Underwater ERT method to image karst cavity distribution below the river water

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2023.10.18

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地球与空间科学系 DEPARTMENT OF EARTH AND SPACE SCIENCES

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Outline

01 Introduction

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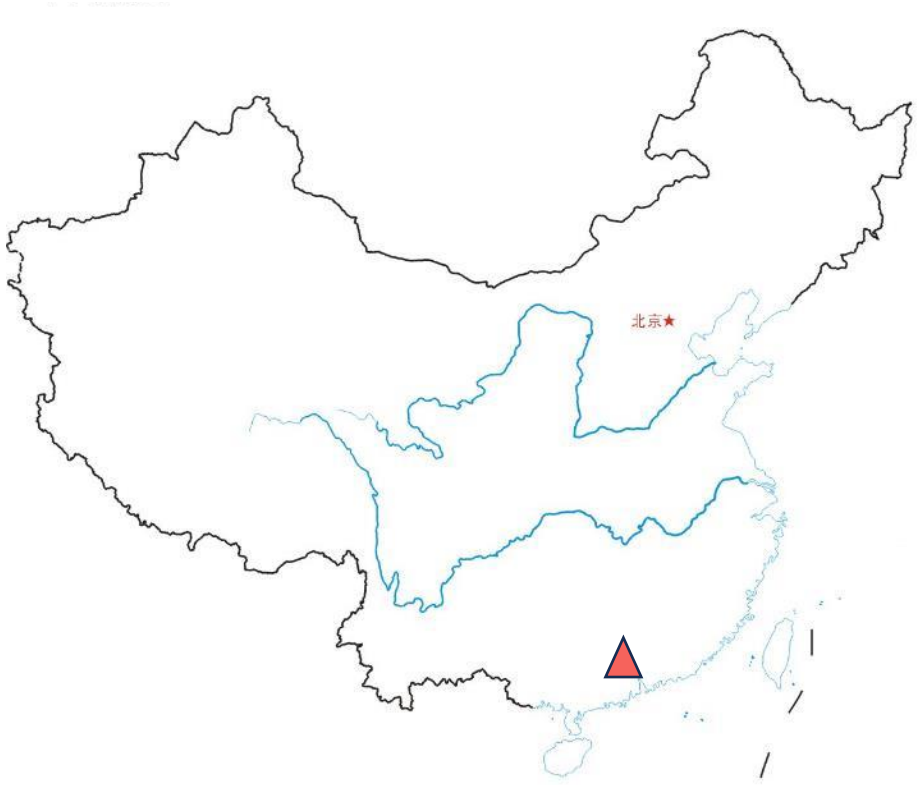
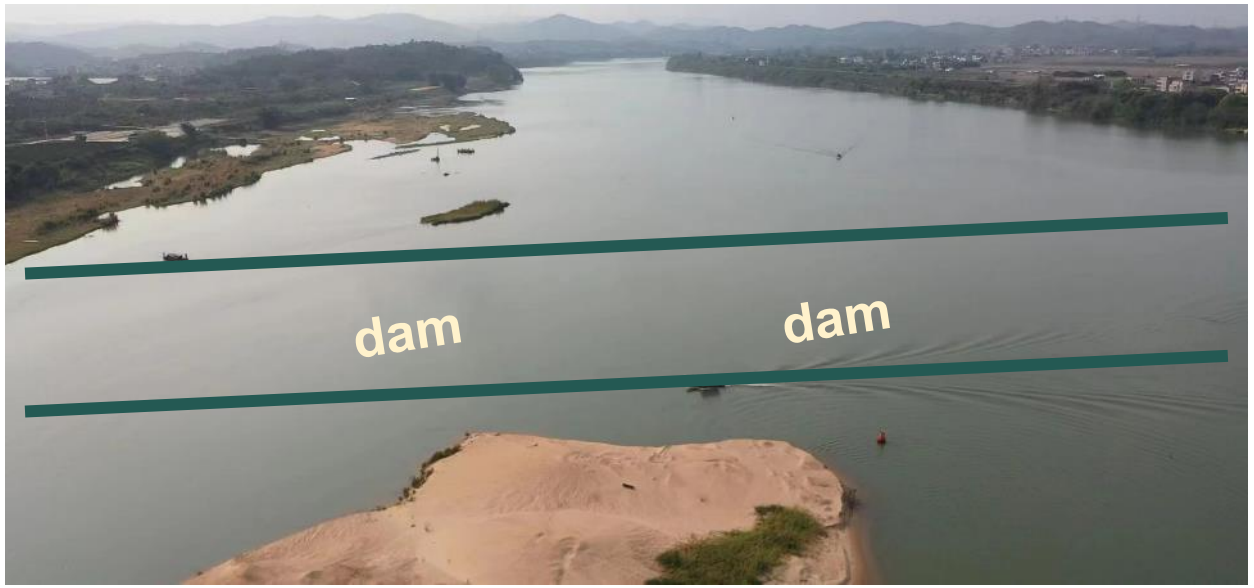


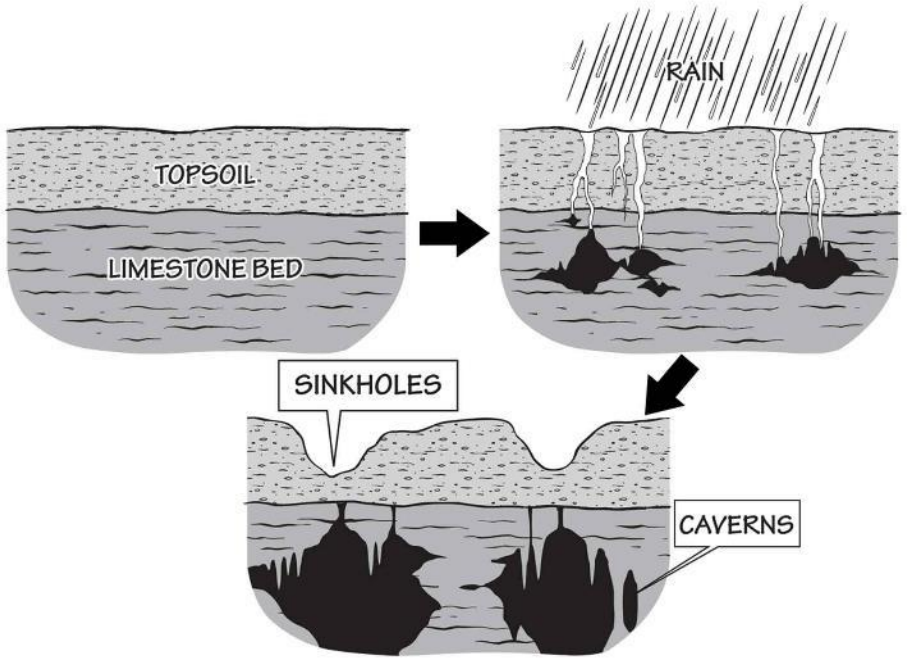
(Huizhou, China)

Dong River



River Info	
River Depth	0.5 — 9m
River Width	Above 700m
Rock Type	silt, weathered limestone, pulverized clay, shale, sandstone …

01 Introduction



Karst Cave

Shallow

Karst cavity

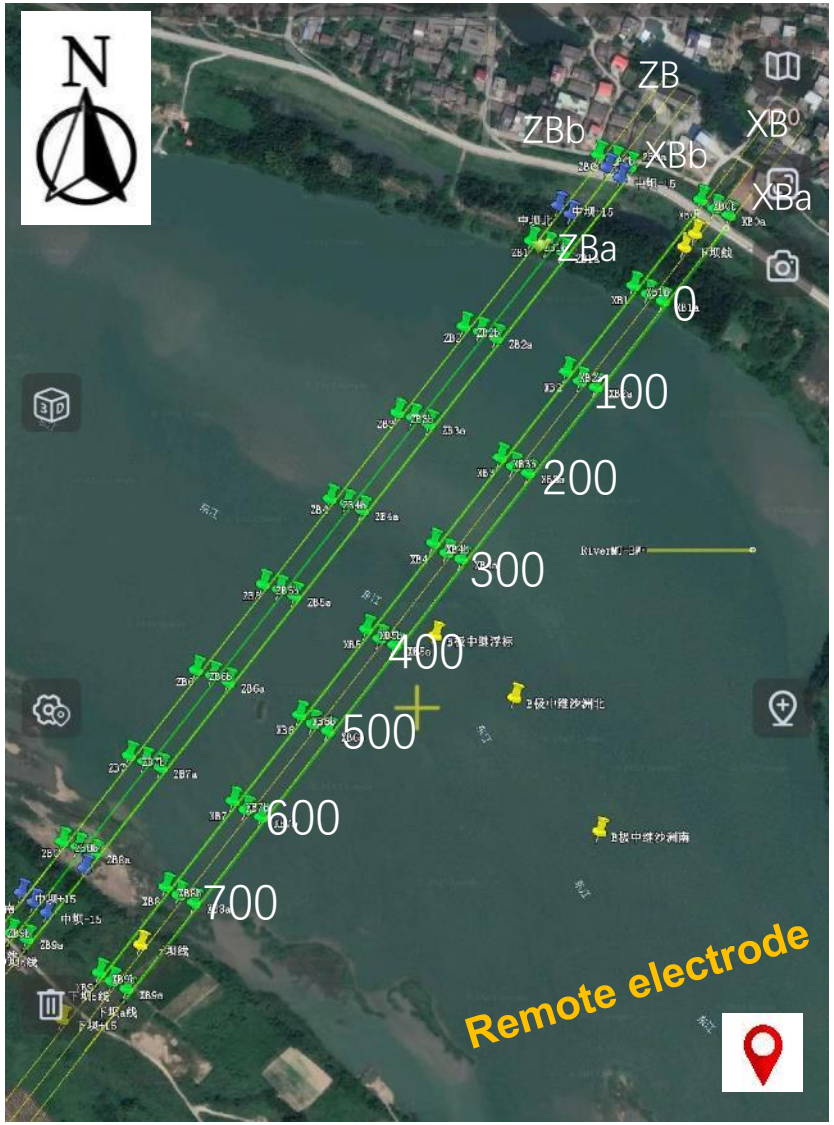
Unevenly developed

Buried deeply

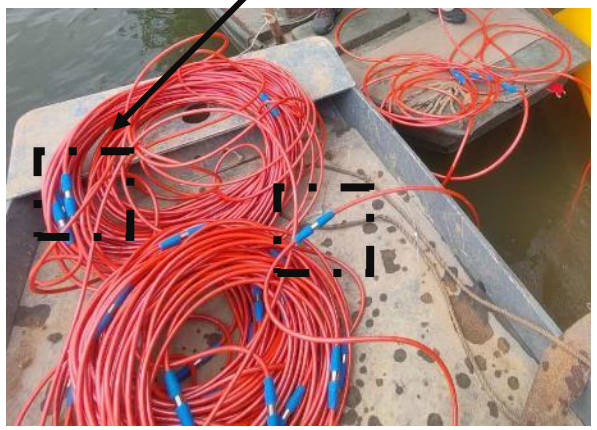
Deep

cavity size < 0.2m > 24 m

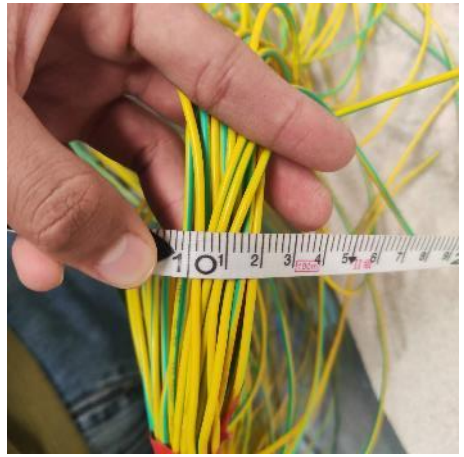
01 Introduction



Survey Lines Layout



Measurement using red cable



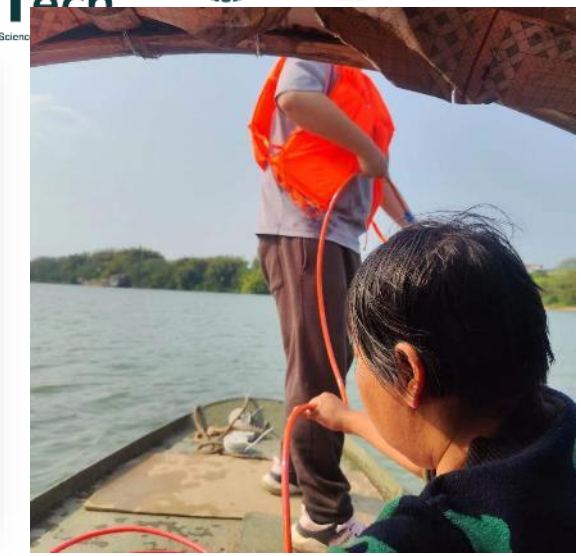
Cable for remote electrode

Titanium plate

- **Red cable length : 200m**
- **Electrode spacing : 5m**
- **Number of electrodes: 40**
- **Transmit voltage: 450V**
- **Remote electrode(B): 800m**

02 Surveys


2023-03-23 16:31:13
XB2
2023-03-23 16:31:15
2023-03-23 15:04:32
2023-03-23 16:36:19



02 Surveys

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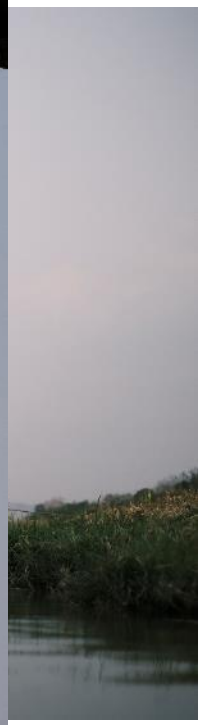
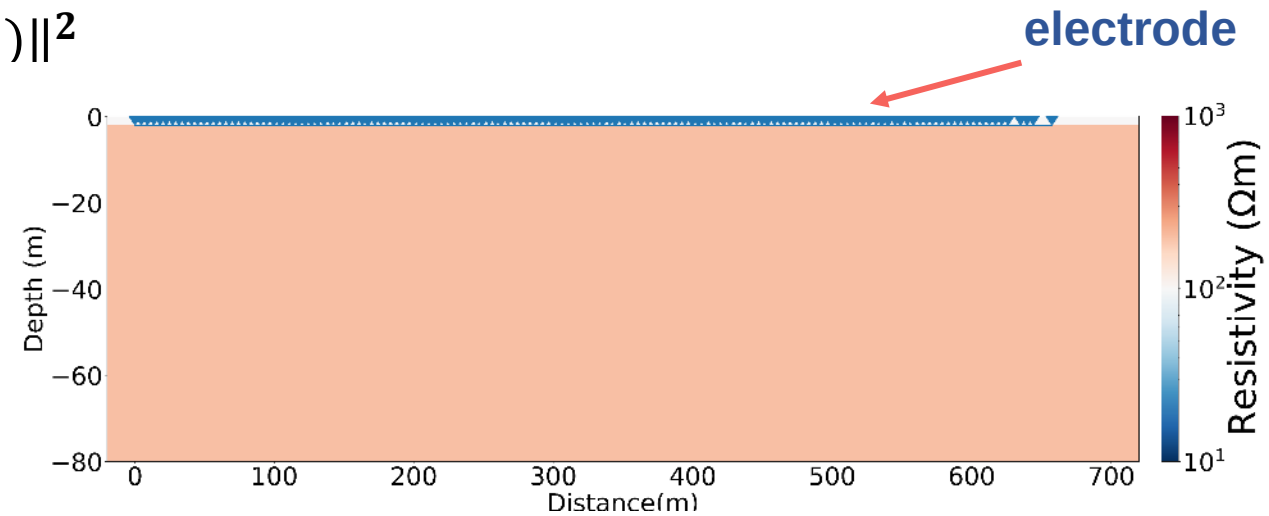


03 Methods

$$\varphi(m) = \left\| W_d\left(d_{obs} - f(m)\right)\right\|^2 + \gamma \left\| W_m(m - m_0)\right\|^2$$

$$W_m = \left(\alpha_s I, \alpha_x W_x^T, a_z W_z^T\right)^T$$

W_m	*model weighted matrix*
$\alpha_s, \alpha_x, \alpha_z$	*Weight coefficient*
m_0	*Reference model*



m_0 Initial Model

simpeg

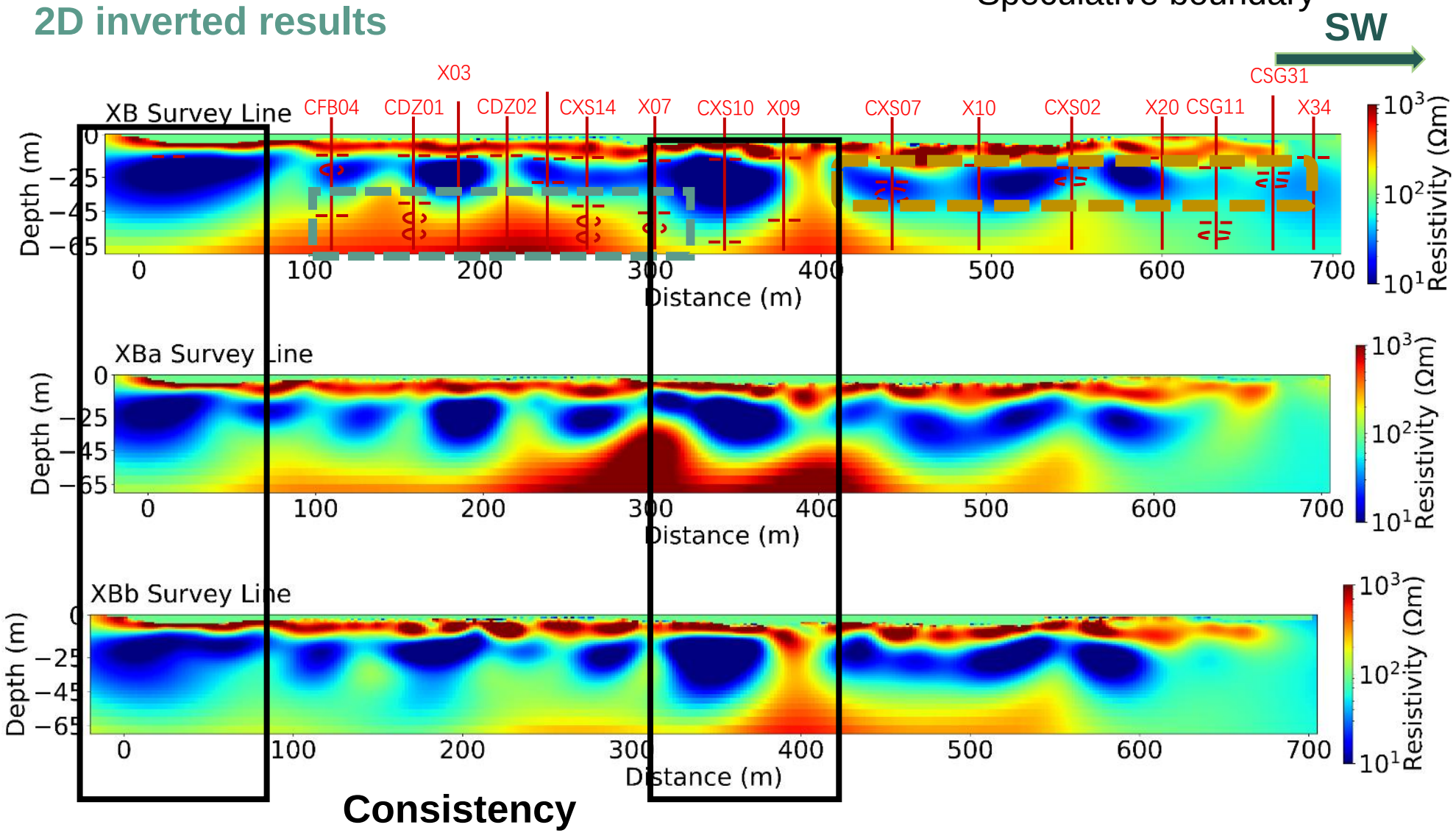
(Cockett, et al., 2015)

04 Results

Known cave

Speculative boundary

2D inverted results

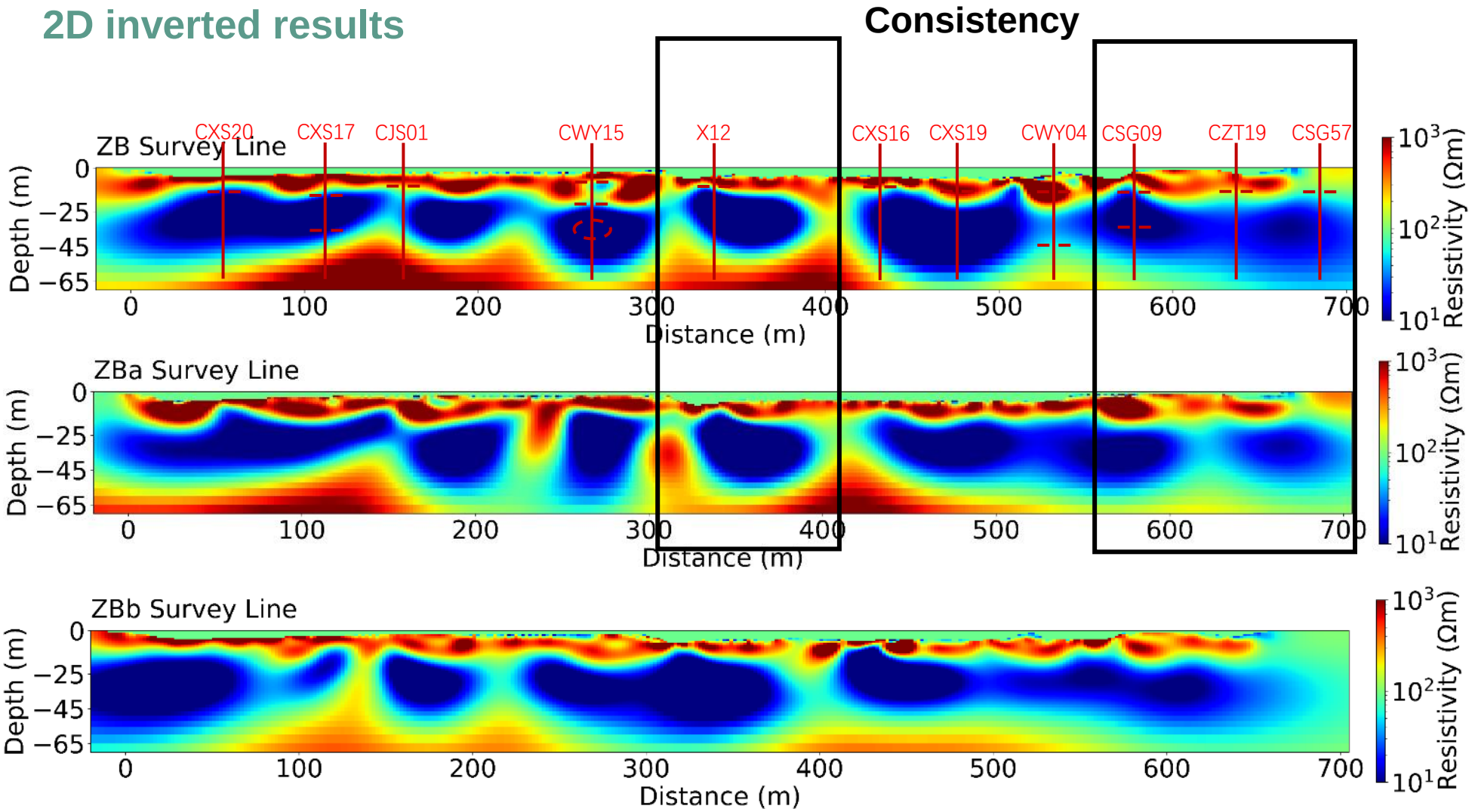


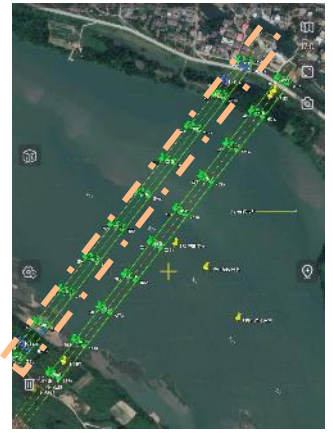
XB area

- **Three-layer electrical structure**
- **Continuity of resistivity structure**

04 Results

2D inverted results





ZB area

- **Cave filling has higher water saturation, presumably**

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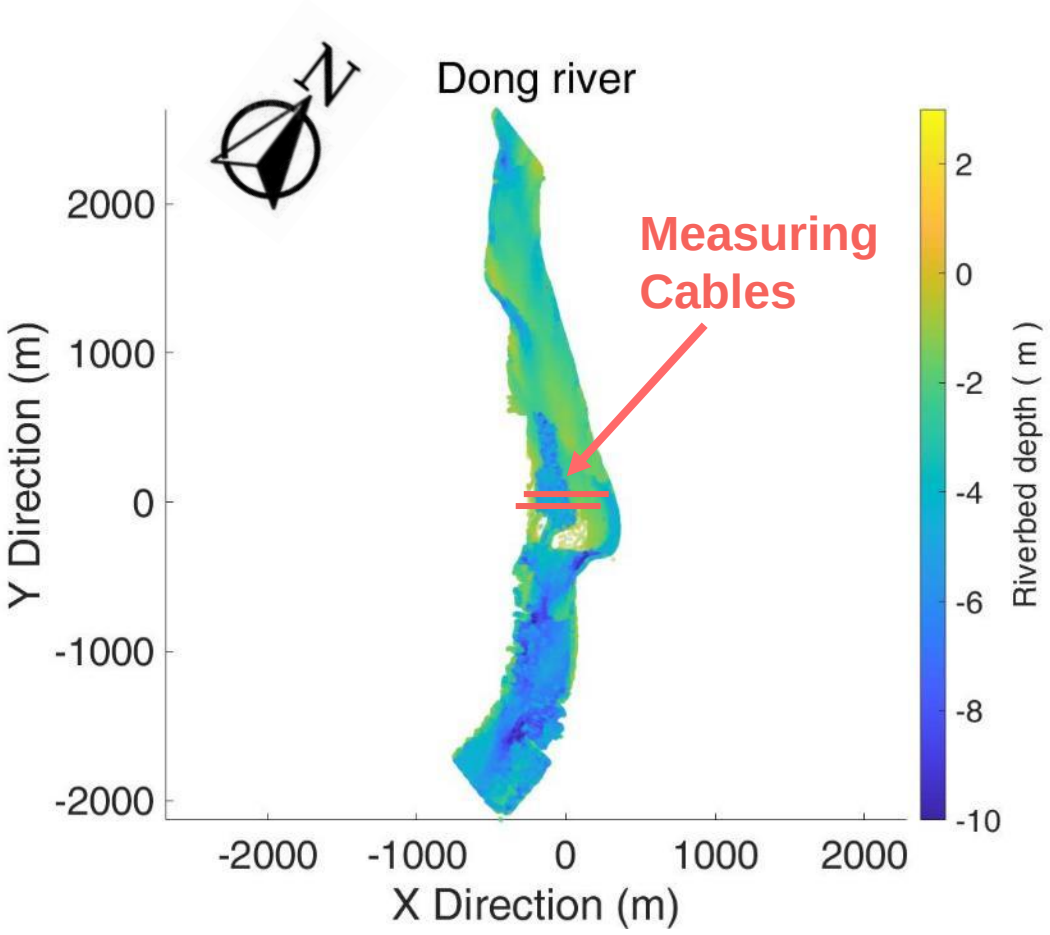
Conclusions -2D :

- The electrical structure of 2D can be roughly divided into 3 layers, which is consistent with the available geologic information.
- The surface silt, gravel cobblestones roughly exhibit high resistivity, the middle sandstone and shale layer exhibit relatively low resistivity, and basement limestone exhibit high resistivity.
- Some of the cave's electrical structures exhibit low resistivity, inferred to be water-filled caves.
- The ERT method can only give the underground electrical layering structure and shallow buried caves, and cannot find caves in the deep limestone.

04 Results

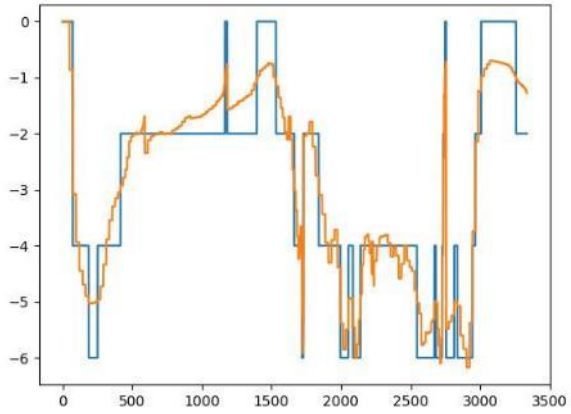


Dong River

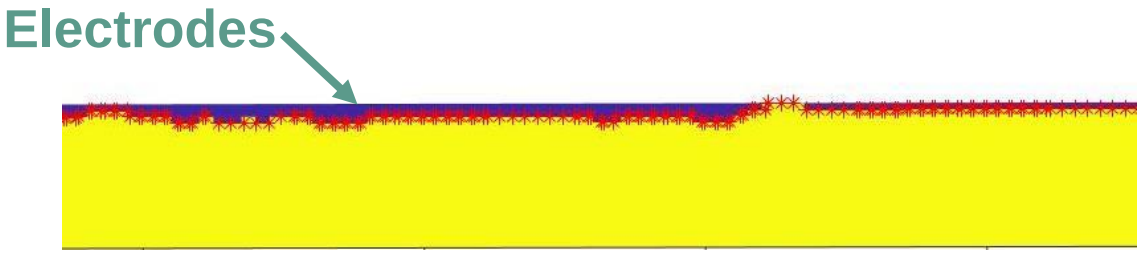
$$W_m = \left(\alpha_s I, \alpha_x W_x^T, a_y W_y^T a_z W_z^T\right)^T \quad \alpha_x : \alpha_y \;\; 10:1$$

MESH:

X unit width : 5m
Y unit width : 5m
Z unit width : 2m

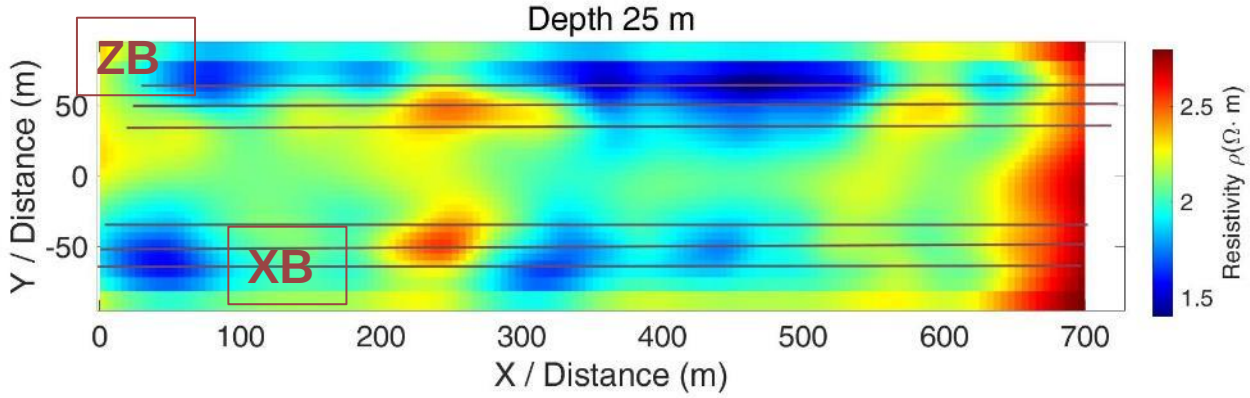


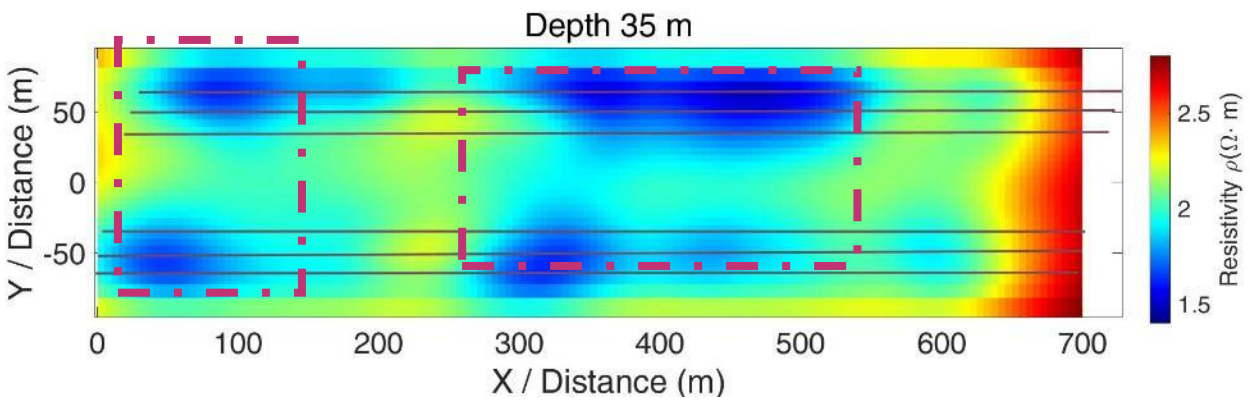
Topographic correction



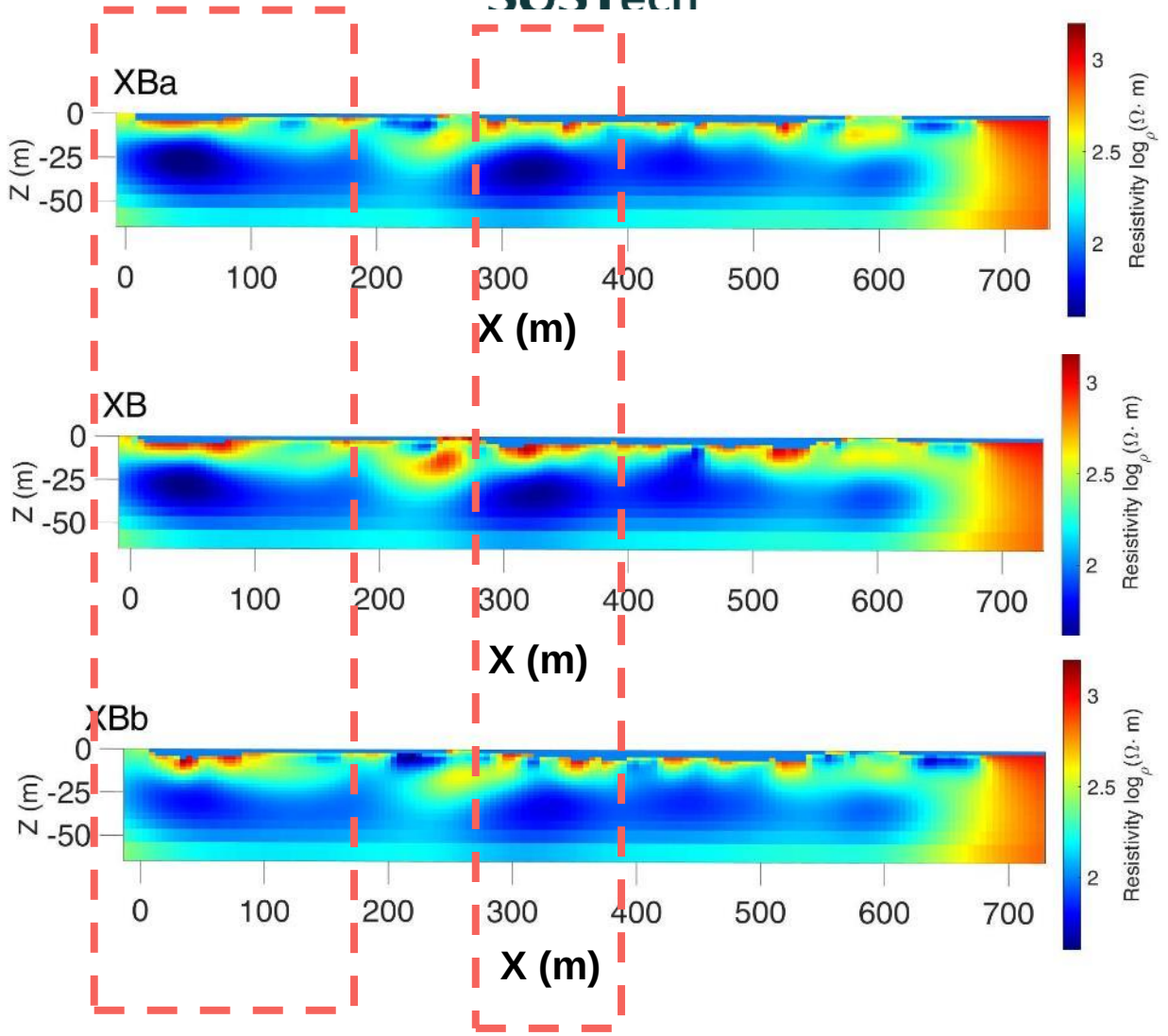
Electrode position at the interface between water and rock

04 Results



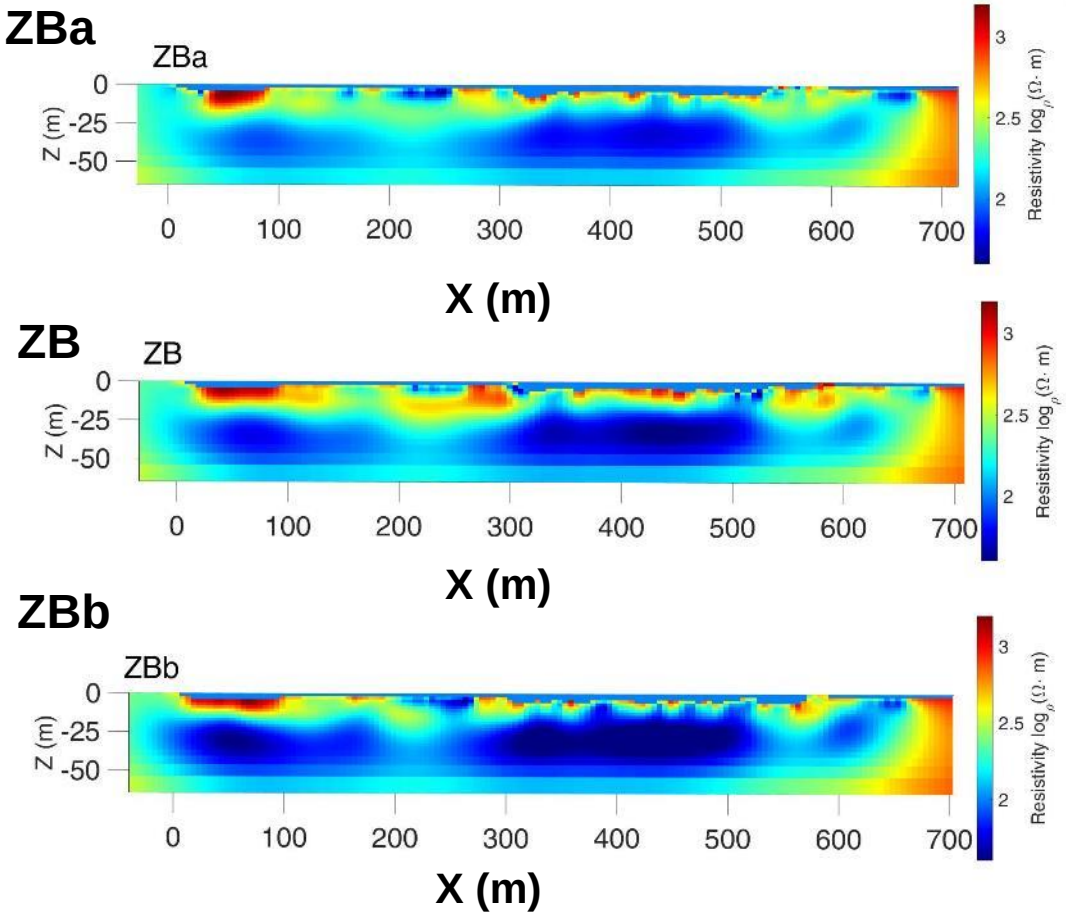


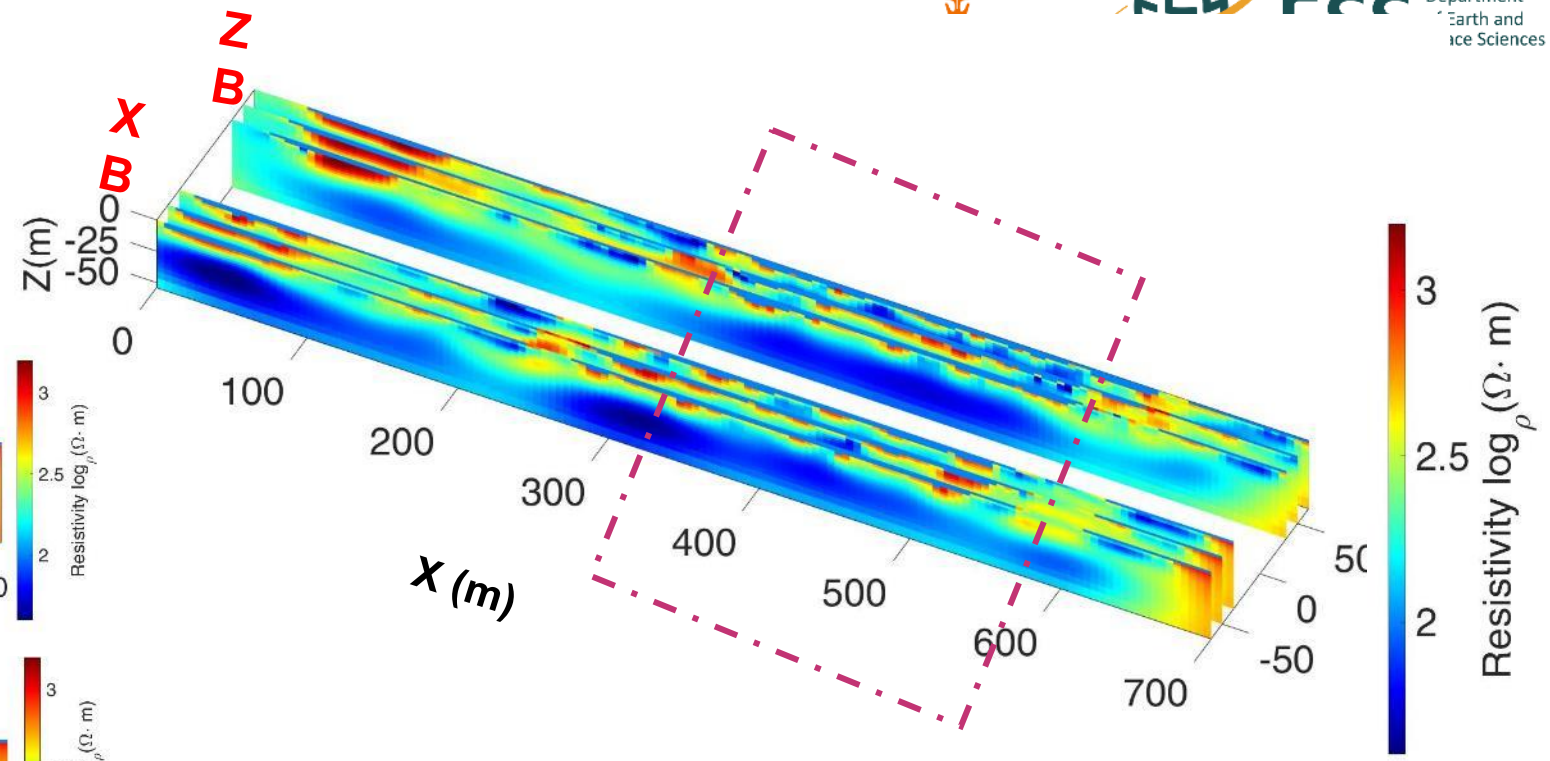
XB



Consistency in position

04 Results





- Two-layer electrical structure
- The electrical structures of some parts of XB area and ZB area are continuously developed in space

04 Results

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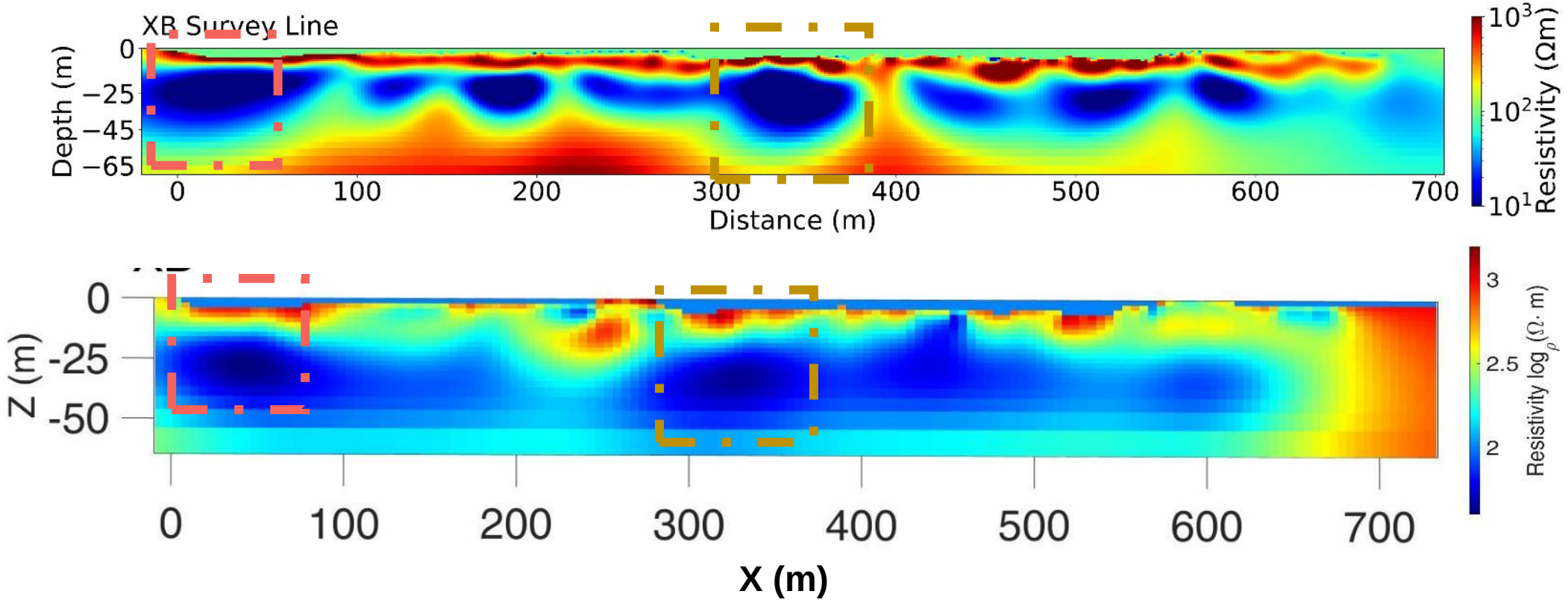
2D > 3D ?

2D

3D



- The results of the 2D and 3D inversions have high similarity in some localizations.
- ERT is capable of effectively recognizing the interfaces of rock partings.
- The electrical partitioning of 2D is in good agreement with the drilling data.

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Conclusions:

- In some cases, 2D electrical results better characterize the distribution of strata.
- Spatial continuity of electrically structured anomalies of XB and ZB
- Low resistivity anomalies revealed in 2D and 3D together can designate potential cavities and improve the reliability of the results.
- Some of the karst exhibits low resistivity characteristics, and ERT is unable to identify cavities if they are buried too deeply.

THANKS!

Q & A?