

Seismic Geomorphology and Analysis of the Ordovician Paleokarst Drainage System in the Central Tabei Uplift, Northern Tarim Basin, Western China*

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Abstract

High-quality 3D seismic data acquired in the central Tabei Uplift, Tarim Basin, western China, provide a rare opportunity to characterize in exceptional detail the 3D geomorphology of a deeply buried (5,500 - 6,500 m) Ordovician unconformity and the related paleokarst drainage system. An integrated approach was applied that emphasized integration of seismic data with available conventional core, wireline logs, and age-equivalent outcrops. The exceptional quality of the seismic data allowed a seismic detection limit of karsted features of less than 75×75 m horizontally and 6 m vertically.

Interpreted geomorphologic and depositional elements include fluvial channels and canyons, fluvial valleys, sinkholes, and tower karsts and hills. The modern tower karst-drainage system in Guilin, China, is very similar to the mapped Ordovician karst-drainage system and is used as a modern analog. Interaction between the surface karst-drainage system and the shallow-subsurface cave-passage system is evidenced by the observation that surface canyons appear to initiate in areas associated with intense sinkhole development. Also, surface river valleys tend to correspond to dip-oriented surface depressions partly related to near-surface cave collapse. During burial into the deeper subsurface, the combination of intrastratal collapse (karsted strata) and suprastratal collapse (postkarst deposited strata) created large damage zones hundreds of meters thick and kilometers wide. Coalesced-collapsed paleocave systems can be interpreted from the unique circular pattern of faults (observed in map view) that are associated with seismic bright spots.

Reference

Loucks, R.G., 1999, Paleocave carbonate reservoirs; origins, burial-depth modifications, spatial complexity, and reservoir implications: AAPG Bulletin, v. 83/11, p. 1795-1834.



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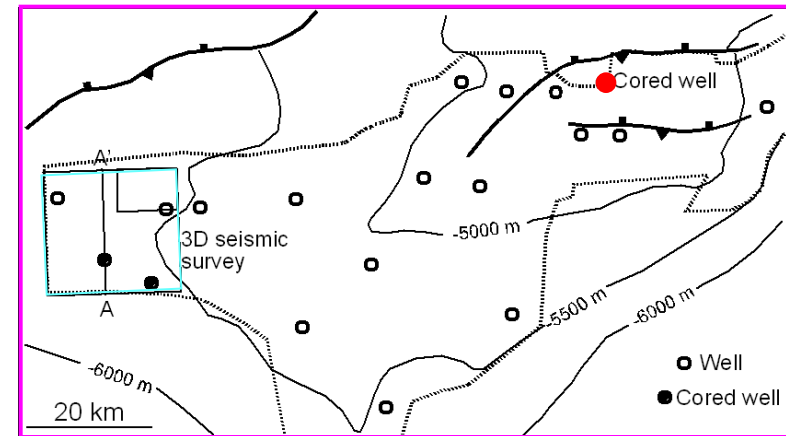
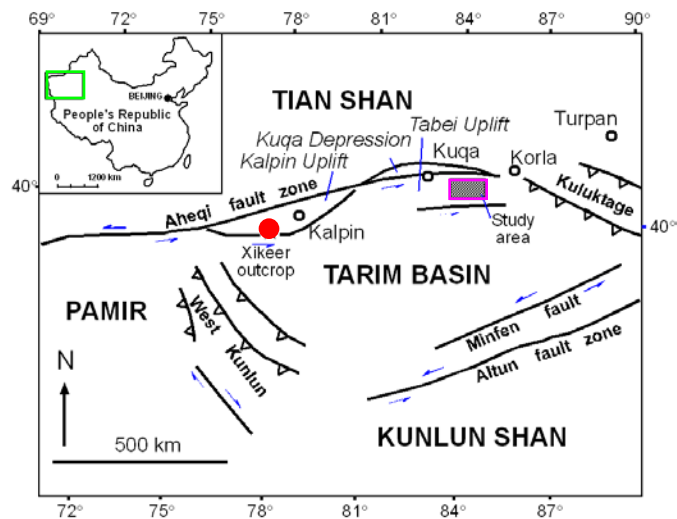
¹ : BEG, The University of Texas at Austin

² : BGP, CNPC, China

Tarim Basin: study areas



530,000 sq. km



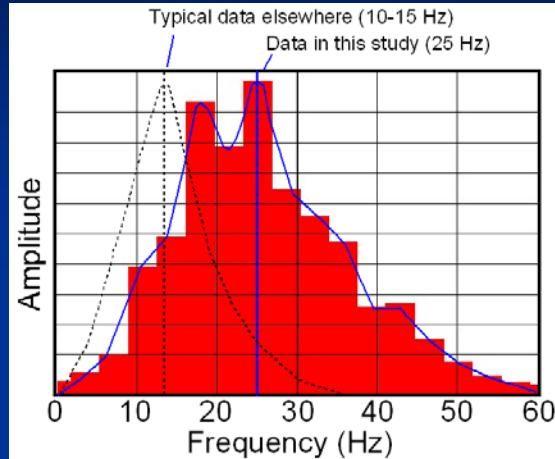


Presentation outline

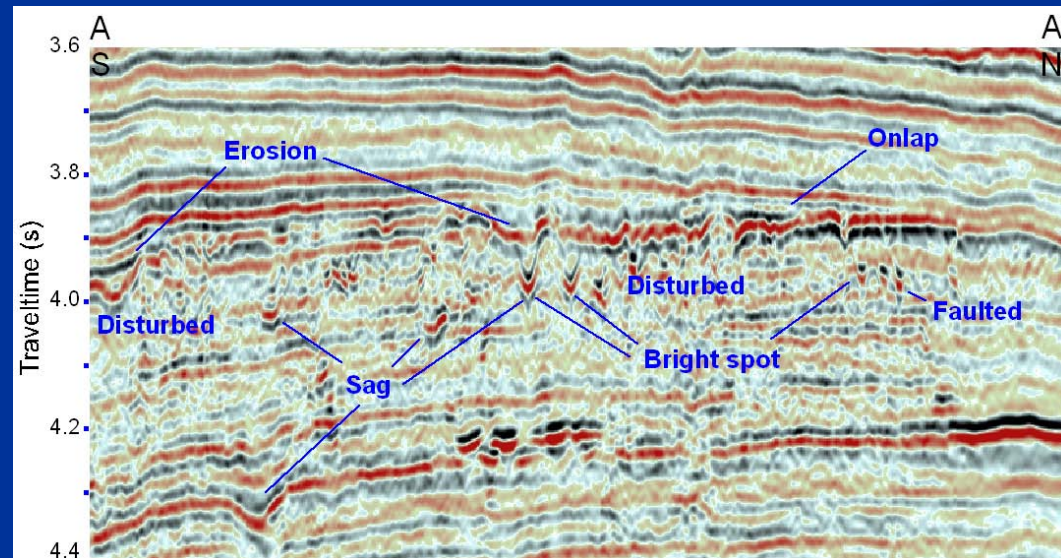
1. Data and geologic background
2. Interpretation of paleodrainage system and near-surface karst features at Ordovician unconformity
3. Interpretation of deeply buried, collapsed paleocave systems in Ordovician (equivalent to Ellenburger in USA)



3D seismic data quality



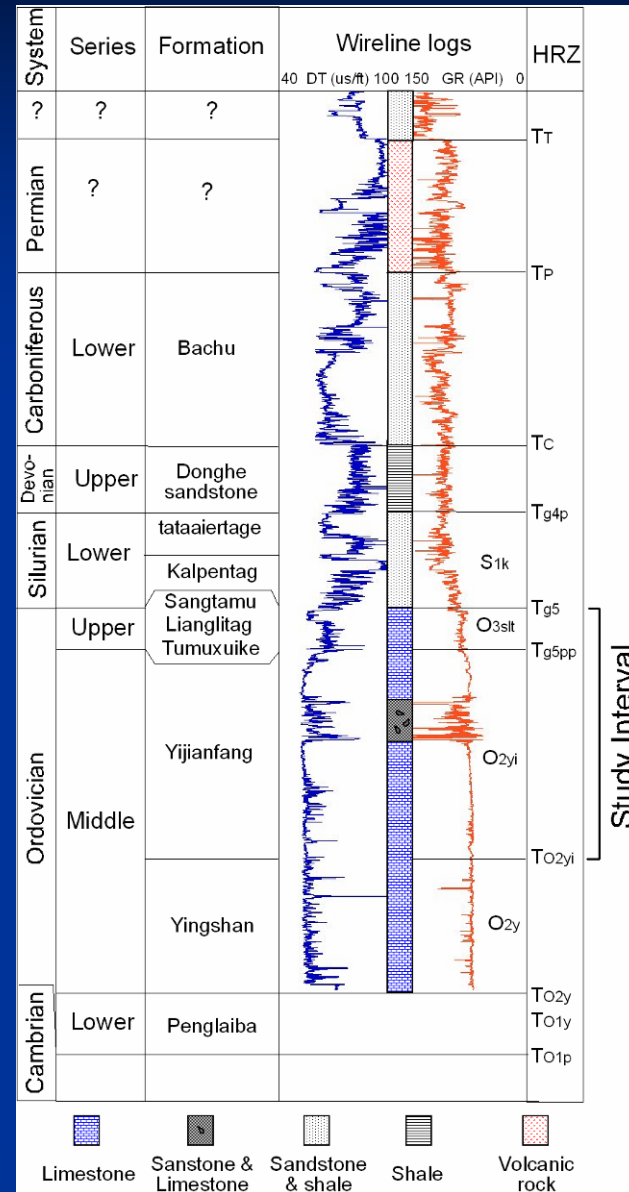
25 Hz at 7000 m !
(typically 10-15 Hz)



Stratigraphy

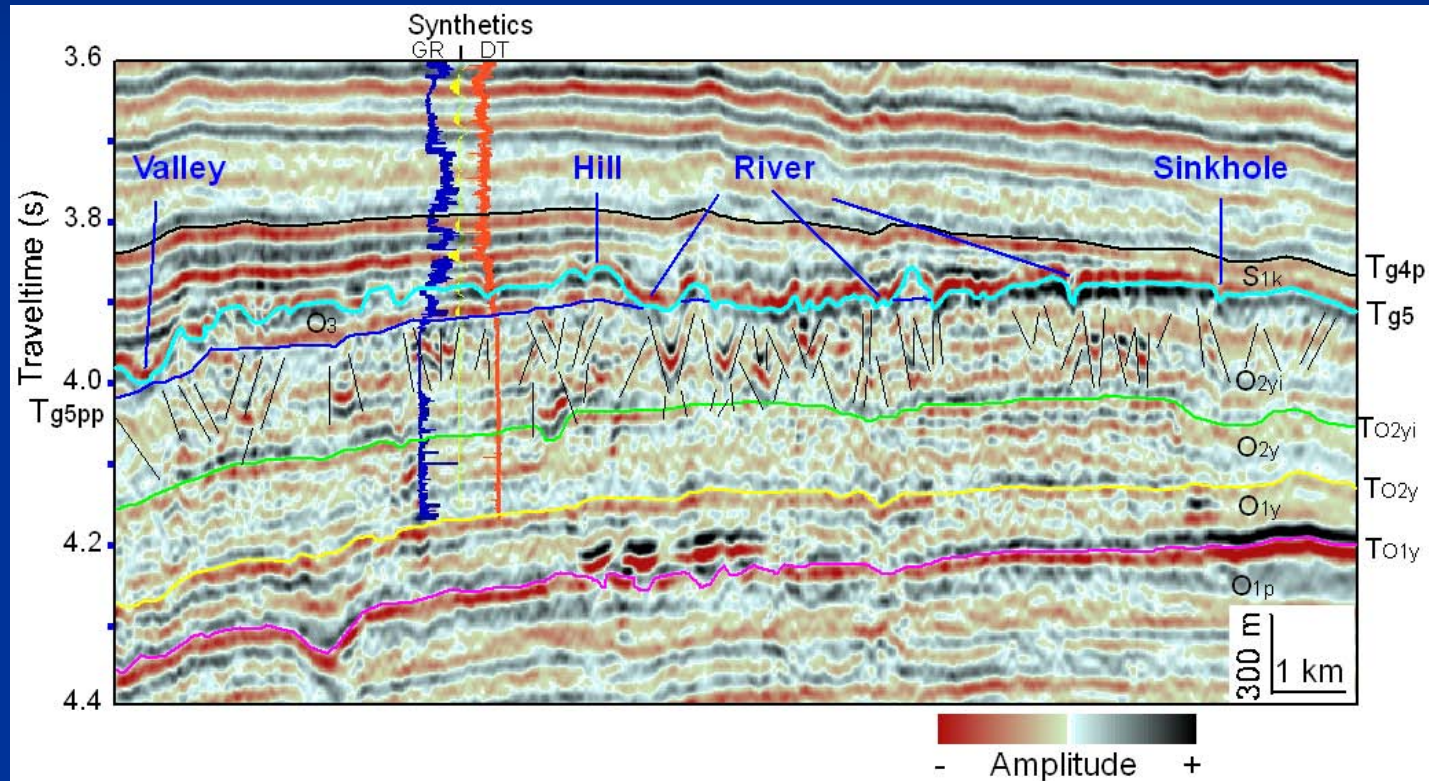


~6,000m



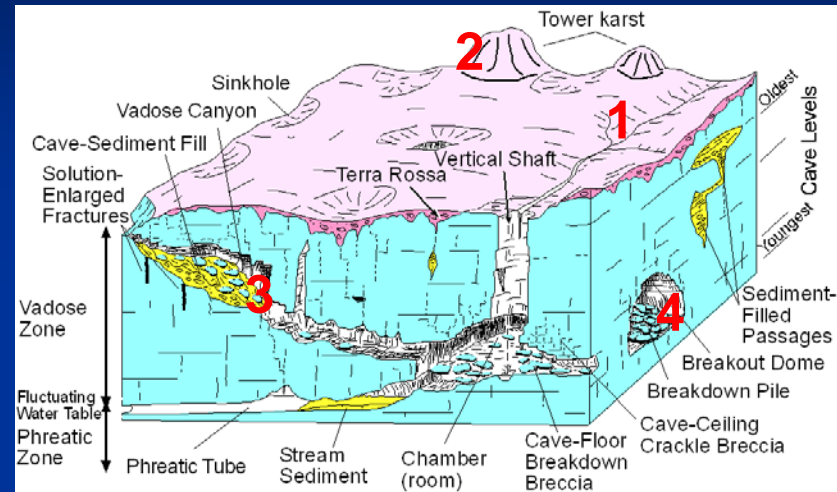


Well-seismic correlation

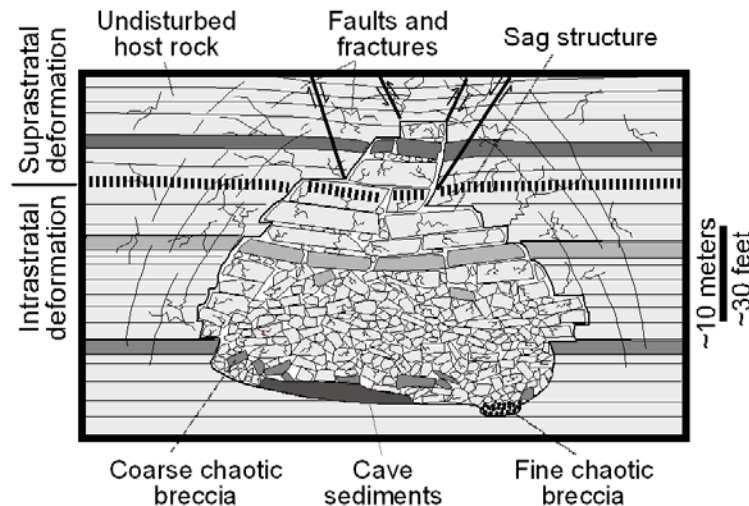


Karst models (modified from Loucks, 1999)

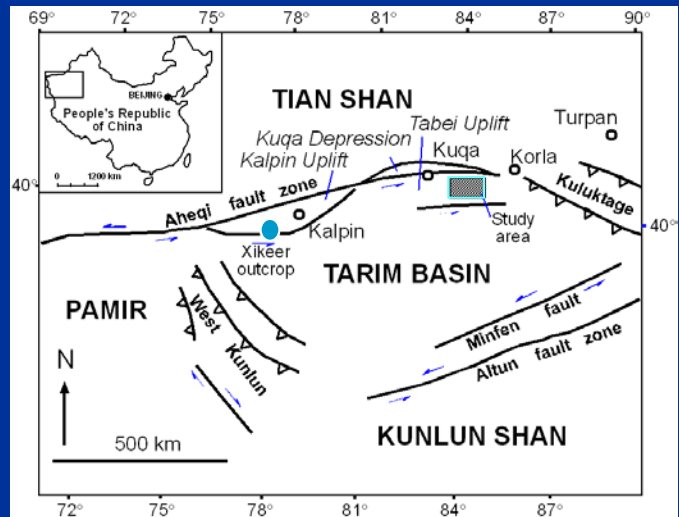
At/near surface



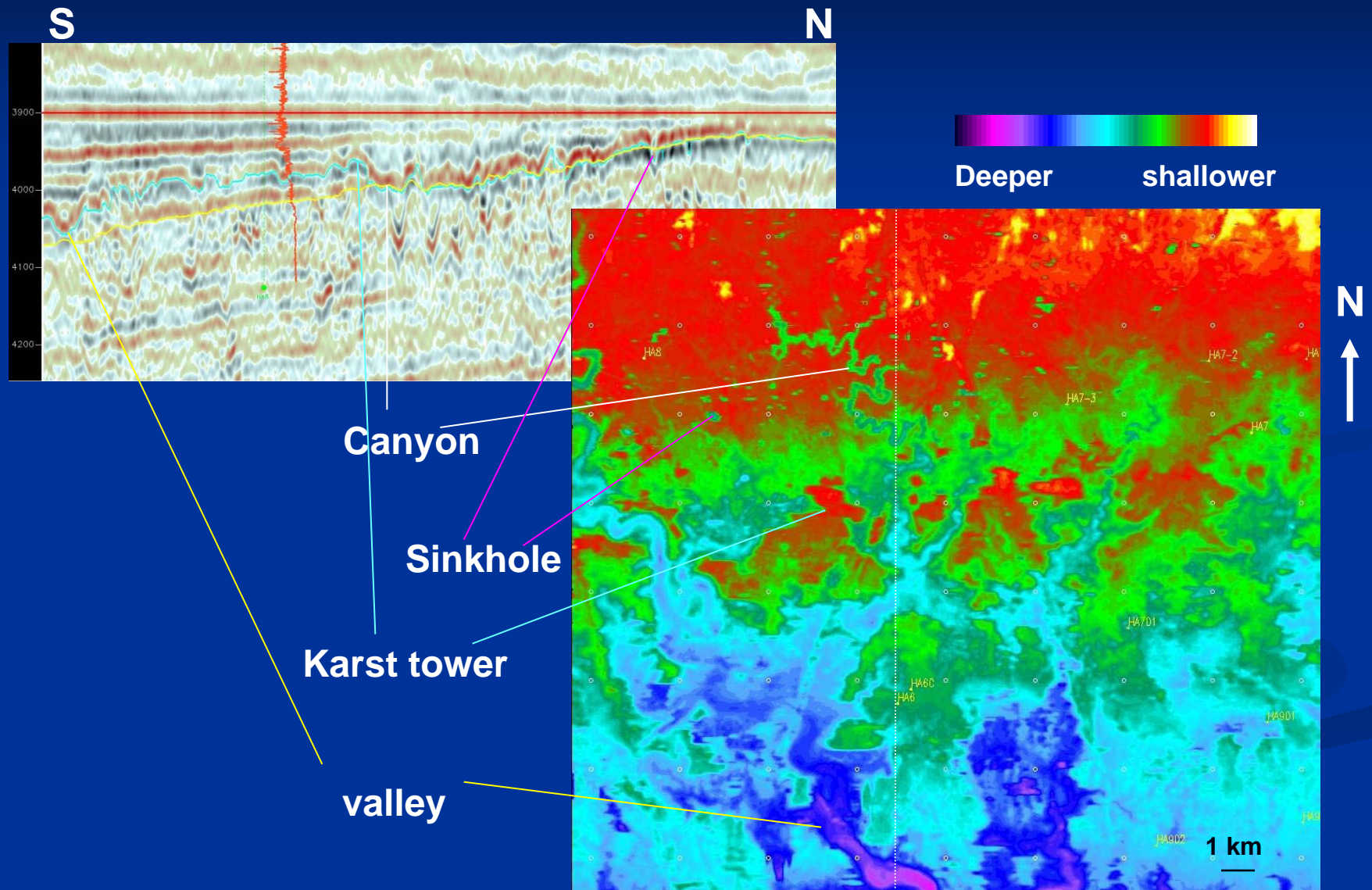
After burial



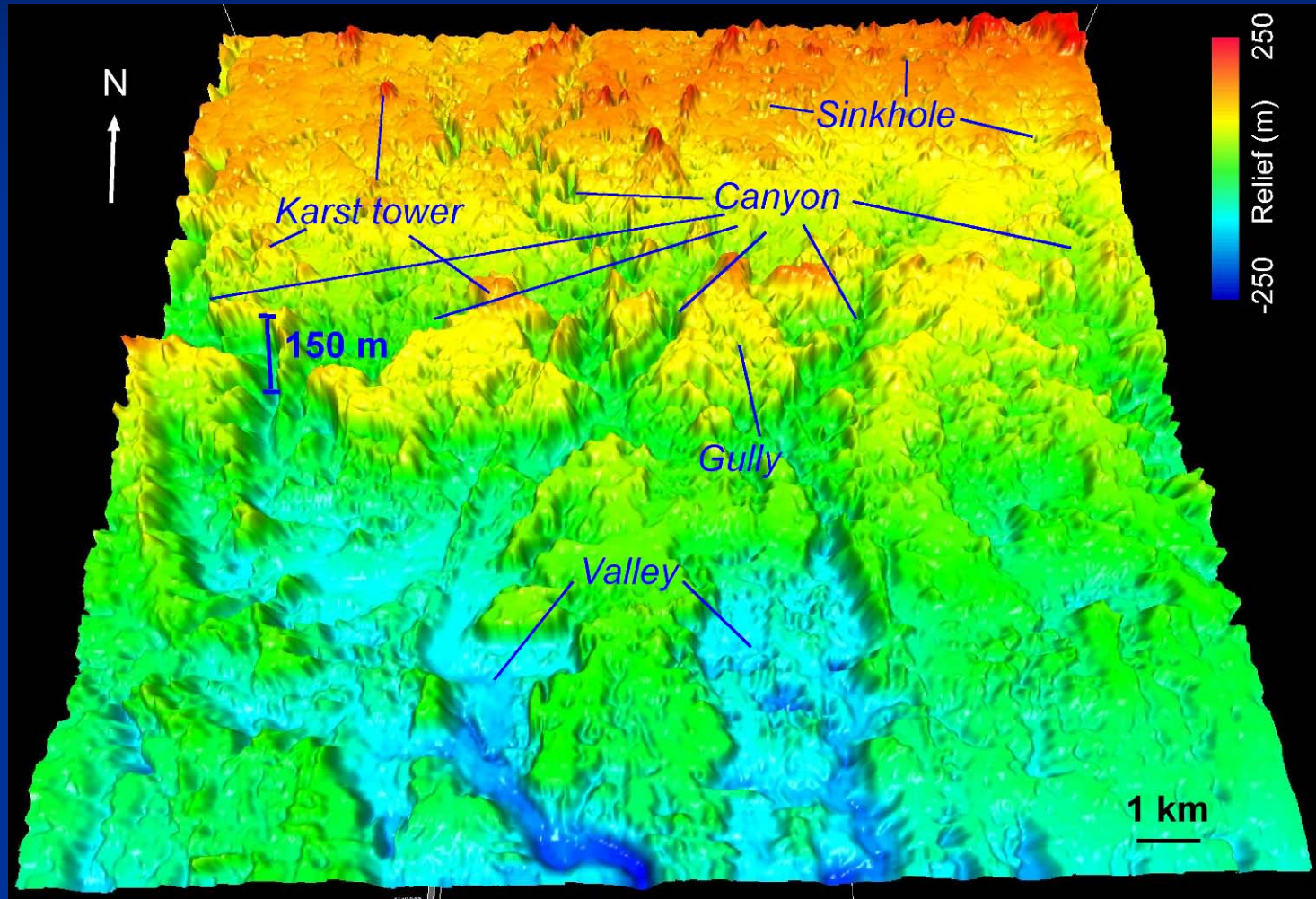
Outcrop photo of Ordovician unconformity



Paleotopography of Ordovician unconformity



3D relief map of Ordovician unconformity





Modern Guilin Karst is a good analog



100 m

~150 m

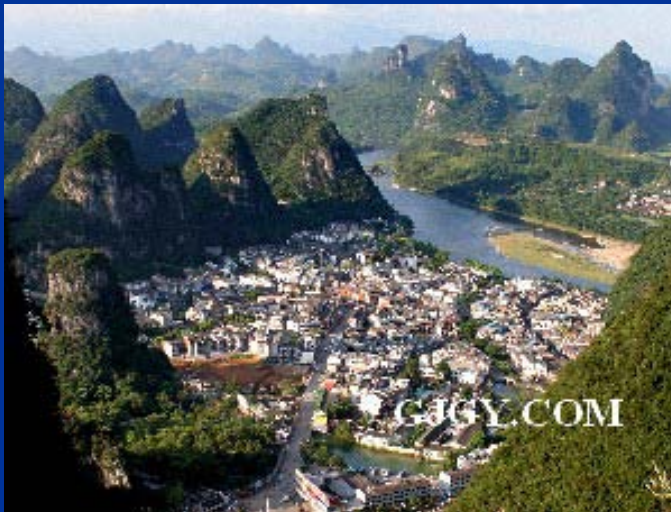
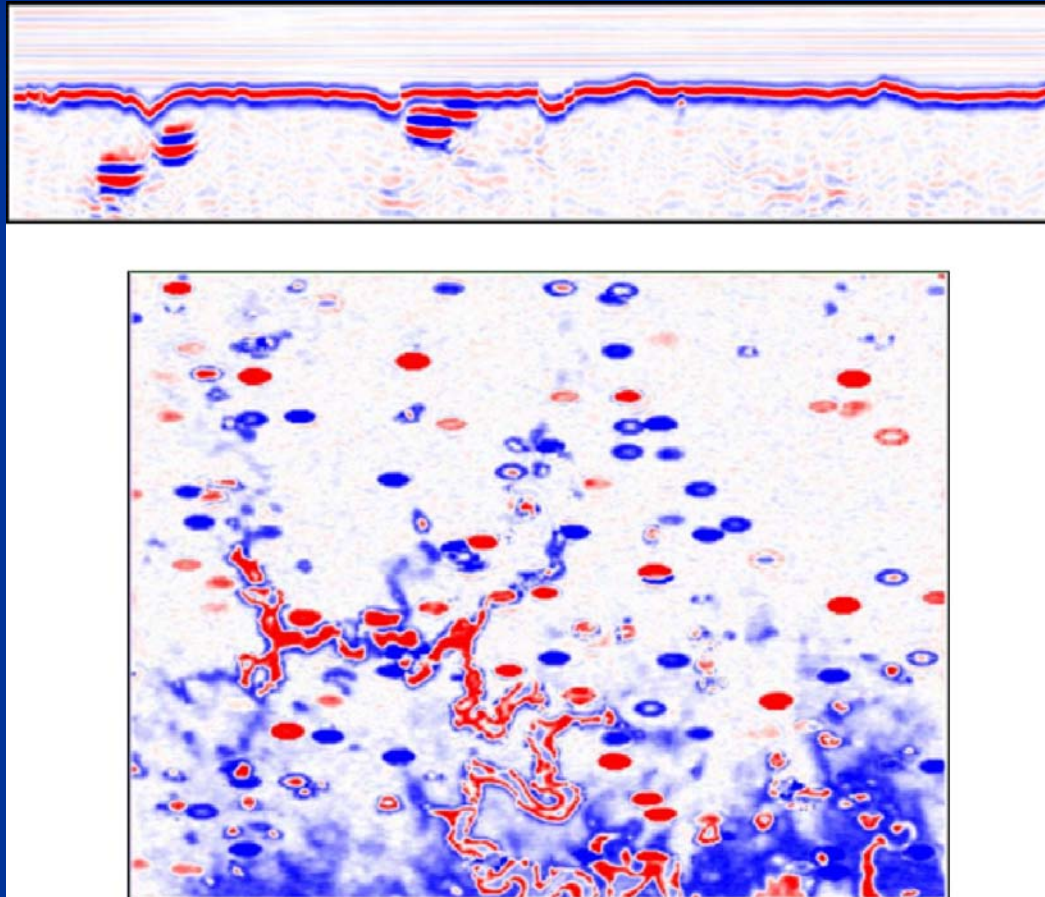


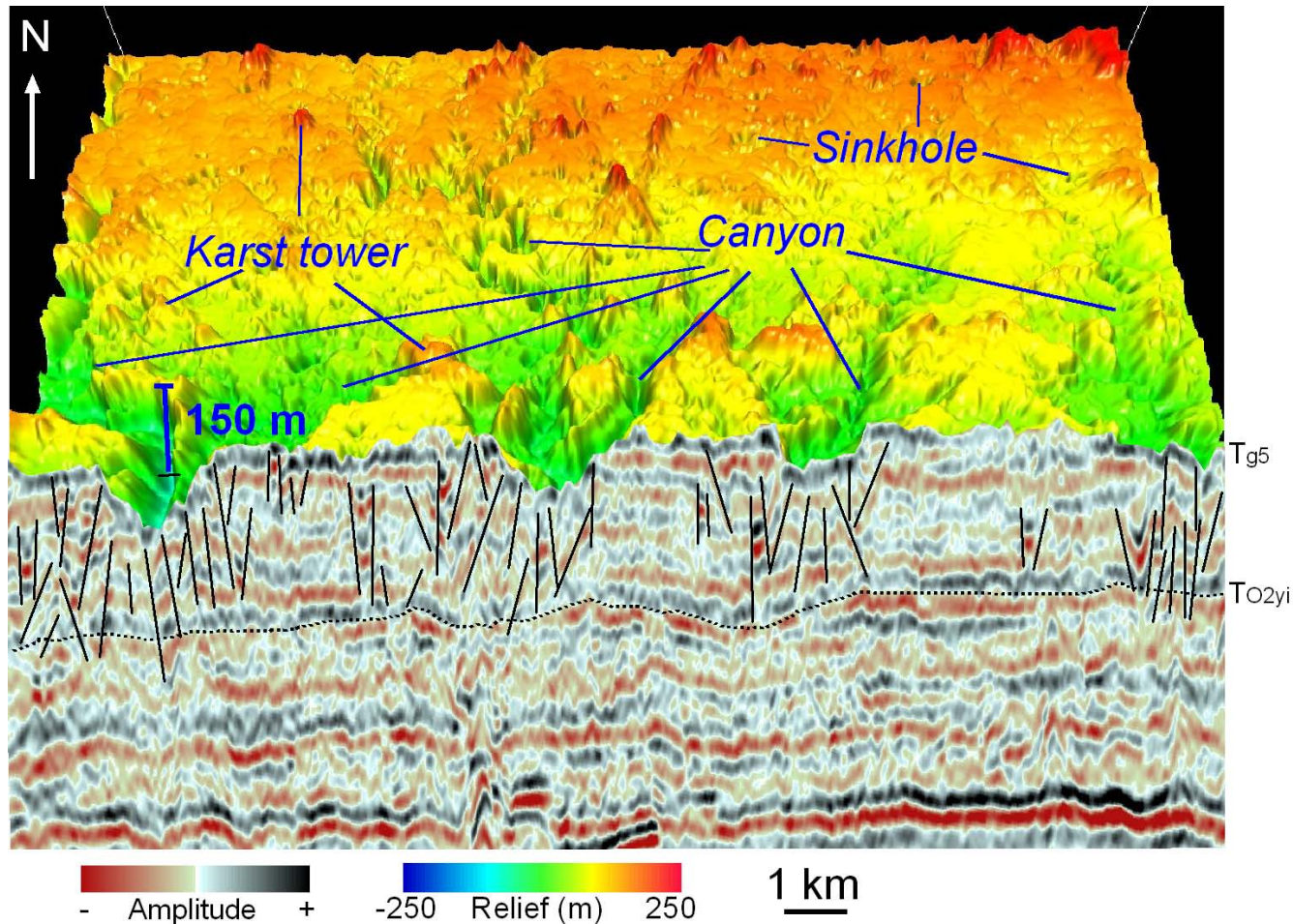
Image © 2011 DigitalGlobe
© 2011 Cnes/Spot Image



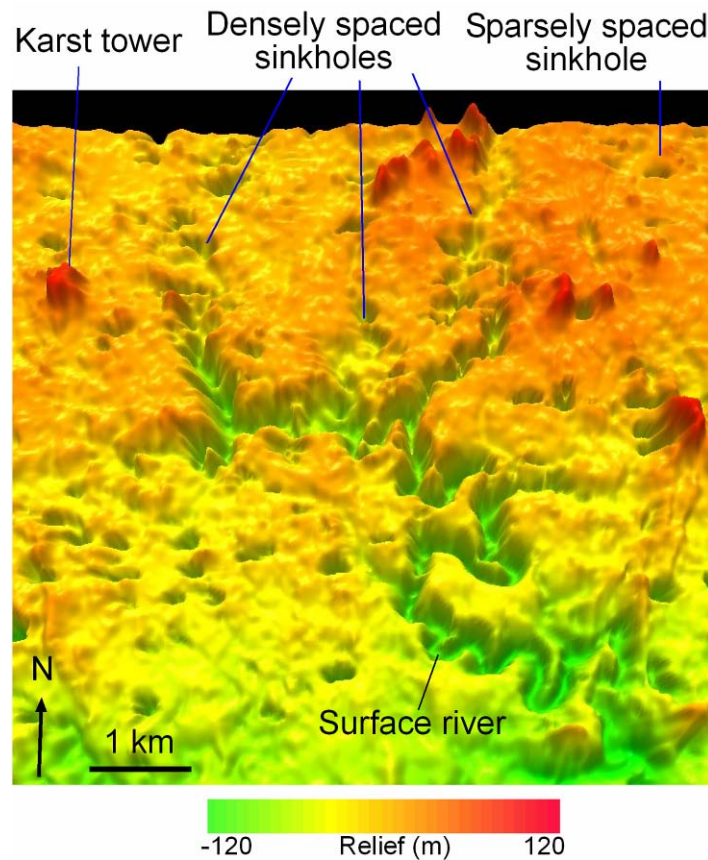
Seismic modeling



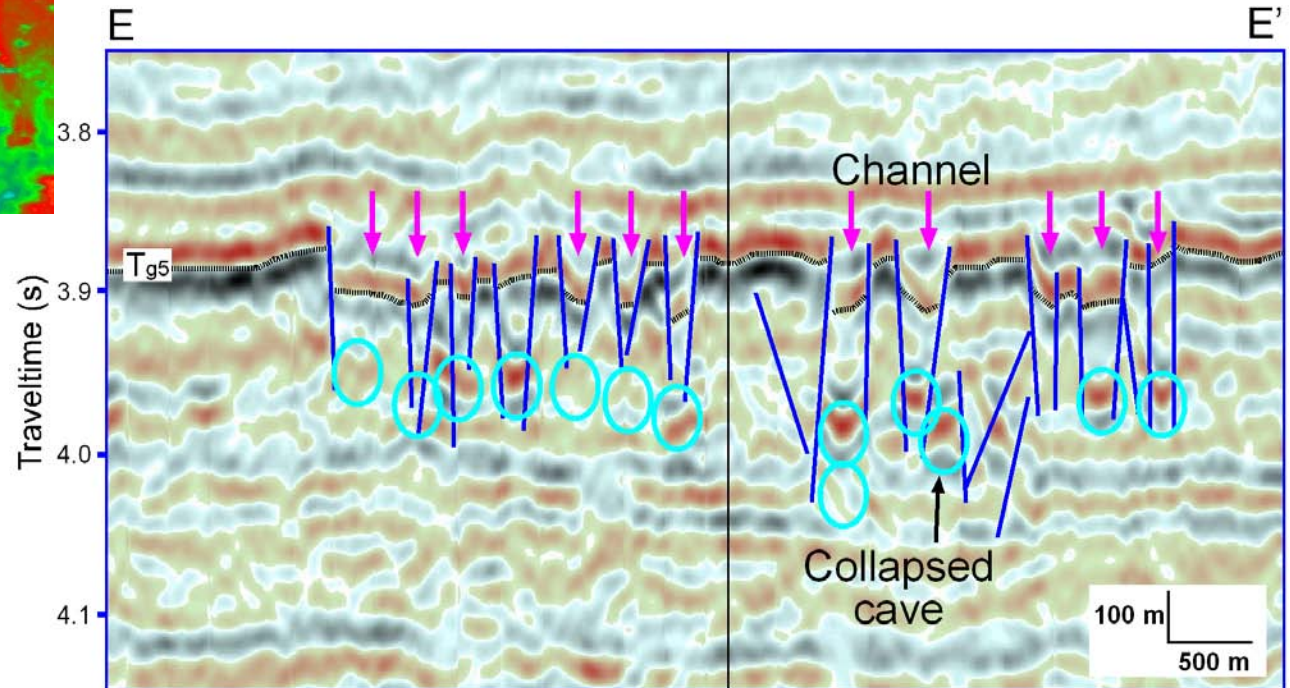
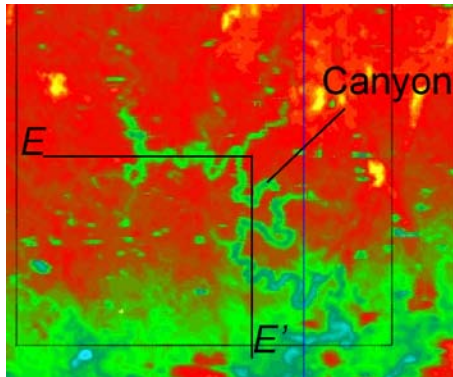
Drainage system is related to near-surface depressions and faults



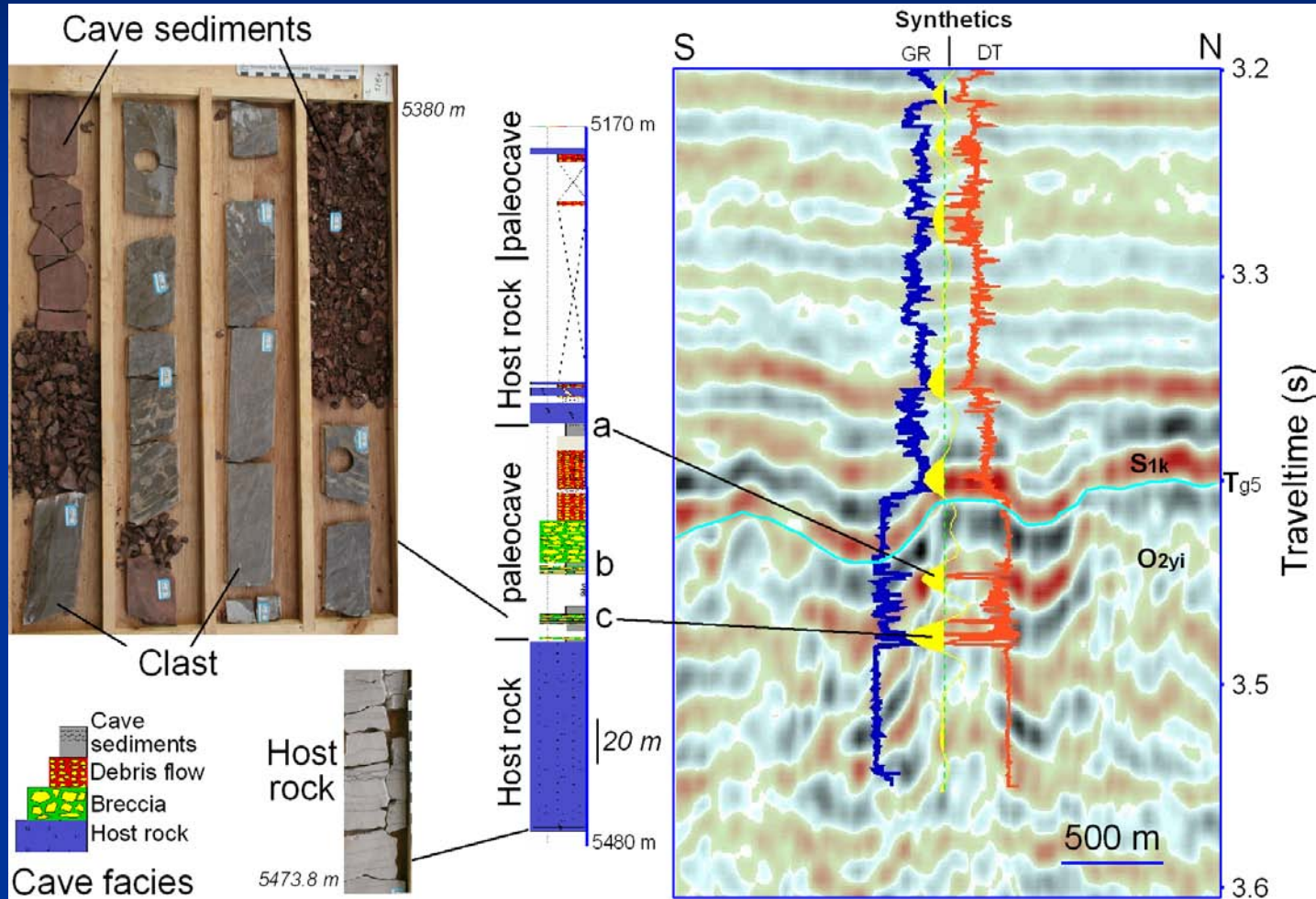
Canyons are related to surface sinkholes



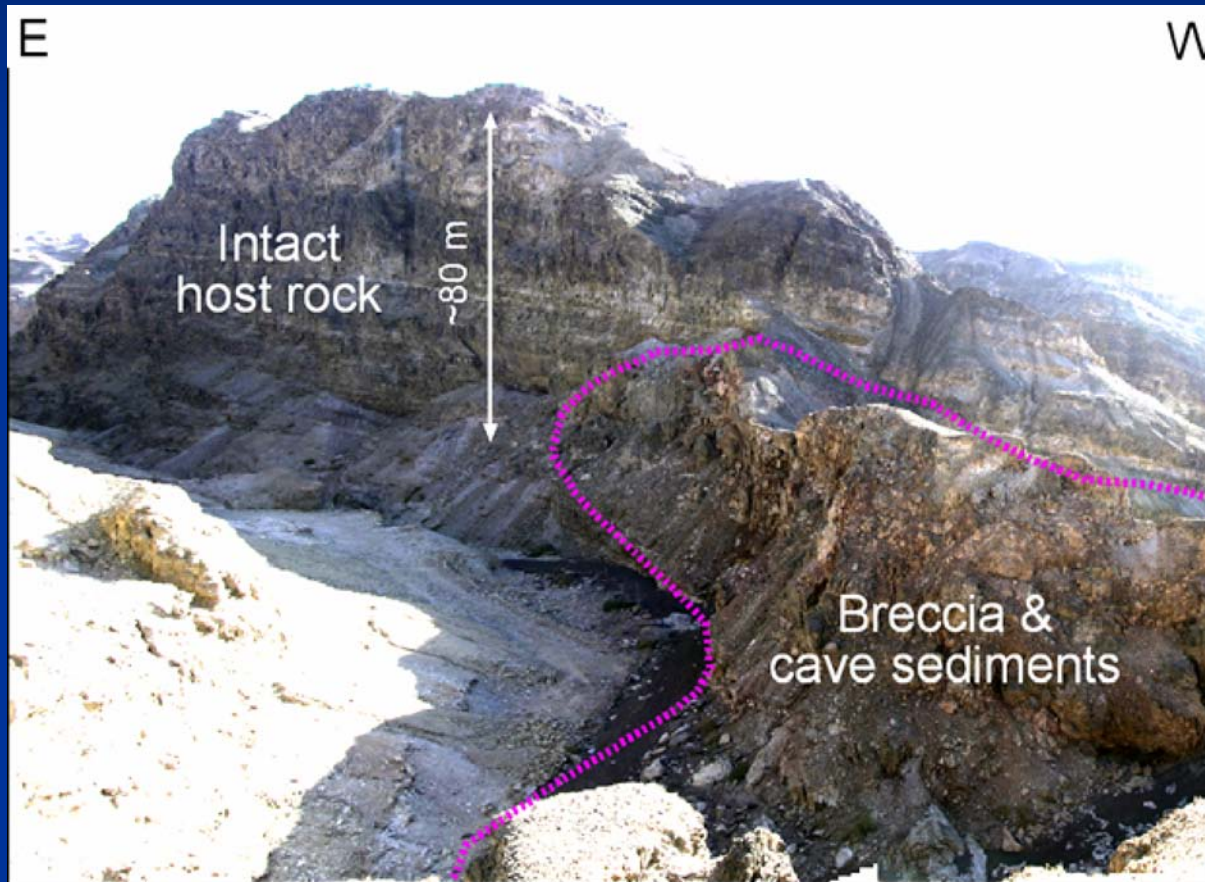
Surface canyons (channels) are clearly related to near-surface collapsed caves



Cave sediments correlate to bright spots

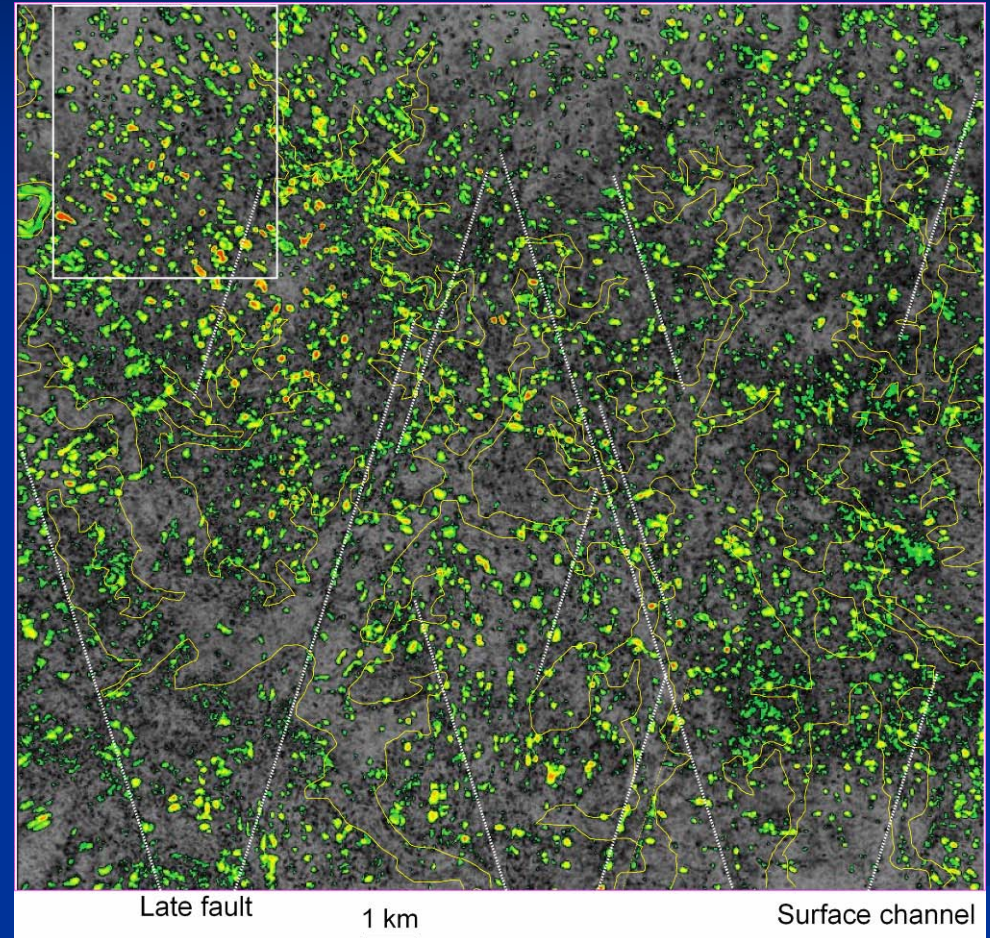
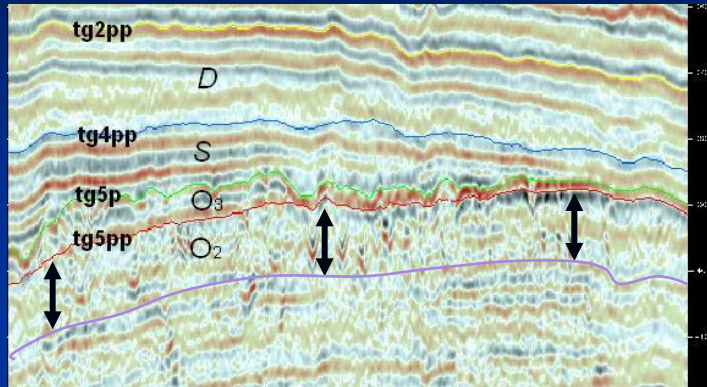


Outcrop photo of Ordovician cave breccia and sediments



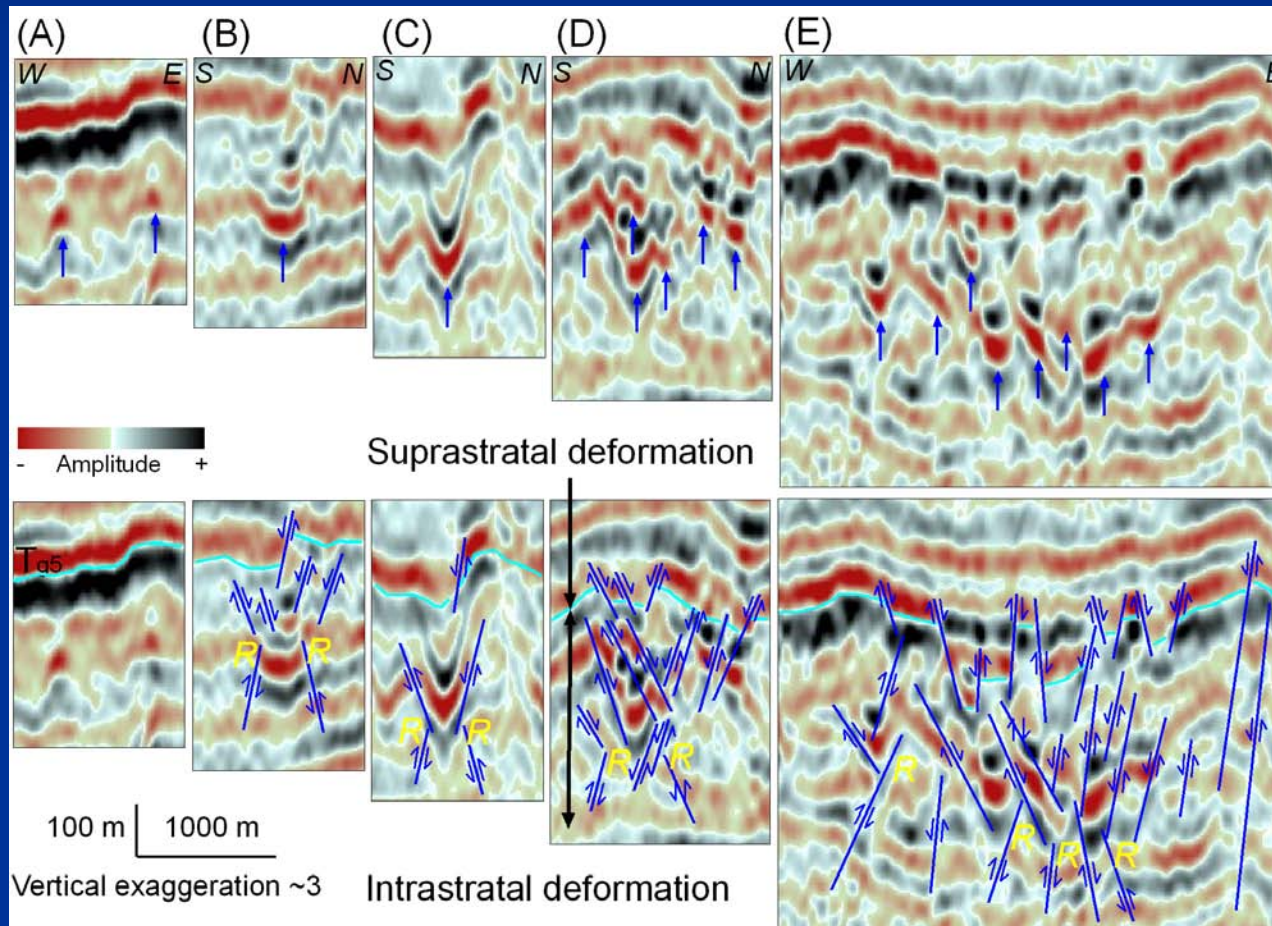


Distribution of bright spots

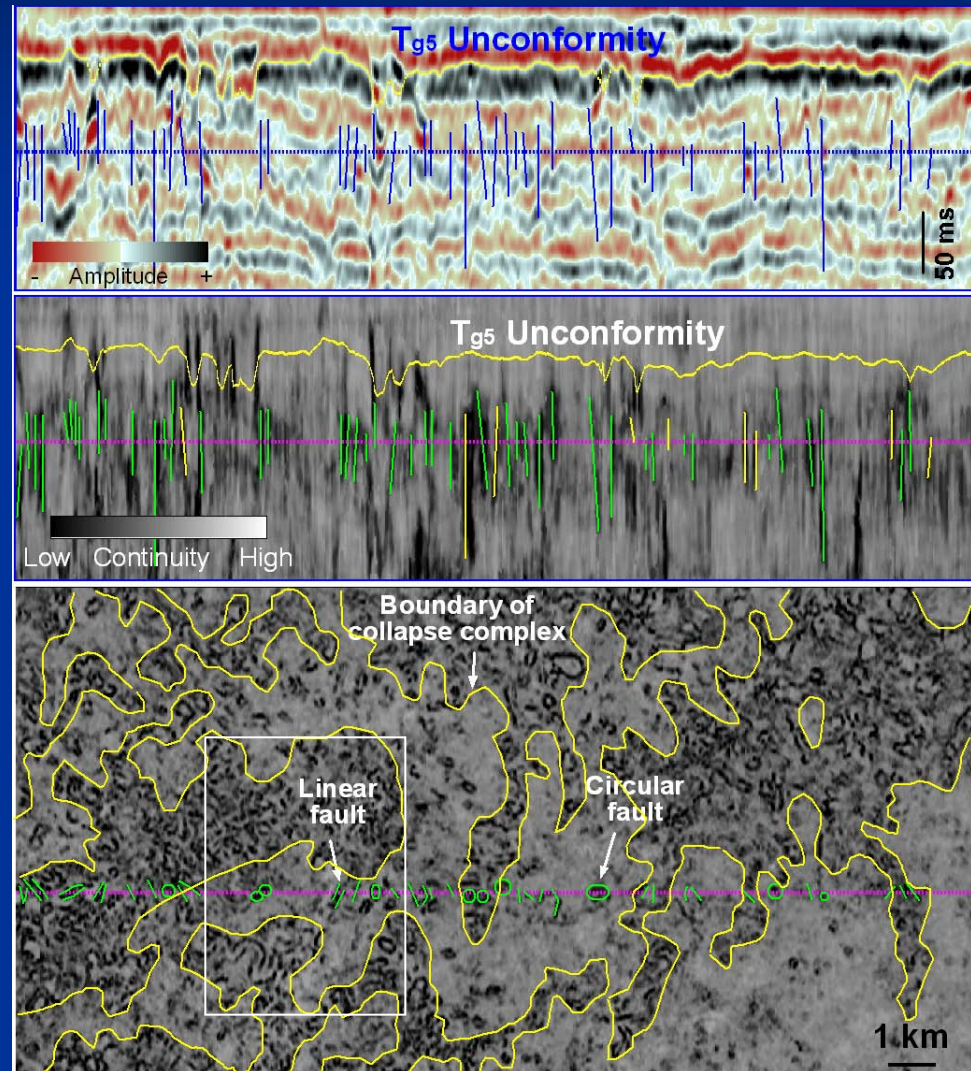
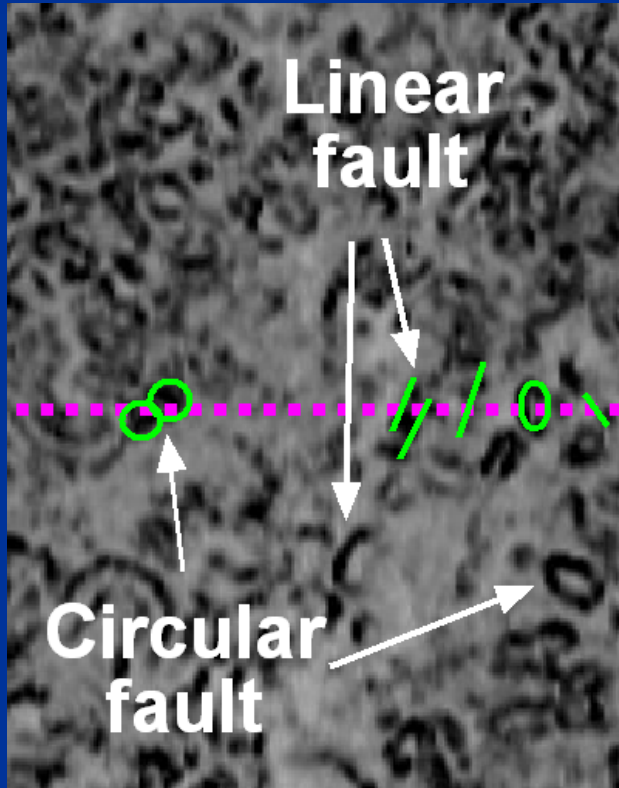


Interpretation of collapsed paleocave complexes (vertical slice)

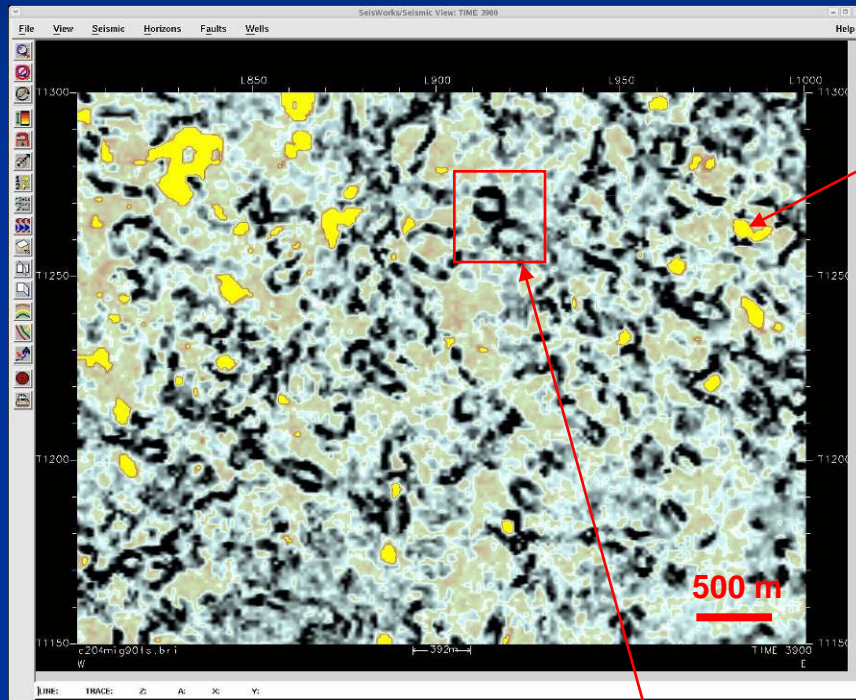
Size →



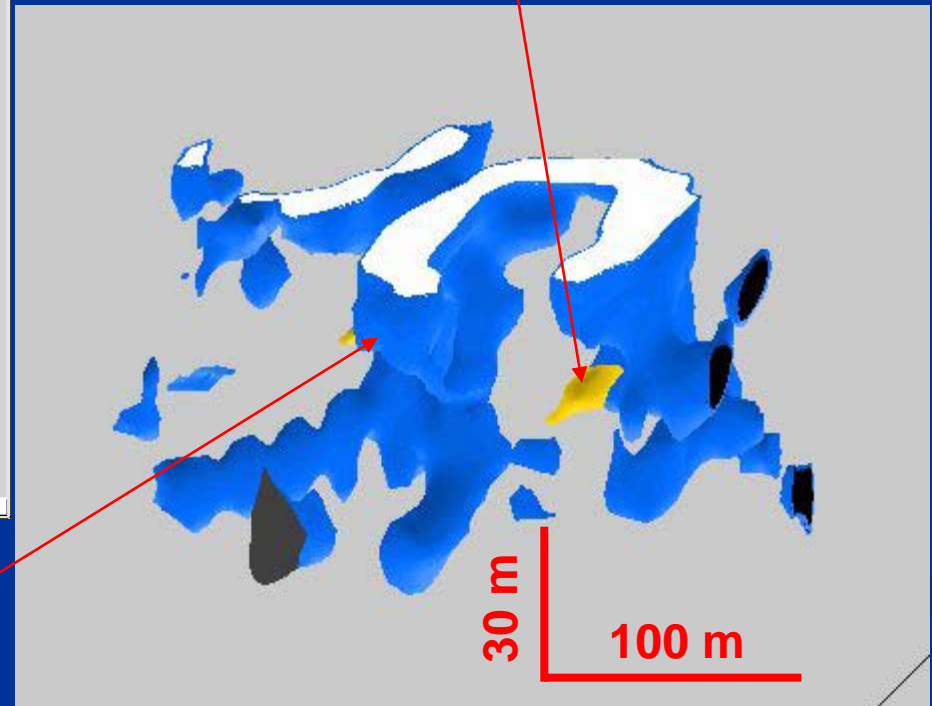
Interpretation of karst-related faults using continuity (coherence) attribute



Interpretation of collapsed paleocave complexes (3D)



Bright spot
(cave sediments)



Cave



Conclusions

1. Data quality is critical for identification of paleokarst system buried in a great depth in great detail
2. Integration (core, outcrop, and seismic) is the key for successful interpretation of complex paleocave systems
3. Surface drainage system, sinkholes, collapse features, and cave sediments are major evidence of paleocave system in the study area
4. Seismic geomorphology can be helpful in predicting paleokarst systems using 3D seismic data



Acknowledgments

1. BGP of CNPC is thanked for providing funds and data for the study
2. Landmark Graphics is thanked for donating seismic interpretation software