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Water- and land-borne geophysical measurements before and after the sudden drainage of large karst lakes in southern Mexico

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Background

We collected seismic, geoelectrical, and electromagnetic data at two karst lakes in the *Selva Lacandona* in the Mexican state of Chiapas (Fig. 1) in order to estimate lake-floor sediment thicknesses. Information on the distribution of sediments in these lakes is essential for the planning of paleolimnological drilling campaigns.

Besides, our measurements also aimed at evaluating the potential of water-borne electromagnetic sounding measurements to provide complementary information to the much more widely used seismic methods. After the sudden and unexpected drainage of the studied lakes, we were not only able to cross-validate our water-borne measurements but also collect reference data directly on the exposed dry lake floor.

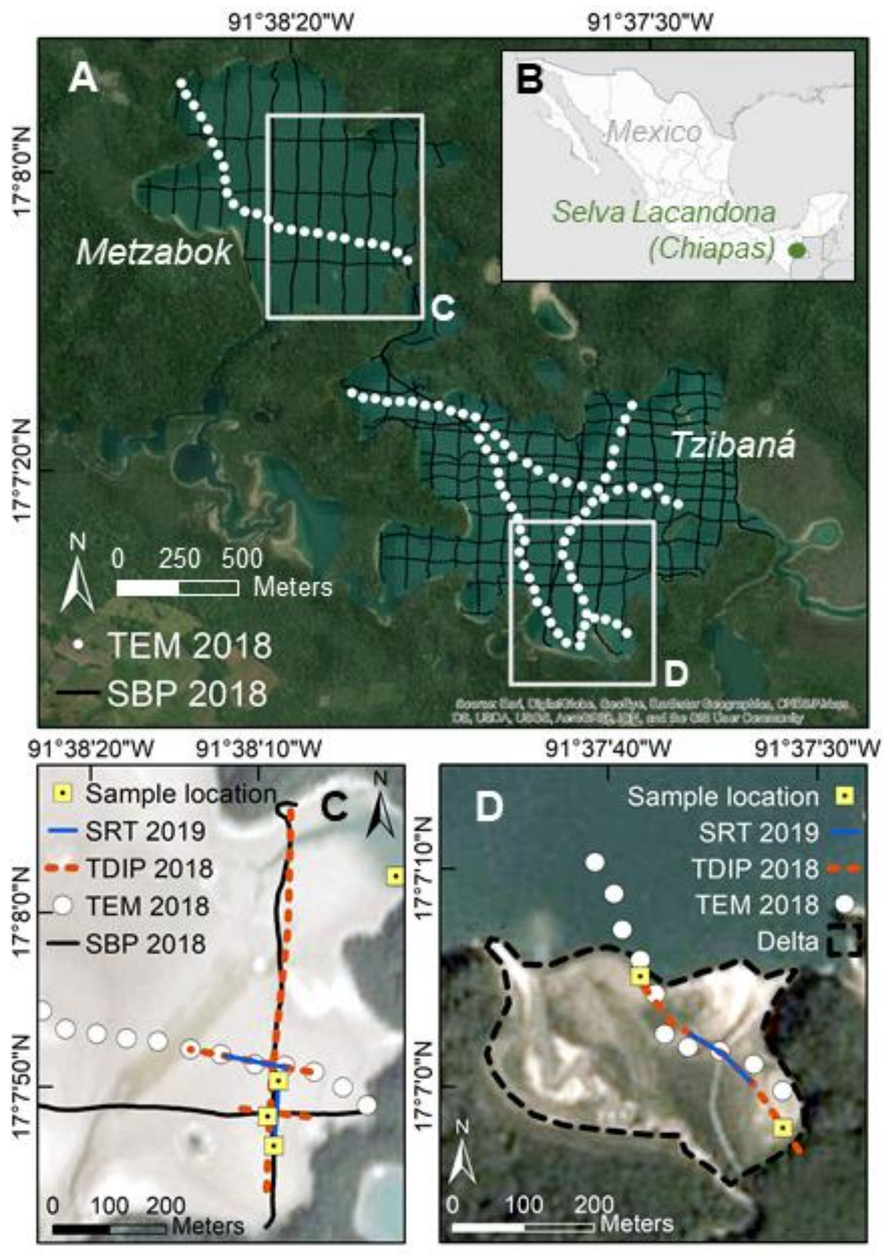

Figure 1. *Study area and layout of the geophysical survey (C & D based on Planet Labs imagery)*

Methods

Measurements on the **filled lakes** (March 2019)

- **SBP**: Sub-bottom profiler, i.e. high-frequency reflection seismics (10 kHz)
- **TEM**: Transient electromagnetics

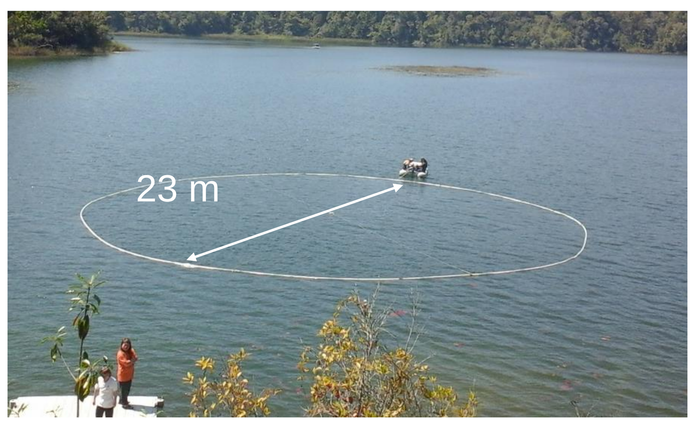

Figure 2. *TEM-sounding measurement using a floating single-loop configuration*

Measurements on the **dry lake floor** (October 2019)

- **TDIP**: Time-domain induced polarization (48 electrodes, 5-10 m spacing)
- **SRT**: Seismic refraction tomography (24 geophones, 5 m spacing)

Results

All geophysical sections at Lake Metzabok (Fig. 3) show at least two geological units: (i) the fine-grained lake sediments and (ii) the underlying limestone bedrock. In particular, the electrical images furthermore indicate the presence of an additional unit between these two layers. We interpret this unit as a highly fractured limestone or collapse debris with fine-grained sediments filling the interspaces.

The coarse fluvial deposits of the delta of Lake Tzibaná (Fig. 4) have high resistivity values and stand out clearly against the more conductive fine-grained lake sediments.

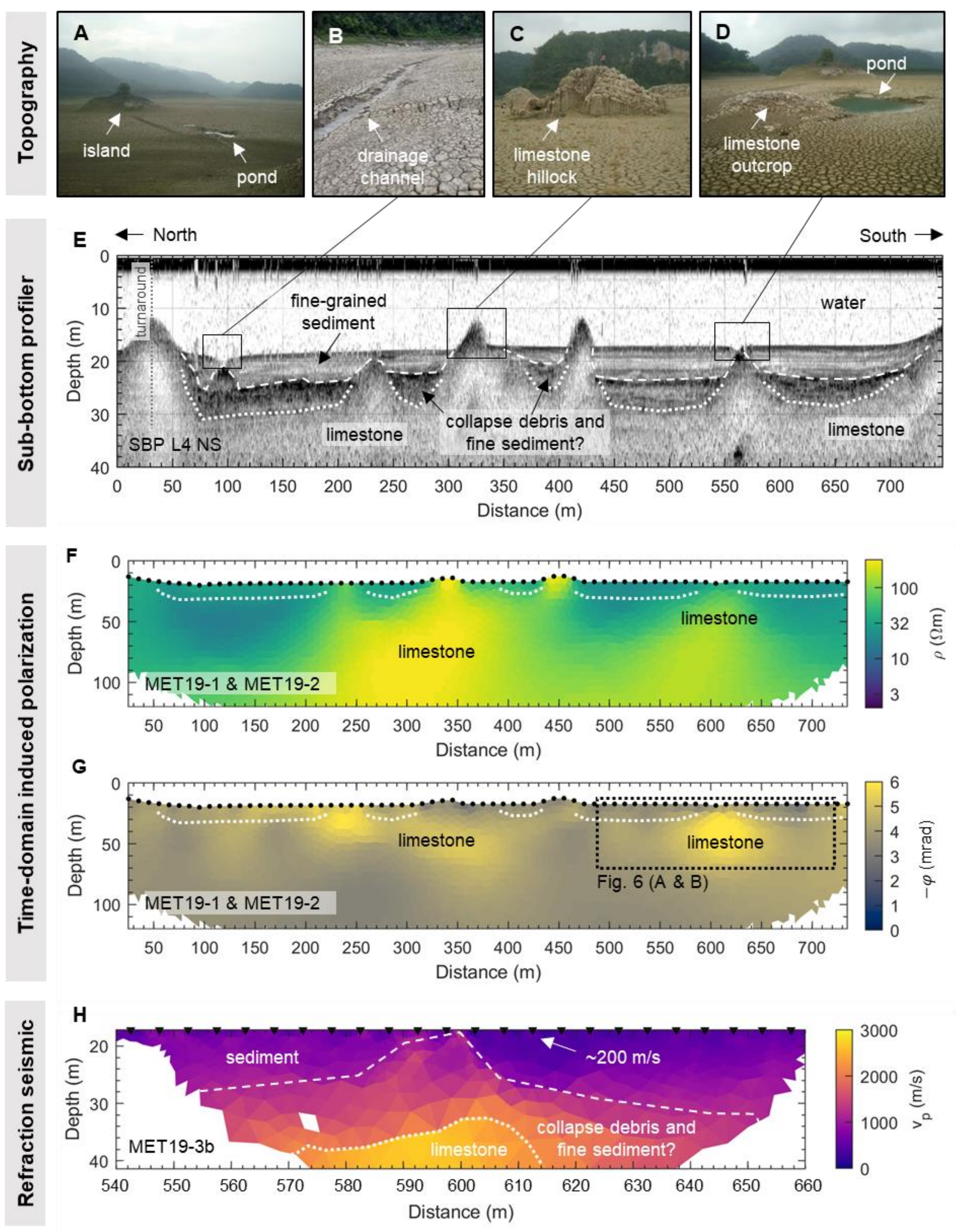

Figure 3. *Topographical features (A-D) and geophysical sections (E-H) along the long north-south oriented profile on the mostly plane bed of lake Metzabok (Fig. 1C).*

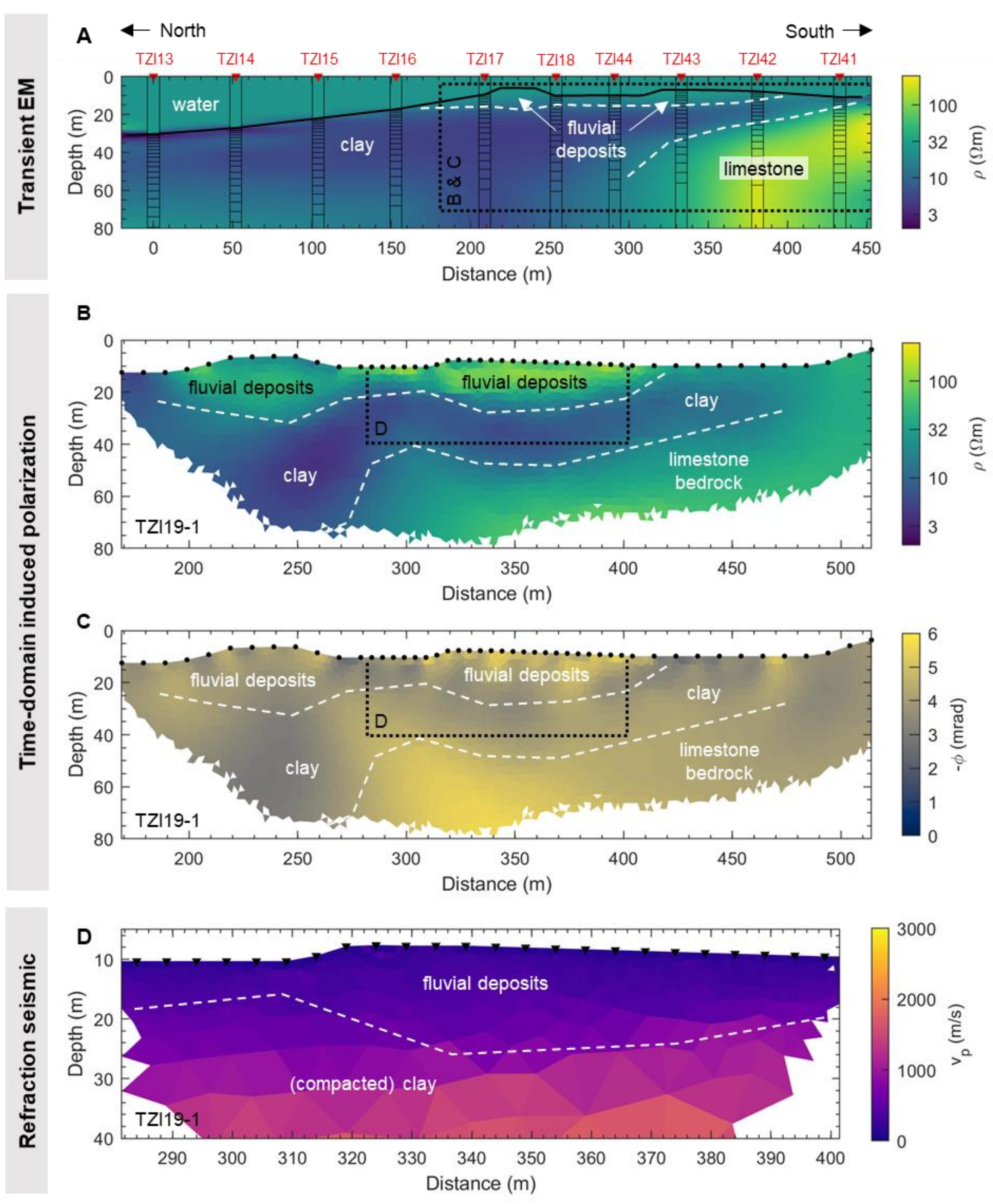

Figure 4. *Geophysical sections along profile crossing the delta of the main tributary of Lake Tzibaná (Fig. 1D)*

Conclusions

Method (general)

- Water-borne TEM measurements yield good results (using our single-loop system with a diameter of 23 m down to water depths > 20 m)
- Reflection seismic method much faster to carry out in the field and more straight-forward to process and interpret

Interpretation (study site)

- Layer of fine-grained sediments best resolved by seismic reflection method
- Thickness mostly between 5 and 10 m
- Resistivity images better resolve depth to bedrock (below limestone debris)
- Fine-grained sediments also detectable by land-borne IP on the dry lake floor.

Acknowledgements

We thank the CONANP and the authorities of the protected area Nahá and Metzabok, in particular Sergio Montes Quintero, Santiago Landois Álvarez Icaza, Miguel García Cruz, Rafael Tarano, and José Ángel Solórzano, as well as the municipalities of Nahá and Metzabok for their openness and friendly support. We are grateful for the help provided by Mauricio Bonilla, Johannes Bücker, Martín Garibay, Carlos Cruz, Roberto Reyes, Lorena Bárcena, Rodrigo Martínez Abarca, and Theresia Lauke, and all other colleagues and students, who were actively involved during the field seasons. Finally, we would like to thank Socorro Lozano, Margarita Caballero, Beatriz Ortega, Sergio Rodríguez, and Alex Correa Metrio from the Institutes of Geology and Geophysics, UNAM, for institutional and logistical support.

Financial support was provided by CONACyT under grant number 252148 and DFG under grant numbers BU3911/1-1 and PE2133/1-1. Parts of this work were funded through the FWF –ANR research project FWF-I-2619-N29 and ANR-15-CE04-0009-01 HYDROSLIDE: Hydro-geophysical observations for an advanced understanding of clayey landslides as well as by the Austrian Federal Ministry of Science, Research and Economy (project: ExploGRAF- Development of geophysical exploration methods for the characterization of mine-tailings towards exploitation).

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