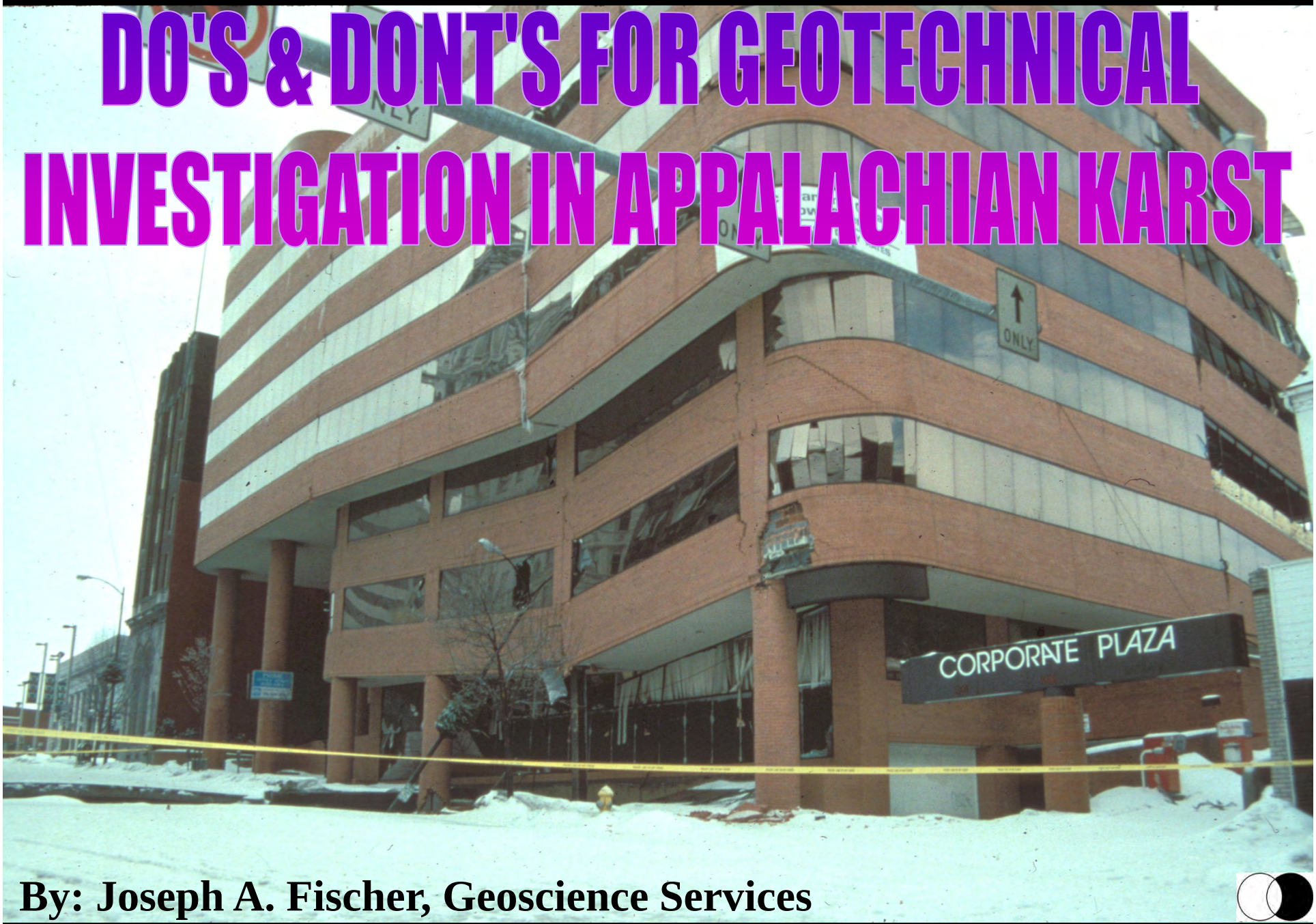
DO'S & DONT'S FOR GEOTECHNICAL INVESTIGATION IN APPALACHIAN KARST



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PRINCIPLE TYPES OF “KARST”

- Recent, sandy and coralline carbonates of Florida and the Caribbean.
- Hard, but flat-lying carbonates of the central U.S.
- Hard, but folded and faulted (and some metamorphosed) carbonates of the eastern & western U.S.


WHAT DOES APPLACHIAN
KARST LOOK LIKE?


ALL TURNS
FROM
RIGHT LANE

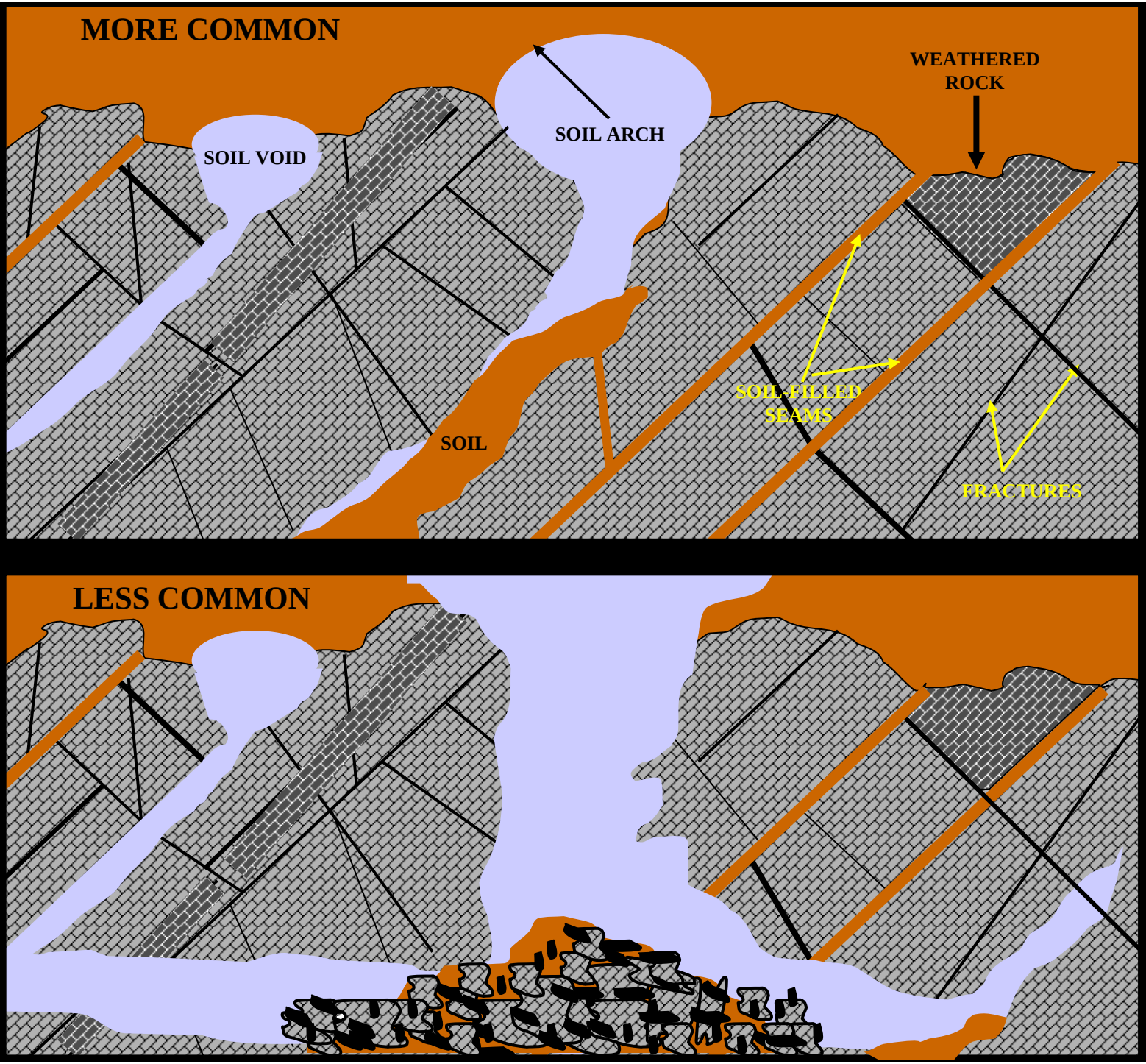
YOU SHOULDN'T BUILD…

UNLESS YOU KNOW WHAT'S UNDERNEATH


BRIDGE
CLOSED


OOPS!!

Failure Modes In Appalachian Karst



GEOTECHNICAL CONCERNS

- Highly variable bedrock surface with soft soils and/or voids right on top of the rock can lead to differential settlement problems.
- Voids within the rock and overburden need to be considered in design to avoid foundation support failures.
- Highly variable properties of “bent” rock and surficial soils can cause support concerns.
- Vertical differences in the bedrock surface of 50 feet or more have been experienced over a horizontal distance of 10 feet.

GEOHYDROLOGICAL CONCERNS

- **Surface water follows solution-enhanced joints, fractures, faults and shear zones.**
- **Fracture orientation in relation to in-situ stress orientation can allow deeper fracture penetration, thus increasing the likelihood of deeper solutioned channels.**
- **Ground water movement in karst usually does not behave like isotropic, anisotropic or slab-fissured/fractured rock aquifers. Can behave like a pipe (conduit) or channel flow.**

GEOHYDROLOGICAL CONCERNS (continued)

- **Contaminants can travel great distances undiluted and unfiltered creating a great concern for water supply wells.**
- **Appropriate well head and aquifer protection needed.**
- **Dye trace studies, where they work, are often necessary to characterize flow within solutioned carbonate aquifers.**
- **Currently, some sinkholes are used to control surface water flows.**

Whether doing…

1. Pre-site selections studies,
2. Site evaluation, or
3. Failure evaluation,

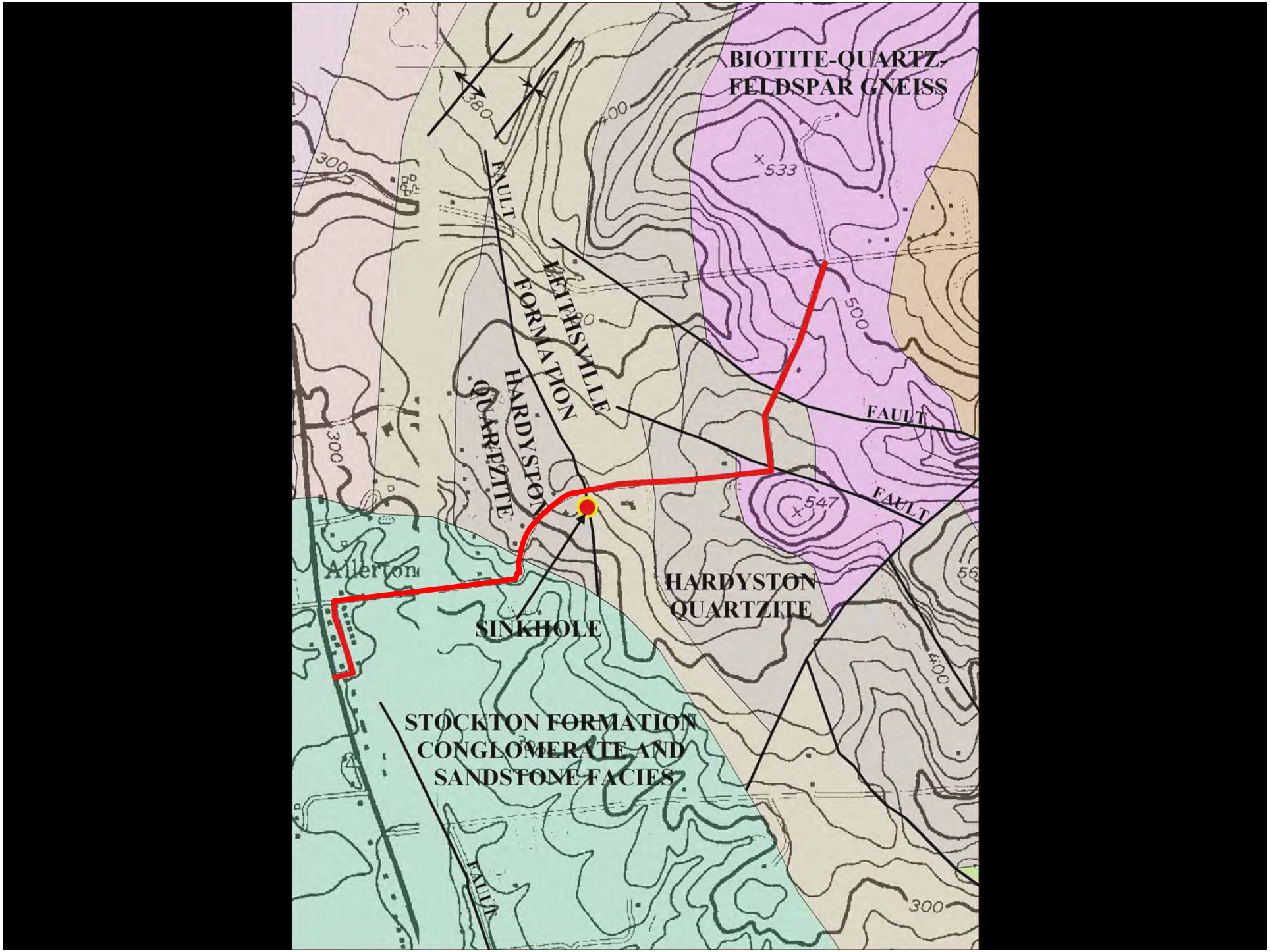
The concepts are generally similar.

Solution Concepts

- Solutions require knowledge/experience in engineering geology, rock mechanics, soil mechanics, hydrogeology/geohydrology, and geophysics (i.e. a multi-disciplined team approach to investigation, evaluation, design and remediation).
- Nature of the project.
- Knowledge/understanding of karst by the owner's design team.
- Funding.

Investigative Tools

- **Available information for the locale of interest.**
- **Experience with the soil and rock types of the locale of interest.**
- **Direct Investigation (drilling, test pits, probes).**
- **Indirect (geophysics).**
- **Dye Tracing.**


BIOTITE-QUARTZ-FELDSPAR GNEISS
FAULT
FAULT
FAULT
FAULT
BETHSVILLE FORMATION
HARDYSTON QUARTZITE
HARDYSTON QUARTZITE
SINKHOLE
STOCKTON FORMATION CONGLOMERATE AND SANDSTONE FACIES
Allerton
533
547
500
400
300
380

Available Information

Glacial Terrain or Karst Terrane?

Kettle Holes or Sinkholes?

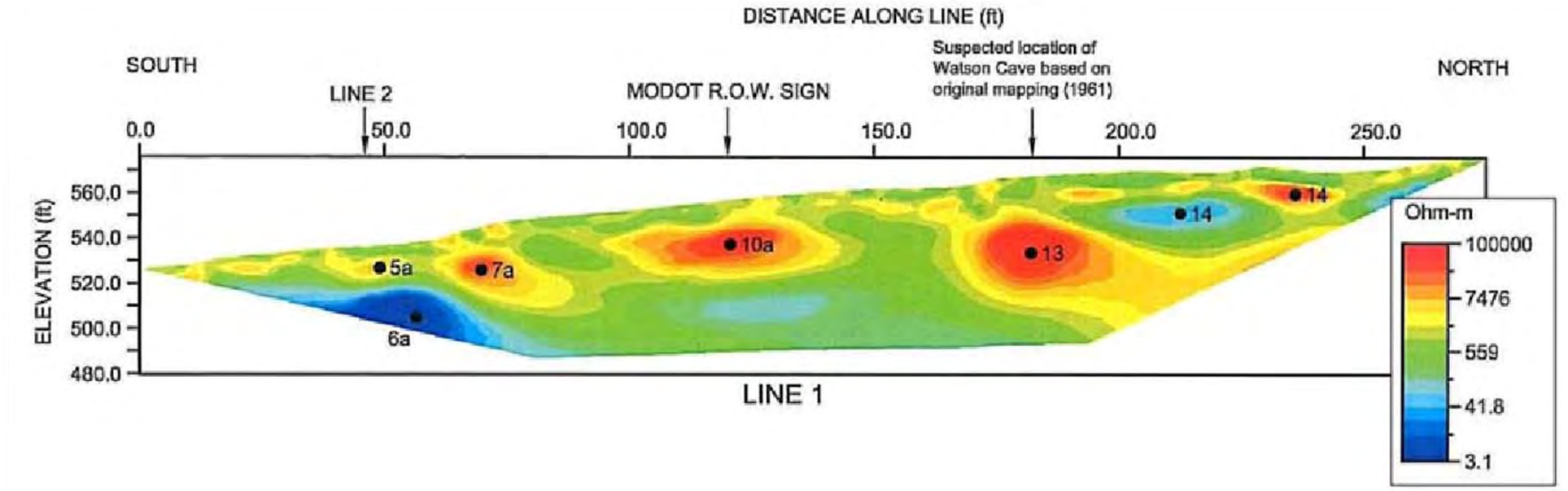

"Bent" Karst
• Aerial Imagery
• On-Site Mapping
• Local Quarries and Rock Cuts
• Resistivity
• Seismic Reflection/ Refraction?
• EM Profiling
• Gravity
• Test Pits
• Test Borings
• VLF?
• GPR?

TOOLS AND TECHIQUES

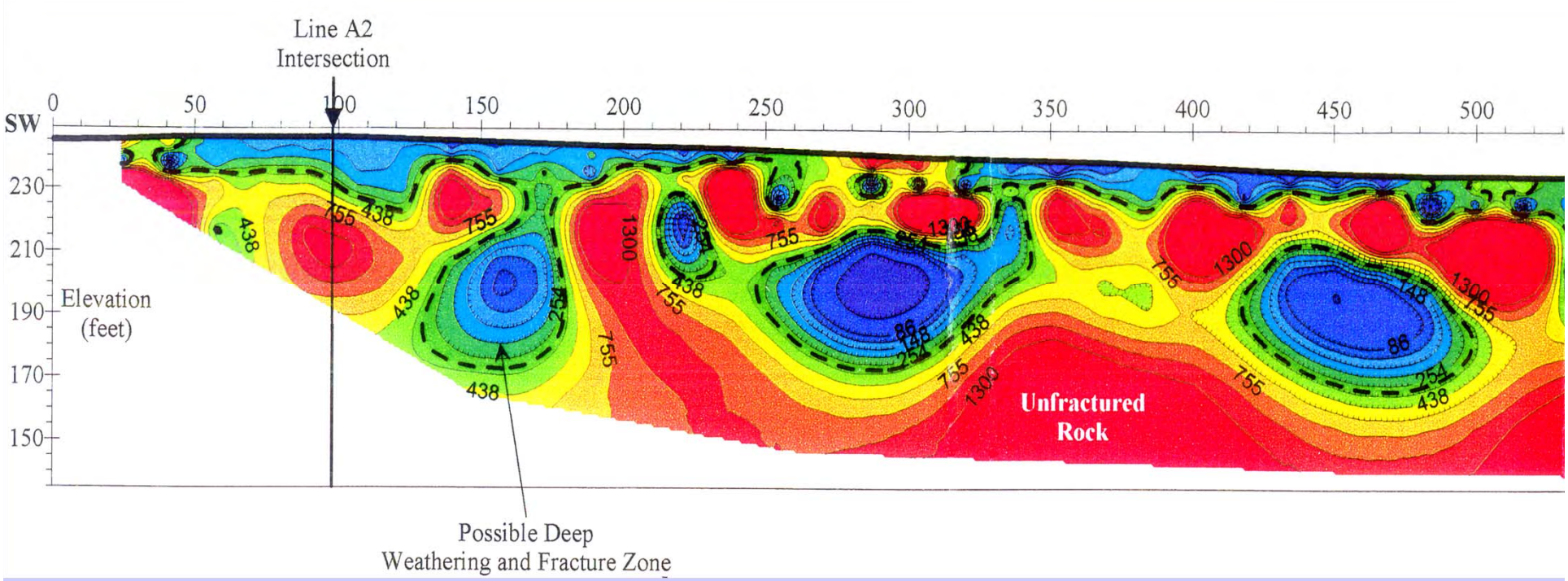
- Use a split, double-tube core barrel for rock sampling. Allows determination of fracture orientation, angle and often recovers void filling.
- Monitor water/air loss quantities and depths.
- Monitor grout-take quantities and depths.

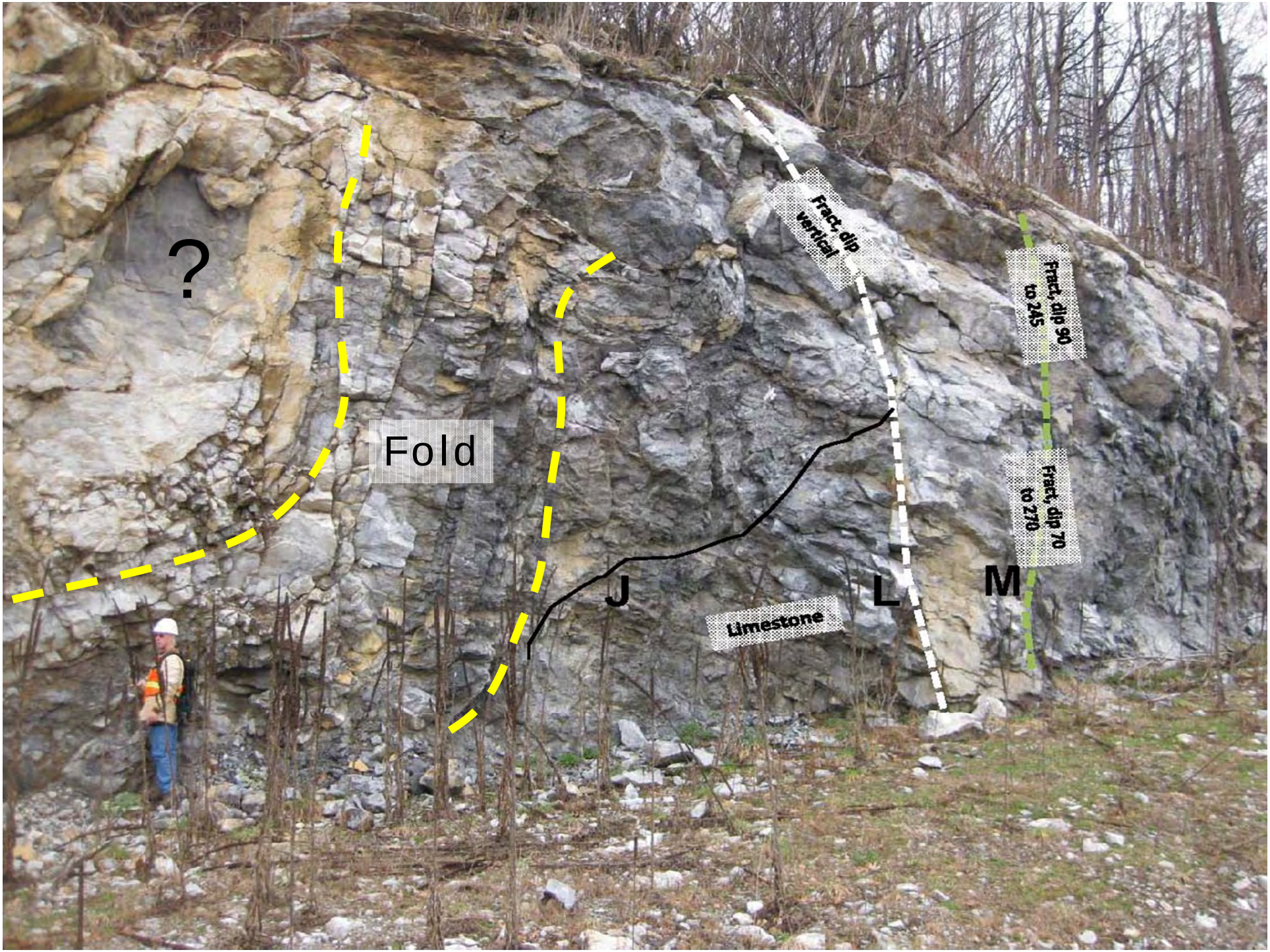
Effectiveness And Utility Of Geophysics In Karst

- Variable
- Young karst – generally good
- Flat karst – generally good
- Bent karst – generally poor, but can work


DISTANCE ALONG LINE (ft)
SOUTH
NORTH
LINE 2
MODOT R.O.W. SIGN
Suspected location of Watson Cave based on original mapping (1961)
0.0
50.0
100.0
150.0
200.0
250.0
ELEVATION (ft)
560.0
540.0
520.0
500.0
480.0
5a
6a
7a
10a
13
14
14
Ohm-m
100000
7476
559
41.8
3.1
LINE 1

2-DIMENSIONAL RESISTIVITY




?
Fold
Fract, dip vertical
Fract, dip 90 to 245
Fract, dip 70 to 270
J
L
M
Limestone

Do's

- Do a karst site study in phases.
- Do use the available information with a site reconnaissance.
- Do develop a preliminary geologic model.
- Do refine the model as site specific data is developed.
- Do consider geophysics as a tool.

Don'ts

- Don't expect to accomplish an economical & comprehensive karst site study in a single step.
- Don't assume that the available information accurately portrays a particular site.
- Don't assume your model is inflexible.
- Don't ignore the value of direct testing.
- Don't interpret the geophysical data without hard data and experience.

Do's

- Do consider resolution and technique when using geophysics.
- Do consider the value of remedial grouting as an interpretive tool for the geologic model developed.
- Do consider other remedial measures such as dynamic destruction.

Don'ts

- Don't assume geophysics or direct testing has shown you everything.
- Don't ignore overburden properties and geologic orientation when choosing a grouting technique.
- Don't forget to inspect open excavations during construction.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