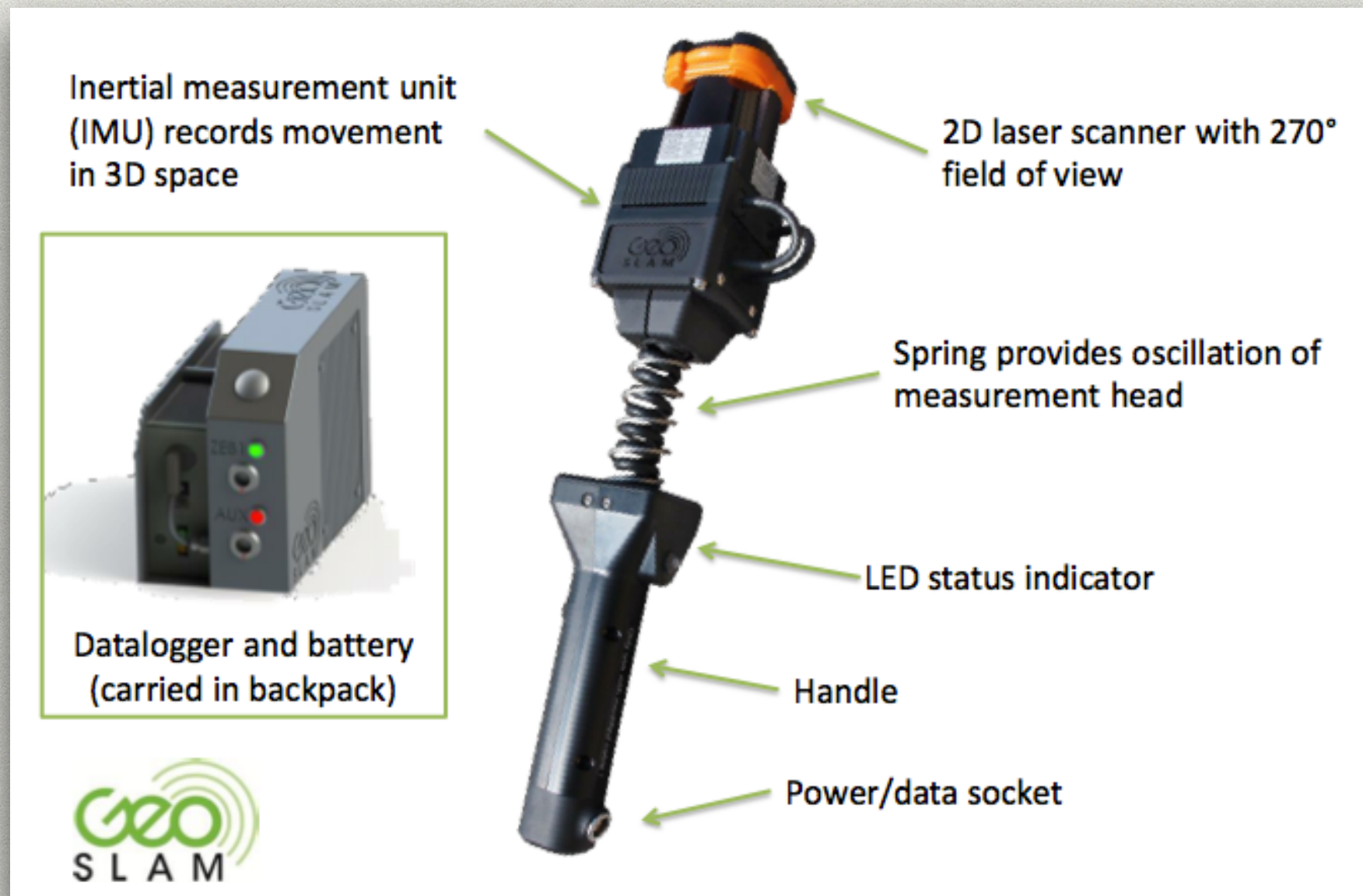
- * The project consist of the geometrical characterization of the Las Cabachuelas Cave System to create a “Swiss cheese model” of the karst reserve.
- * The geometrical characterization of a cave consists in the creation of a 3D cave cartography using light detection and ranging (LiDAR).
- * For this study we will show the results of 6 (out of 11) caves: Cristales Cave, Gemelos Cave, Corazón Cave, Buruquena Cave, Blacky Cave and Los Angelitos Cave.

LiDAR Cave Cartography Method

- * The Geoslam ZEB1 (3-D Laser Mapping) hand held mobile LiDAR was used to obtain the measurements.
- * ZEB1 is a mobile laser scanning system that uses relative measurements to the environment that travels. The system maps the area in around the same time it takes to walk.
- * The data processing consists in that the system estimate the trajectory (position and orientation) using simultaneous localization and mapping (SLAM).



LiDAR Cave Cartography Method



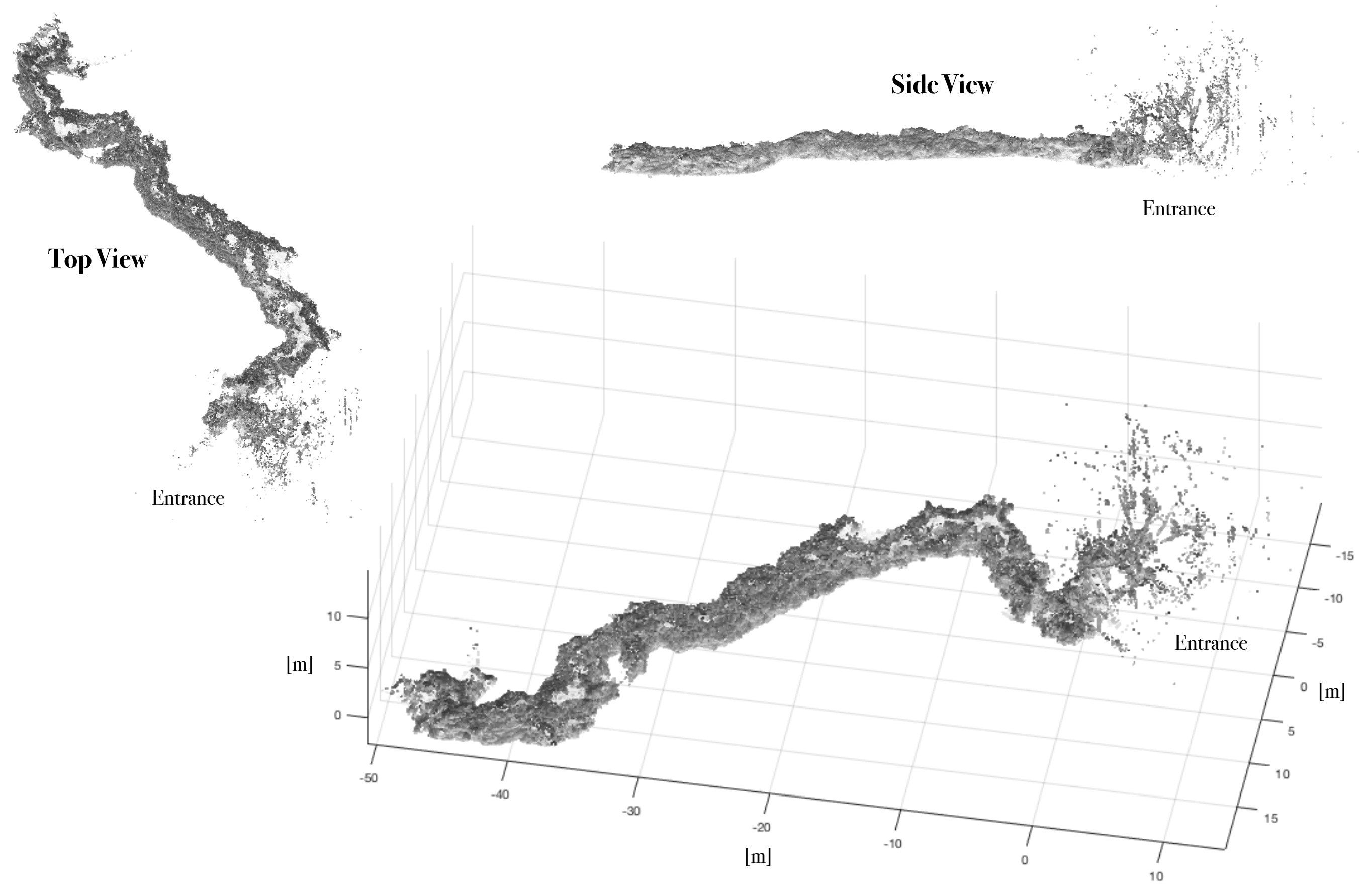
Data Acquisition Speed: 43,200 pts/s

Range: 30 m

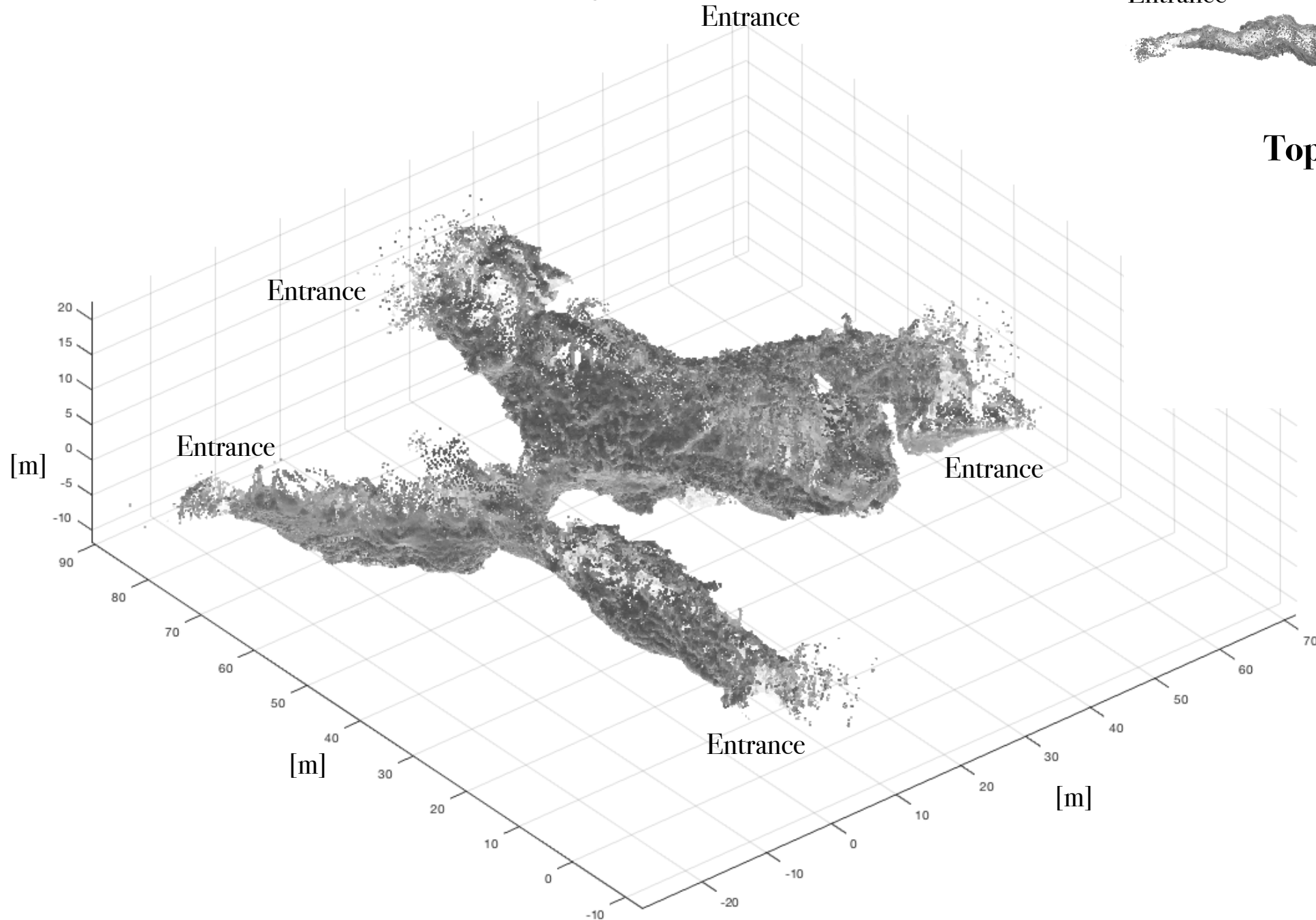
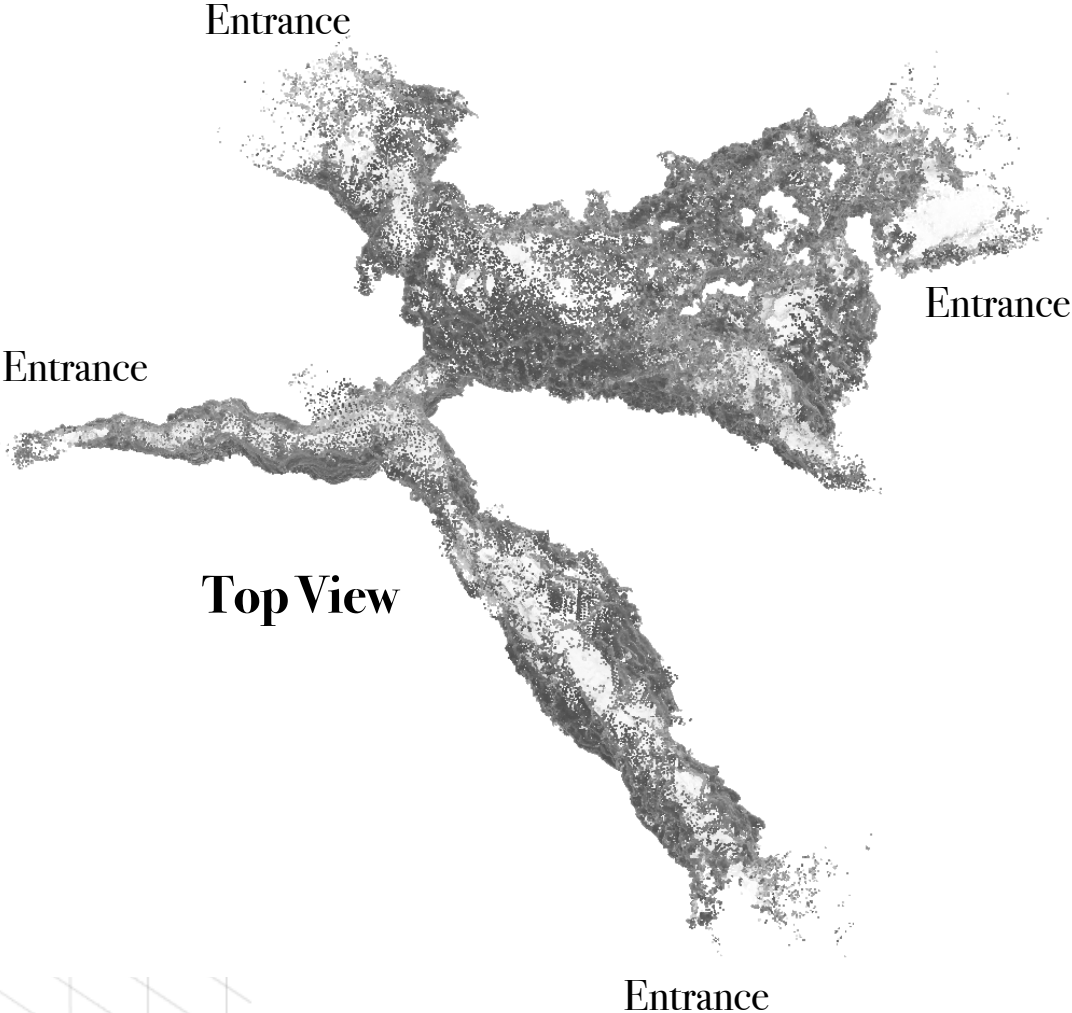
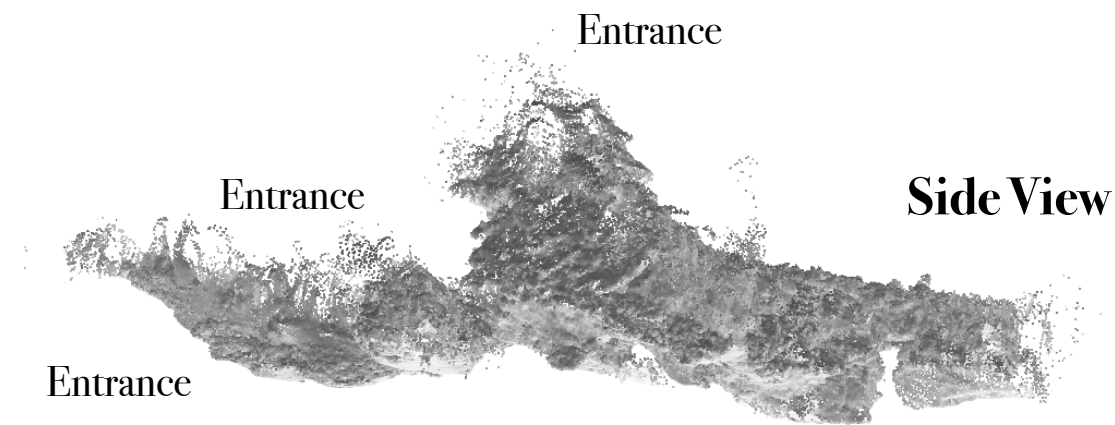
Field of view: 270° x 100°

Source: 905nm laser diode (infra-red)

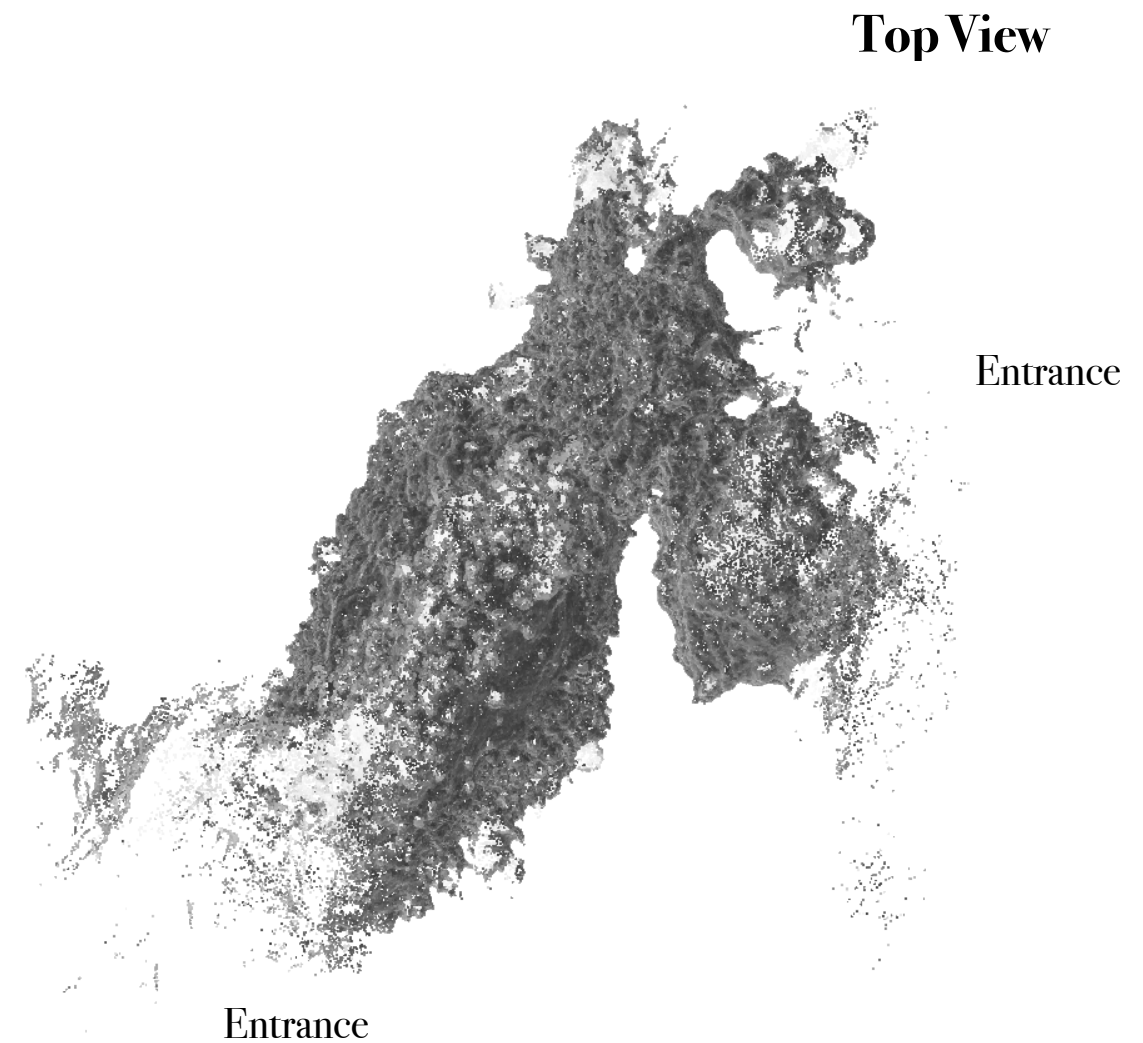
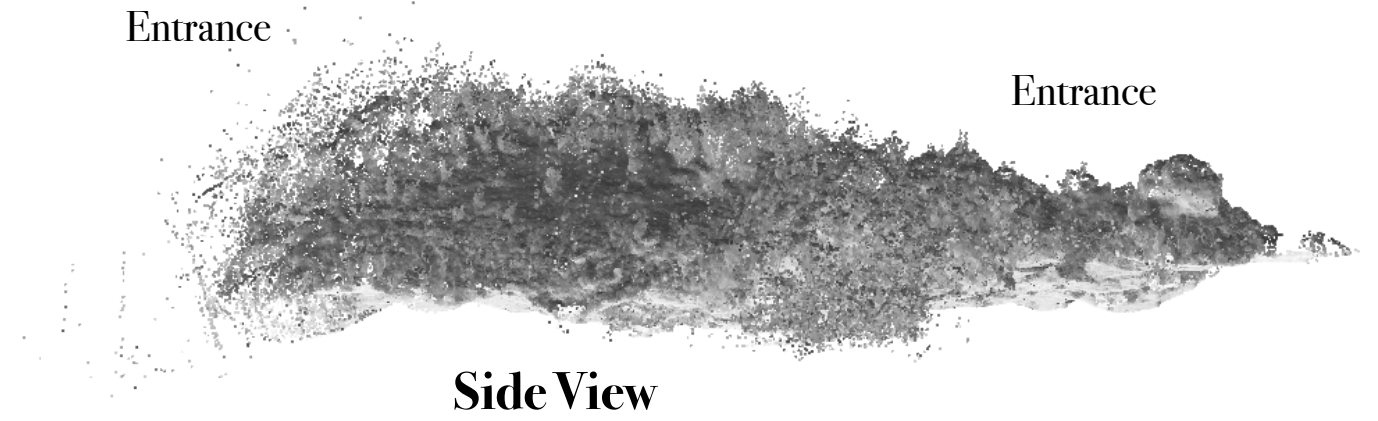
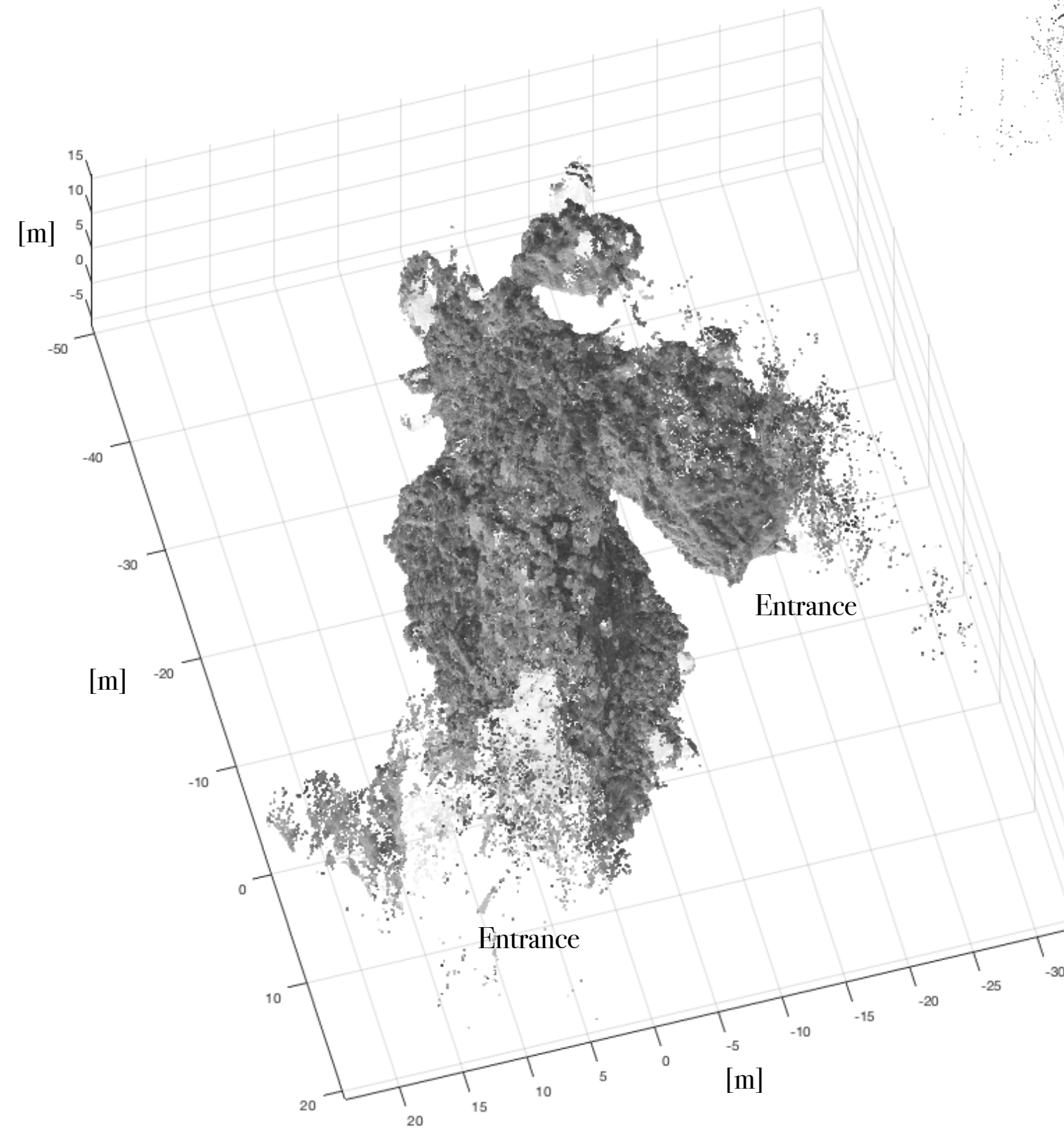
Cristales Cave (no. 6)



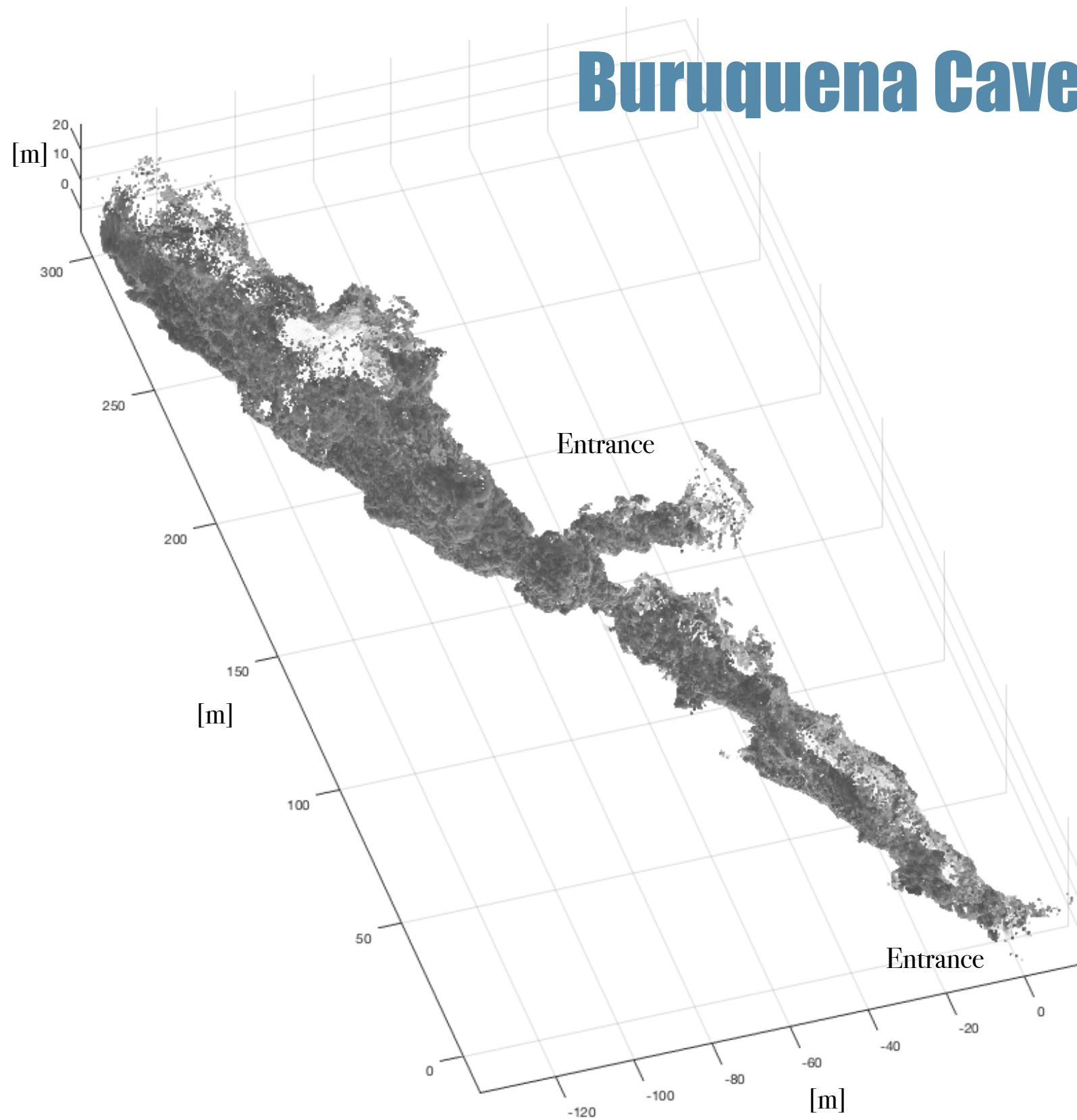
Los Angelitos Cave (no. 17)



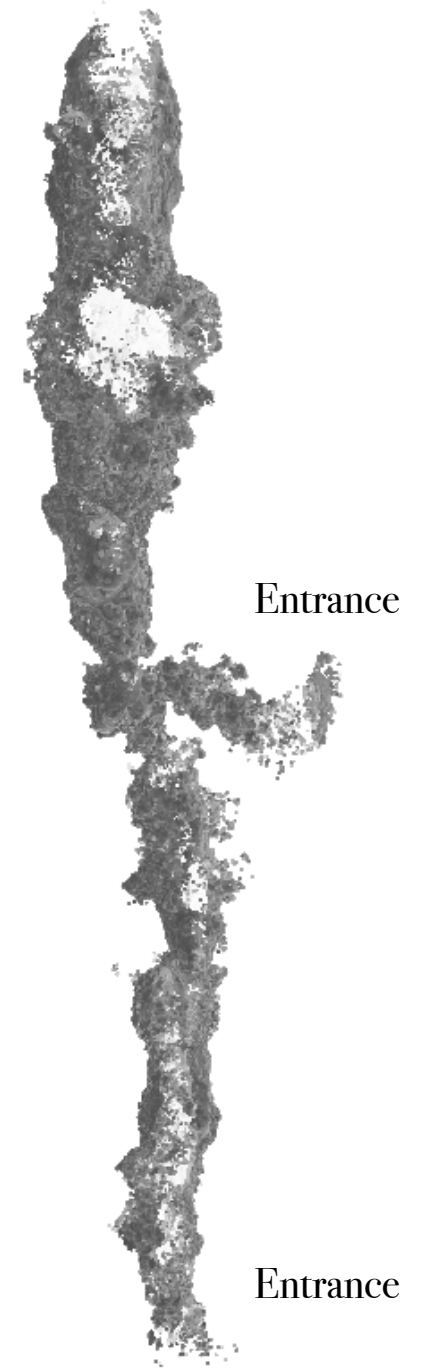
Blacky Cave (no. 14)



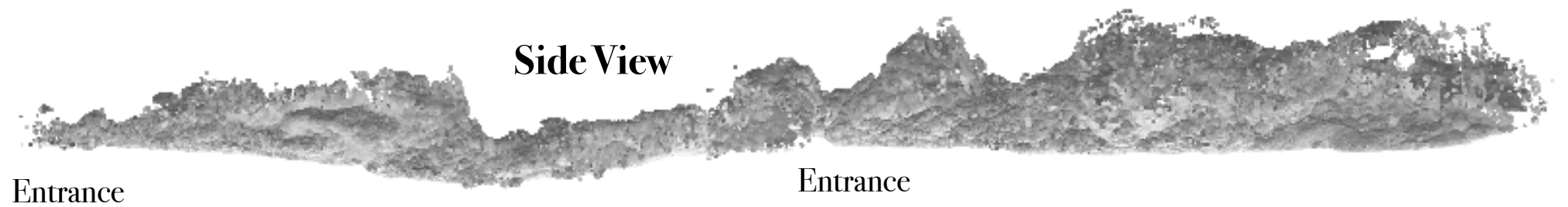
Buruquena Cave (no. 18)



Top View

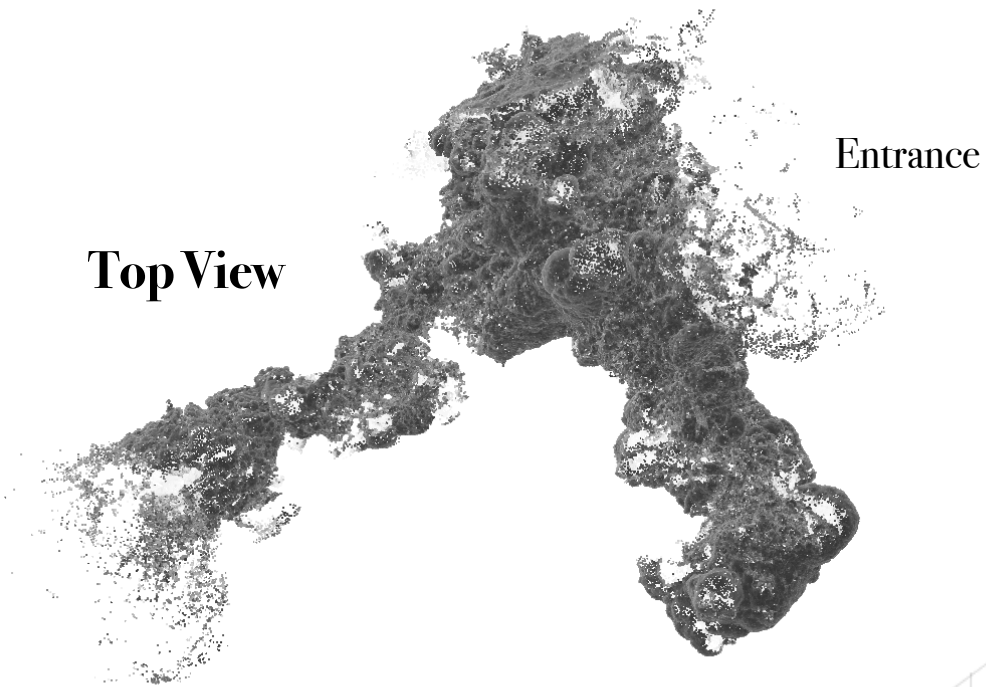


Side View



Gemelos Cave (no. 2)

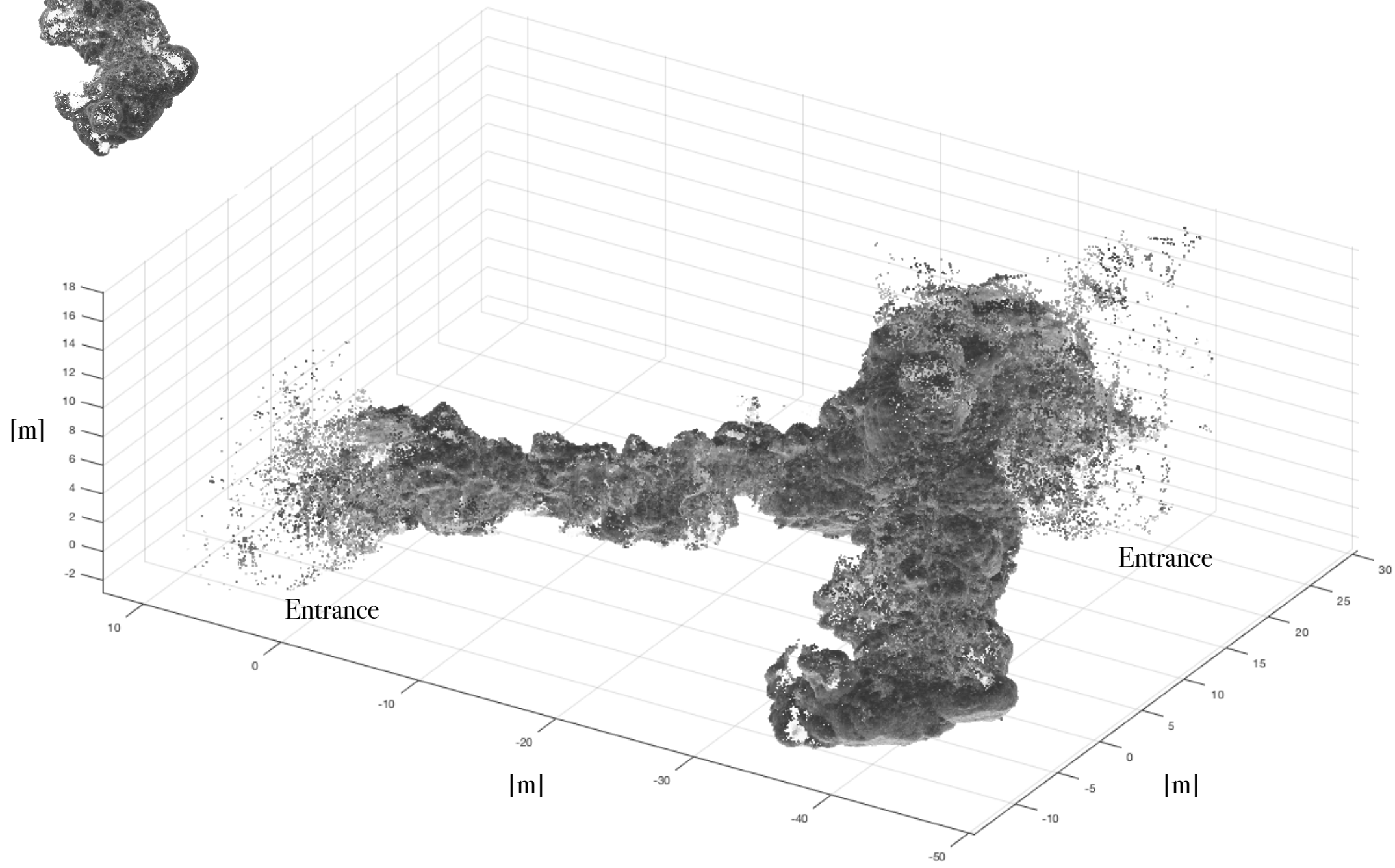
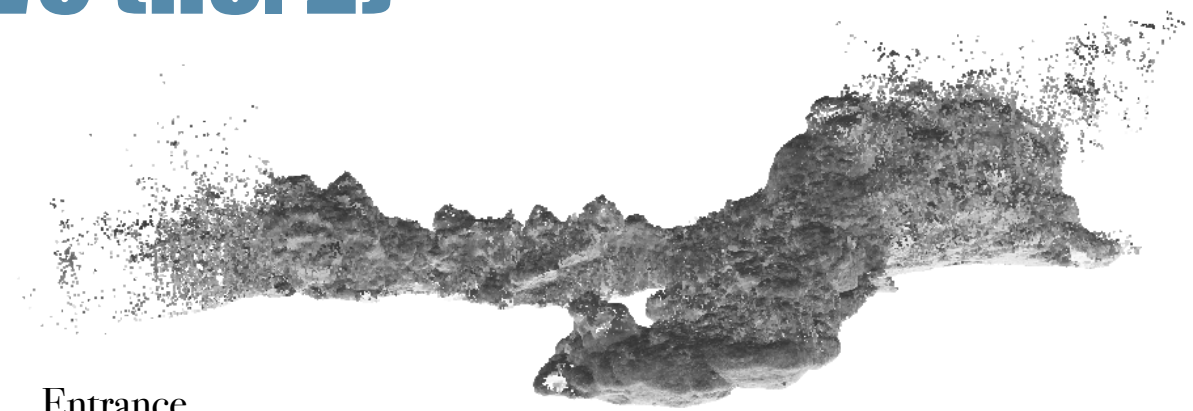
Top View



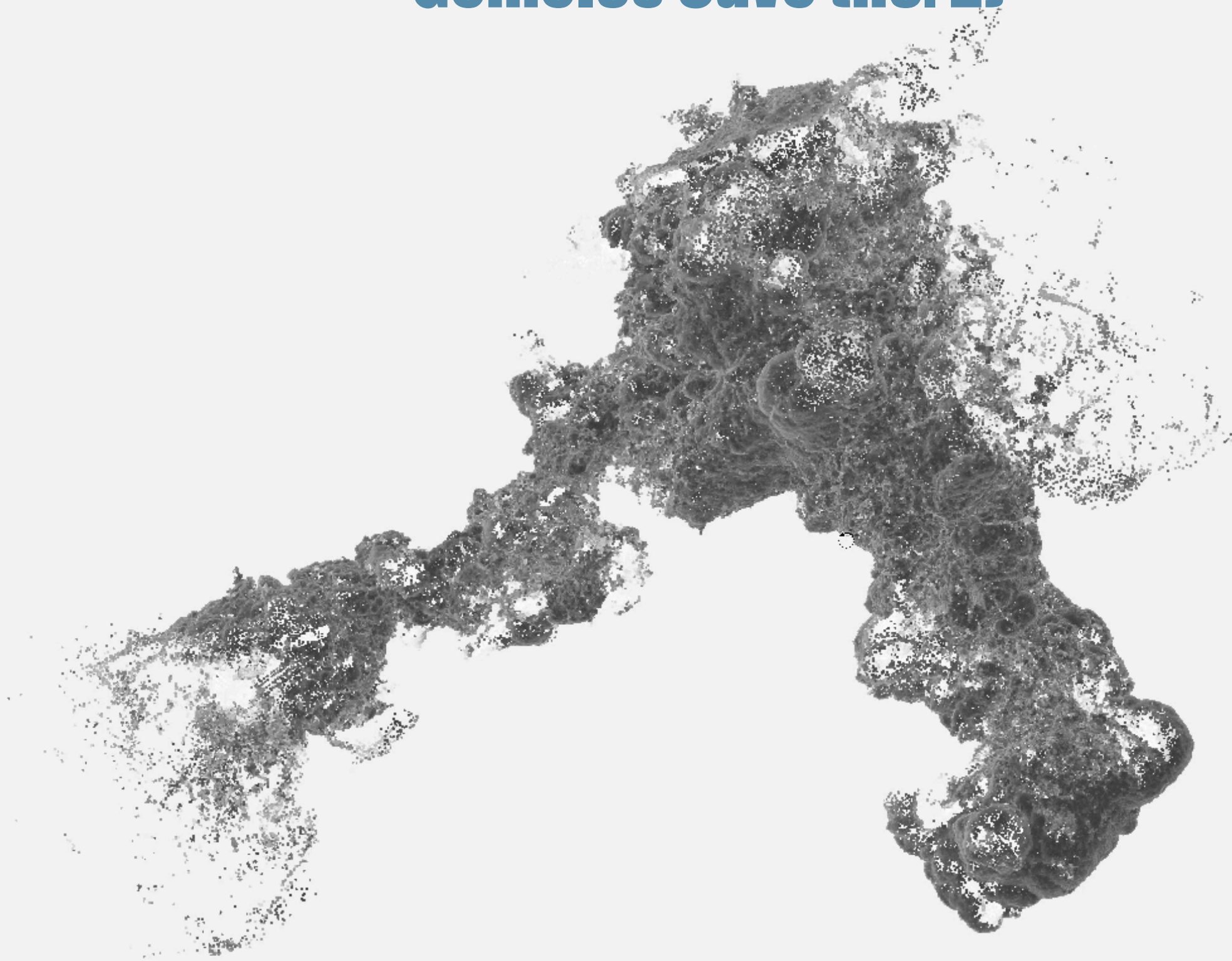
Entrance

Entrance

Side View

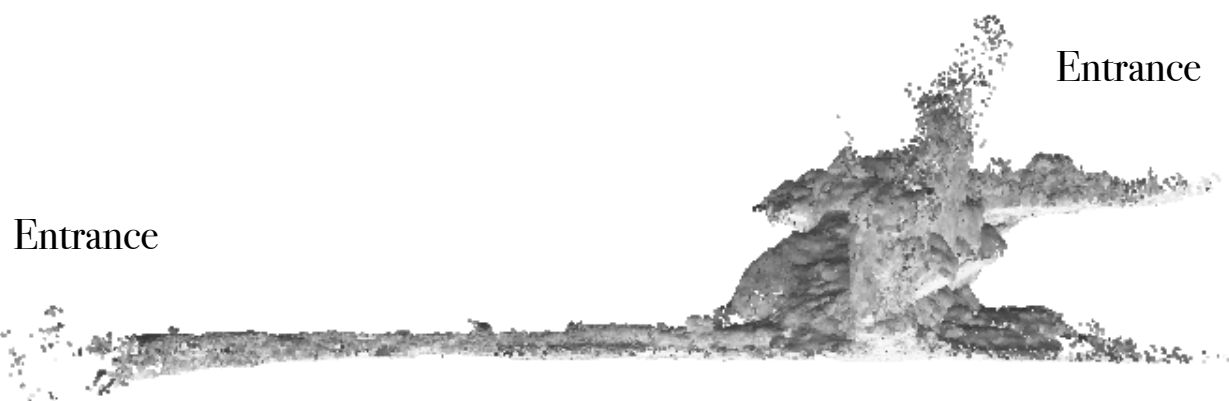
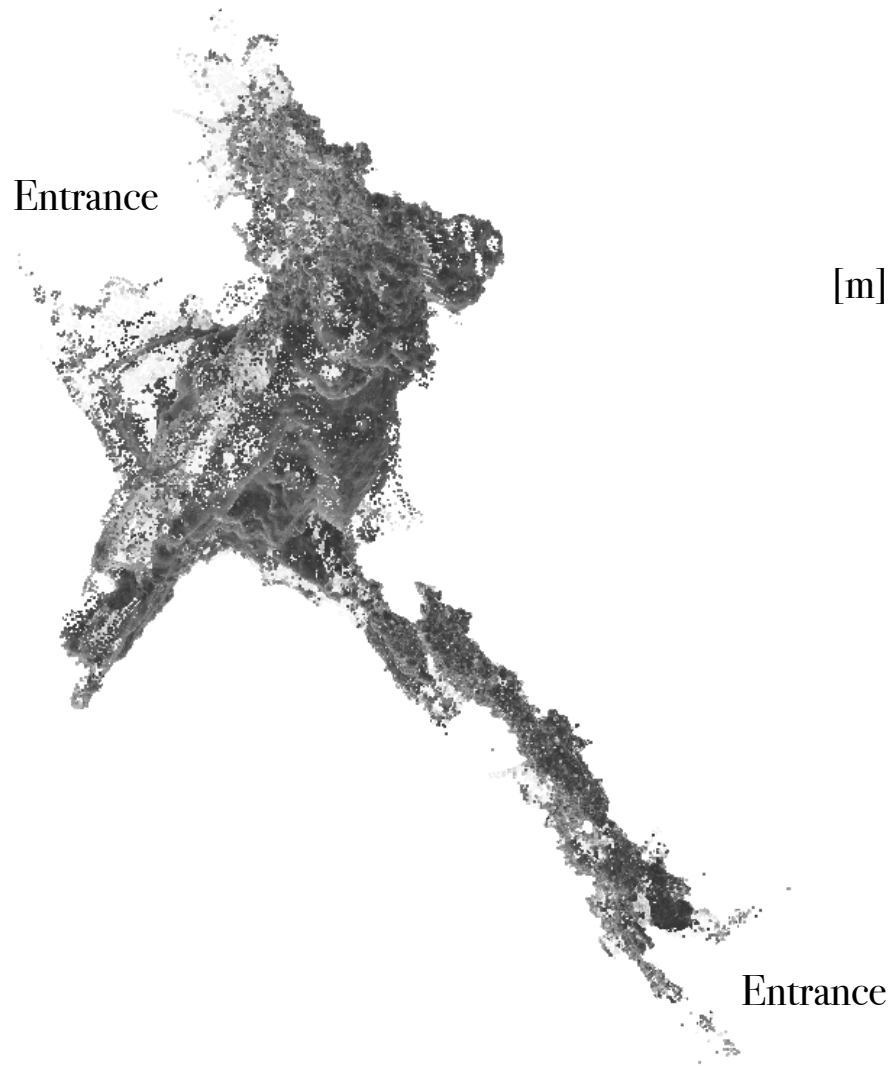


Gemelos Cave (no. 2)

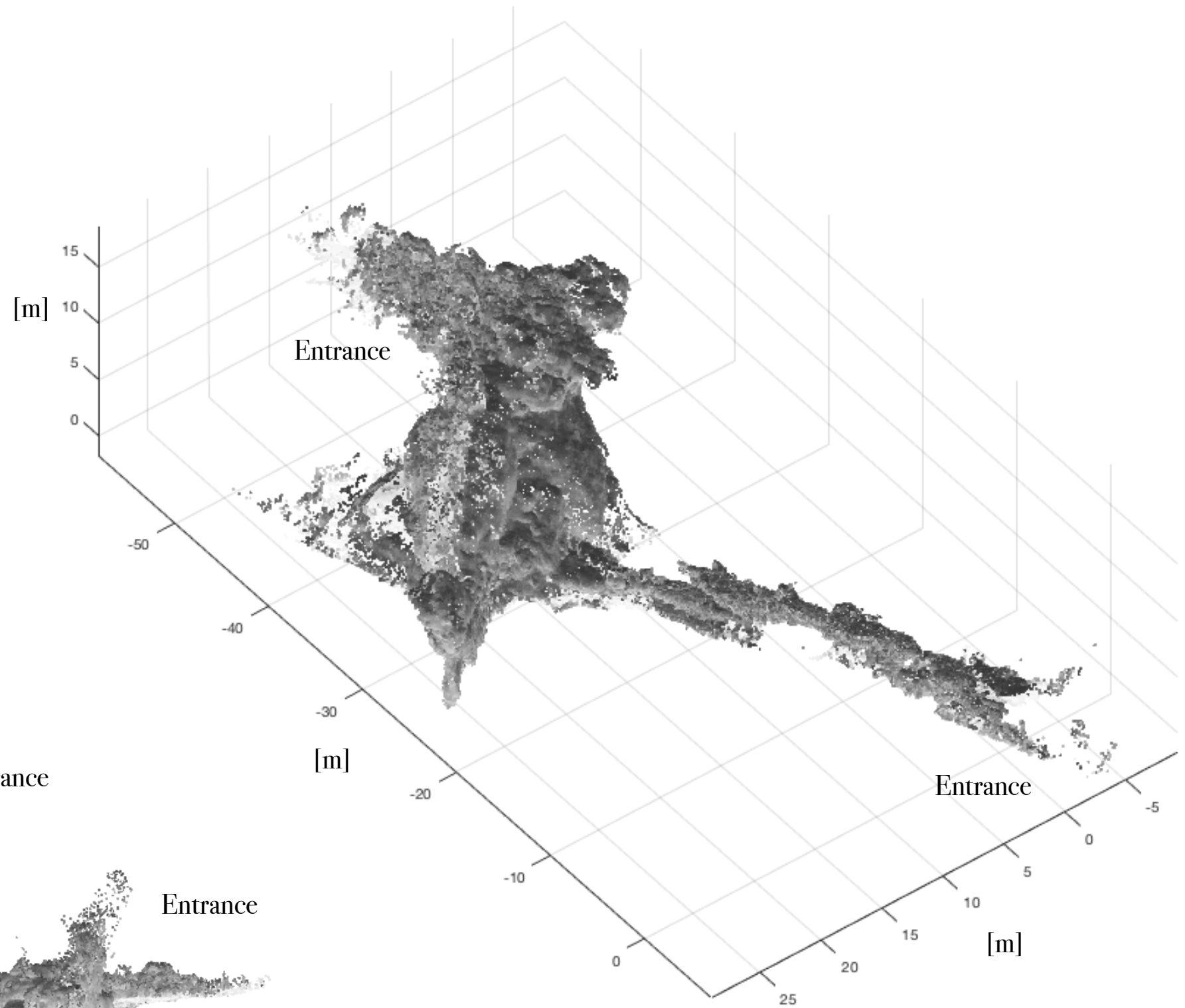


Corazón Cave (discovered)

Top View



Side View



Summary of Geometrical Characterization

Cave Name	Data Collected (in Millions)	Mapping Data 9% reduction (in Millions)	Length (m)
Cristales Cave	7.08	6.5	67
Gemelos Cave	15.4	14.0	~ 39
Corazón Cave	15.3	13.9	44
Buruquena Cave	35.6	32.4	323
Blacky Cave	14.2	12.9	~ 50
Los Angelitos Cave	22.8	20.7	~ 94
Totals	110.4 M		0.62 Km

Summary of Las Cabachuelas Project

- * Las Cabachuelas Nature Reserve region consists of approximately 60 caves.
- * For this study we created the cave maps for 6 caves: Cristales Cave, Gemelos Cave, Corazón Cave, Buruquena Cave, Blacky Cave and Balcones Cave.
- * A total of ~ 0.62 Km were cartographed and 110.4 Millions data points collected.
- * The maps created can be used to develop ecotourism guided routes, cave safety management and develop mitigation plans for karst biodiversity and land protection.
- * Future work consists in map all caves (~60) to create the 'swiss model' of the karst region of Las Cabachuelas to study paleo-underground rivers and karst landforms and its geomorphology.

Acknowledgments

UPRA-MSEIP (P120A110098) for partial funding for this project.

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Puerto Rico Louis Stokes Alliance for Minority Participation for support of my students.



PUERTO RICO LOUIS STOKES



ALLIANCE FOR MINORITY PARTICIPATION

Thanks...
Questions?



Gemelos Cave