CARBONATE CRITICAL ZONES RESEARCH COORDINATION NETWORK

Working Group 1: Hydrology (Hydrology, weathering, climate & land use change, time)

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Question 1: What defines the base of the critical zone in karst systems?

Justification

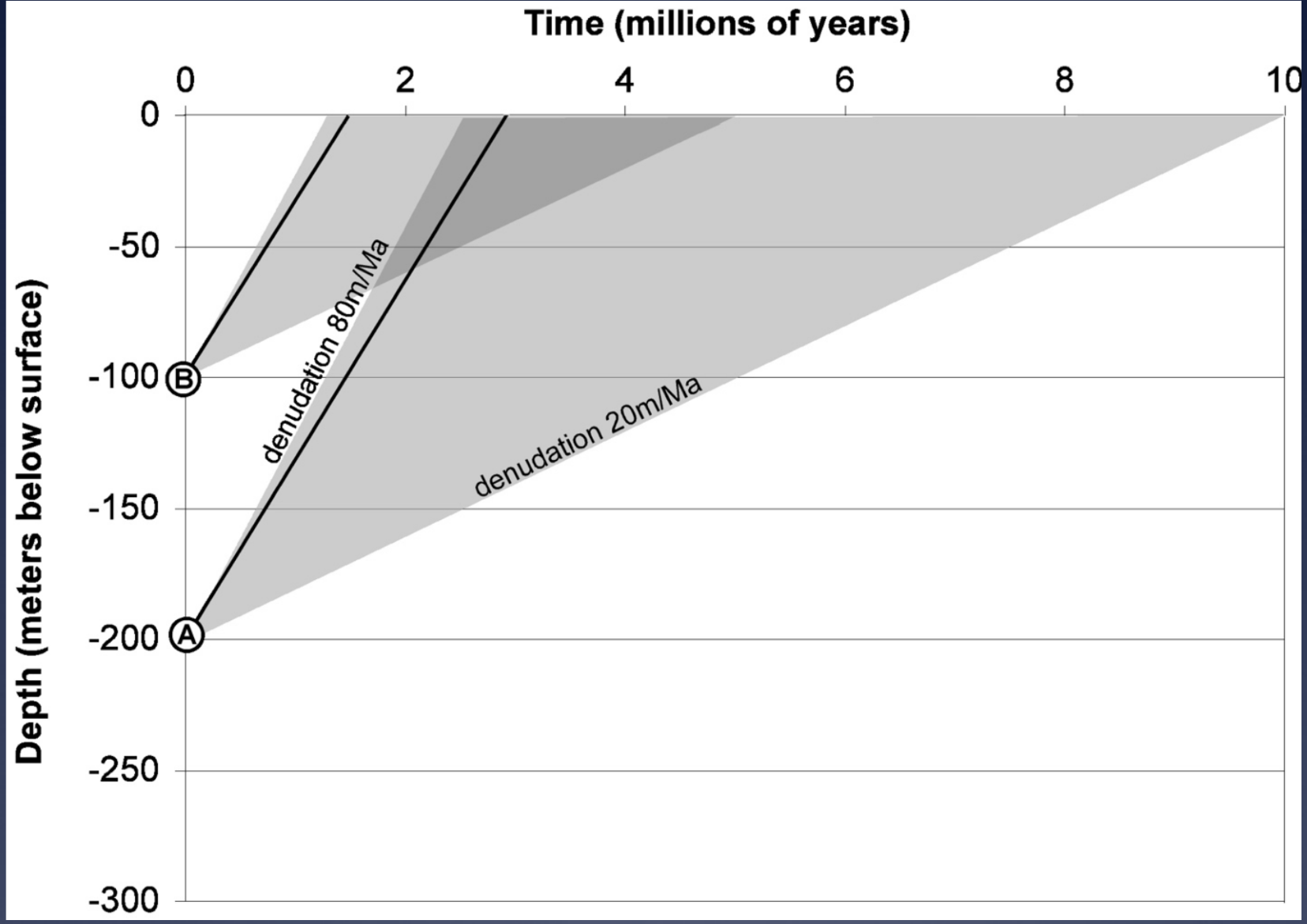
- In comparing carbonate and silicate settings, one of the substantial differences is the depth at which surface-driven influences can be propagated (temperature, chemistry, biology) with timescales varying from individual recharge events to timescales associated with climate change and tectonic processes.

- While layers within the CZ, including the bottom boundary, are often conceptualized as planar, karst settings are highly heterogeneous in their permeability and the corresponding influences from Earth's surface. How can conceptual models of the CZ account for such heterogeneity?

Question 1: What defines the base of the critical zone in karst systems?

* Data Needs
- Geochemical data and geochronological tools
- Materials and proxies - speleothems, water, sediments, pollen, tree rings, bat guano, fossils, biota, microbial life

* Methods
- Install continuous monitoring sensors and instrumentation
- Calibrate geochemical models with modern observation and chronology data



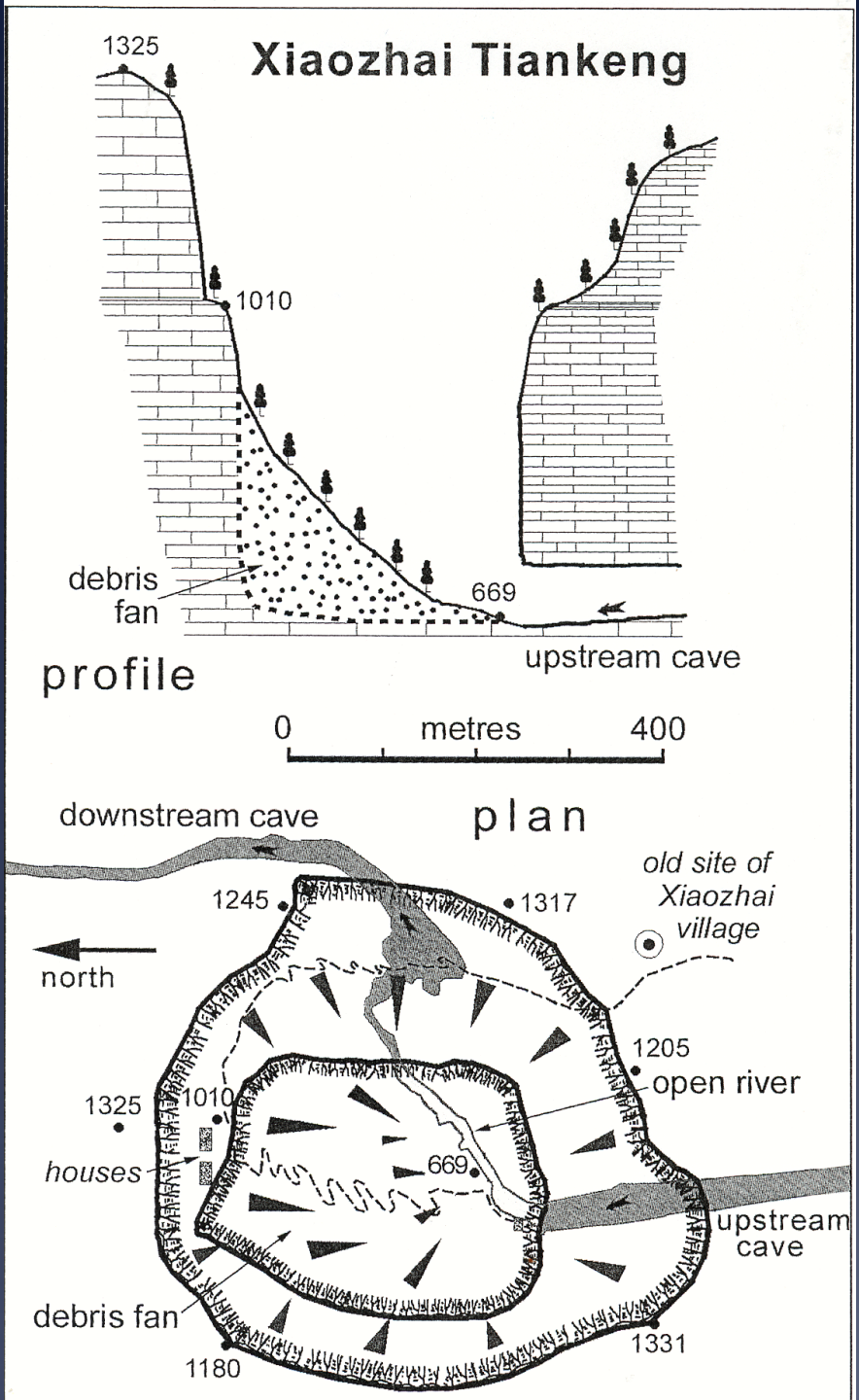
Theoretical persistence of caves in an erosional environment

Sasowsky, I.D., 2007, Clastic sediments in caves - imperfect recorders of processes in karst in: Kranjc, A., Gabrovsek, F., Culver, D.C., and Sasowsky, I.D. (eds.), Time in Karst: Special Publication 12, Karst Waters Institute, Leesburg, Va., p. 143-149.

Xiaozhai Tiankeng

Waltham, 2006

Zhu and Chen, 2006



Xiaozhai Tiankeng

Dating Methods of Tiankeng

- $^{26}Al/^{10}Be$ burial ages in cave sediments (quartz)
- ^{36}Cl exposure age of Tiankeng rocks
- Pollen compositions in the cave deposit
- Paleomagnetism of sedimentary sequence
- Speleothem ages using U/Th or U/Pb isotopes

Question 2: What controls the distribution of CO_2 within carbonate critical zone?

Justification

- CO2 is the primary driver of carbonate weathering in most settings. However, we have little understanding of what controls spatial and temporal variation in CO_2 within the subsurface. To what extent are CO_2 concentrations controlled by production (i.e. availability of organic matter, oxygen, or water), transport by water, transport within air, or consumption?

- There are many potential feedback mechanisms between biological, physical, and chemical processes, and the evolution of permeability structures. These feedbacks are not well understood. How does the structure of the carbonate CZ co-evolve with ecological systems?

Question 2: What controls the distribution of CO_2 within carbonate critical zone?

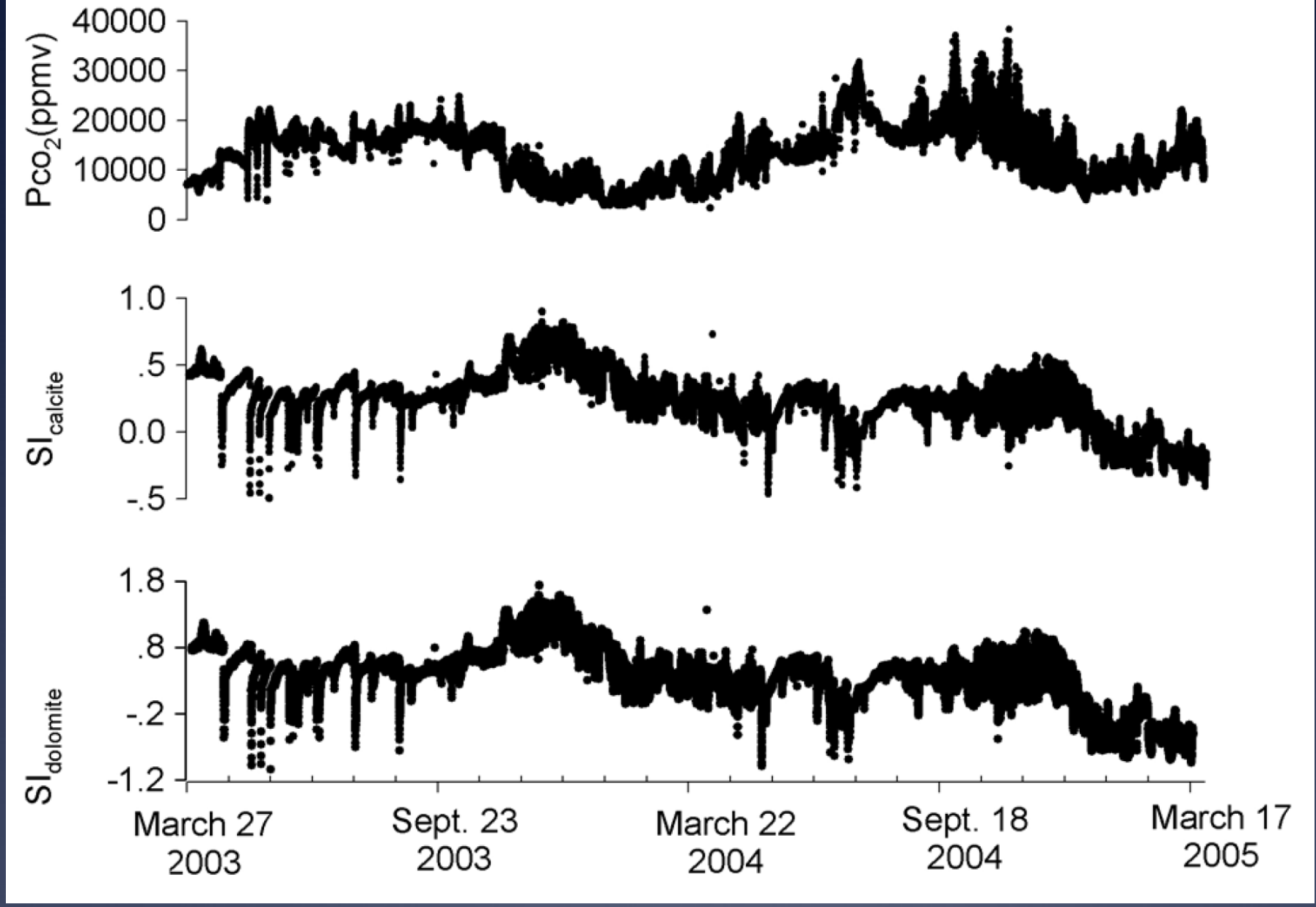
* Data Needs
- Much is known about CO2 dynamics within the soil zone and caves, but less is known about vadose zone more broadly. Part of this results from relatively limited data available from boreholes and wells within karst systems and the difficulty of interpreting such data due to the presence of strong preferential flow paths.

* Methods
- Establish time series data within boreholes, springs, caves, and soil
- Characterize the depth distribution of organic matter (such as roots) and porosity

Nongla spring (photo 1)
Maolan spring (photo 2)
SW China

(from Liu *et al*., 2007, J. Hydrol. 337, 207–223).

Rooting in epikarst, Guizhou, China
Photo courtesy of Alan Fryar



Calculated continuous values of P_{CO_2} and saturation indices for calcite and dolomite at Nongla epikarst spring (Guangxi, China), 27 March 2003 – 27 March 2005 (from Fig. 2, Z. Liu *et al*., 2007, J. Hydrol. 337, 207–223).

Question 3: What is the role of infrequent events in sculpting the carbonate critical zone as opposed to gradual change?

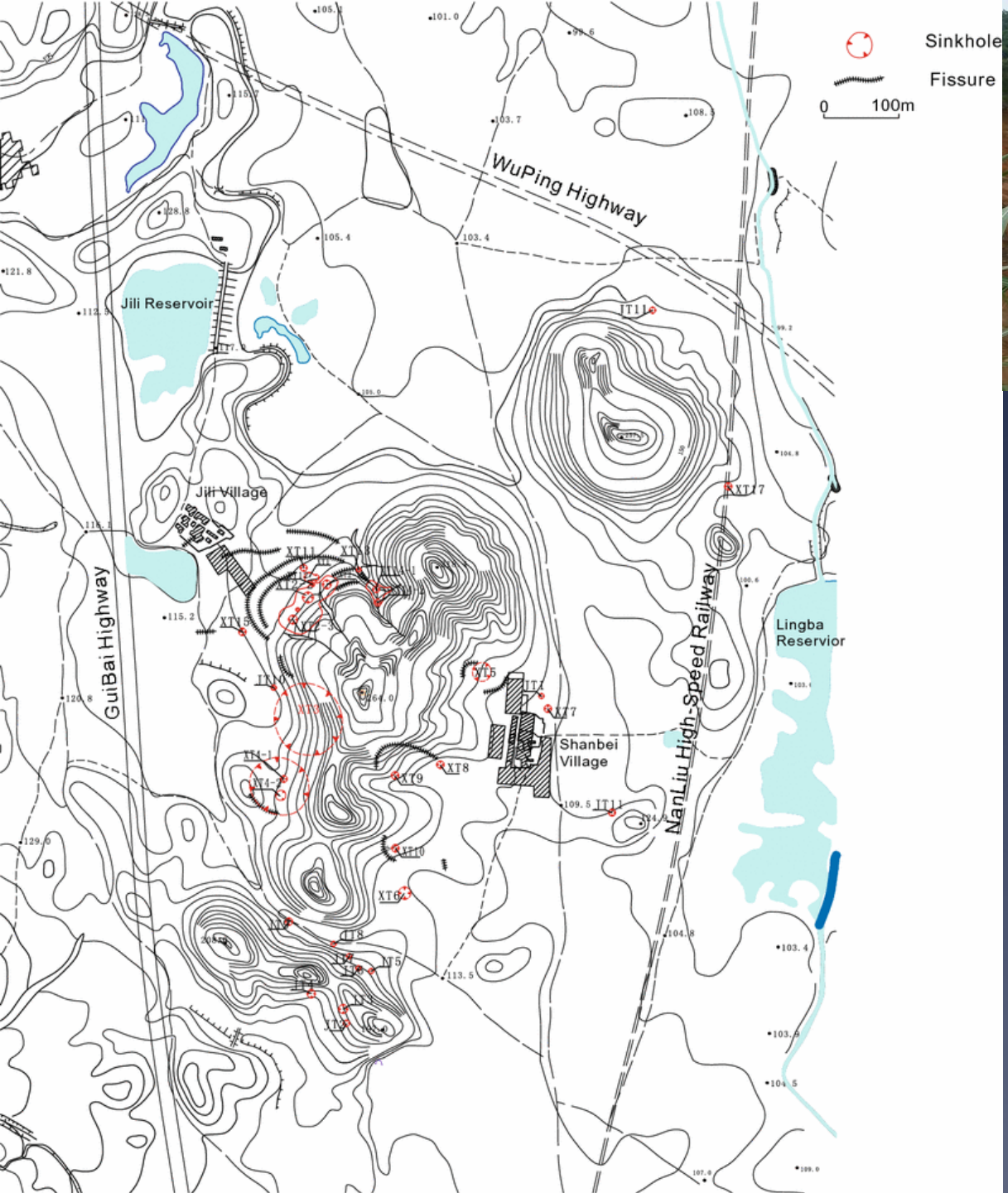
* Justification

- Large magnitude infrequent events often represent short durations of intense "work" in a karst system (or any earth system really). Current research is heavily biased to the intervals in between, and yet dissolved/solid mass movement is tied to these events.
  - Sinkhole / conduit collapse
  - Floods and sedimentation
  - Tropical Cyclones / Extreme Weather
  - Point source / Non-point source contamination
  - Land use change – forest fires / paving
- Systems often shift to new dynamic equilibrium with events

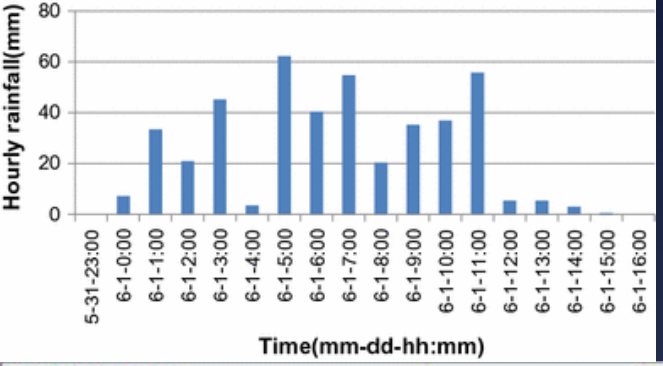
Question 3: What is the role of infrequent events in sculpting the carbonate critical zone as opposed to gradual change?

* Data Needs
- Frequent, high-resolution data and common field site visits focused around event.
- Open source code / data for weather, water quality, land-use, and topography

* Methods
- Establish time series data of CZ deformation, water quality, and hazard development
- Characterize karst hazards and climate change.



On June 3, 2010, twenty-two sinkholes (XT1–XT17) occurred in Jili village and Shanbei village, Guangxi, China. Sinkhole XT2-2 (above), the largest one in this area, is 85 m in diameter and 38–82 m in depth. (from Fig. 1 & 2, X. Jiang *et al*., 2017, Environmental Earth Sciences, 76:823).



Hourly rainfall and Seismic wave image on June 1, 2010 in Laibin, Guangxi, China. (from Fig. 9 & 10, X. Jiang *et al.*, 2017, Environmental Earth Sciences, 76:823).