GPR coherence attribute applied to the structure interpretation of limestone epikarst in Guizhou karst plateau

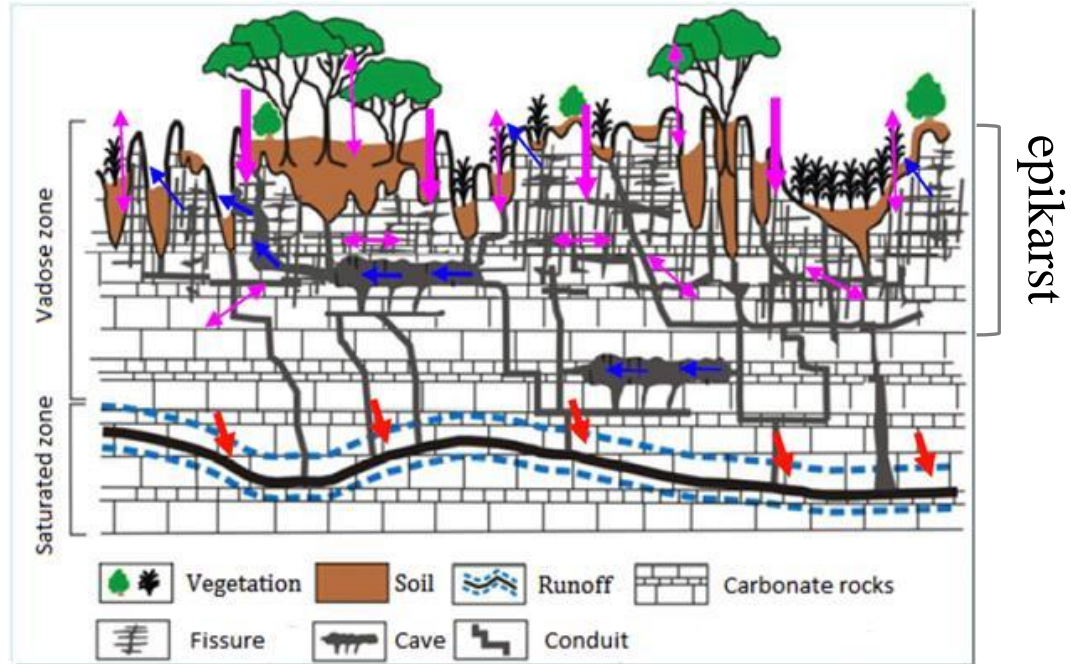Qiangshan Gao[*] , Tao Peng, Shijie Wang and Tianchun Yang

*Institute of Geochemistry, Chinese Academy of Sciences

HS8.2.6|EGU2020-1977, Friday, 8.5.2020

Introduction

▸ The epikarst ecosystem plays a key role in biogeochemical cycling and energy and material storage and transport.

▸ Ground penetrating radar (GPR) attributes are not widely used in the interpretation of epikarst structure.

epikarst

Legend:
- 🌳 🌲 Vegetation
- ▨ Soil
- ≈ Runoff
- ▦ Carbonate rocks
- ☰ Fissure
- Cave
- Conduit

Vadose zone

Saturated zone

Epikarst   zone   (Peng *et al.*, 2017)

➢ We applied coherence attributes to interpret the structure features of two typical epikarst profiles.

▸ Institute of Geochemistry, Chinese Academy of Sciences

Method

- The coherence attribute is extracted after the original radar data has been processed by the conventional methods.

- The coherence attribute was first proposed by Bahorich and Farmer (1995) for seismic data interpretation.

- The extraction method of the attribute is based on the classical mutual correlation algorithm, describing the waveform similarity of multi traces by the value $(0,1)$.

$$\rho_x(\mathbf{x}_i, \mathrm{t}, \triangle \mathrm{t}_x) = \frac{\displaystyle\sum_{\tau=-\omega}^{\omega} u(\mathbf{x}_i, \mathrm{t}-\tau) u(\mathbf{x}_{i+1}, \mathrm{t}-\tau-\triangle t_x)}{\sqrt{\displaystyle\sum_{\tau=-\omega}^{\omega} u^2(\mathbf{x}_i, \mathrm{t}-\tau) \sum_{\tau=-\omega}^{\omega} u^2(\mathbf{x}_{i+1}, \mathrm{t}-\tau-\triangle t_x)}}$$
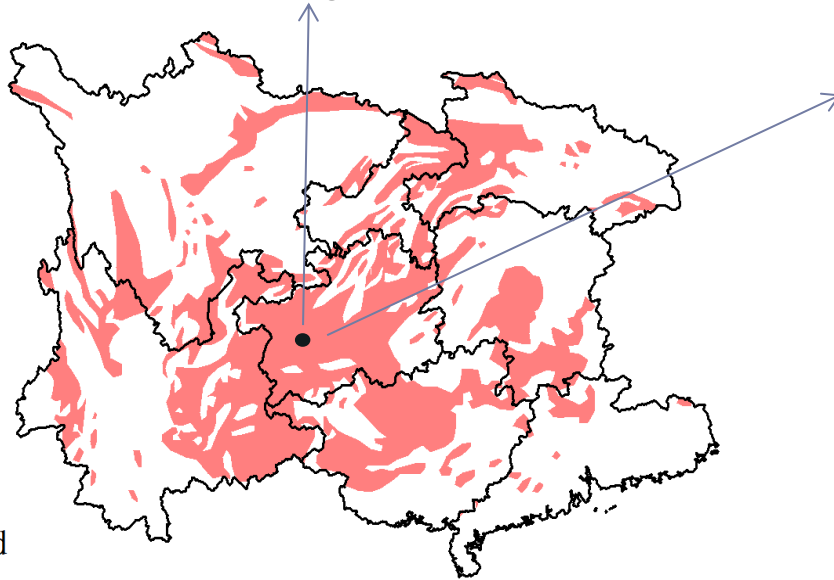
Survey site & equipment

Position: Maguan town, Puding county, Guizhou province
Lithology: limestone; Elevation: 1305 m;
Subtropical monsoonal humid climate;
The Triassic Guanling formation

Epikarst and karst landforms are well developed; karst plateau
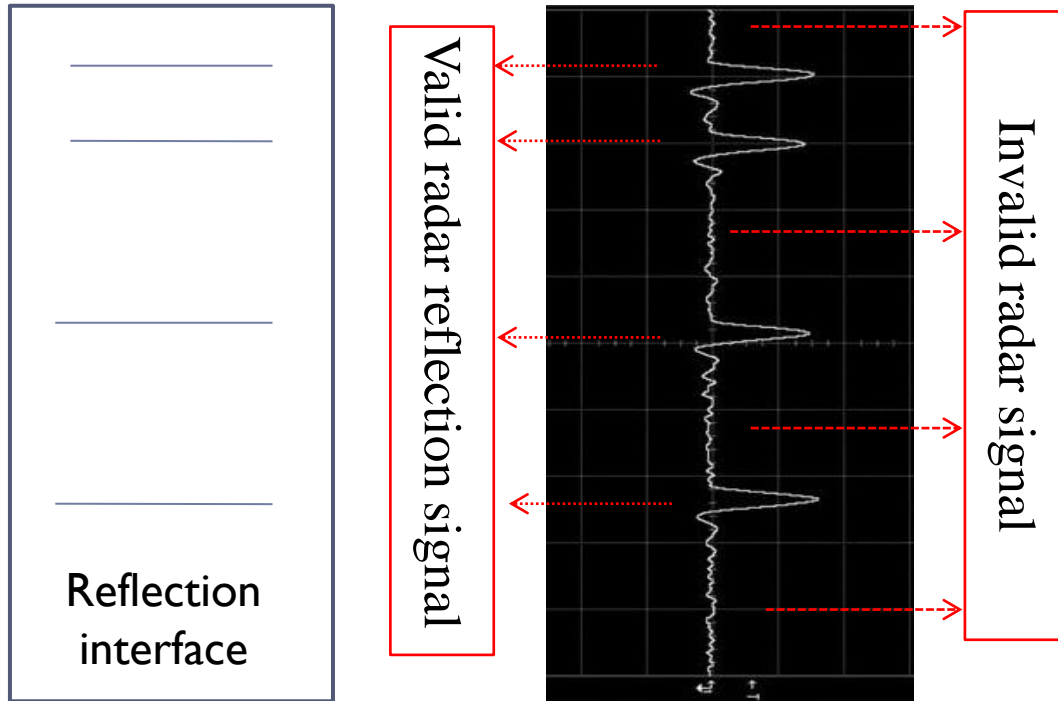Two typical epikarst profiles are chosen

GPR equipment: MALA
Antenna frequency: 500 MHz shielded

The conventional processing methods were conducted by REFLEXW software.
The coherence attribute data was extracted in C Language procedure.

Legend

☐ **provincial border**

🟥 **karst area**

SW China map

▶ Institute of Geochemistry, Chinese Academy of Sciences

Preliminary Knowledge

Reflection interface

Valid radar reflection signal

Invalid radar signal

- ▸ Valid signal is the reflection signal which waveform is similar with triggered signal, wavelet.

- ▸ Invalid signal is radar system inherent noise signal which waveform is random.

For multi-traces, the coherence value of valid signals is higher than that of invalid signals.

▸ Institute of Geochemistry, Chinese Academy of Sciences
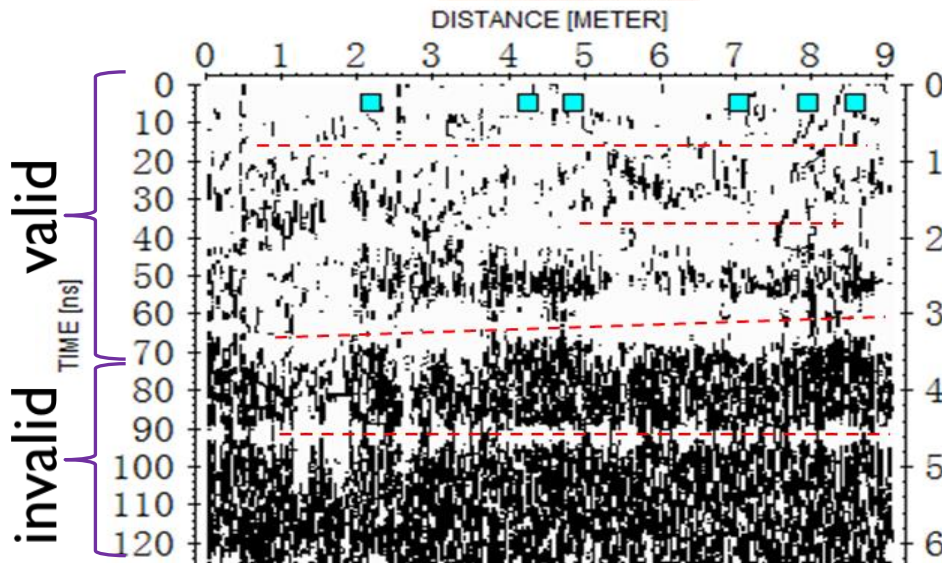
Results & Discussions
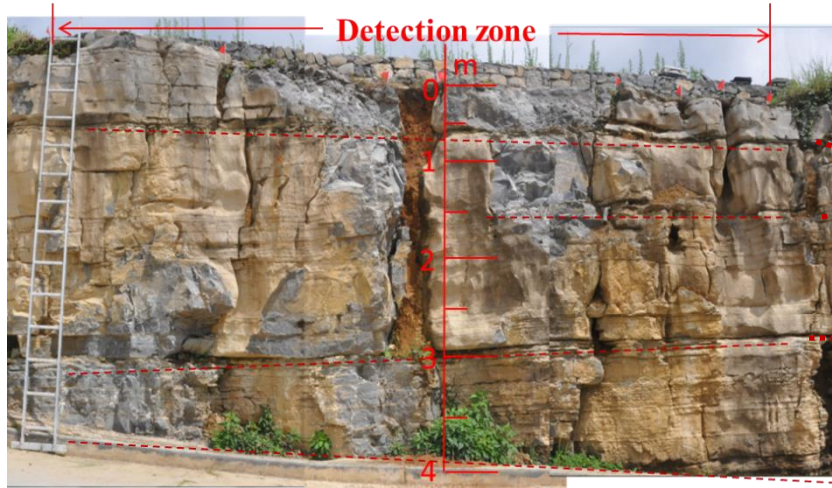
Typical epikarst profile photo: deep fissure soil type

bedding layers

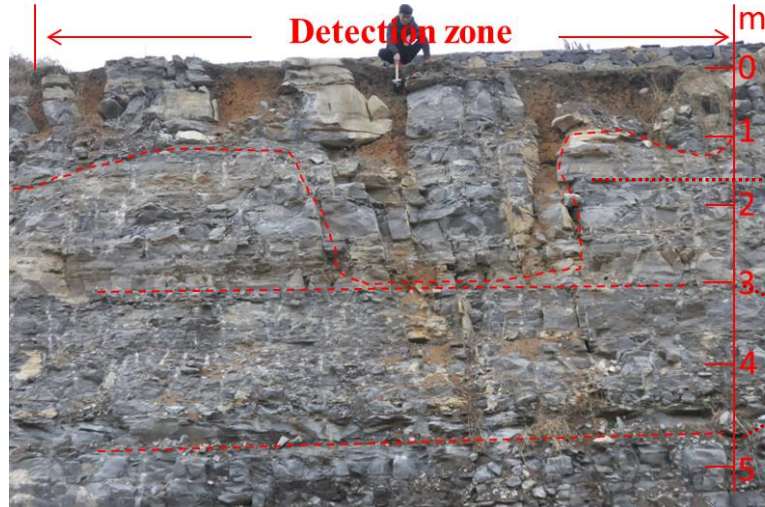Lower boundary of epikarst

concrete pavement, not geological term

GPR coherence attribute figure: White is high value and black is low value

Boundary of valid and invalid signal areas

radar signal not decays to zero there, but less reflection interfaces

▶ Institute of Geochemistry, Chinese Academy of Sciences

Results & Discussions

Detection zone

m

0

1

2

3

4

5

Typical epikarst profile photo:
deep fissure soil type

Lower boundary of epikarst

bedding layers

DISTANCE [METER]

valid

invalid

TIME [ns]

DEPTH [METER] at v=0.1 [m/ns]

GPR coherence attribute figure:
White is high value and black is low value

Boundary of valid and invalid signal areas

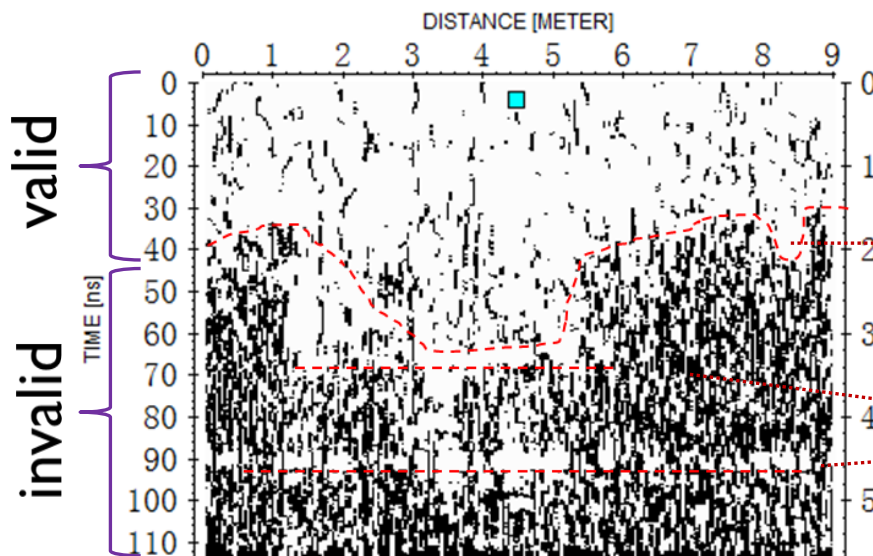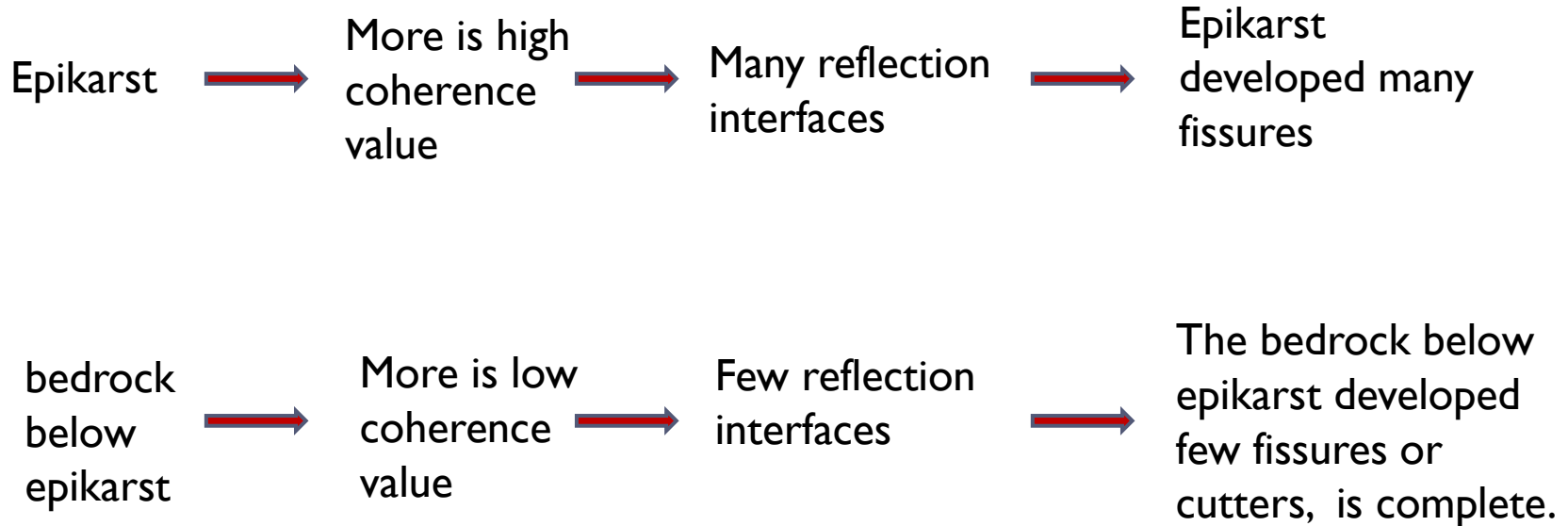radar signal not decay to zero there,
but less reflection interfaces than that in
the epikarst area

Institute of Geochemistry, Chinese Academy of Sciences

Results & Discussions

Epikarst $\longrightarrow$ More is high coherence value $\longrightarrow$ Many reflection interfaces $\longrightarrow$ Epikarst developed many fissures

bedrock below epikarst $\longrightarrow$ More is low coherence value $\longrightarrow$ Few reflection interfaces $\longrightarrow$ The bedrock below epikarst developed few fissures or cutters, is complete.

GPR coherence attributes give additional evidence about the structure of limestone epikarst in Guizhou karst plateau area.

Institute of Geochemistry, Chinese Academy of Sciences

Results & Discussions
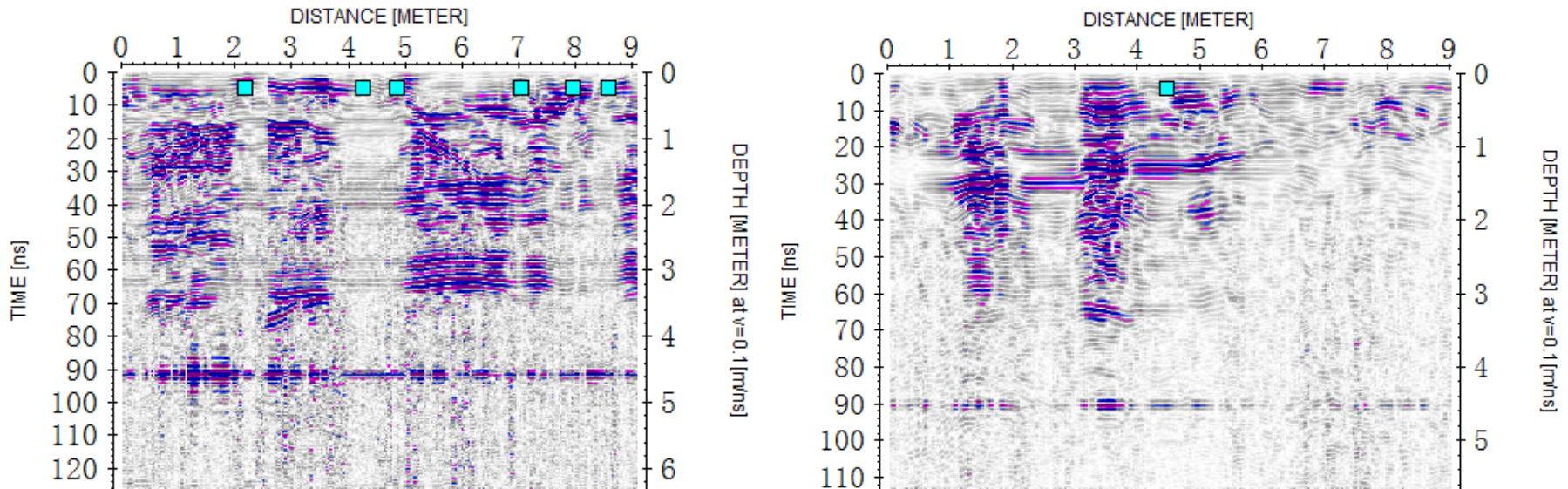
the radar figures of the two typical epikarst profiles'
GPR data processed by conventional methods

▸ It is more difficult to interpret the general boundary of epikarst by conventional radar image, comparing with the GPR coherence attribute image.

▸ Institute of Geochemistry, Chinese Academy of Sciences

Results & Discussions

▸ Coherence attribute displays the valid and invalid signal areas of the GPR profiles;

▸ The epikarst is corresponding to the valid area and the bedrock below epikarst is corresponding to invalid area;

▸ The boundary of valid and invalid areas reflects generally the lower boundary of epikarst.

▸ Institute of Geochemistry, Chinese Academy of Sciences

Conclusion

- Coherence attribute provides additional evidence that the epikarst developed lots of fractures but the bedrock below is complete.

- The validity of GPR signals is useful to analyze the structure of epikarst.

Institute of Geochemistry, Chinese Academy of Sciences