

3-D cave mapping in the paleokarst region of Batu Katak in Northern Sumatra, Indonesia

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Why Batu Katak?

The Batu Katak village in Northern Sumatra, Indonesia lies in a karst forest. A group of scientists from the University of Puerto Rico with Harimau Conservation Organization explored the karst forest to find caves as a conservation action to protect the region and its geological importance. The unprotected karst forest is located next to the Gunung Leuser National Park (UNESCO World Heritage Site). This region is impacted with palm oil farms and possible mining. Our main goal was to create caves maps to be used for sustainable ecotourism and to understand the karst biodiversity including troglodytes species such as bats, snakes, cave swallows, tigers and many more.

Cave Cartography Method

Light Detection And Ranging (LiDAR) was used to create 3-D cave maps. The Geoslam ZEBI (3-D Laser Mapping) hand held mobile LiDAR was used to obtain the measurements. 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 acquisition speed is 43,200 pts/s with a range of 30 m. The field of view: 270° by 100° and its source is a 905 nm laser diode (infra-red). The data processing consists in that the system estimate the trajectory (position and orientation) using simultaneous localization and mapping (SLAM).



Figure 1. Geoslam Zeb 1 LiDAR

Geologic Setting of Batu Katak

The Batu Katak village in Northern Sumatra, Indonesia is located in the Batumilil formation (Bachtiar et. al., 2014), a paleokarst that consist in dark gray to reddish gray limestone. By understanding the cave characteristics, can be concluded that the caves were created in an ancient karstification (paleokarst). Recent karstification processes is occurring and creating stalactite and stalagmites (new calcite deposition) in most of the caves.

Figure 2. Map of study location.



Figure 3. Geological Map of Sumatra (Crow & Barber, 2005)

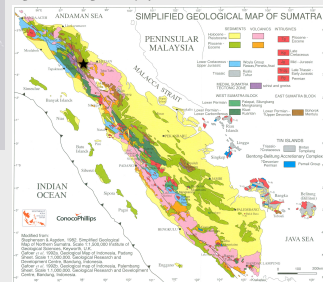
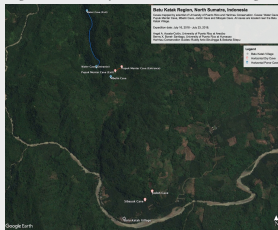


Figure 4. Location of caves in the Batu Katak Region



References:
- Bachtiar et. al., Sedimentology and Petrography of Selected North Sumatra Pre-Tertiary Formations: Anticipating New Petroleum Systems in Western Indonesia, 3rd International Conference on Geological and Environmental Sciences, 2014.
- M. J. Crow and A. J. Barber, Maps Simplified geological map of Sumatra, Geological Society, London, Memoirs, 31, NP, 2005.

Cave Cartography Results

(all axes in meters)

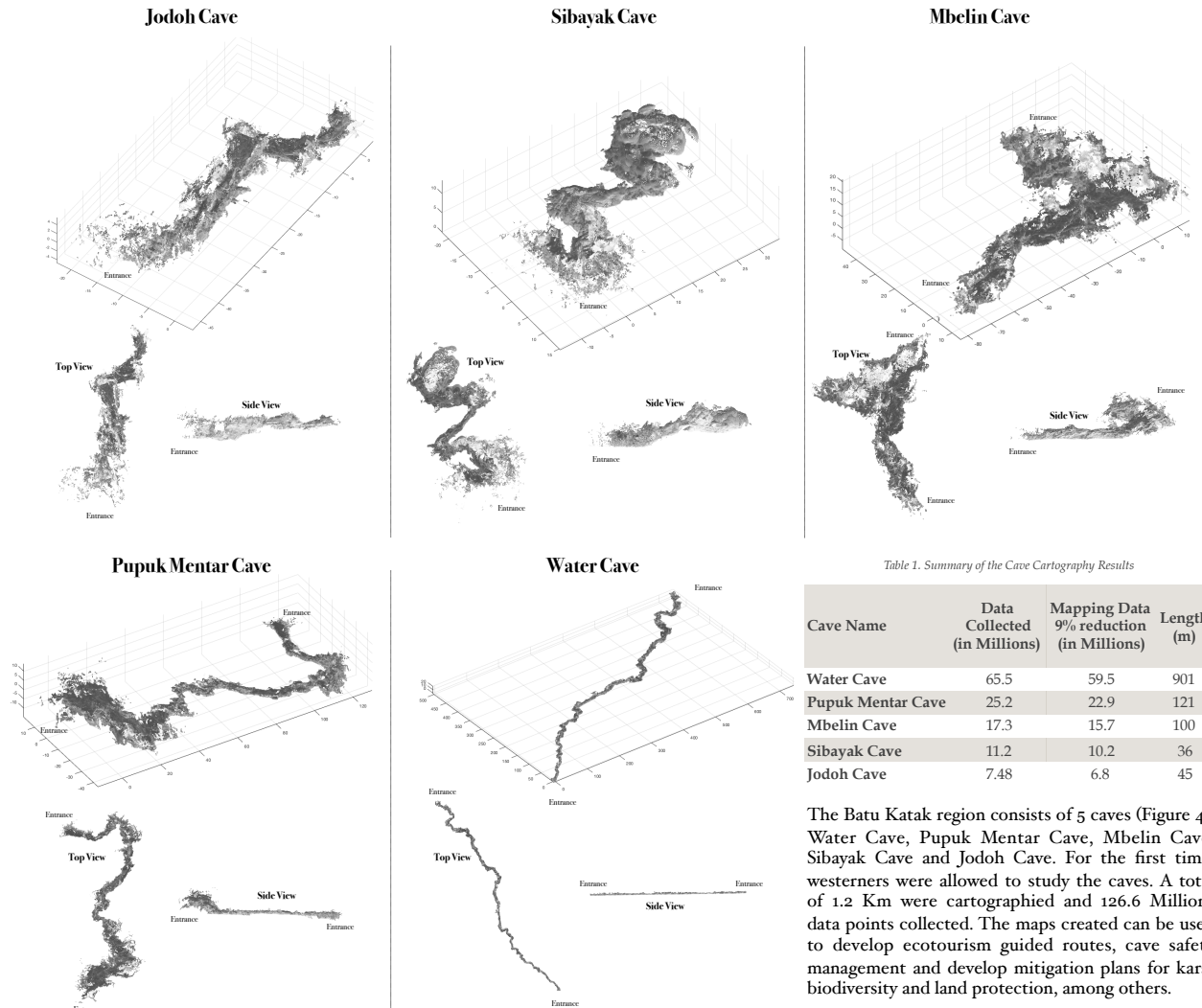


Table 1. Summary of the Cave Cartography Results

Cave Name	Data Collected (in Millions)	Mapping Data 9% reduction (in Millions)	Length (m)
Water Cave	65.5	59.5	901
Pupuk Mentar Cave	25.2	22.9	121
Mbelin Cave	17.3	15.7	100
Sibayak Cave	11.2	10.2	36
Jodoh Cave	7.48	6.8	45

The Batu Katak region consists of 5 caves (Figure 4): Water Cave, Pupuk Mentar Cave, Mbelin Cave, Sibayak Cave and Jodoh Cave. For the first time, westerners were allowed to study the caves. A total of 1.2 Km were cartographed and 126.6 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, among others.

Cave Environment

Cave Name	pH (inside/outside)	Temperature (°C) (inside/outside)	Relative Humidity % (inside/outside)
Water Cave	7.85/8.06 (water)	22.8/23.5	94.2/88.0
Pupuk Mentar Cave	7.85/7.95 (water)	23.3/24.2	91.5/89.3
Mbelin Cave	8.39/8.21 (water)	22.8/22.9	93.9/93.4
Sibayak Cave	5.16/7.88 (soil)	23.9/24.7	92.9/85.3
Jodoh Cave	7.66/7.81 (soil)	23.7/24.8	90.8/87.7

Table 2. Summary of cave environmental parameters.

Cave environmental parameters consisted of insitu measurements of water or soil pH, temperature and relative humidity for the different caves. We used a Extech pH module and Delmhorst thermo-hygrometer. These parameters can provide us with information about water safety, cave environment and conditions for the possibility of ecotourism.

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