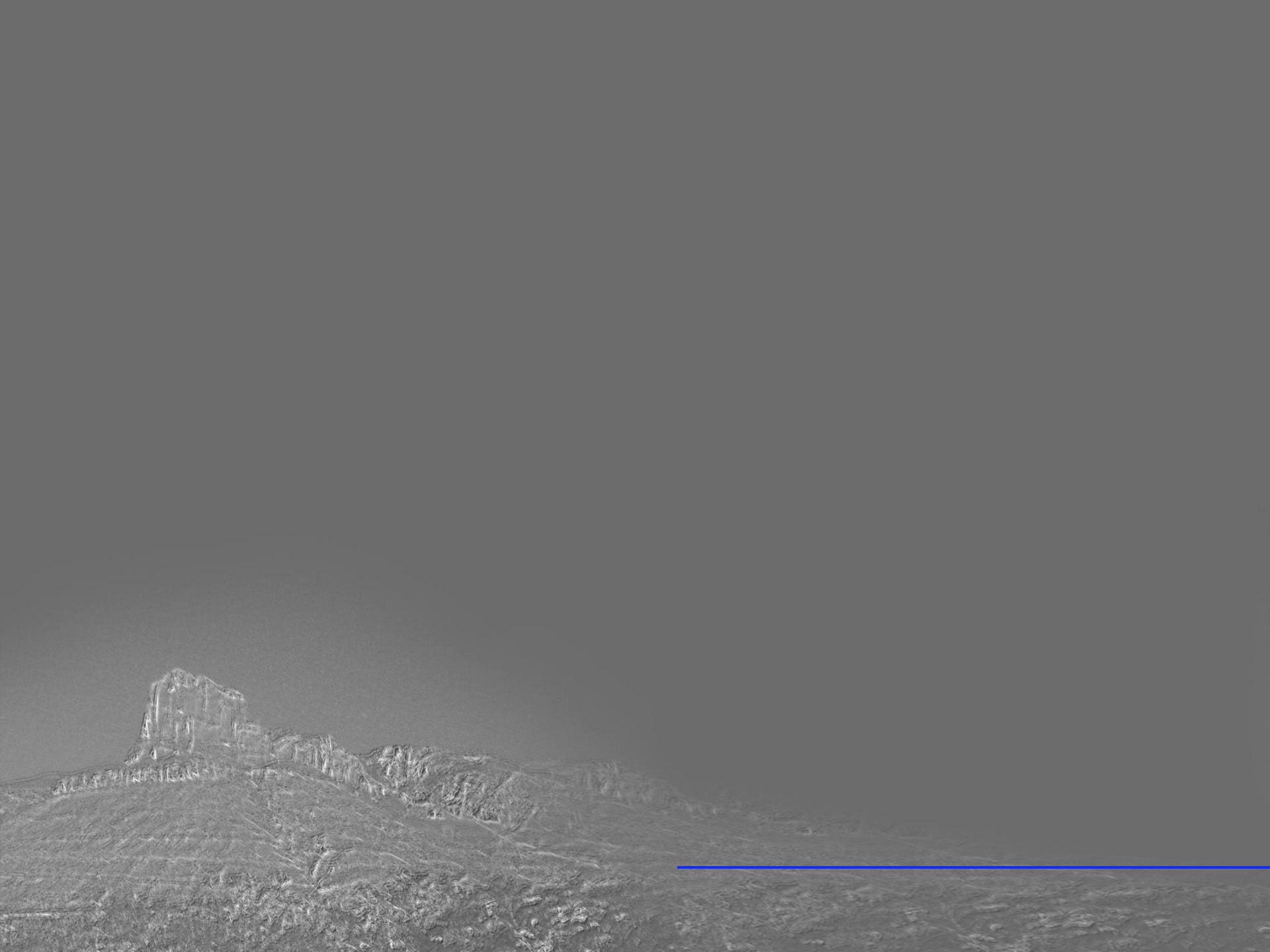


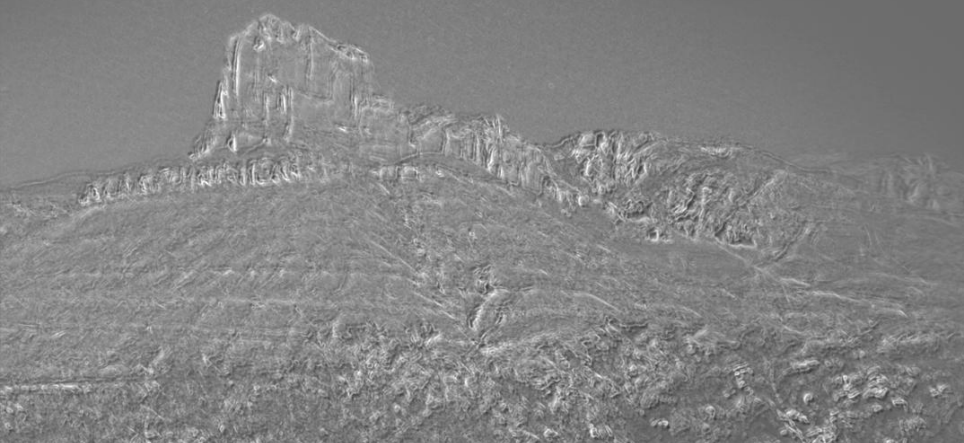
Introduction to Oil and Gas Drilling and Production in Karst Areas

James R. Goodbar

Senior Cave and Karst Specialist
USDOI Bureau of Land Management
5-15-2008

What we will cover:

- What is “karst”?
- What are cave/karst resources?
- Impacts of drilling and production activities in karst areas
- How does BLM manage these activities?
  - Detection
  - Avoidance
  - Mitigation



What is Karst?

Karst is a landform in soluble rock types (ie. limestone, gypsum) **that contains features, such as:**

- **sinkholes**
- **sinking streams**
- **resurgences**
- **caves**

Most drainage is underground.

Sinkholes

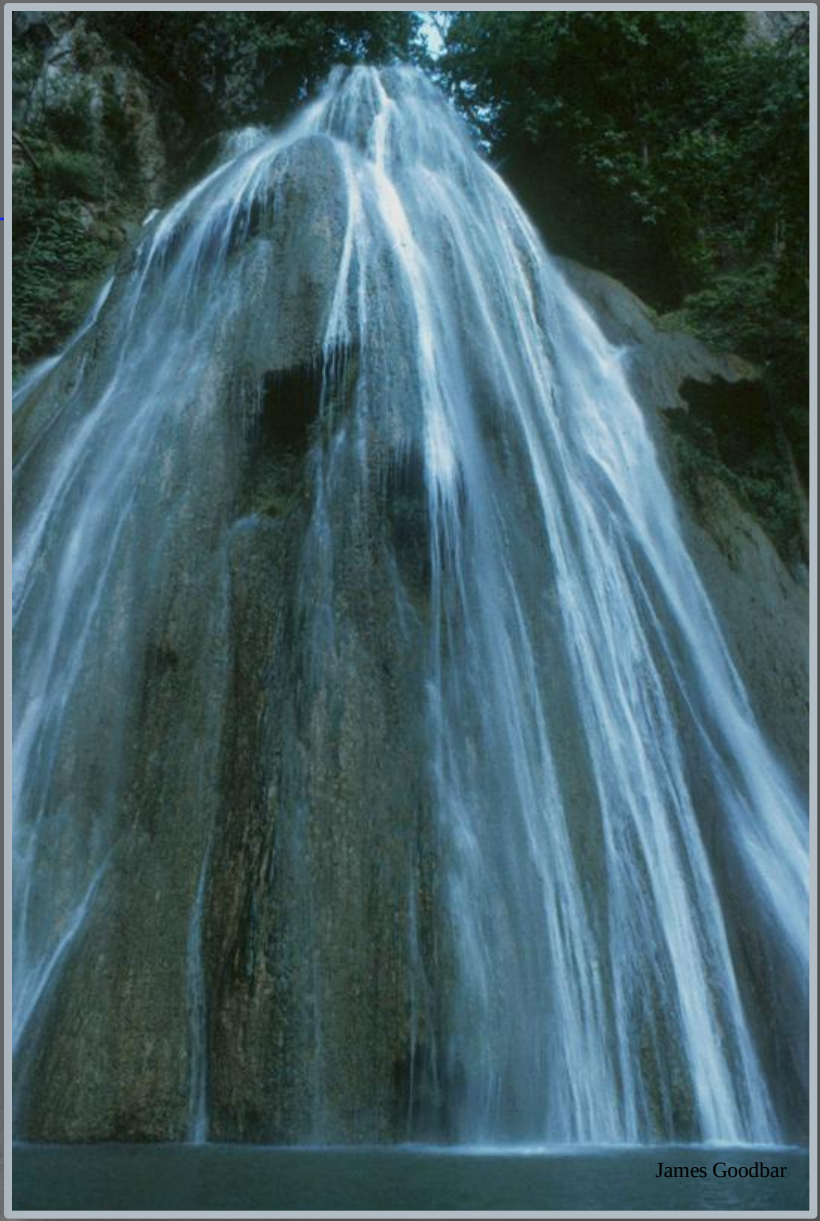
Closed depression: Point source for groundwater recharge

Sinking Streams

Surface streams that go underground

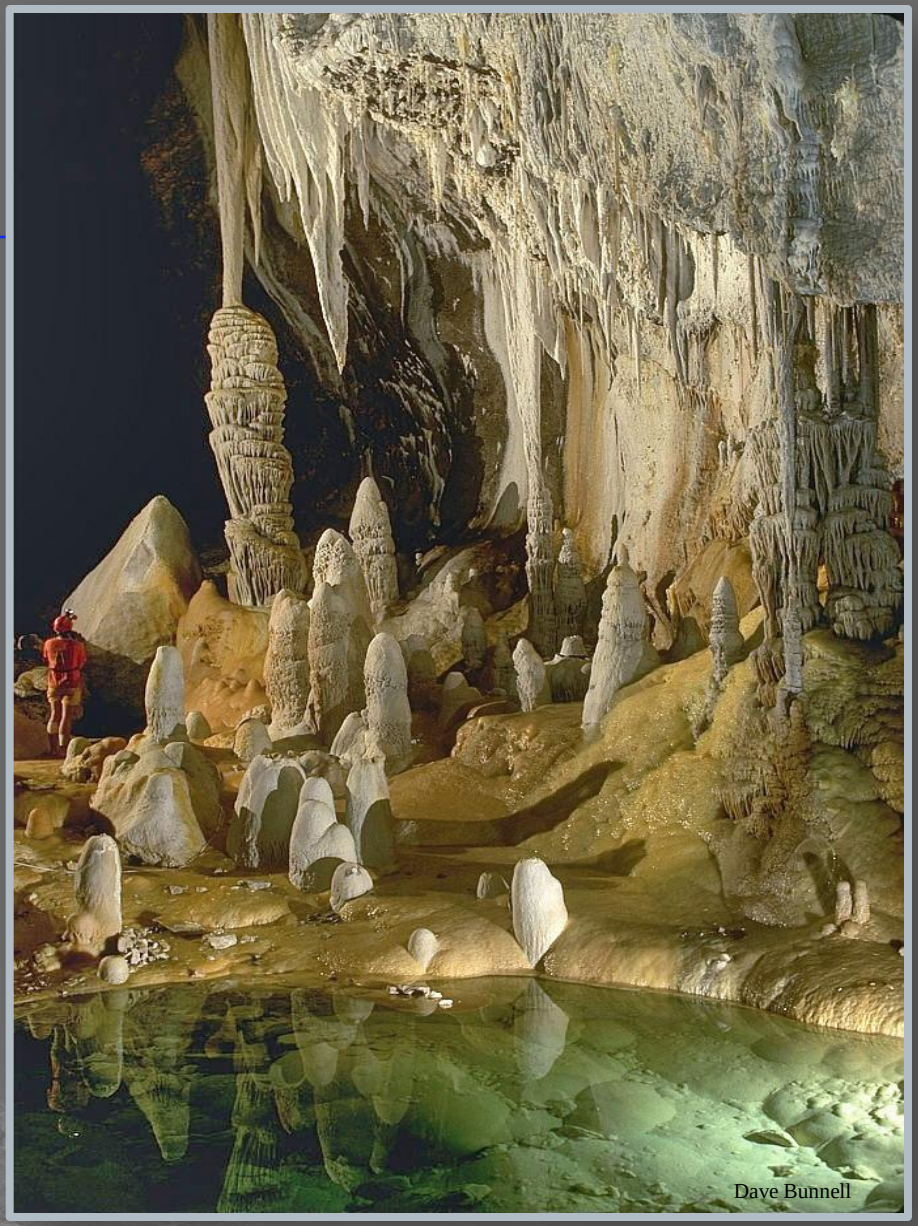
Resurgences

Underground streams that come to the surface



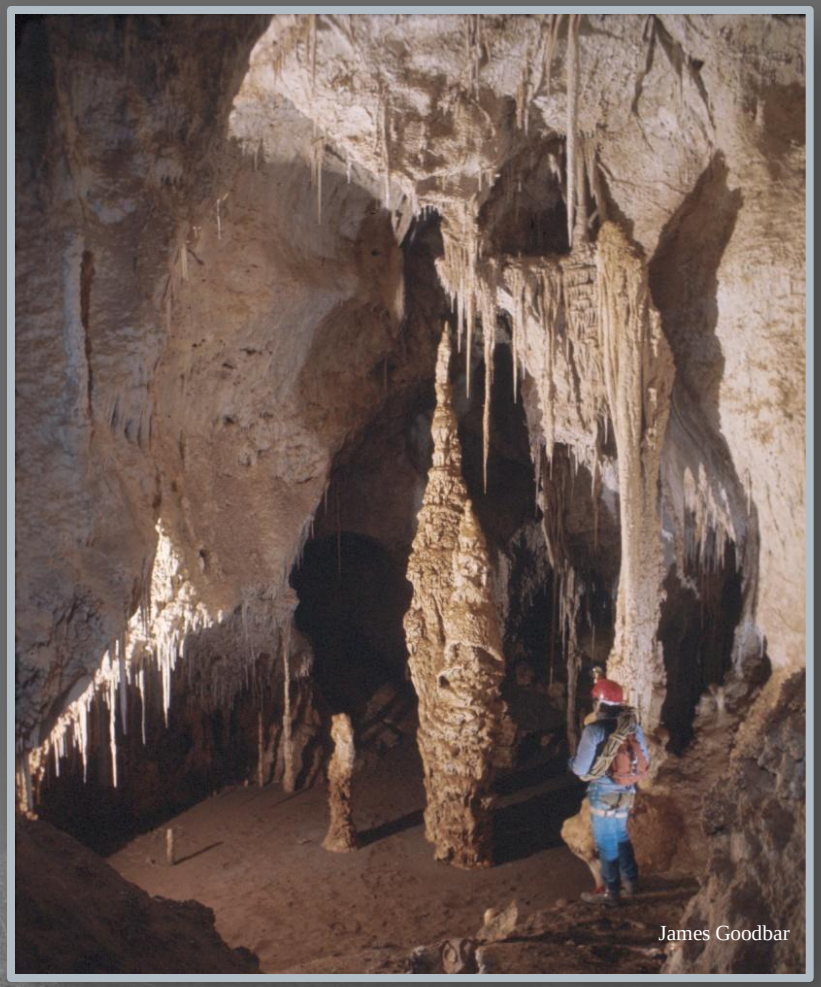
Caves

A naturally occurring void inside the earth large enough to allow human entry.



What are cave and karst resources?

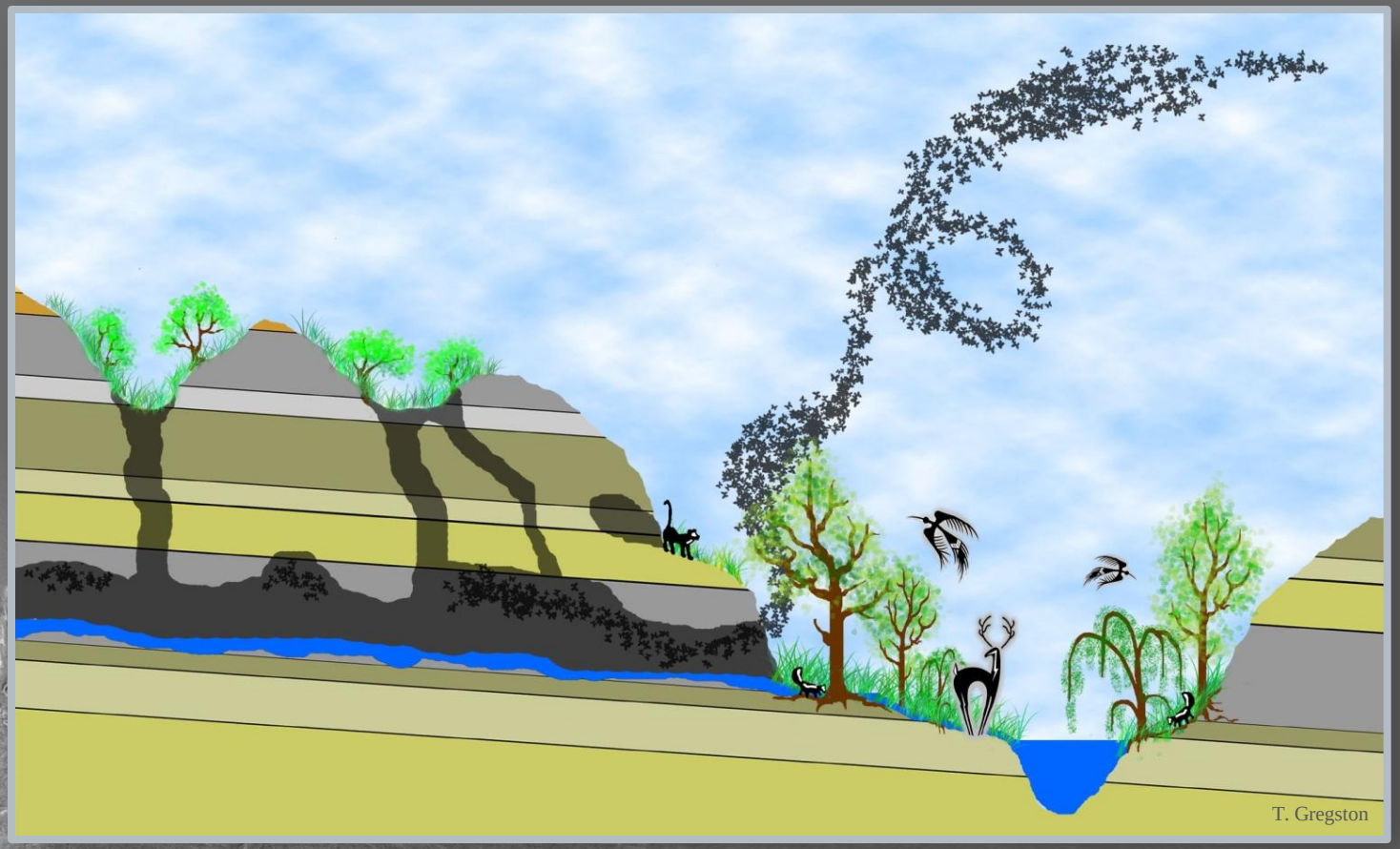
- Biologic
- Hydrologic
- Geologic
- Mineralogic
- Paleontologic
- Cultural
- Scientific/Educational
- Recreational



43 CFR Part 37 Significant Cave Criteria

Biologic

Karst Ecosystems



Biologic

Cave Life

Biologic

Microbiology

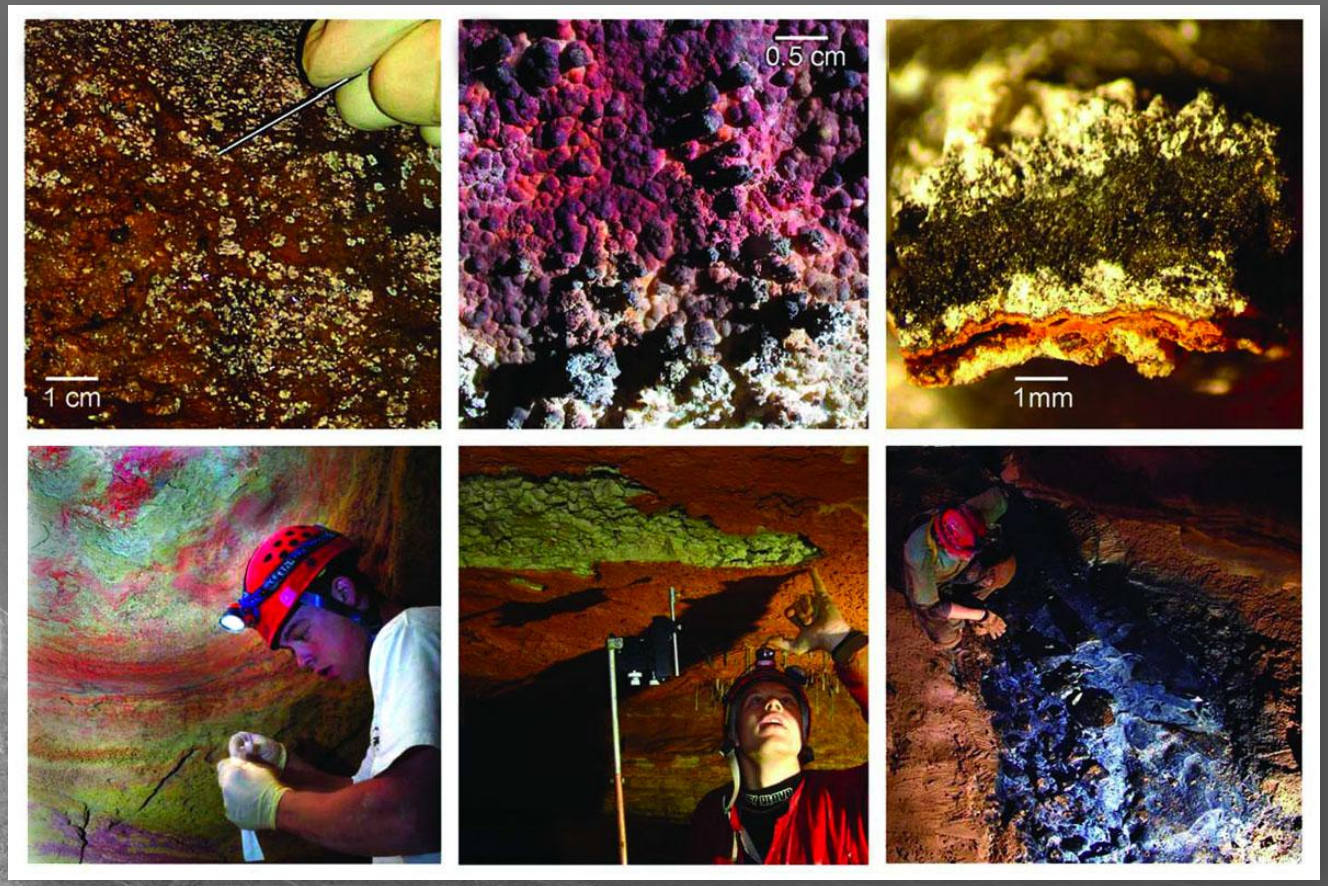
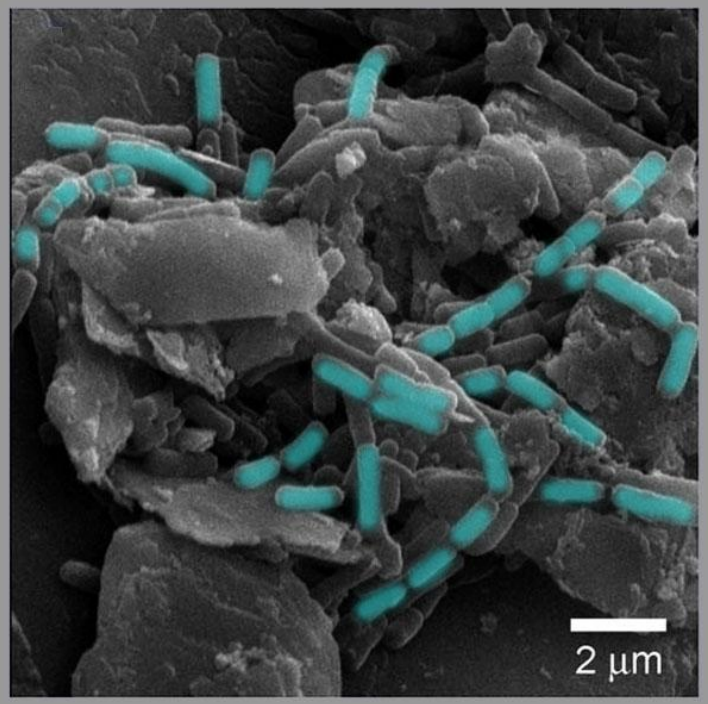
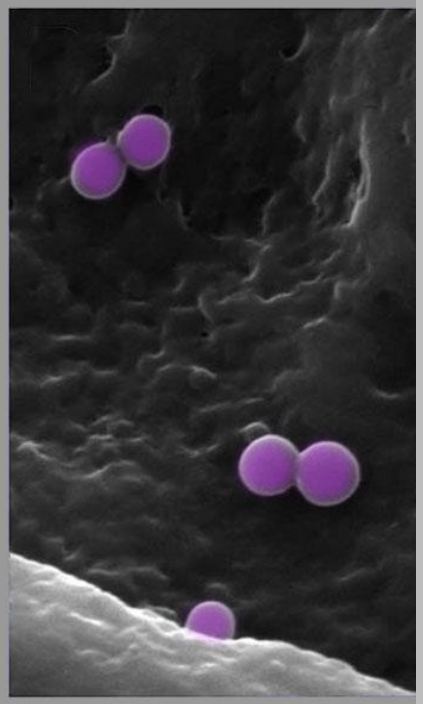


Image from: Hazel A. Barton
Journal of Cave and Karst Studies, v. 68, no. 2, p. 43–54.

Biologic

Microbiology





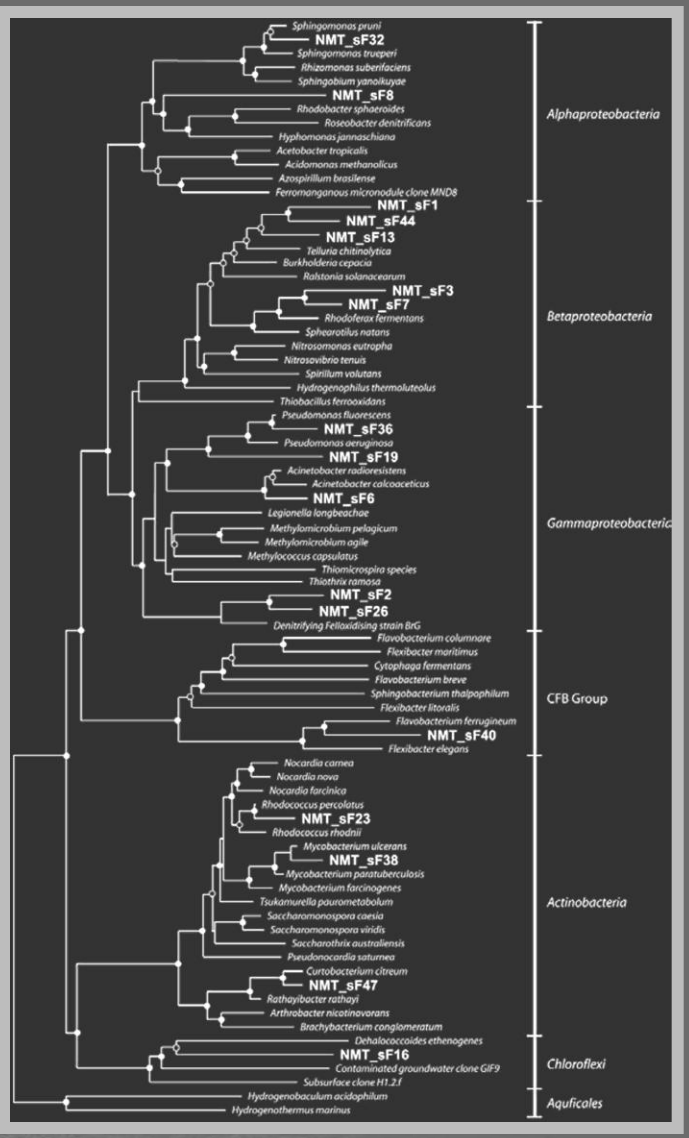
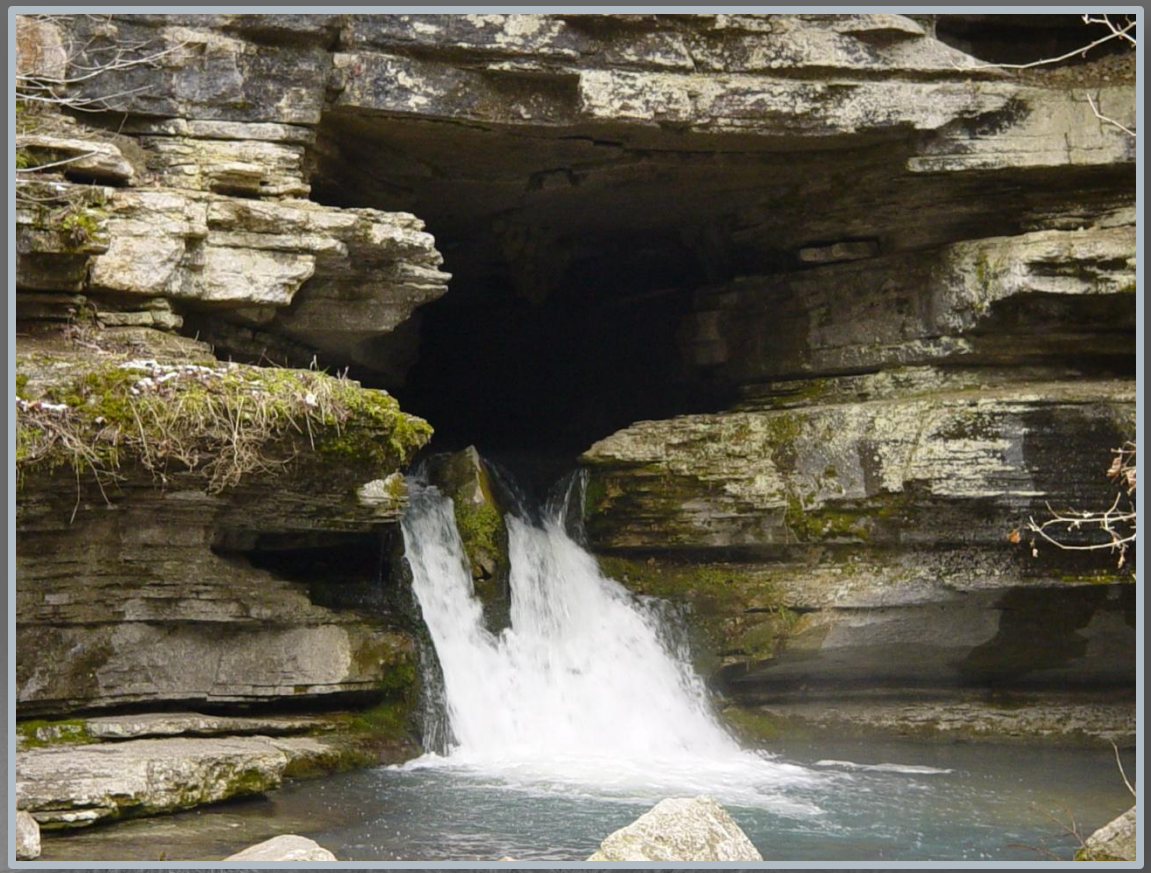
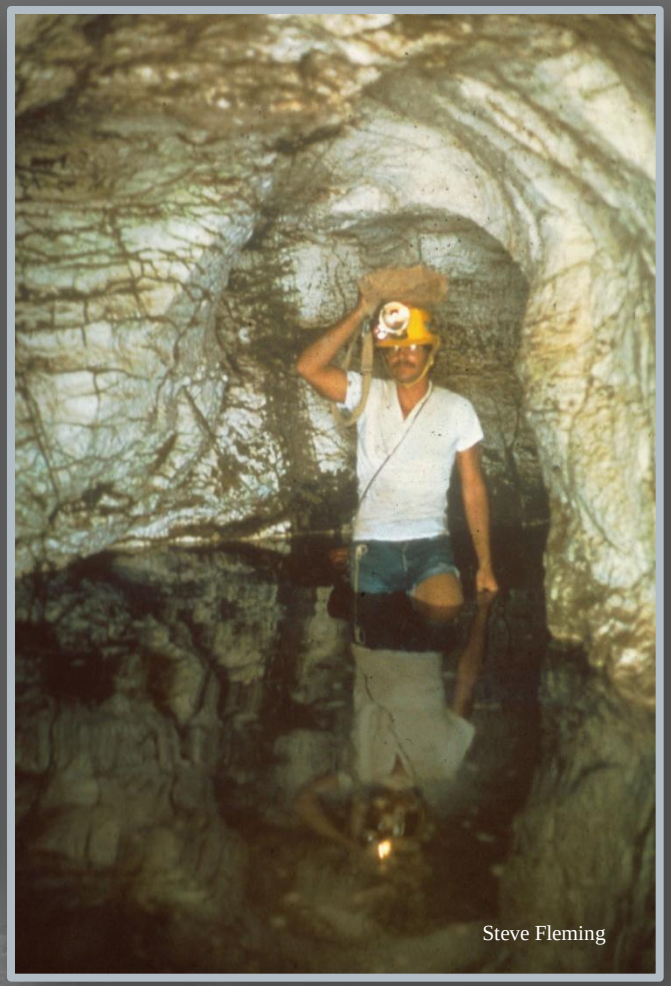


Image from: Hazel A. Barton; *Introduction to Cave Microbiology: A Review for the Non-specialist*. Journal of Cave and Karst Studies, v. 68, no. 2, p. 43–54.

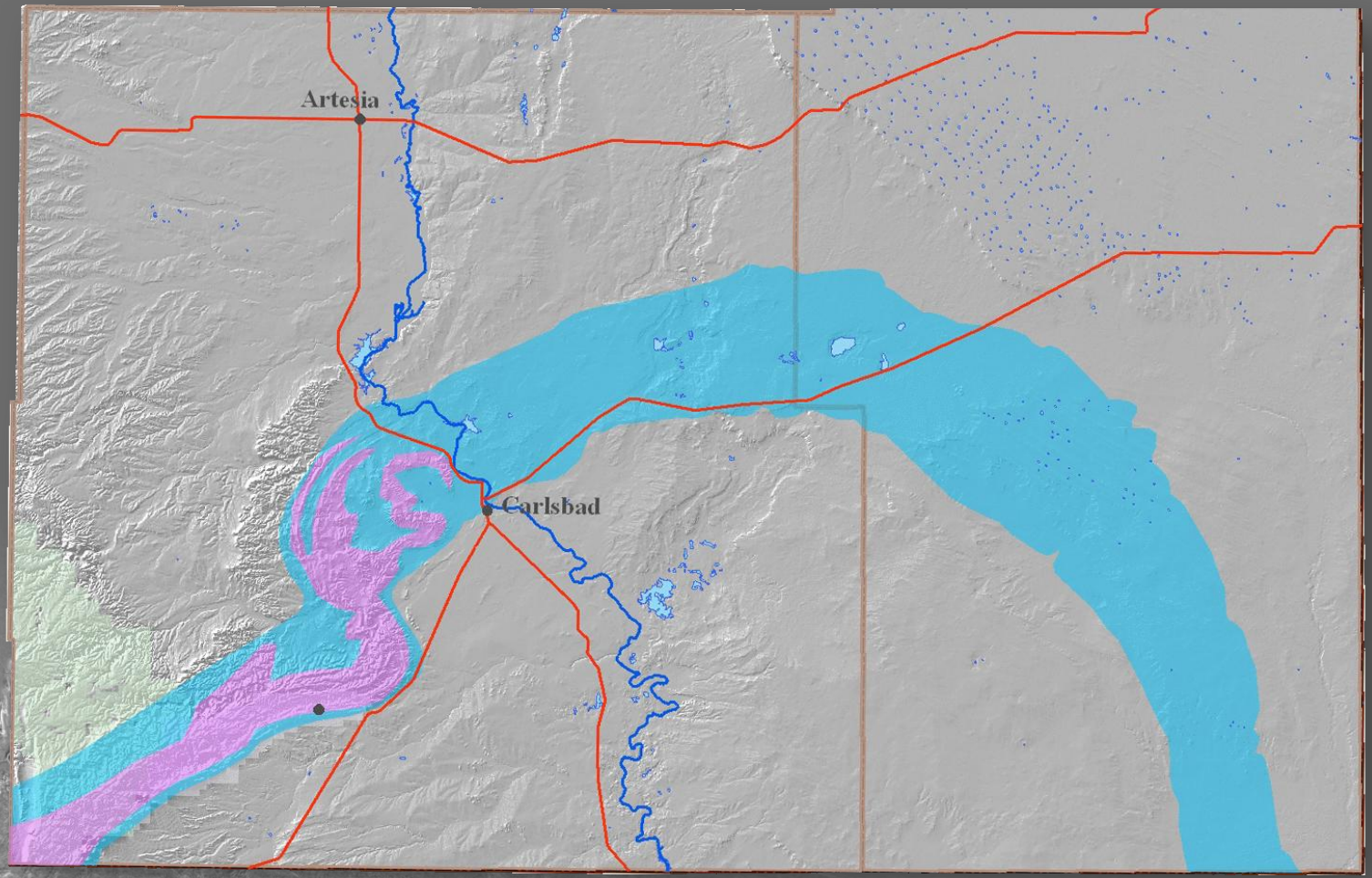
Hydrologic



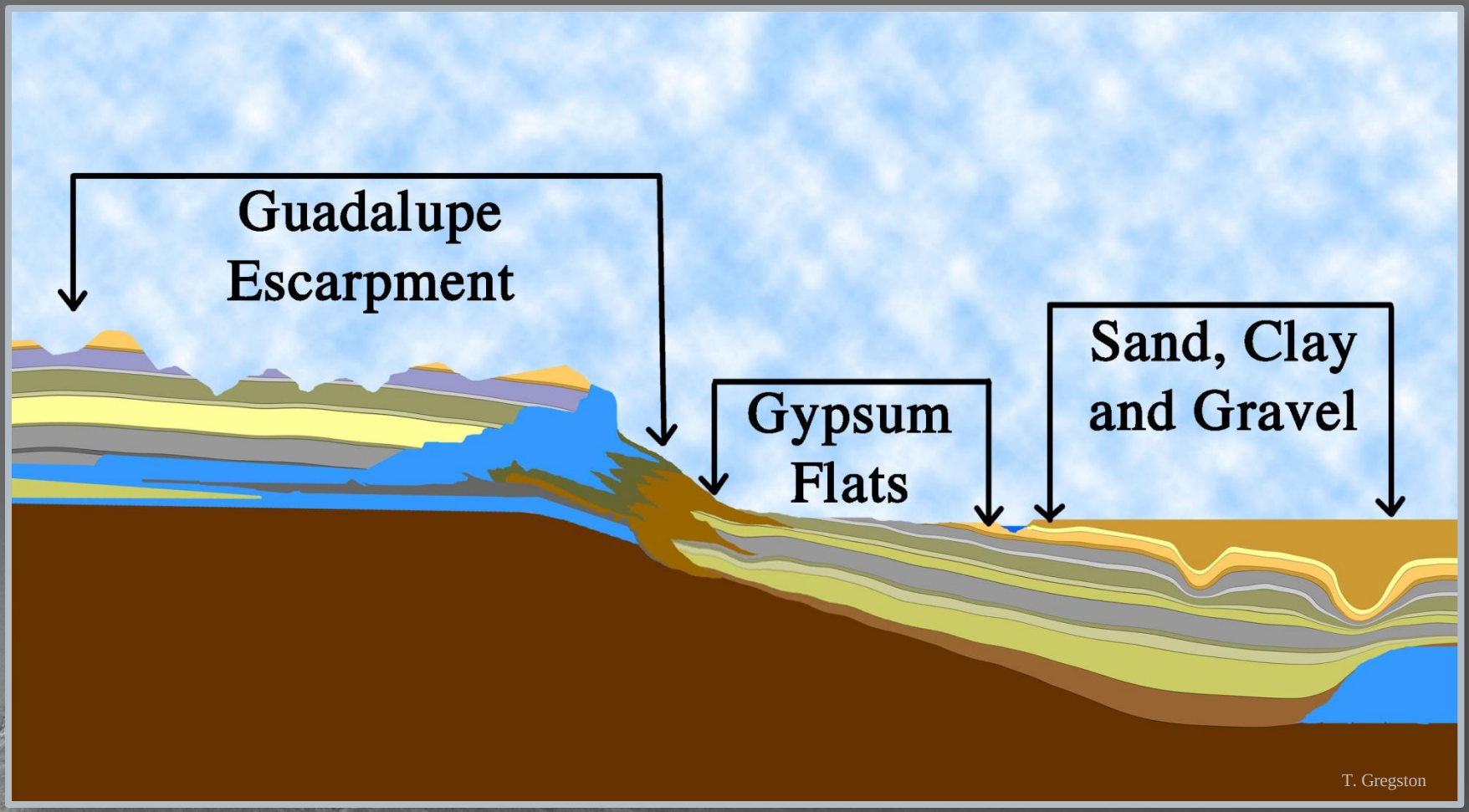


Steve Fleming

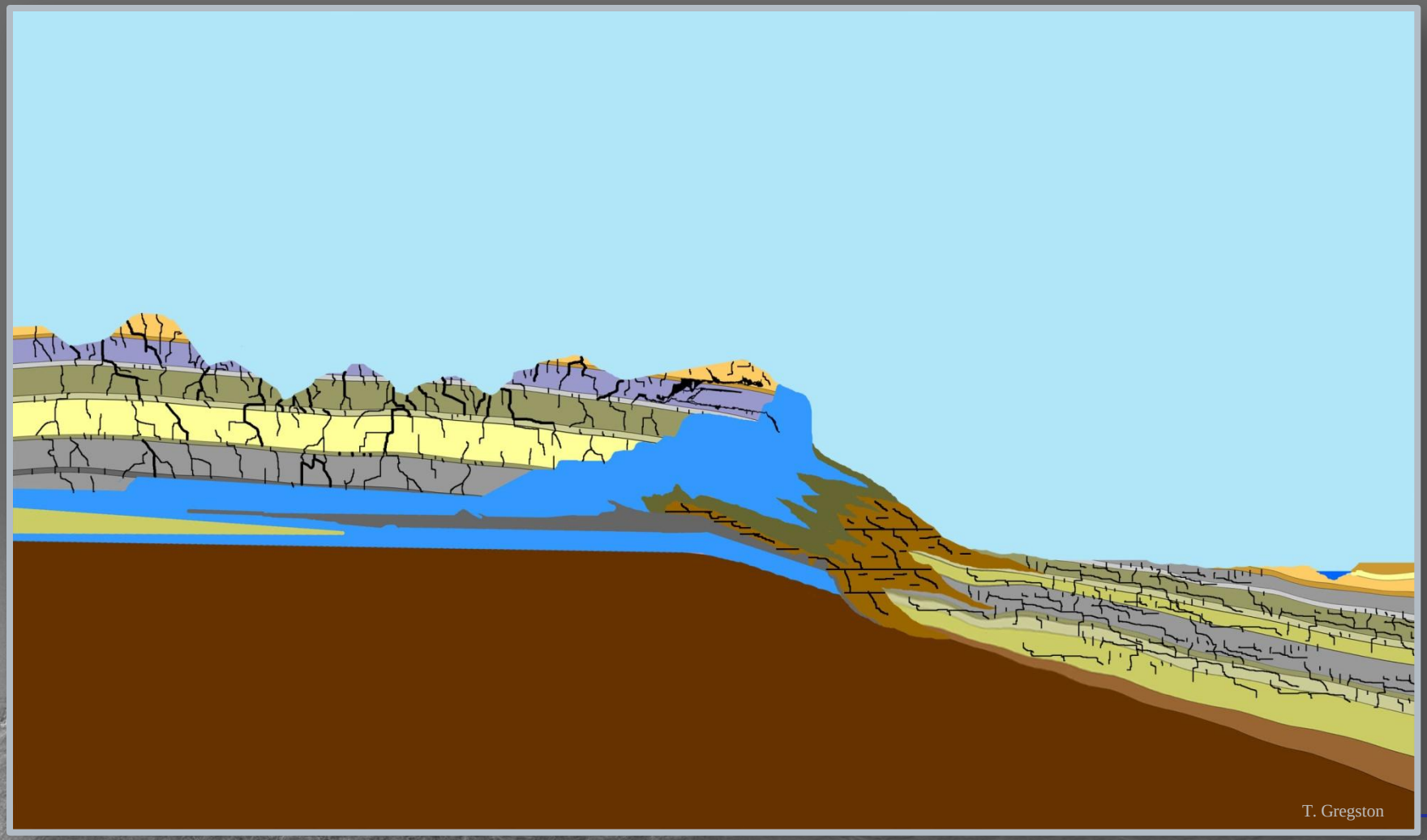
Hydrologic



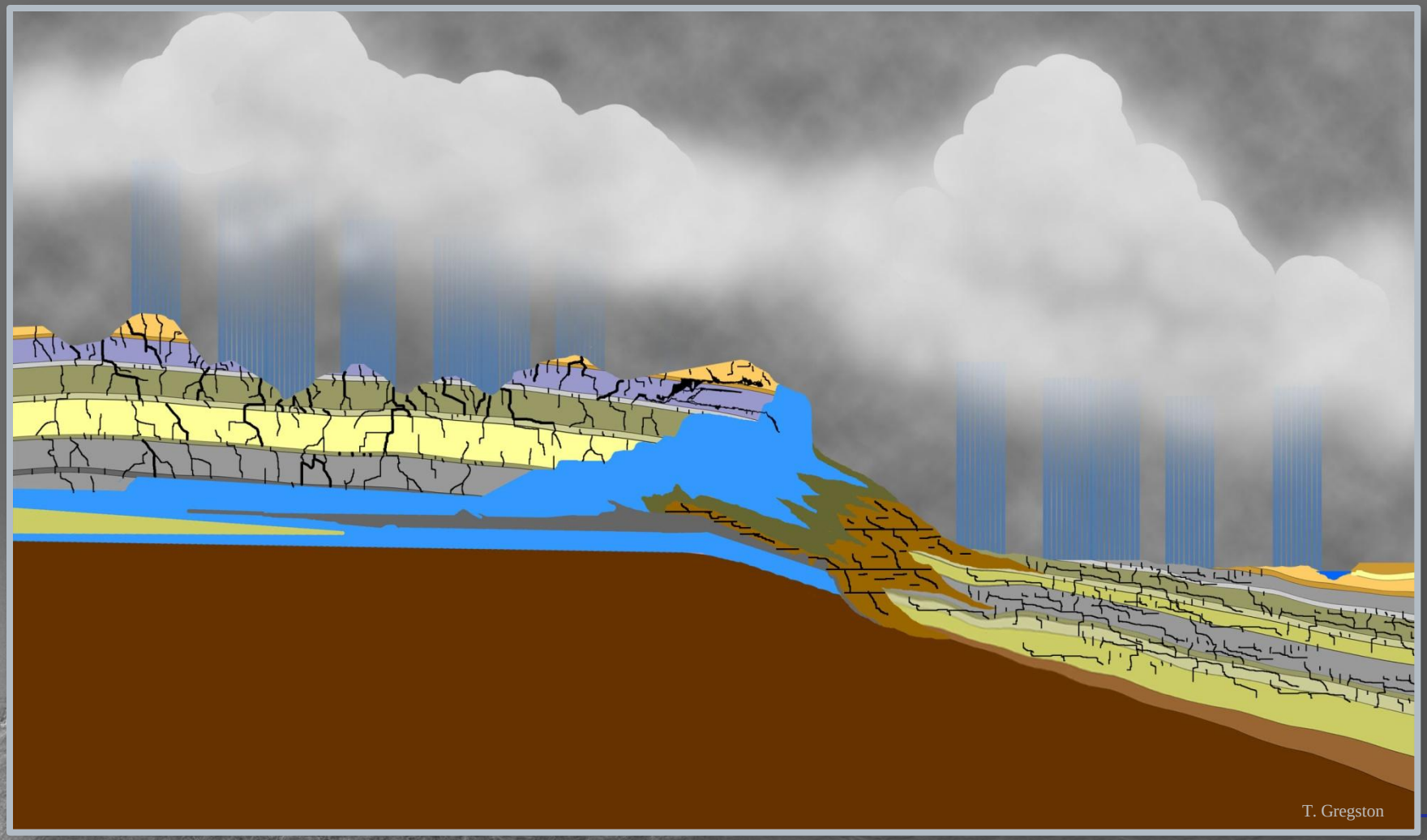
Hydrologic


Guadalupe
Escarpment
Gypsum
Flats
Sand, Clay
and Gravel
T. Gregston

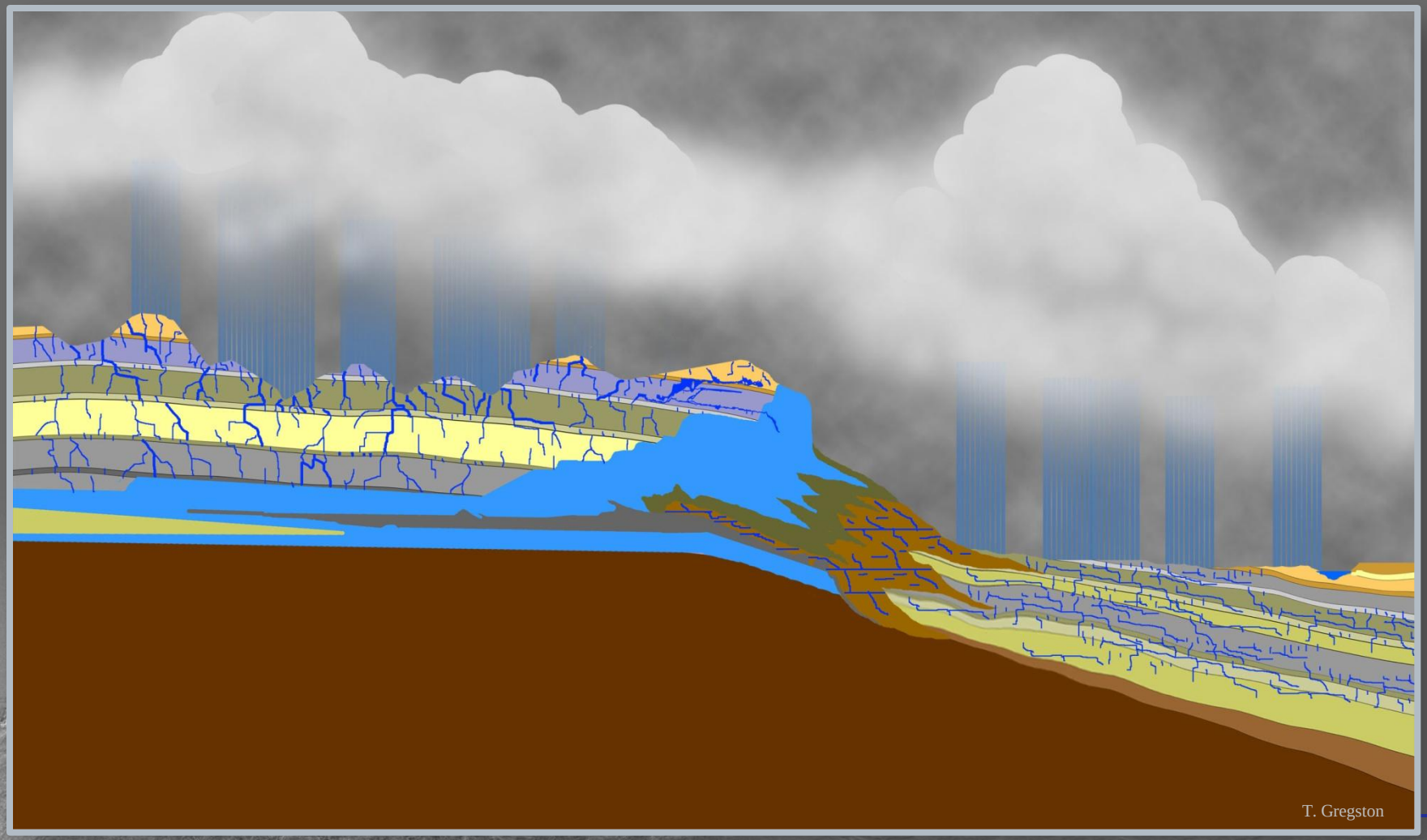
Hydrologic



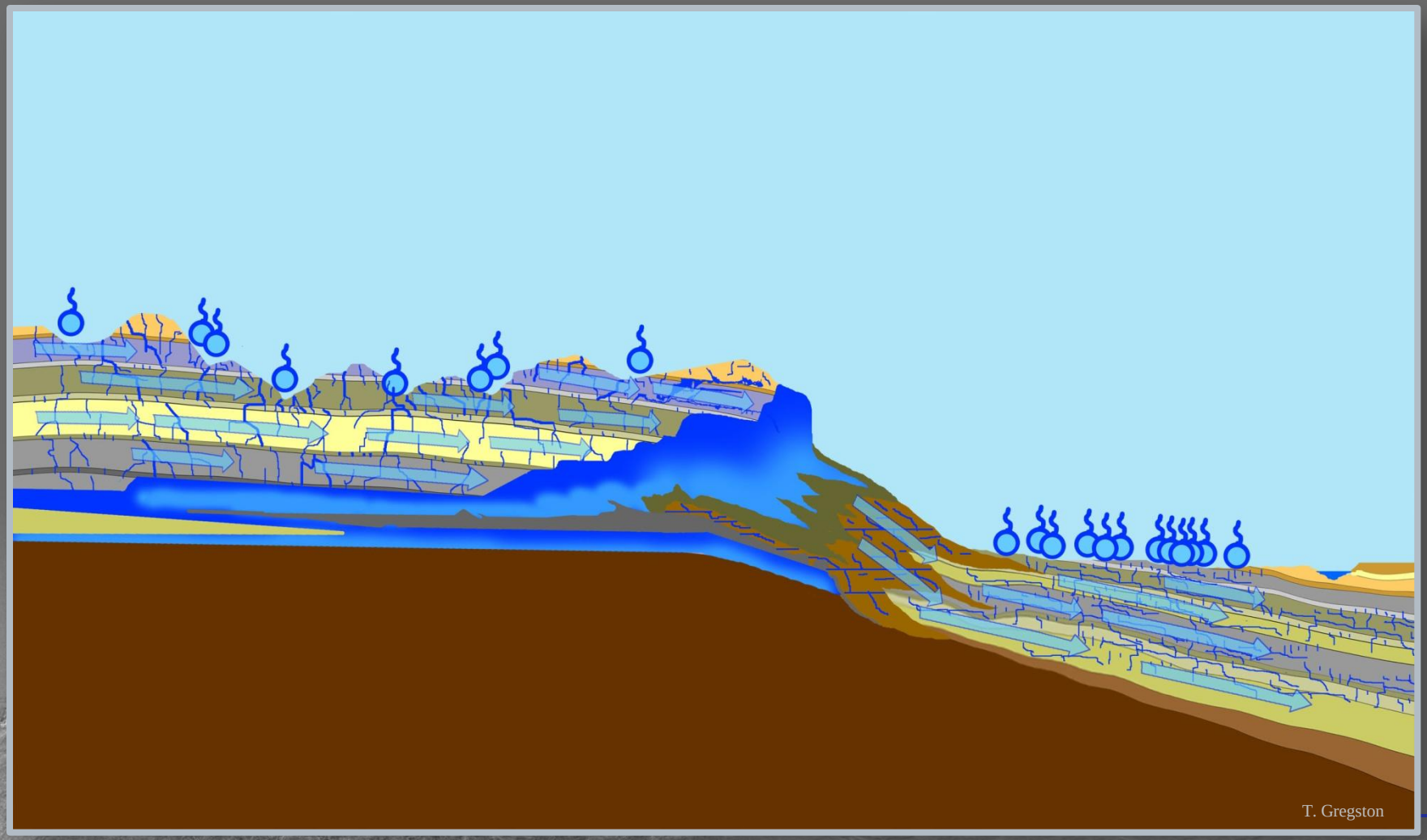
Hydrologic



Hydrologic

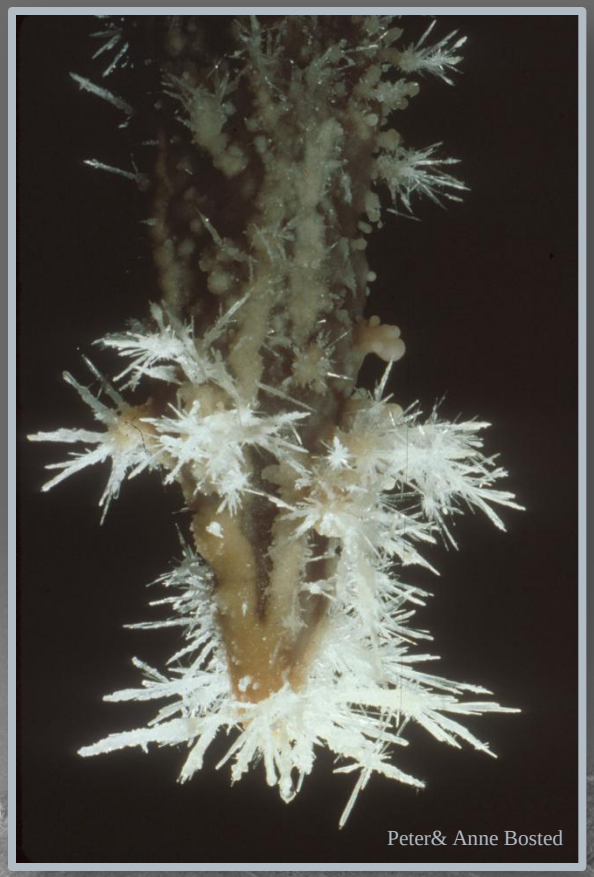


Hydrologic

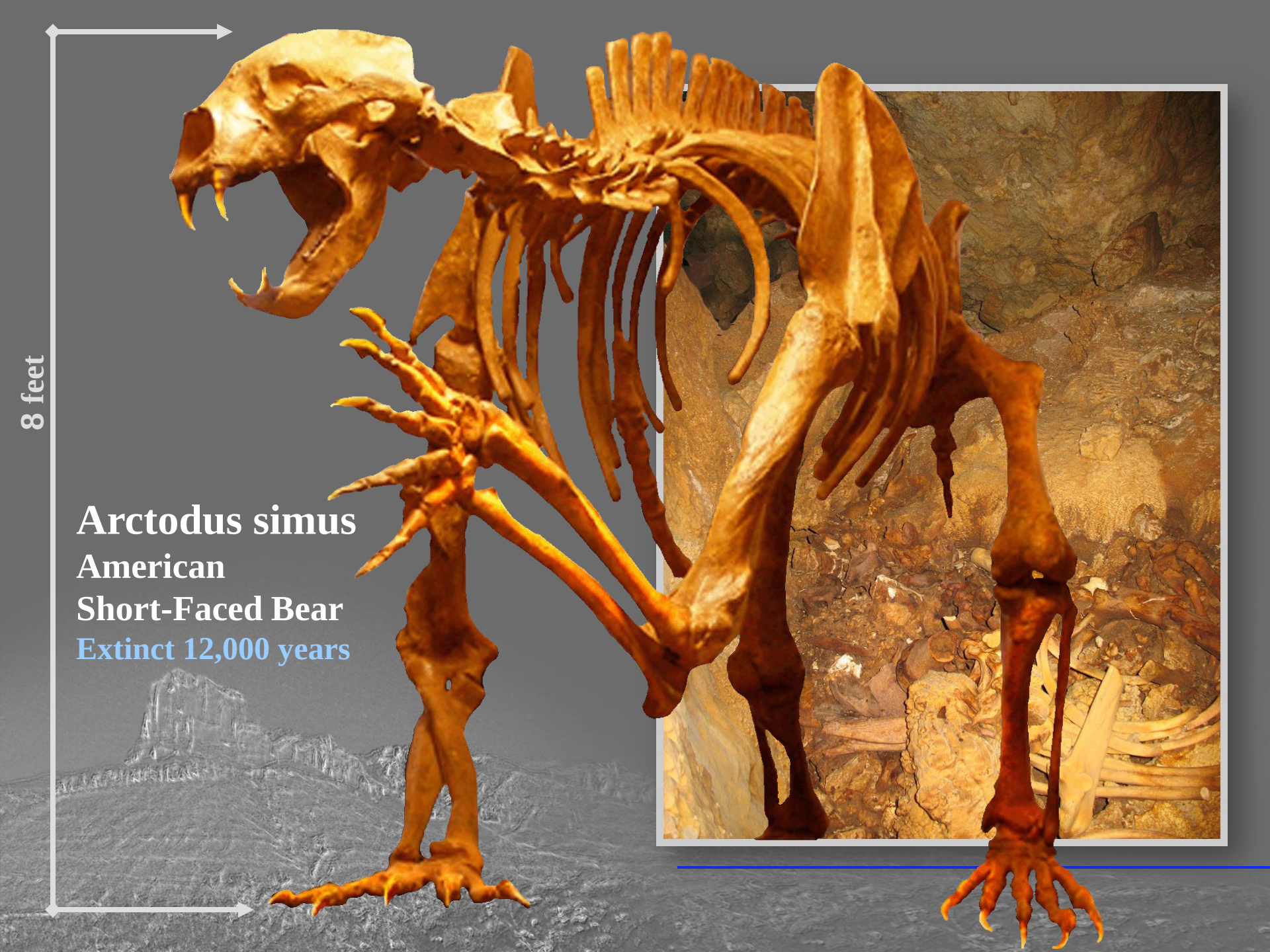


Geologic

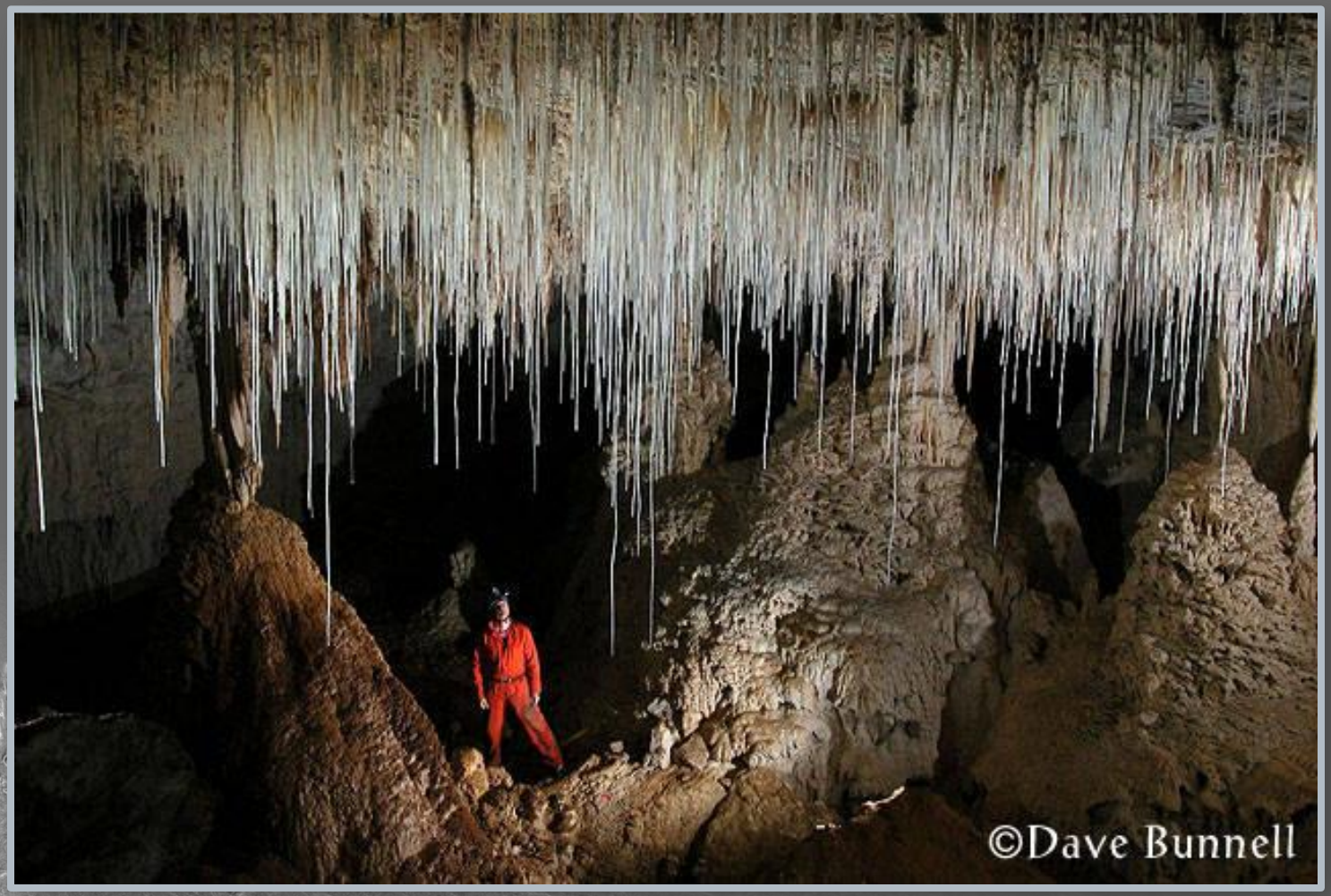
Mineralogic



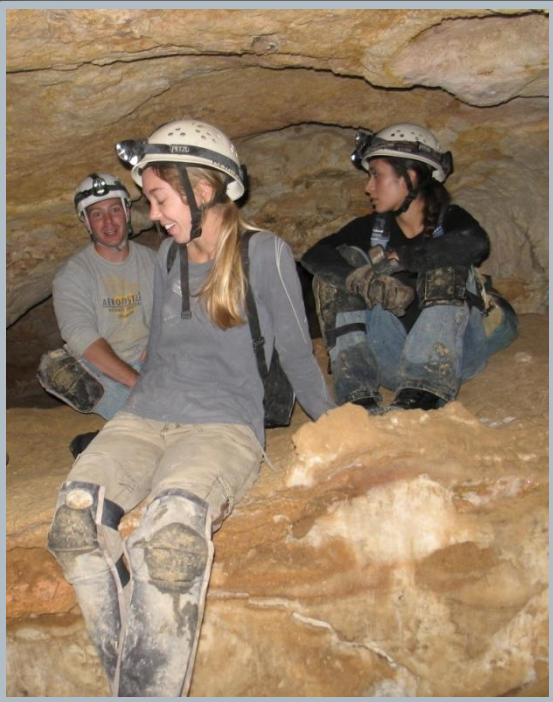
Paleontologic


8 feet
Arctodus simus
American
Short-Faced Bear
Extinct 12,000 years

Scientific and Educational

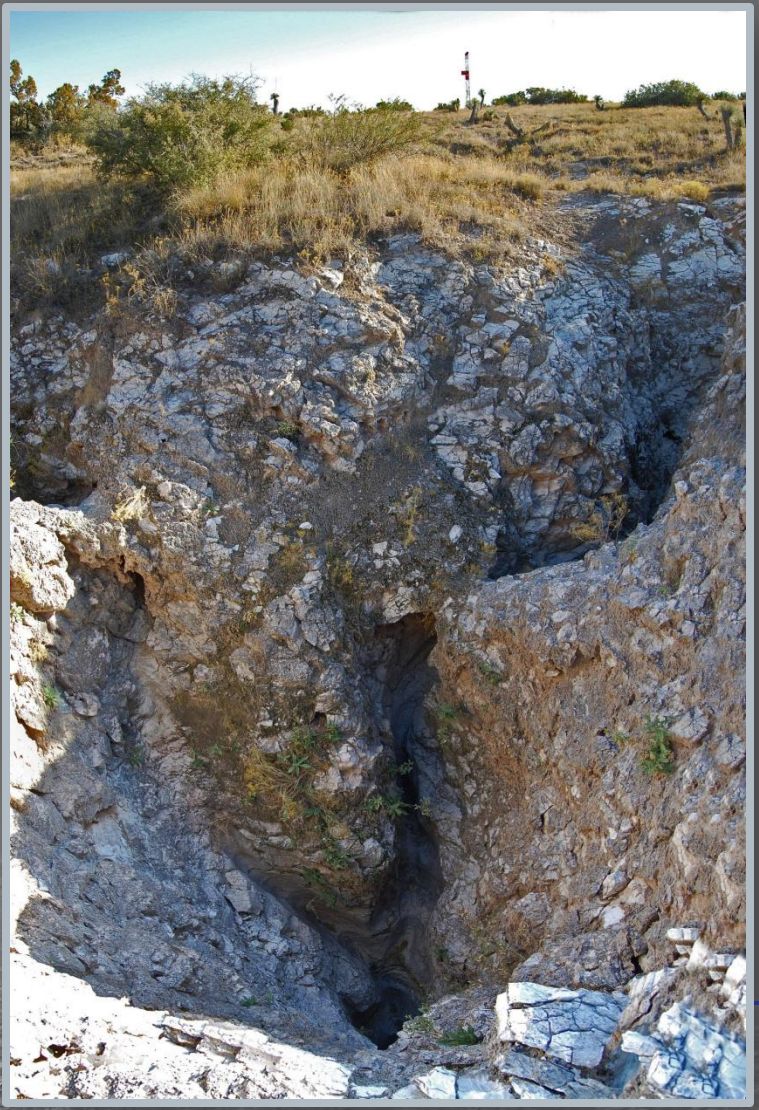


Recreational



Impacts of Drilling and Production in Karst Areas

- Construction
- Drilling
- Production
- Abandonment



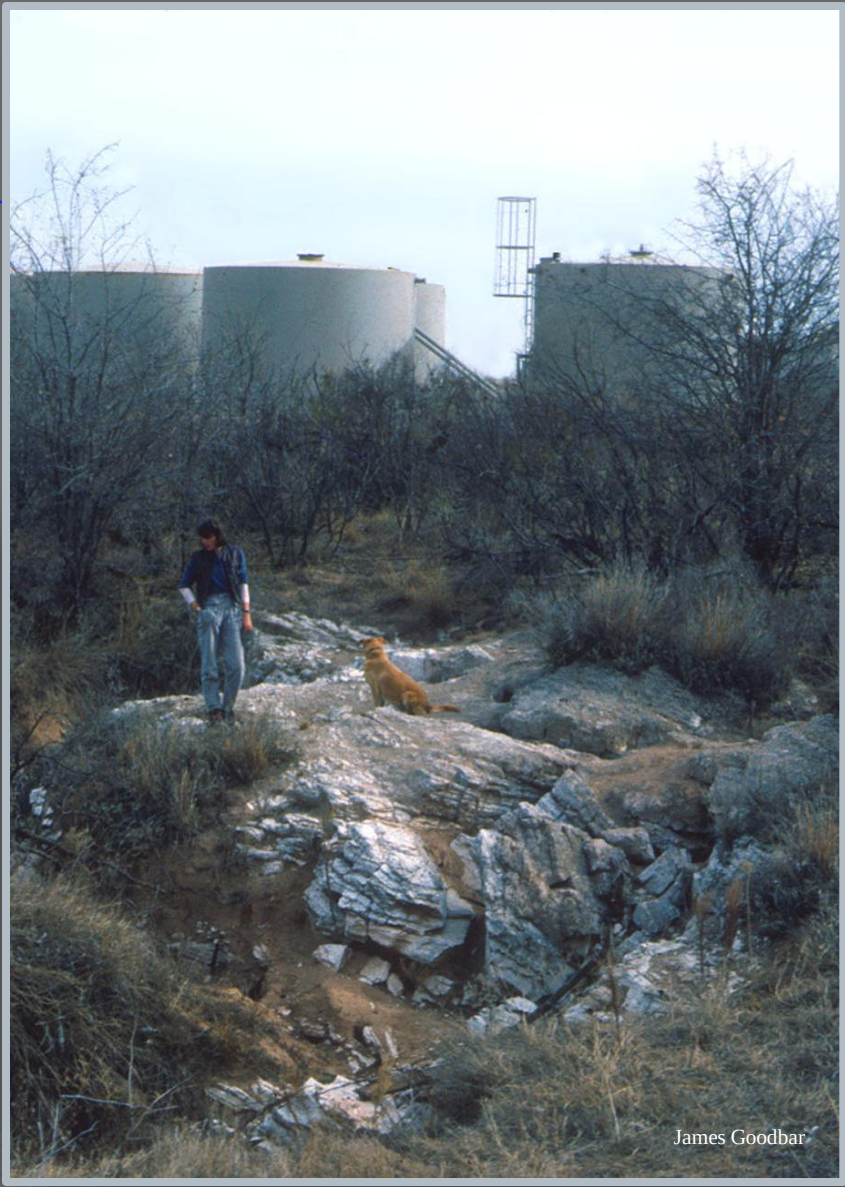
Potential Impacts

Drilling and Production:

- Lost circulation
- Collapse
- Spills
- Alterations in aquifer recharge and outflow patterns
- Failure to isolate critical formations
- Contamination of groundwater supplies
- Impacts on cave ecosystems, wildlife, tourism, and recreational cave usage

Construction

- **Groundwater Recharge**



Construction

- **Collapse**

Drilling

- Lost circulation and collapse

Production

- **Collapse**

Drilling/Production

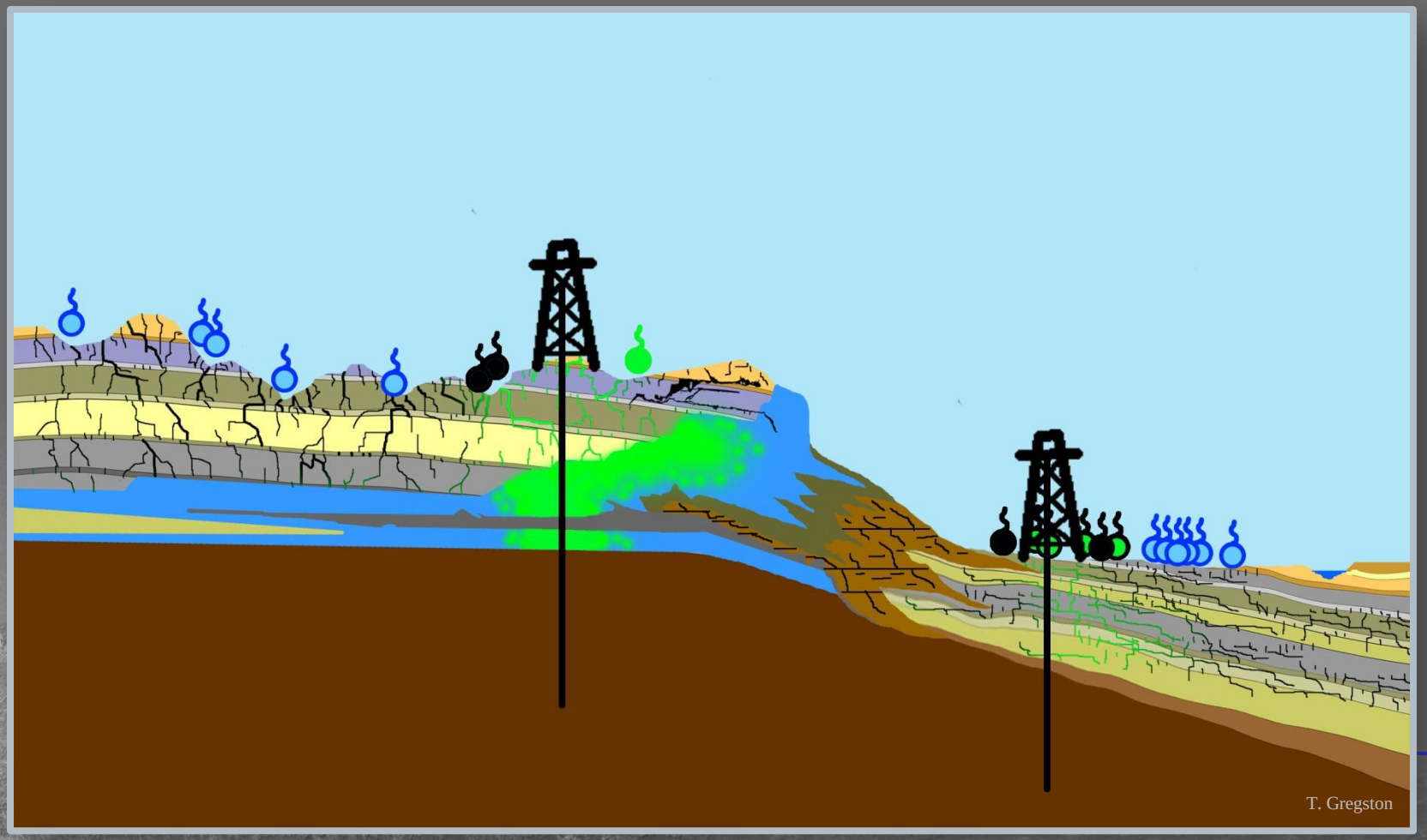
- Spills

Drilling/Production

- **Illegal fluid dumping**

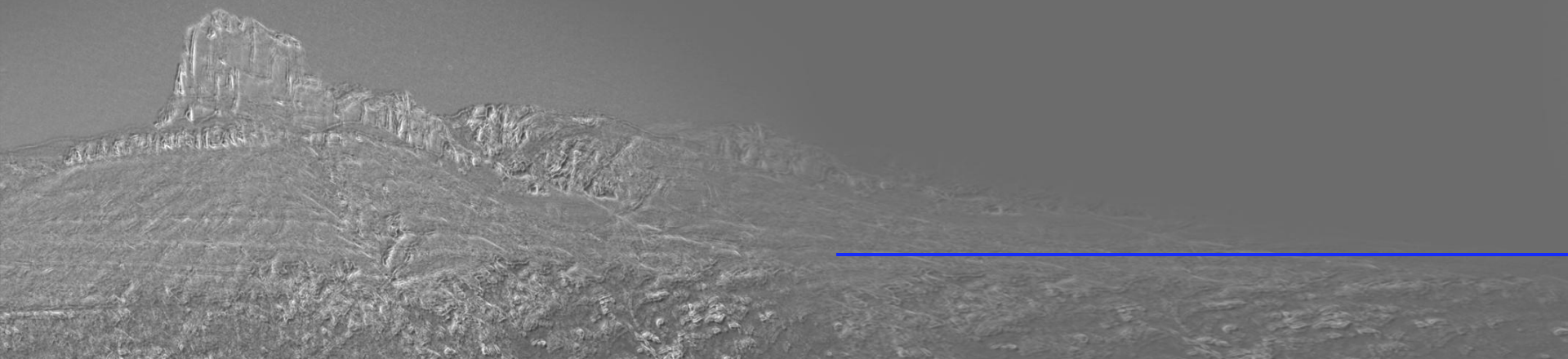
Drilling/Production

- **Groundwater Contamination**



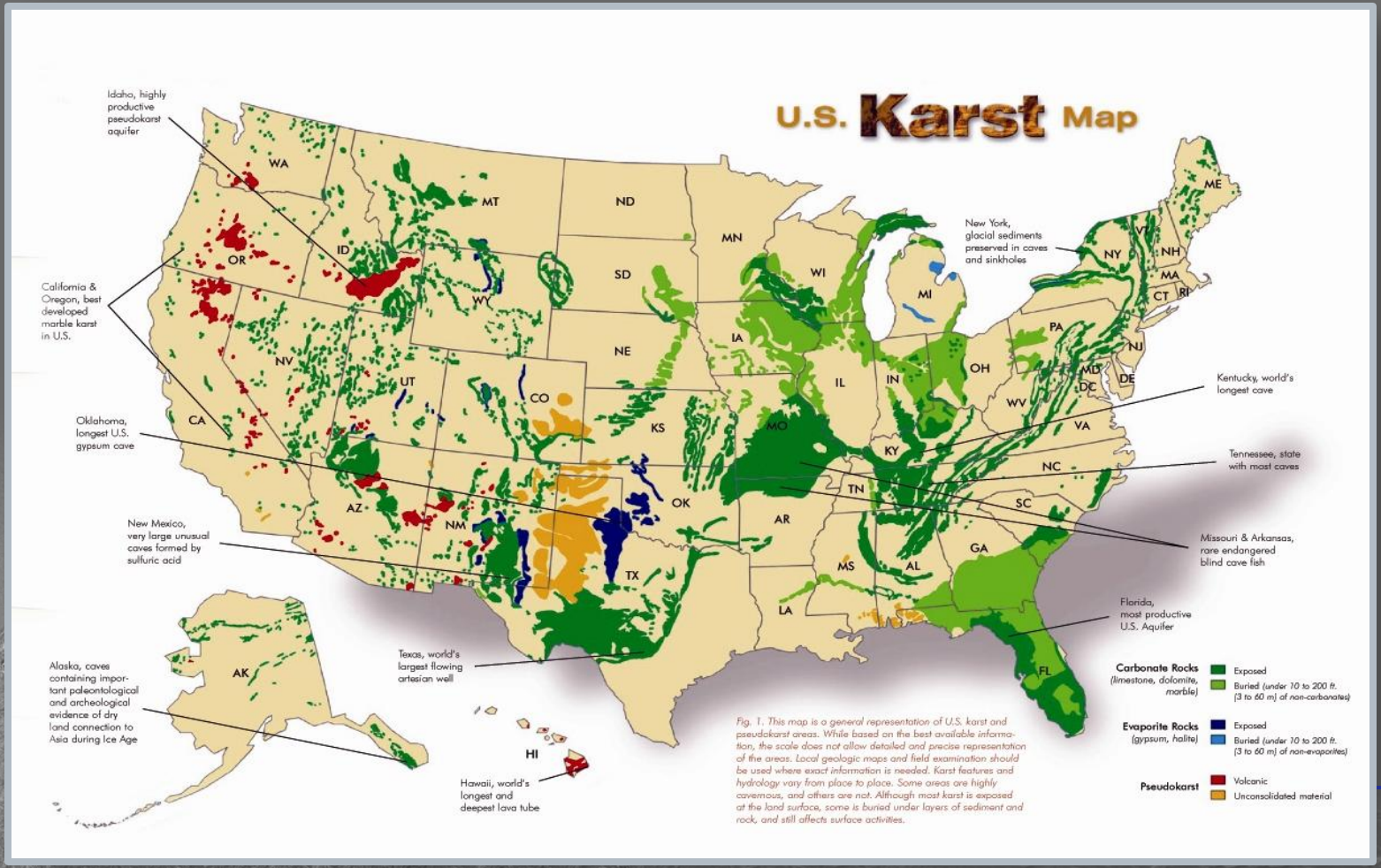
How does BLM manage these activities?

- **Detection**
- **Avoidance**
- **Mitigation: Best Management Practices**



Detection

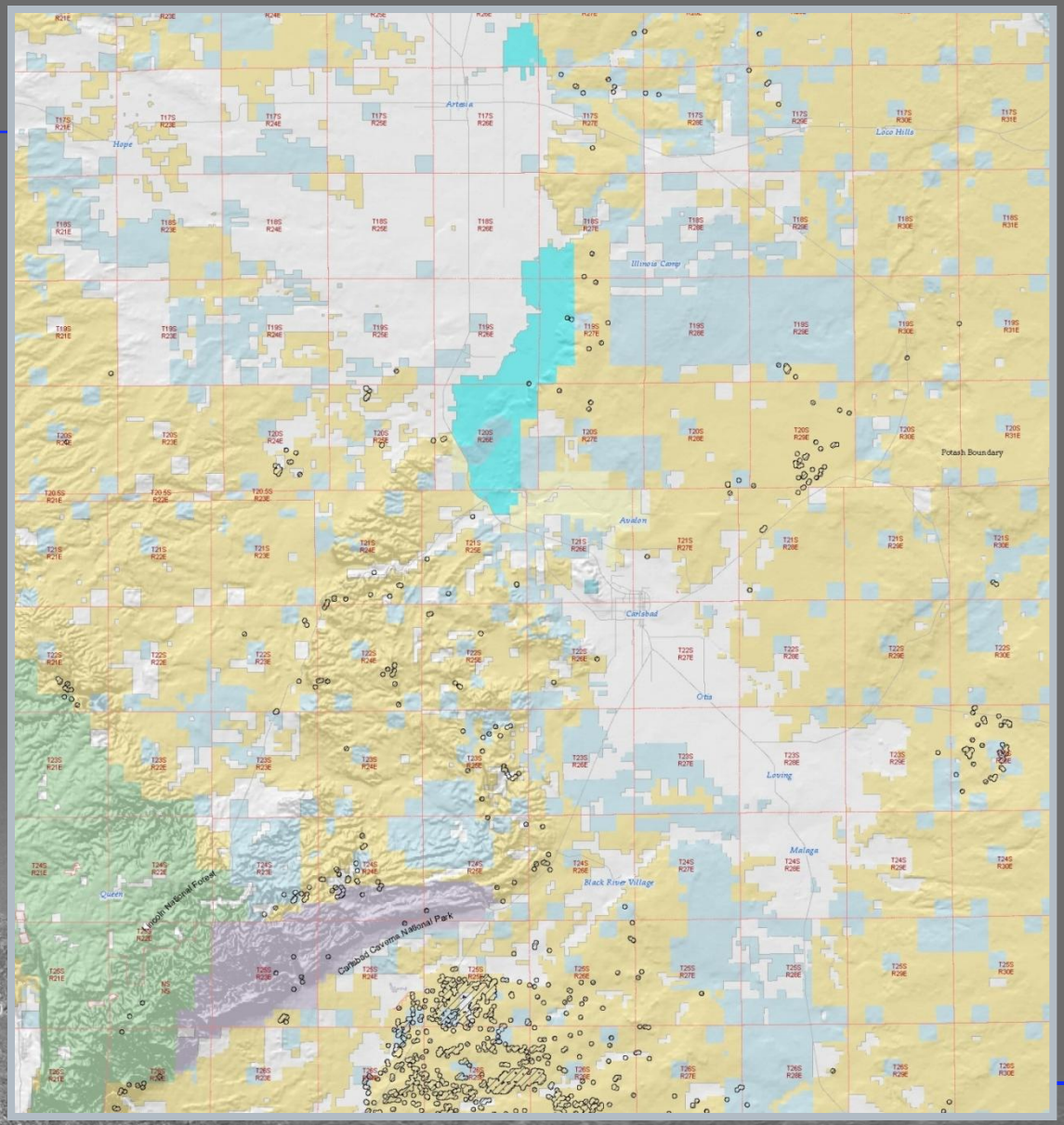
- **Remote:** Maps, GIS, Satellite Images



Detection

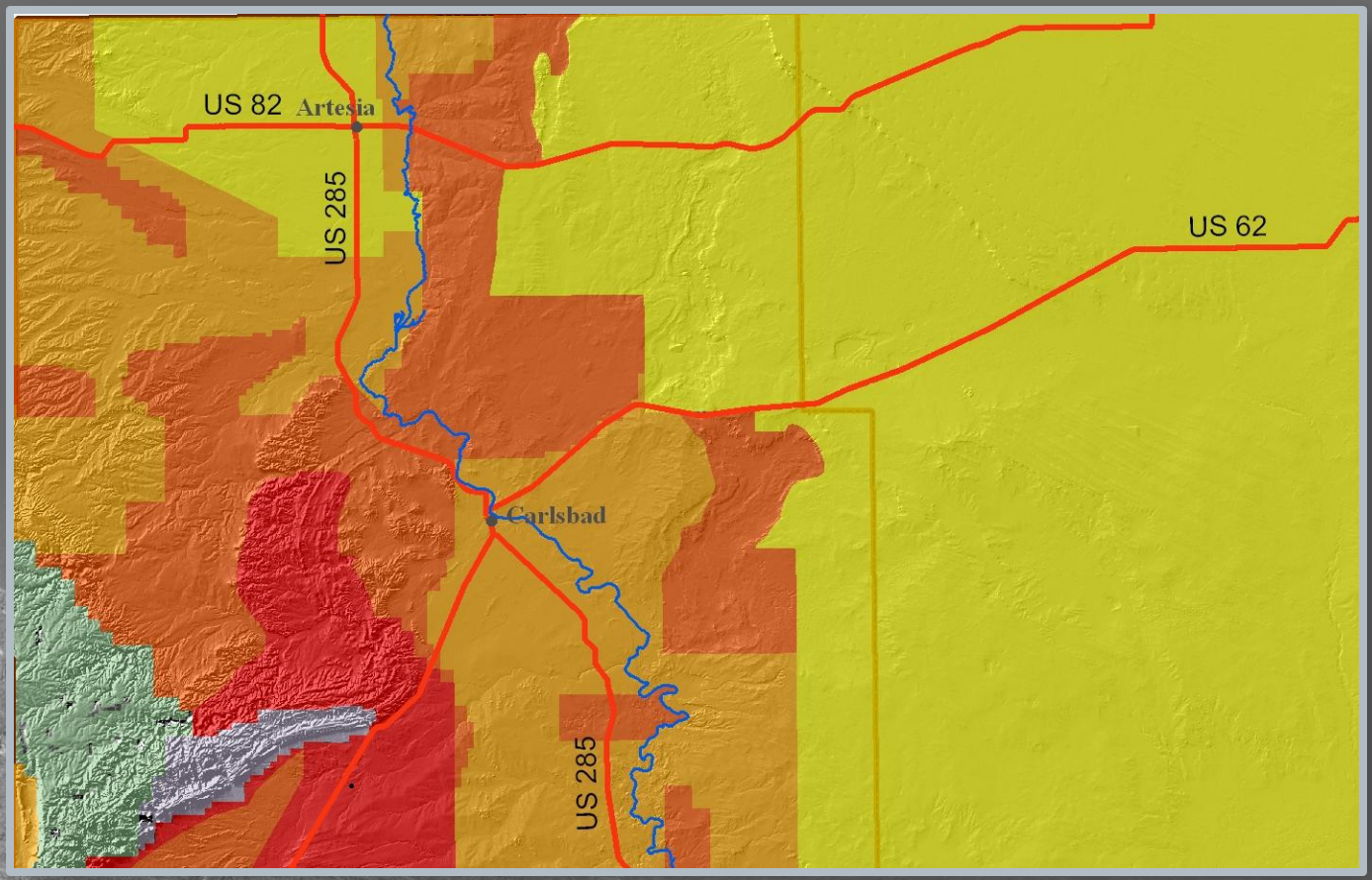
- **Remote:**
  Maps –

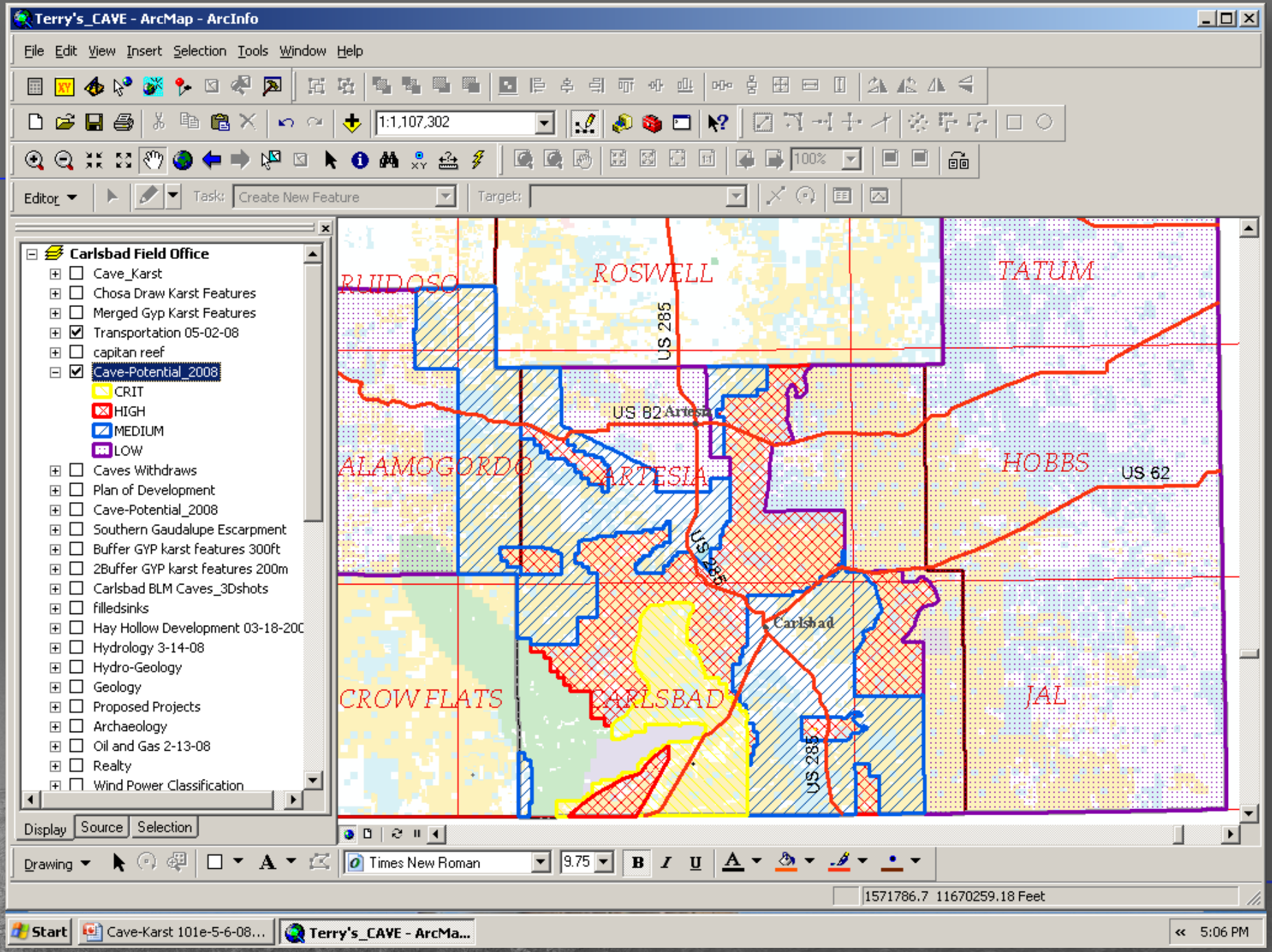
Known Karst Features in the Carlsbad Field Office



Detection

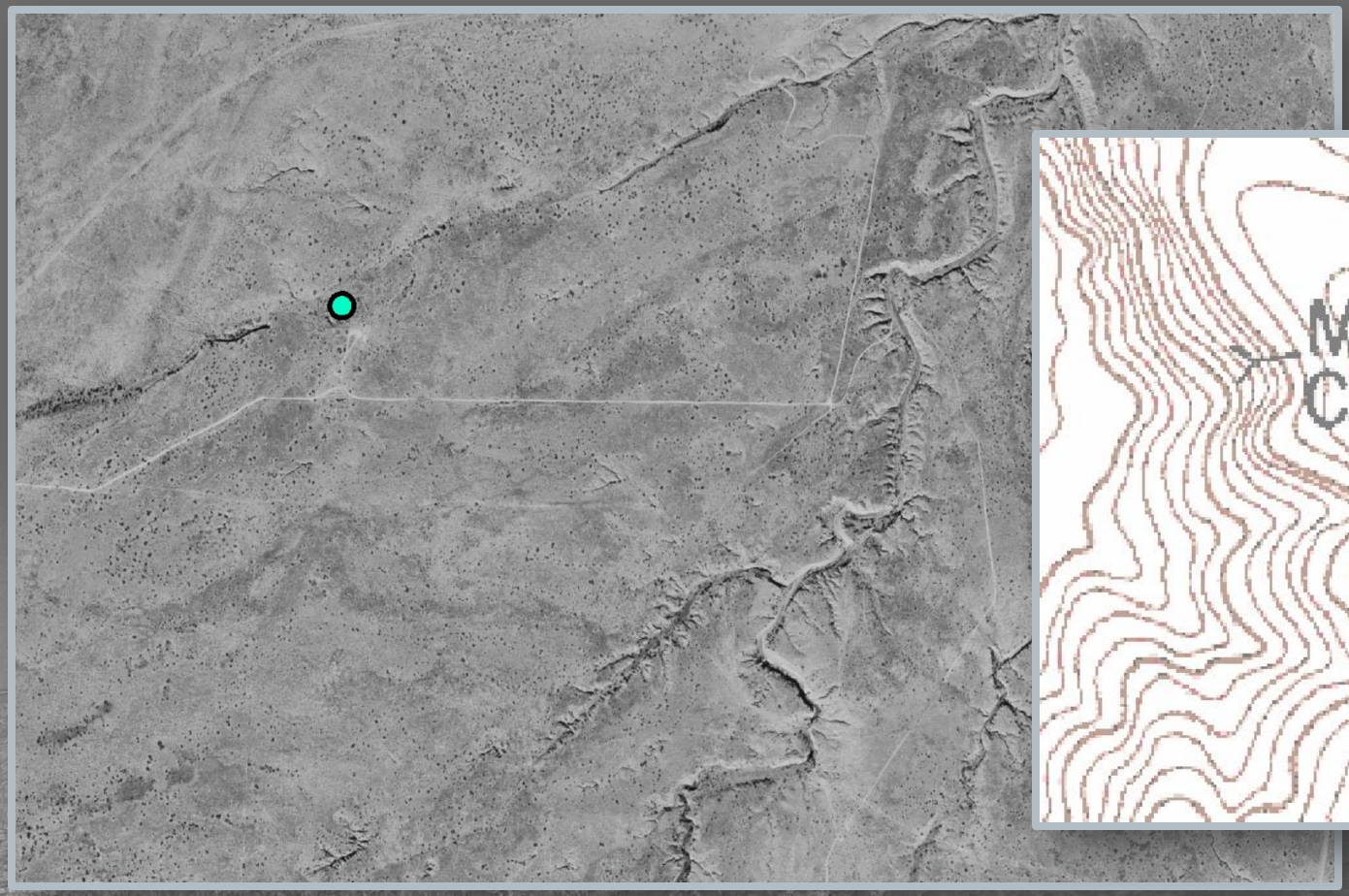
- **Remote:** **Maps, GIS, Satellite Images**

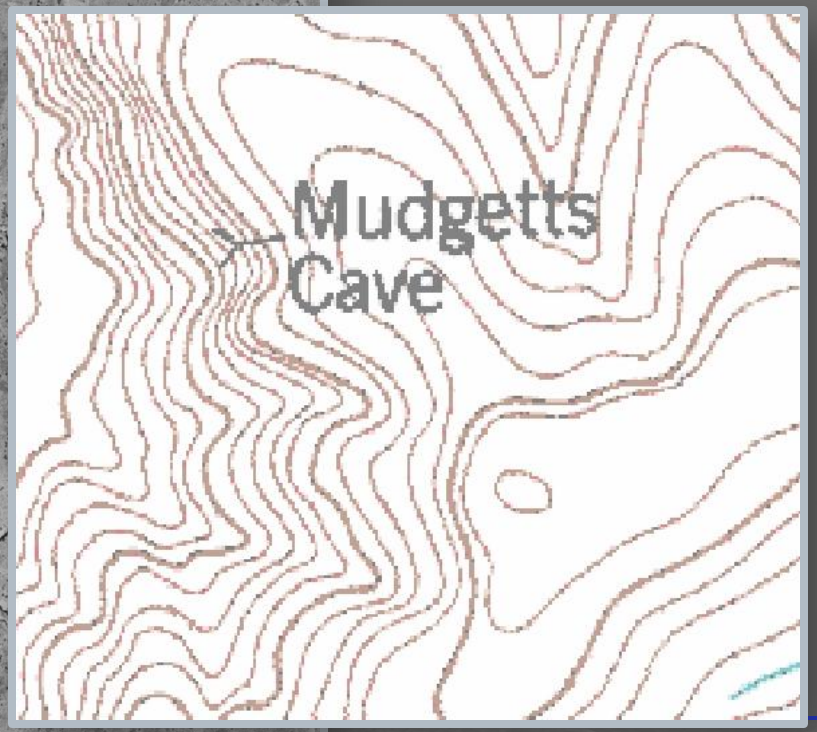



Terry's_CAVE - ArcMap - ArcInfo
File Edit View Insert Selection Tools Window Help
1:1,107,302
Editor
Task: Create New Feature
Target:
Carlsbad Field Office
Cave_Karst
Chosa Draw Karst Features
Merged Gyp Karst Features
Transportation 05-02-08
capitan reef
Cave-Potential_2008
CRIT
HIGH
MEDIUM
LOW
Caves Withdraws
Plan of Development
Cave-Potential_2008
Southern Gaudalupe Escarpment
Buffer GYP karst features 300ft
2Buffer GYP karst features 200m
Carlsbad BLM Caves_3Dshots
filledsinks
Hay Hollow Development 03-18-20C
Hydrology 3-14-08
Hydro-Geology
Geology
Proposed Projects
Archaeology
Oil and Gas 2-13-08
Realty
Wind Power Classification
Display Source Selection
ROSWELL
RUIDOSO
TATUM
US 285
US 82
Artesia
ALAMOGORDO
ARTESIA
HOBBS
US 62
Carlsbad
CROW FLATS
CARLSBAD
JAL
Drawing
Times New Roman
9.75
1571786.7 11670259.18 Feet
Start
Cave-Karst 101e-5-6-08...
Terry's_CAVE - ArcMa...
5:06 PM

Detection

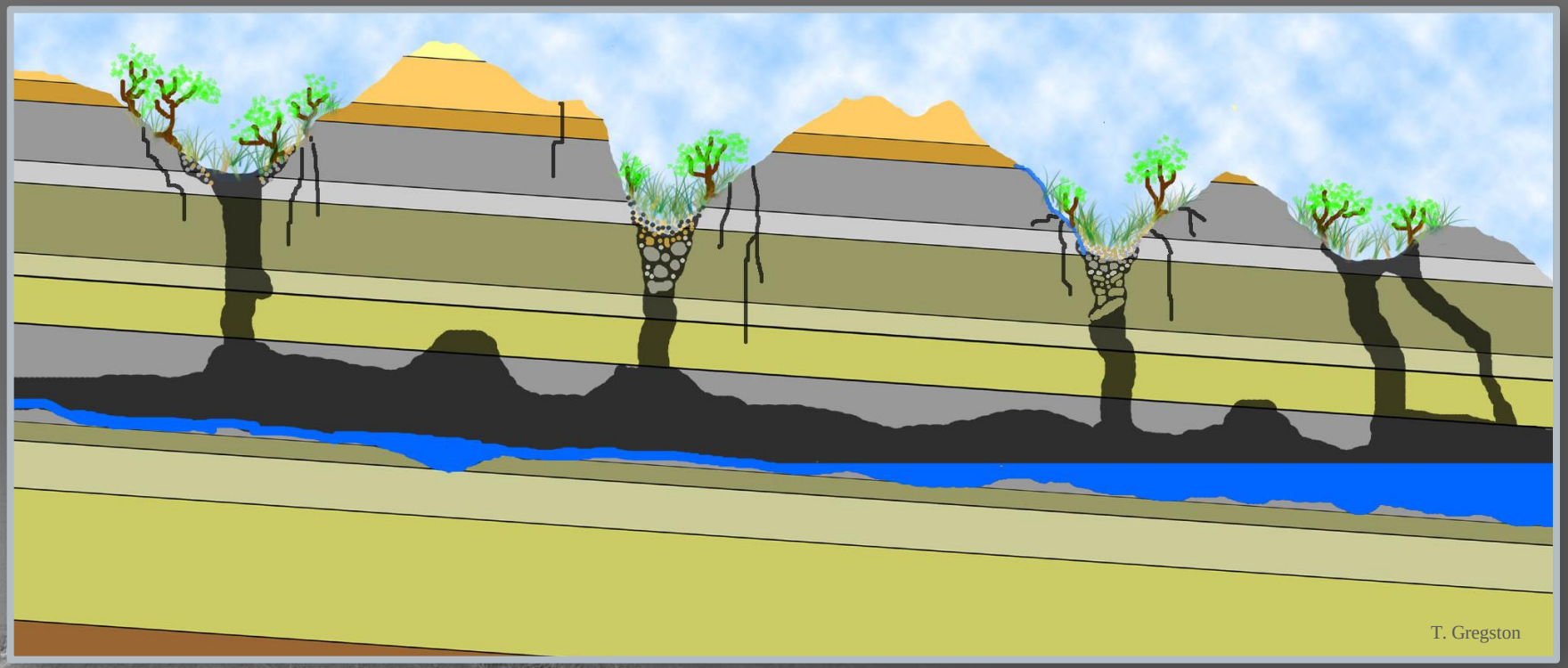
- **Remote:** Maps, GIS, Satellite Images





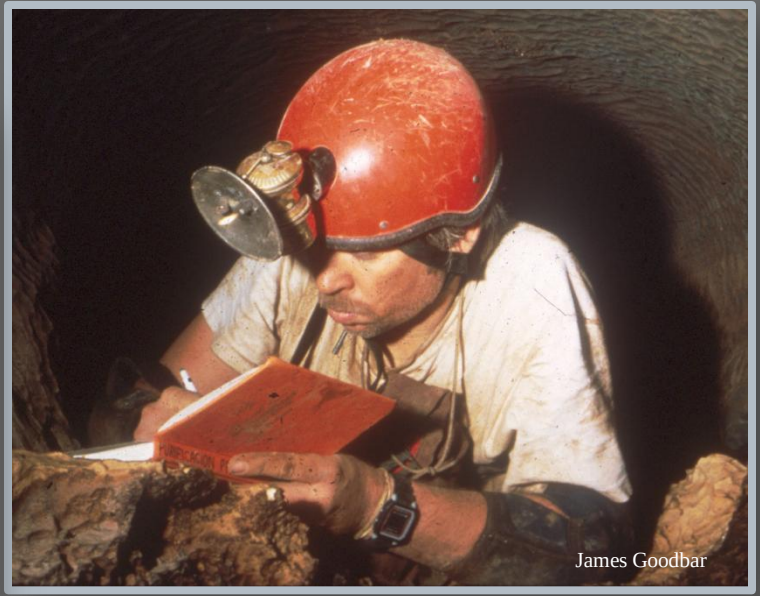
Detection

- **Remote:** Maps, GIS, Satellite Images

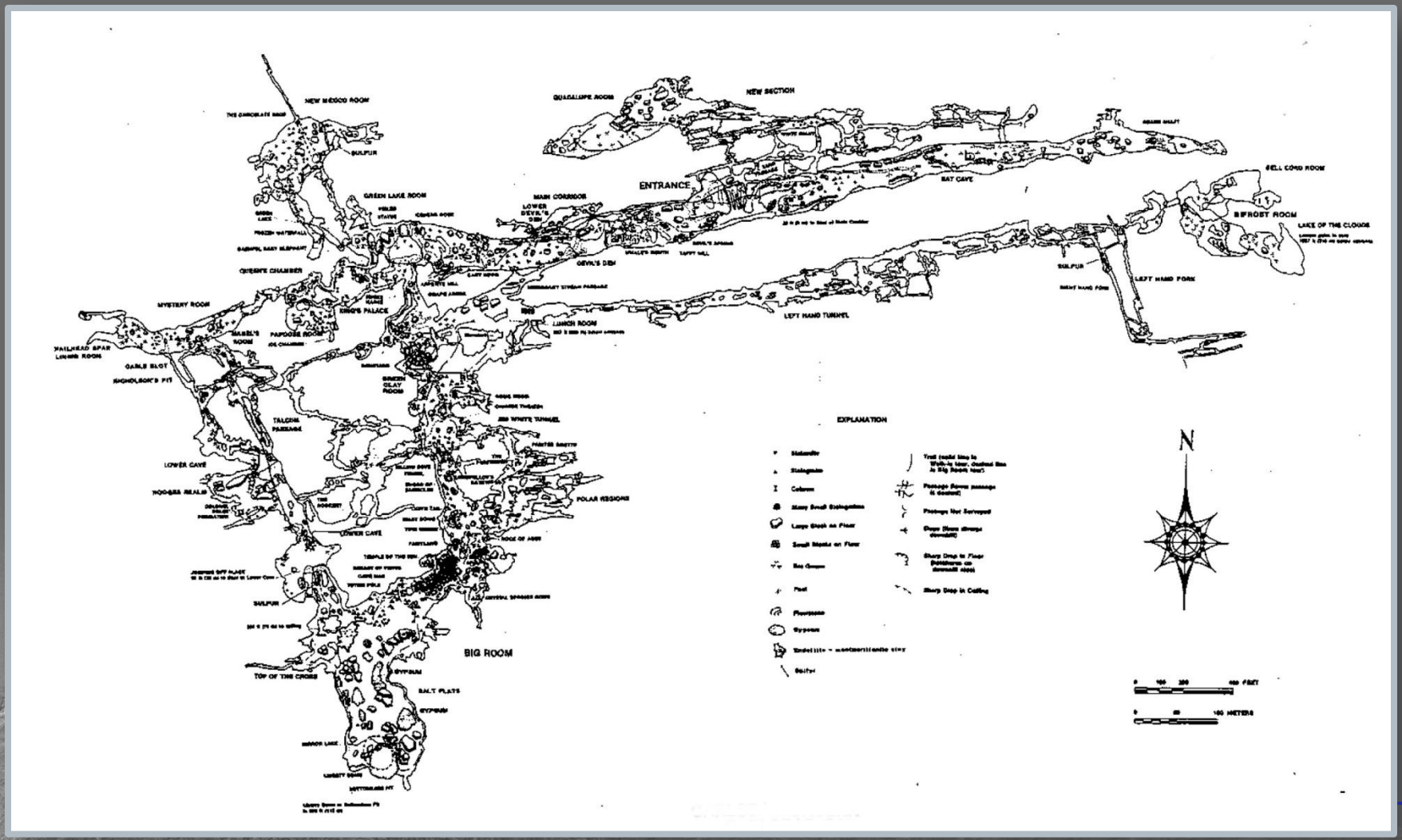


Detection

- **Field work:** GPS mapping, surface surveys, and cave surveys

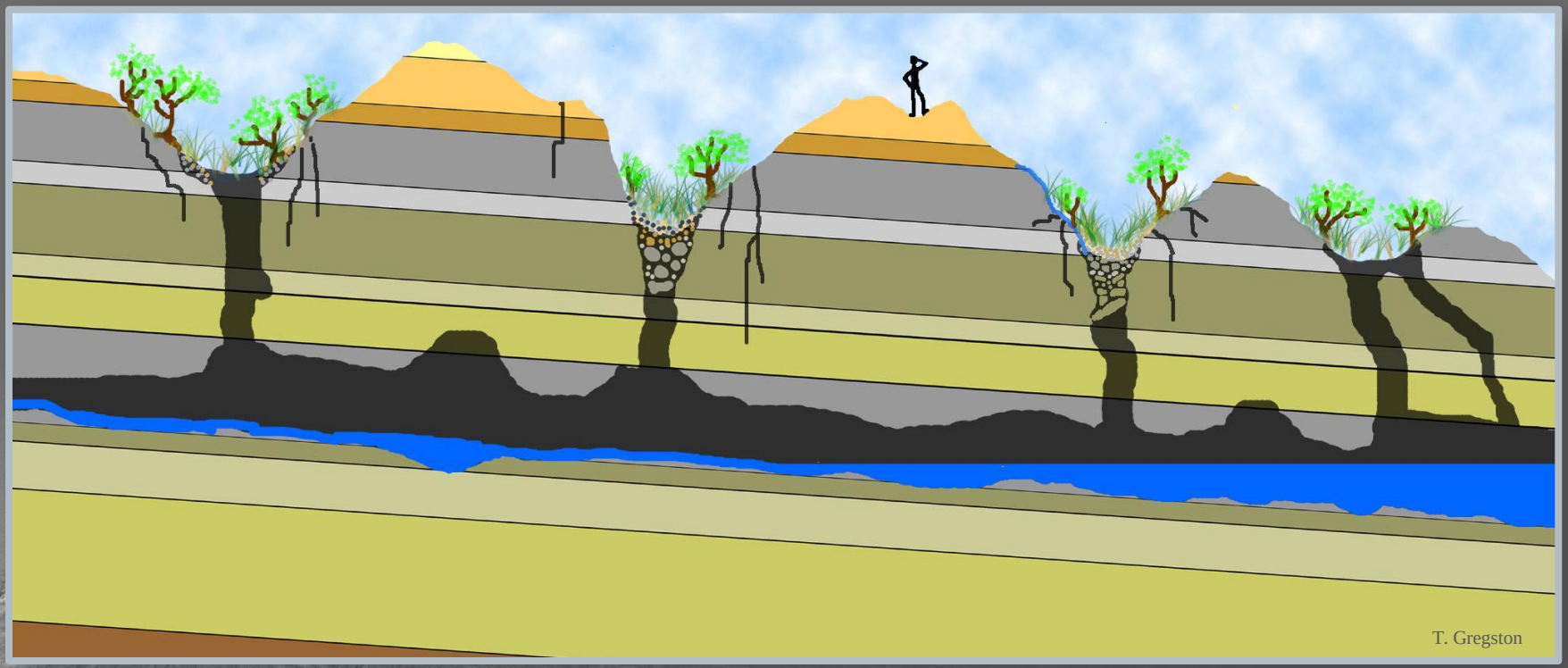


Detection


NEW MEXICO ROOM
GREEN LAKE ROOM
MAIN CORRIDOR
ENTRANCE
NEW SECTION
QUADALUPE ROOM
BAT CAVE
BELL COND ROOM
BIFROST ROOM
LAKE OF THE CLOUDS
SULPHUR
LEFT HAND FORK
LEFT HAND TUNNEL
LUNCH ROOM
KING'S PALACE
QUEEN'S CHAMBER
MYSTERY ROOM
NAILHEAD SPAR
GABLE SLOT
NICHOLSON'S PIT
TALCOM PASSAGE
LOWER CAVE
POLAR SESSIONS
BIG ROOM
TOP OF THE CROSS
GYPSUM
SALT FLATS
EXPLANATION
N
FEET
METERS

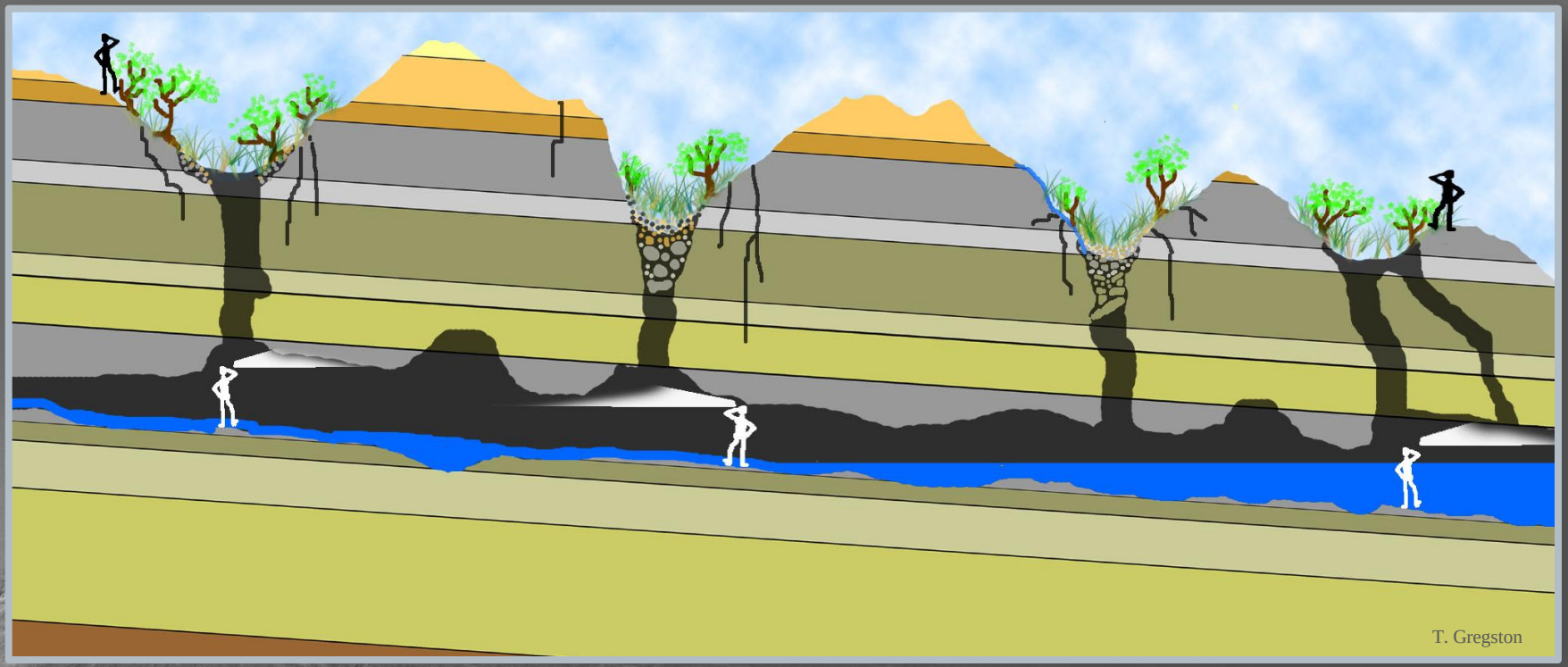
Detection

- **Field work:** GPS mapping, surface surveys, and cave surveys



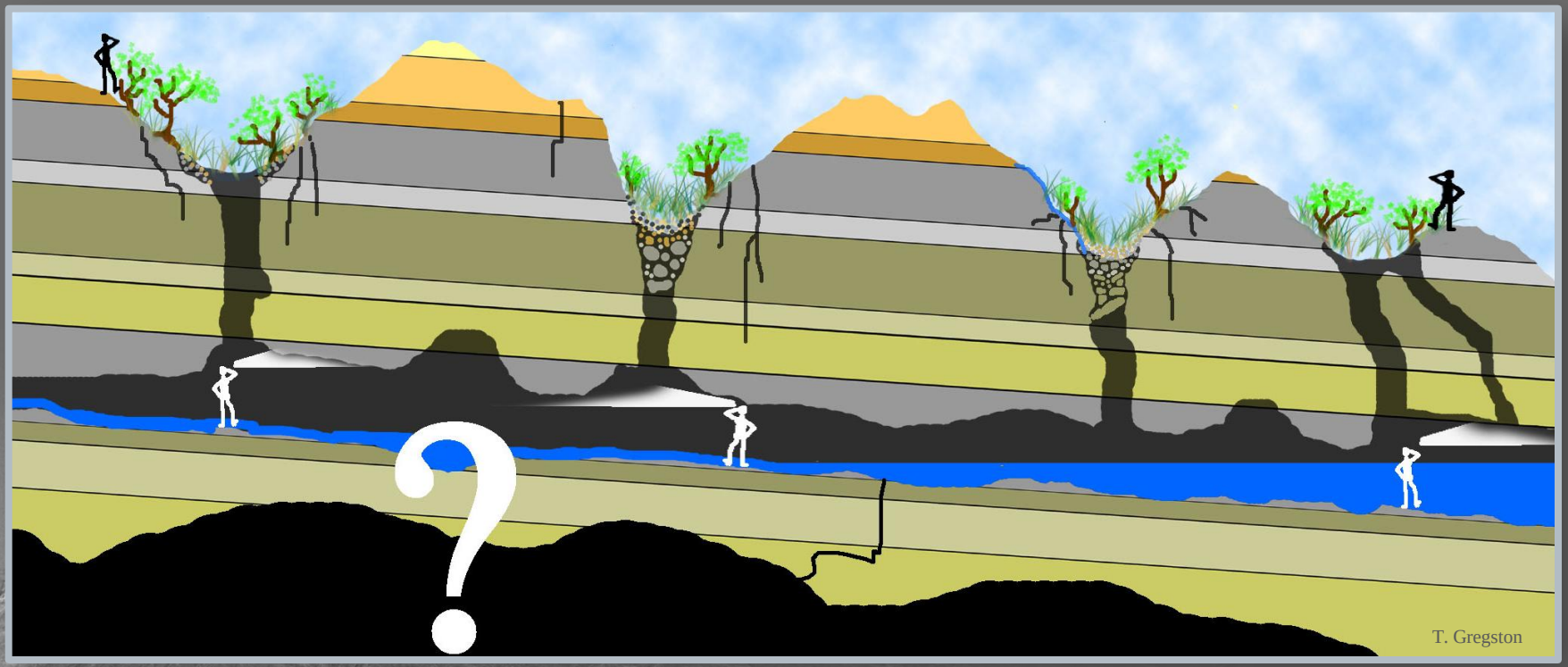
Detection

- **Field work:** GPS mapping, surface surveys, and cave surveys



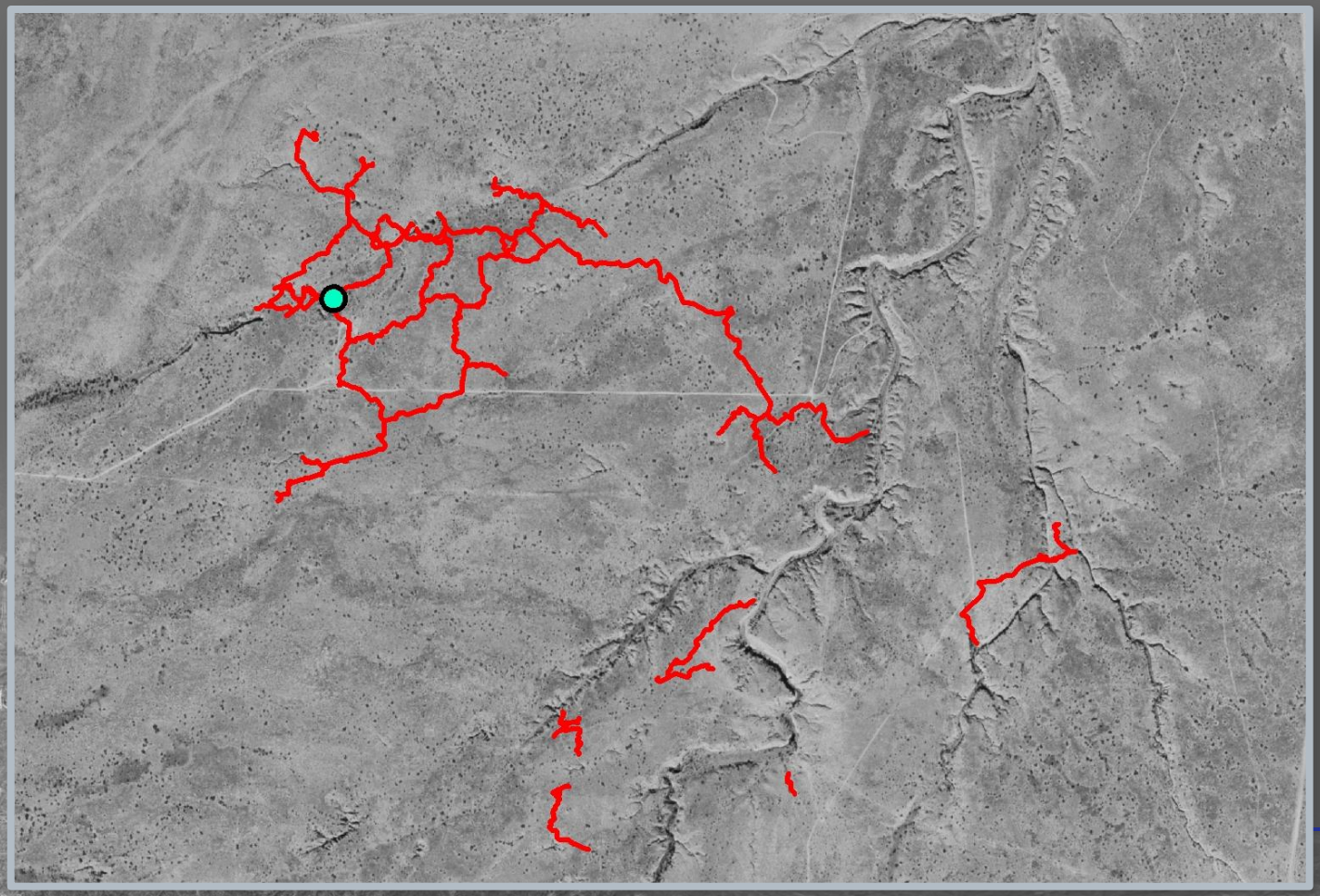
Detection

- **Field work:** GPS mapping, surface surveys, and cave surveys



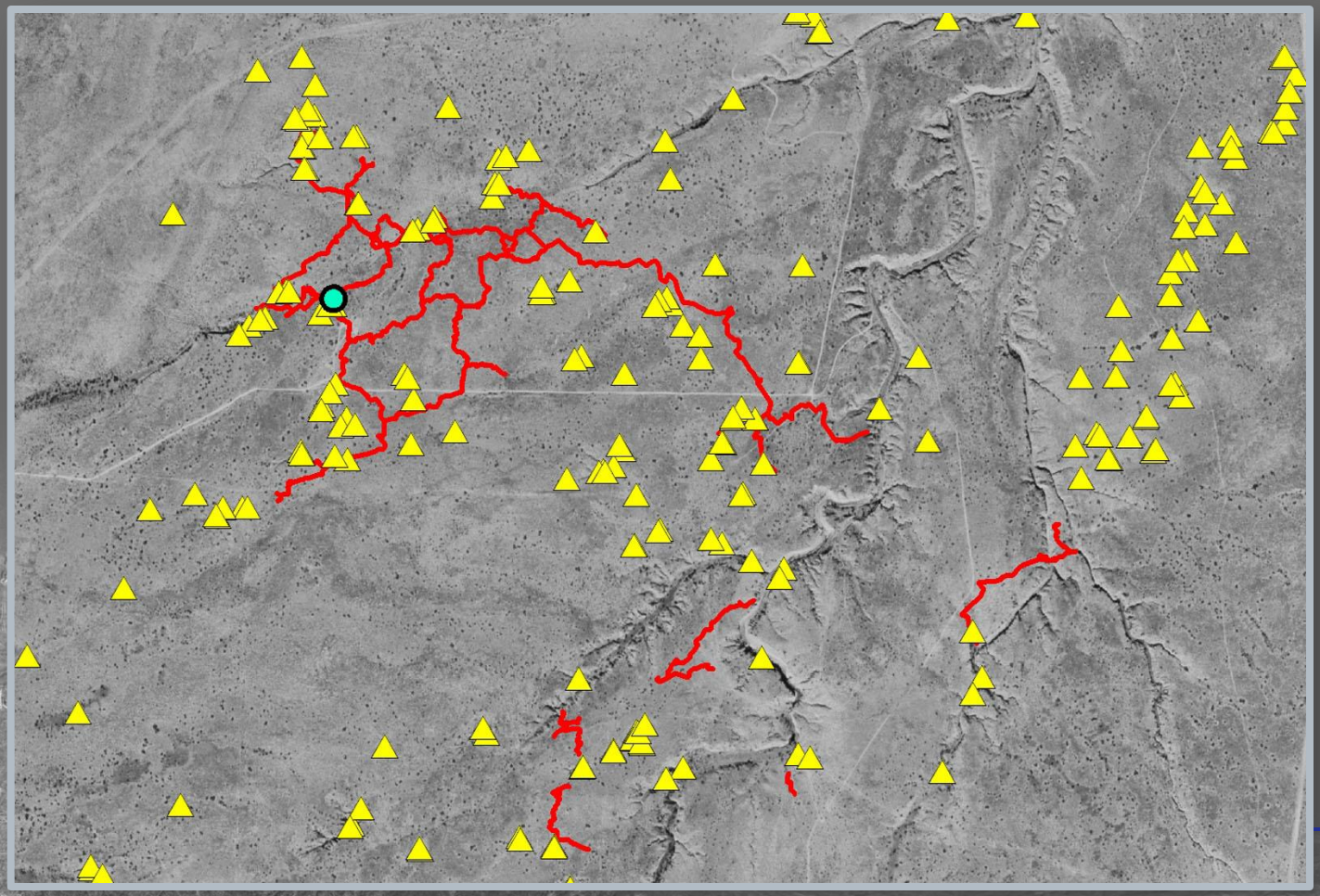
Detection

- **Field work:** GPS mapping and cave surveys



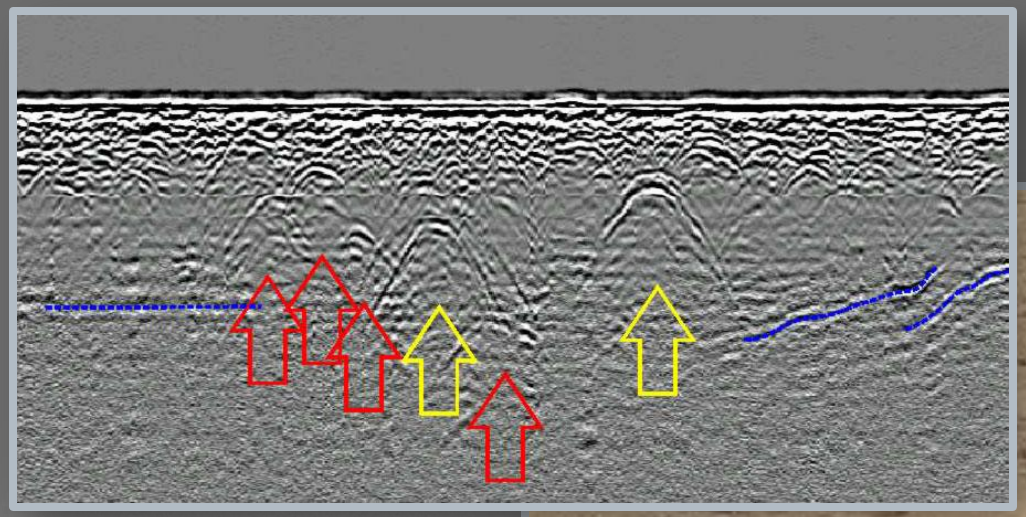
Detection

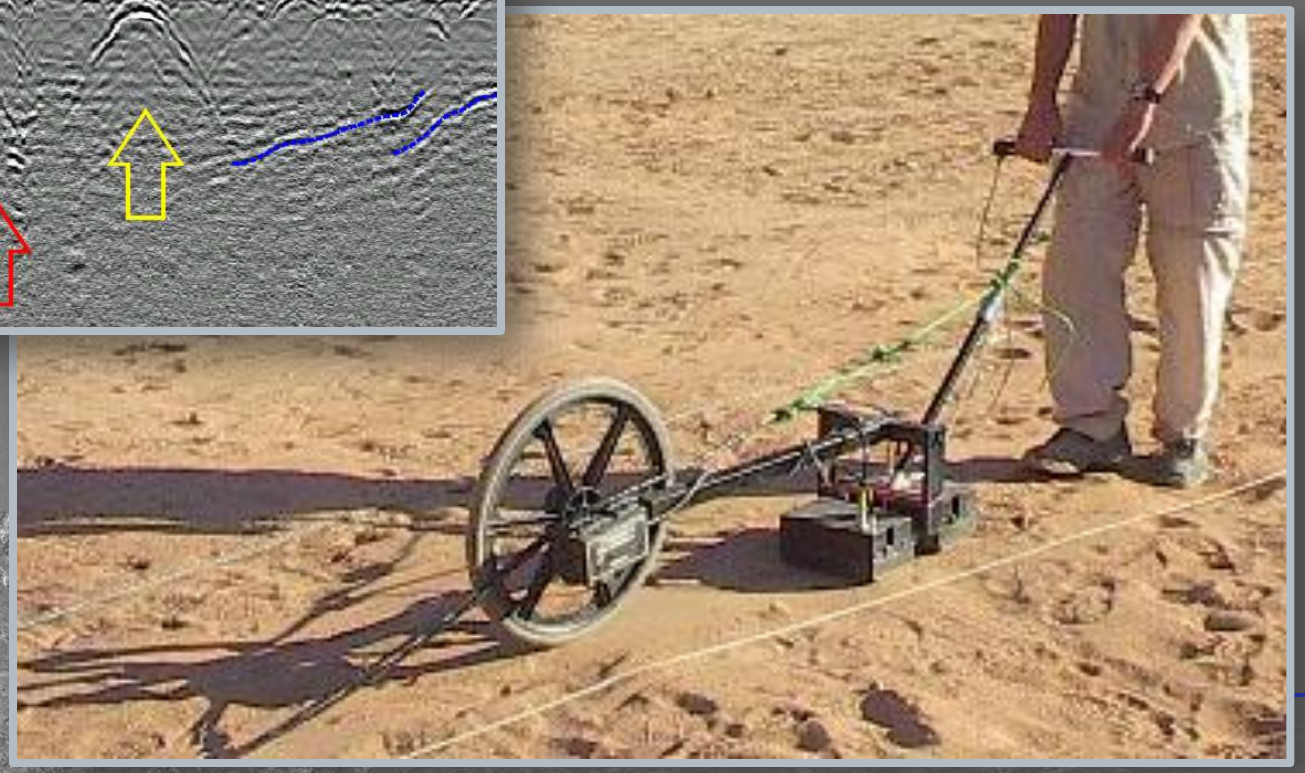
- **Field work:** GPS mapping and cave surveys



Detection

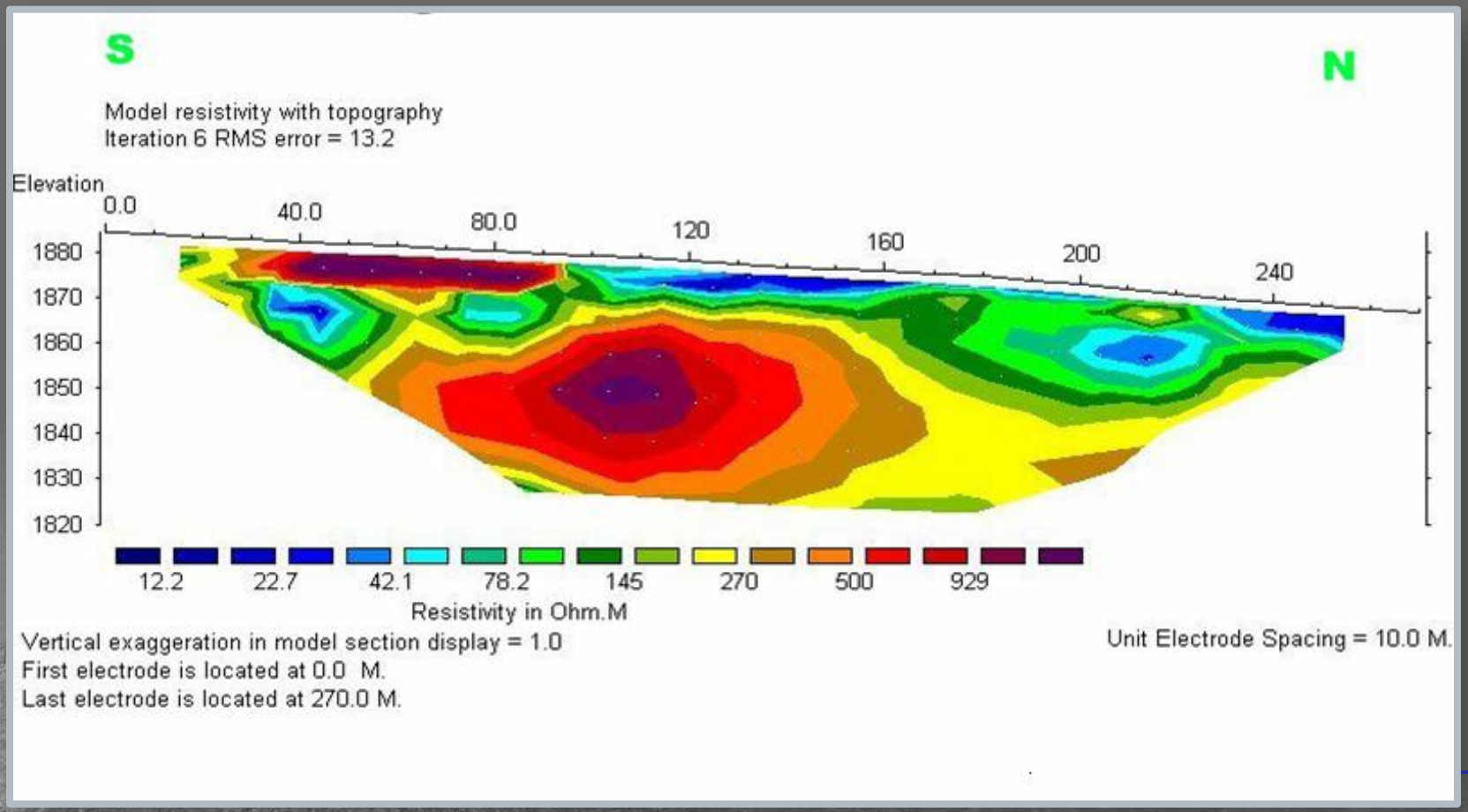
- **Geophysical:** radar, resistivity, and natural potential





Detection

- **Geophysical:** radar, resistivity, and natural potential



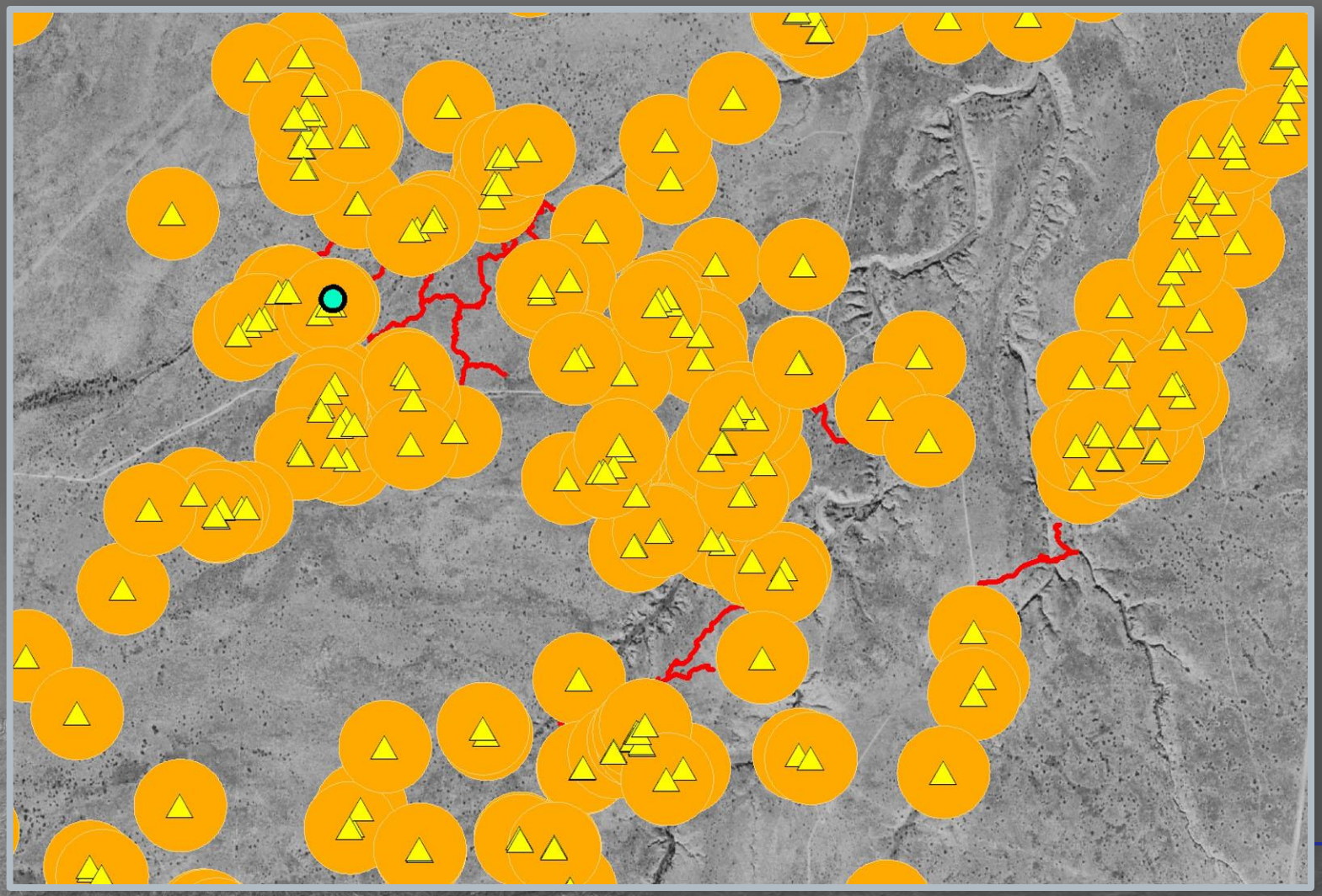
Detection

- **Geophysical:** seismic

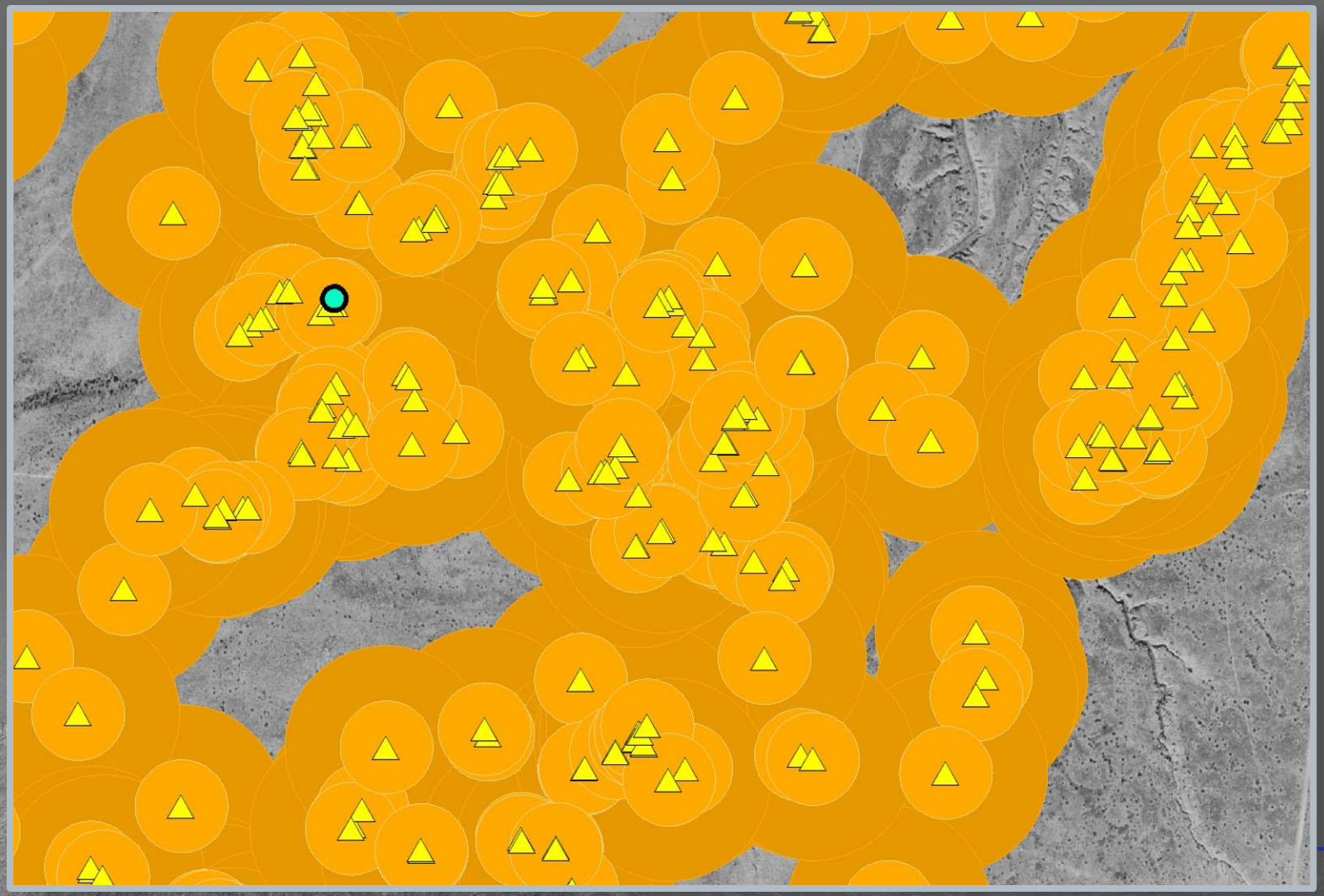
Avoidance

- **Move Location**

Avoidance



Avoidance



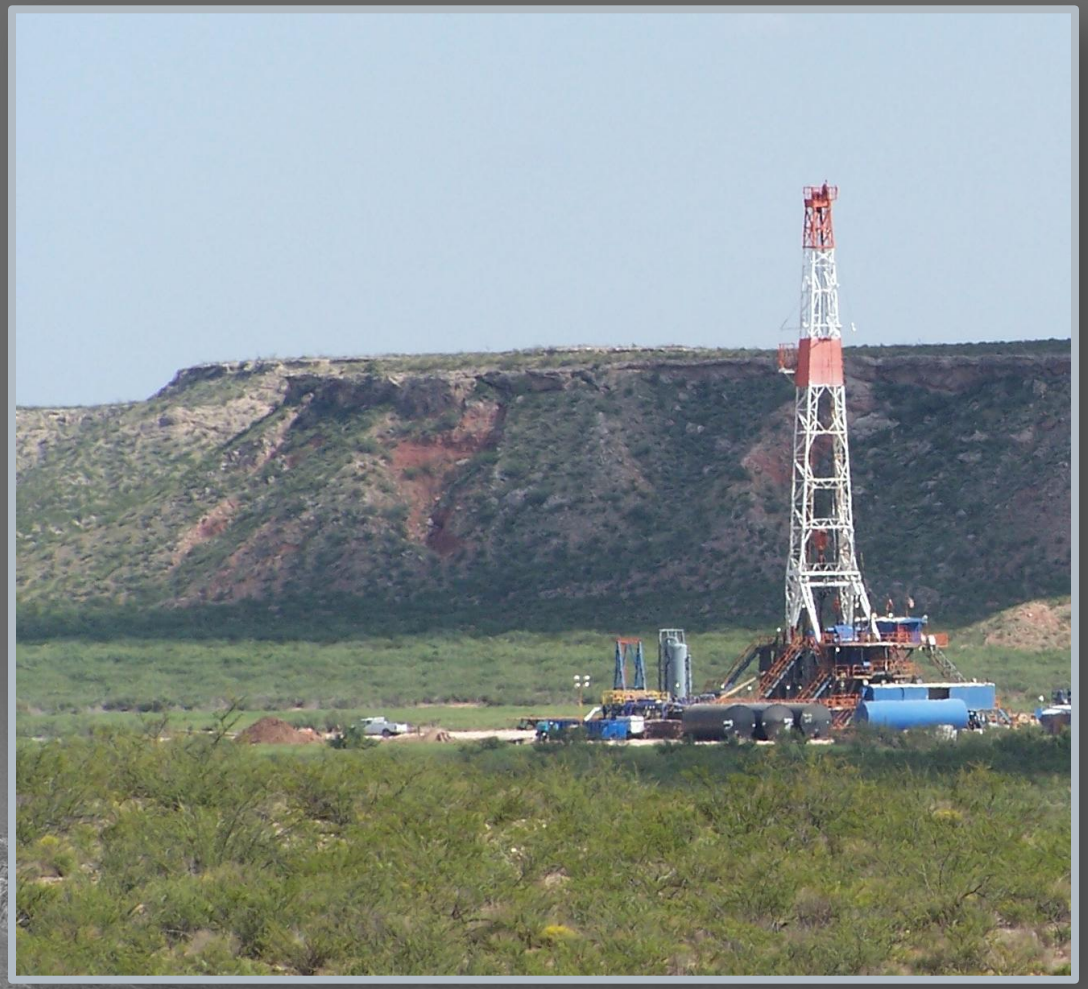
Avoidance

- **Reroute:**

-road
-pipeline
-power line

Mitigation: Best Management Practices

- Surface
- Downhole
- Abandonment
- Monitoring



Minimize Surface Disturbances

- Smaller locations
- Reduce cut-and-fill

Minimize Surface Disturbances

- **Multiple well locations**
- **No blasting**

Minimize Surface Disturbances

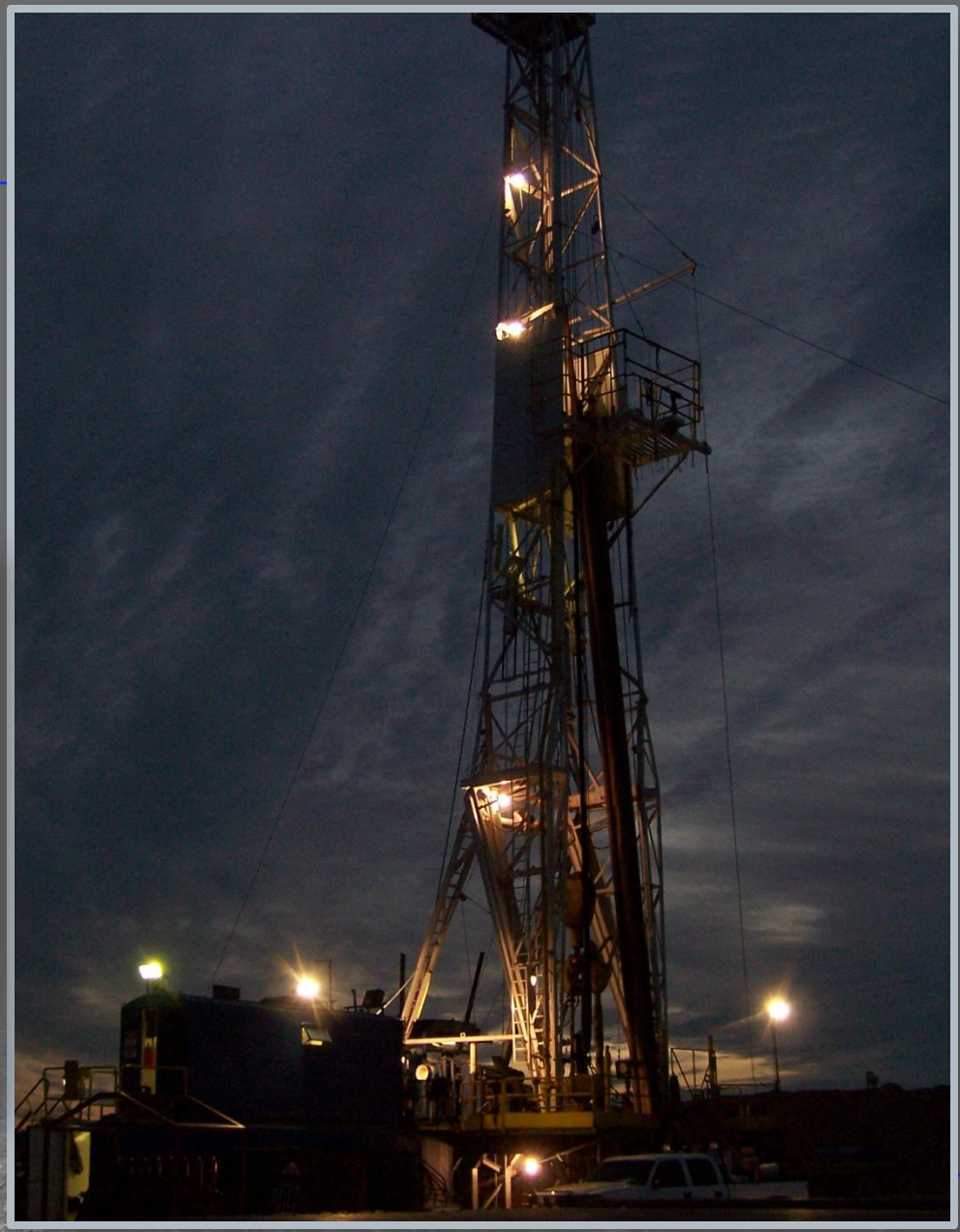
- Closed loop systems

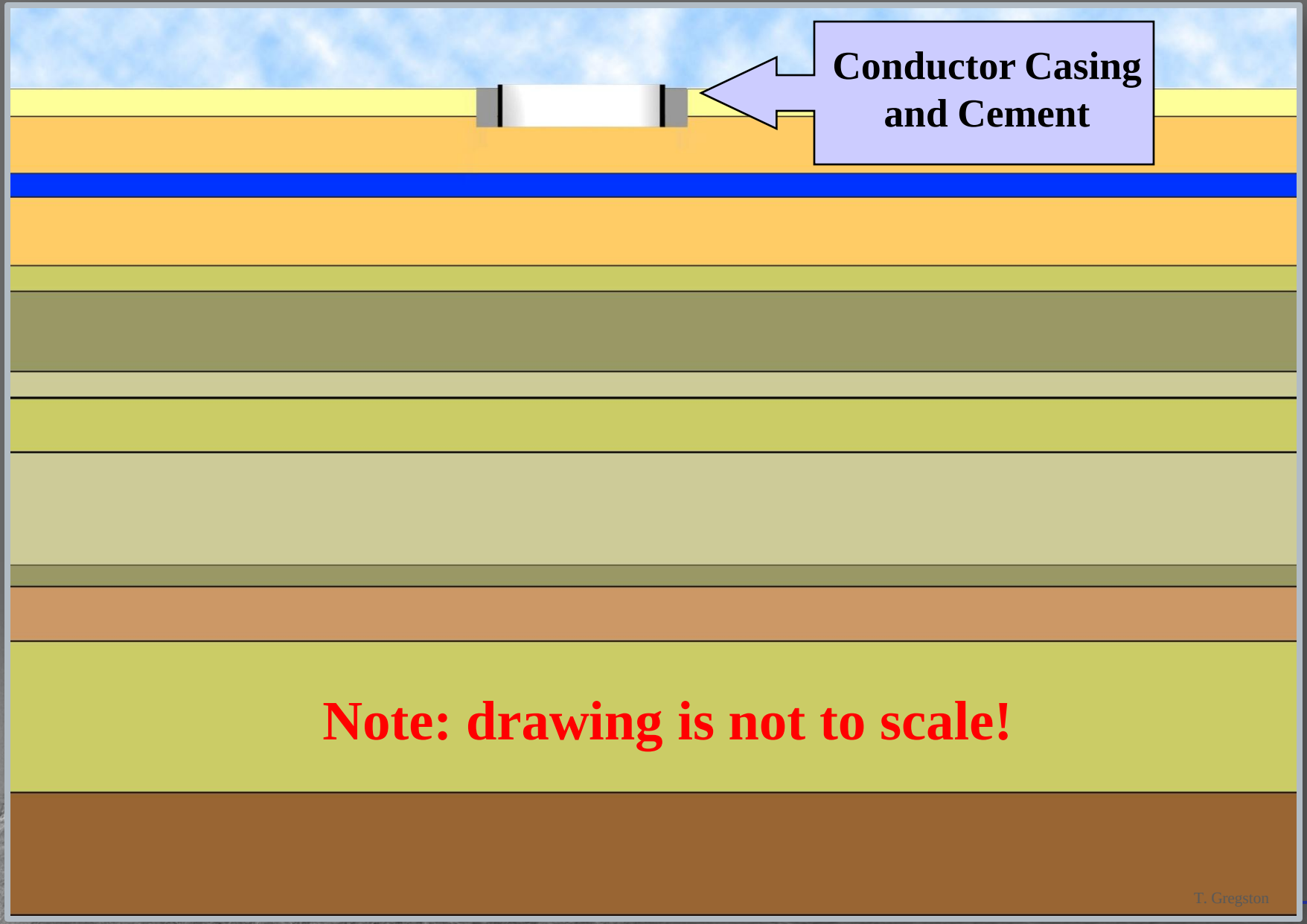
Minimize Surface Disturbances

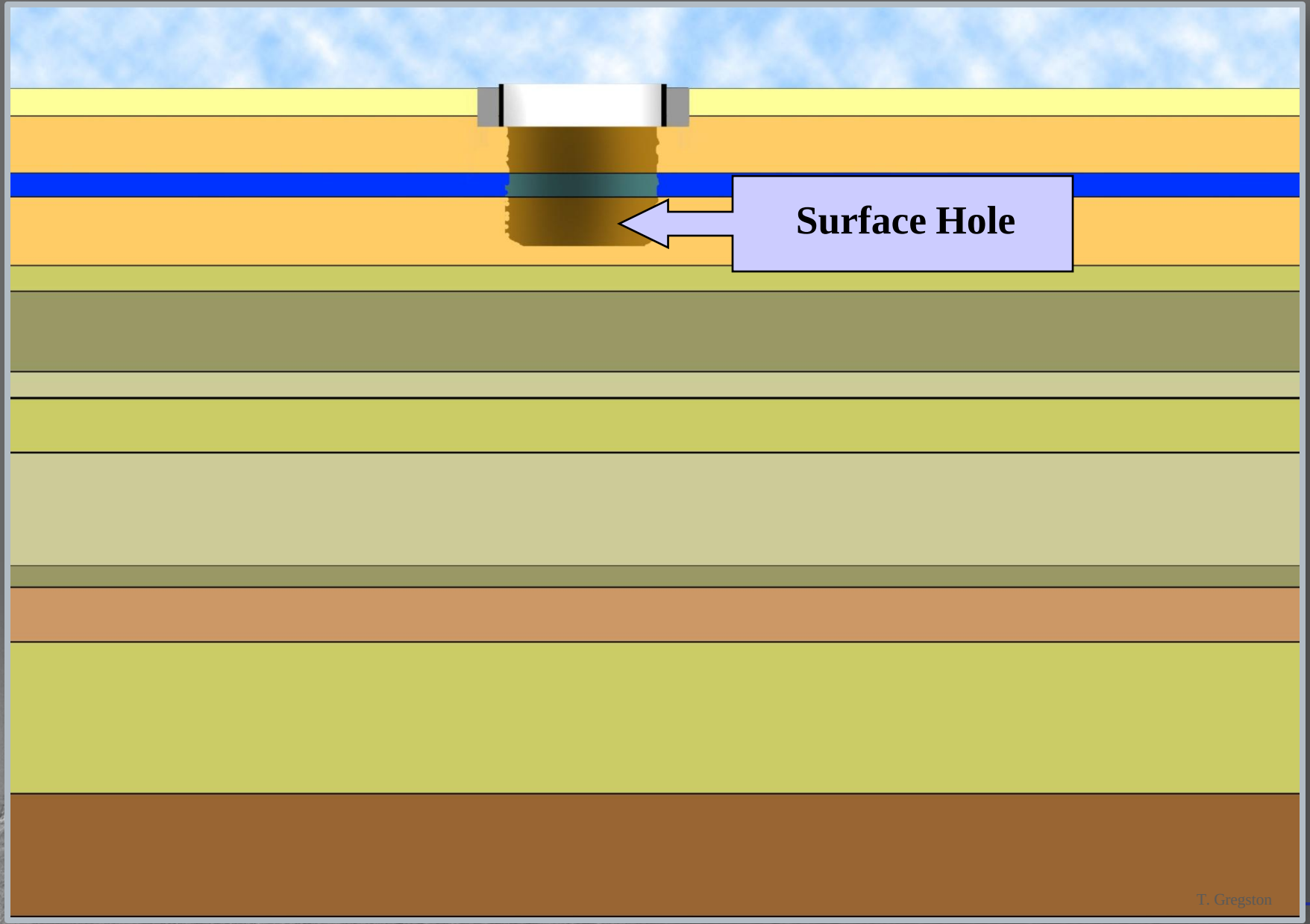
- Lined berms
- Leak detection systems

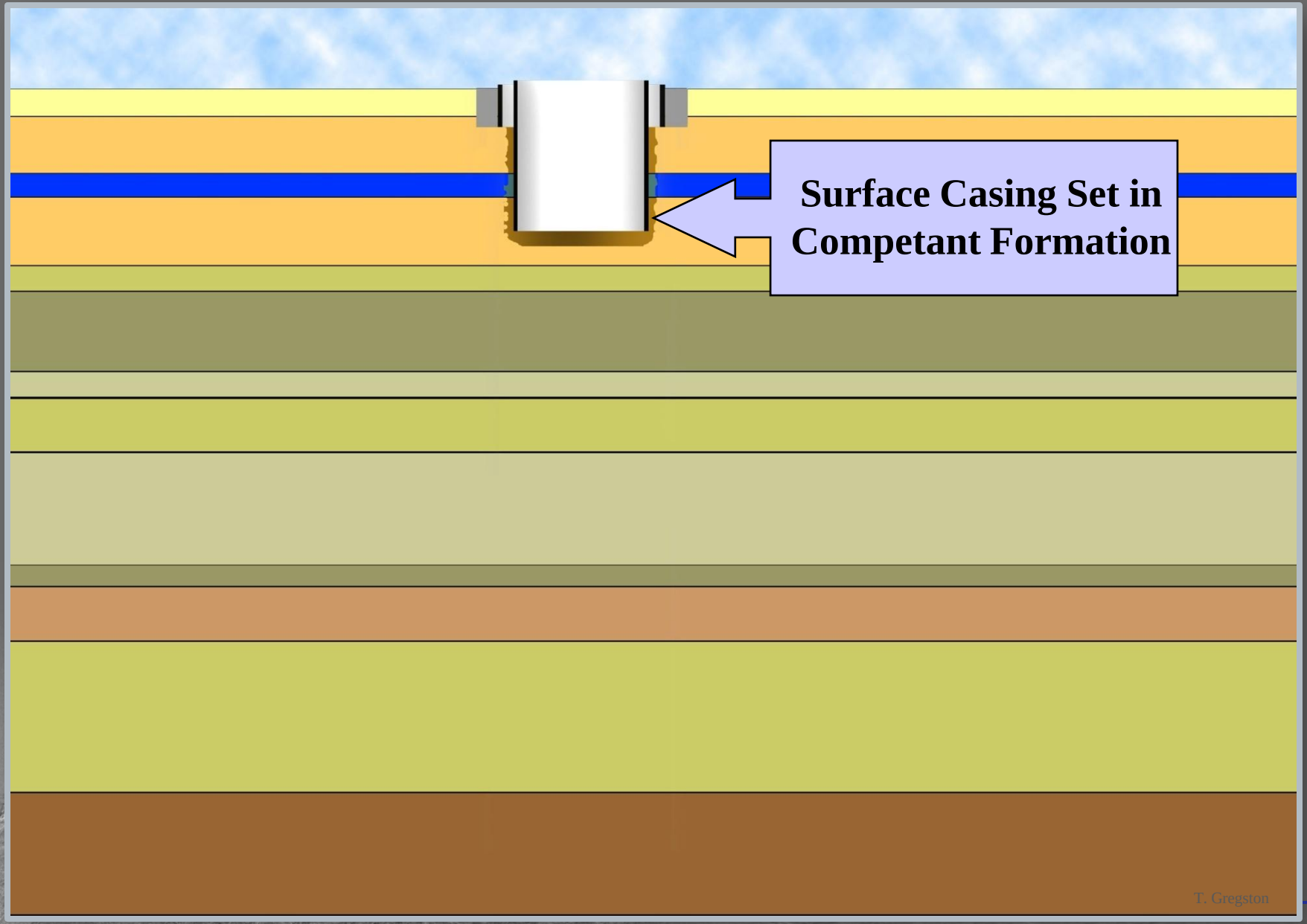
Downhole

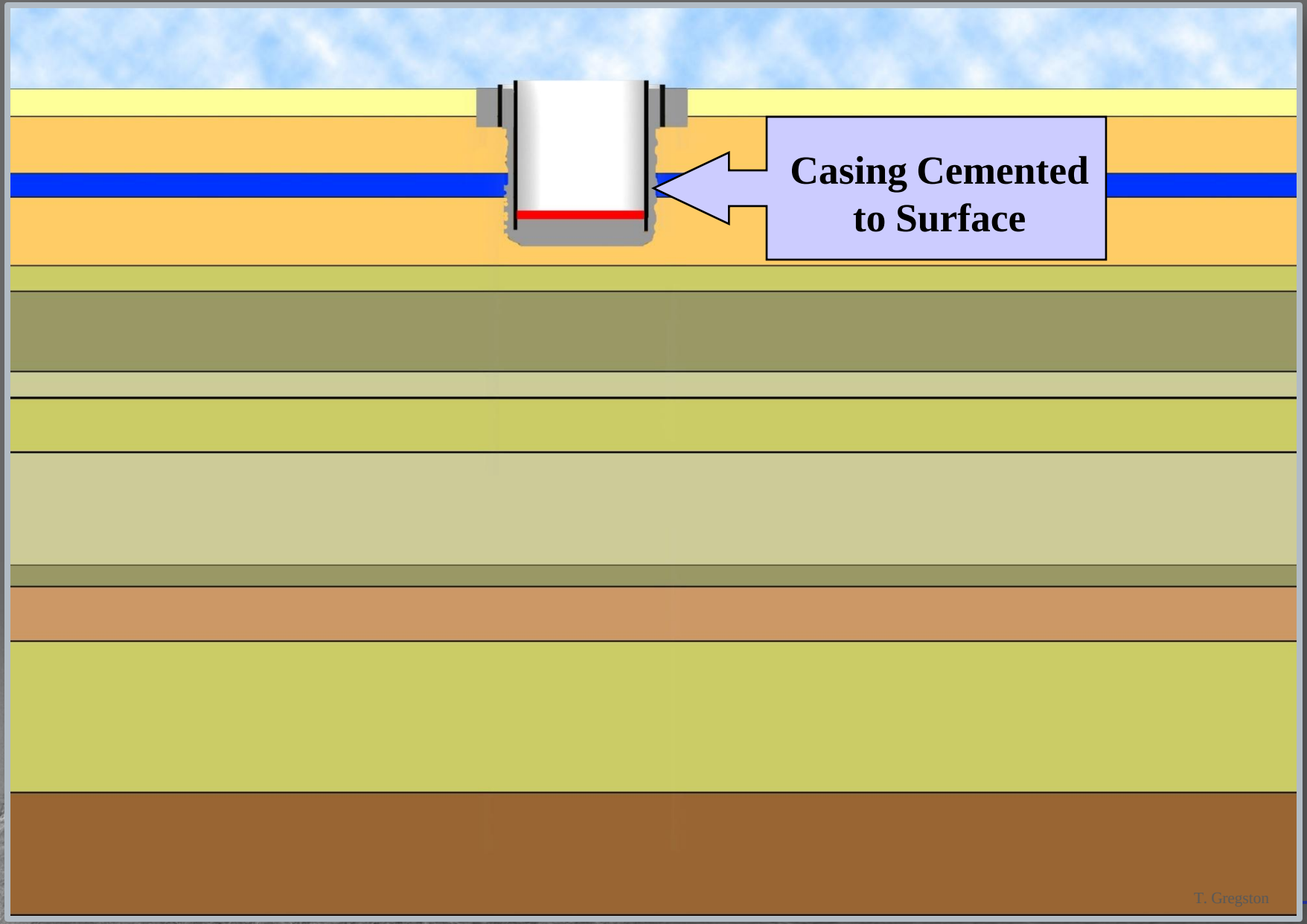
- Drilling
- Casing
- Cementing

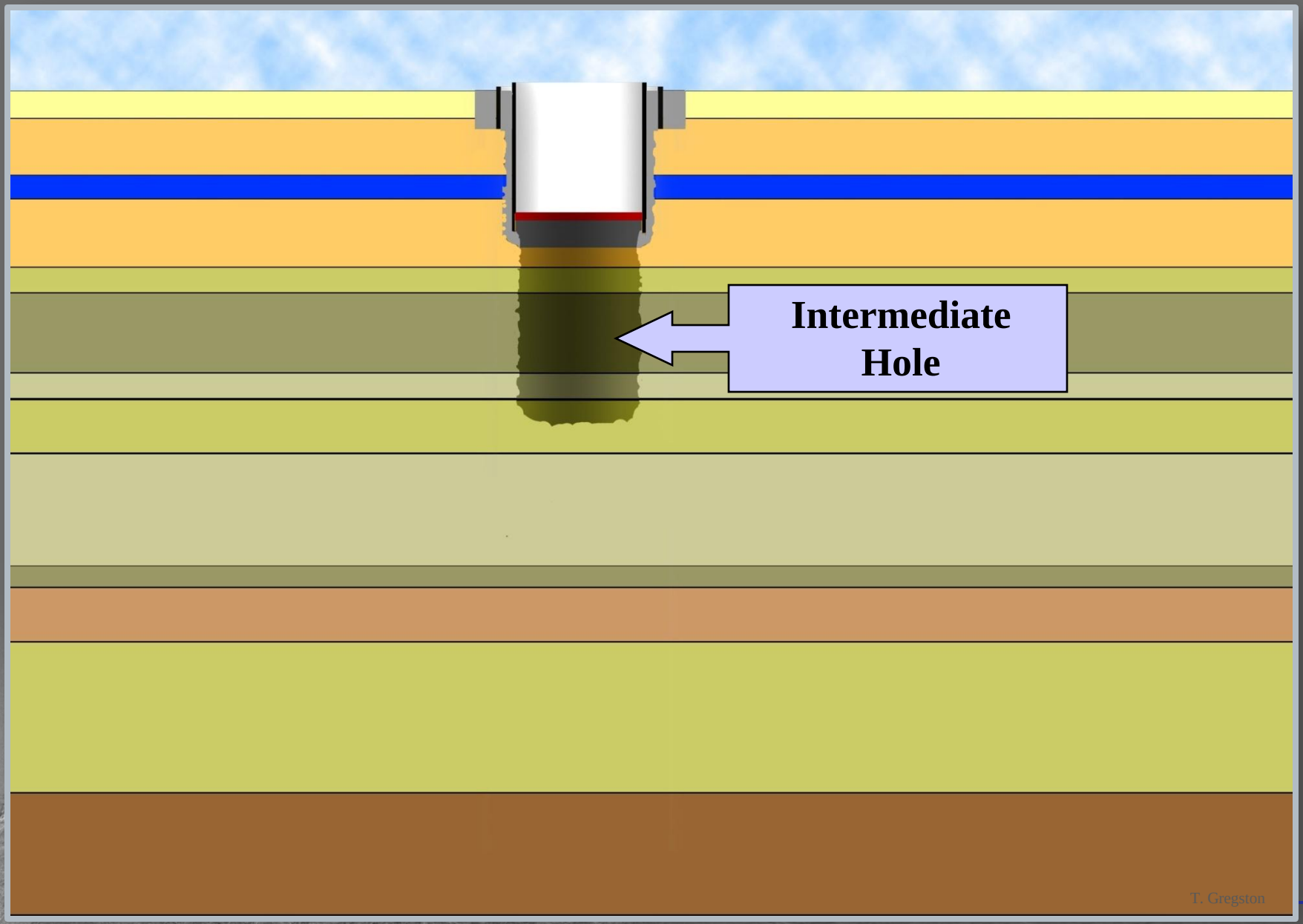


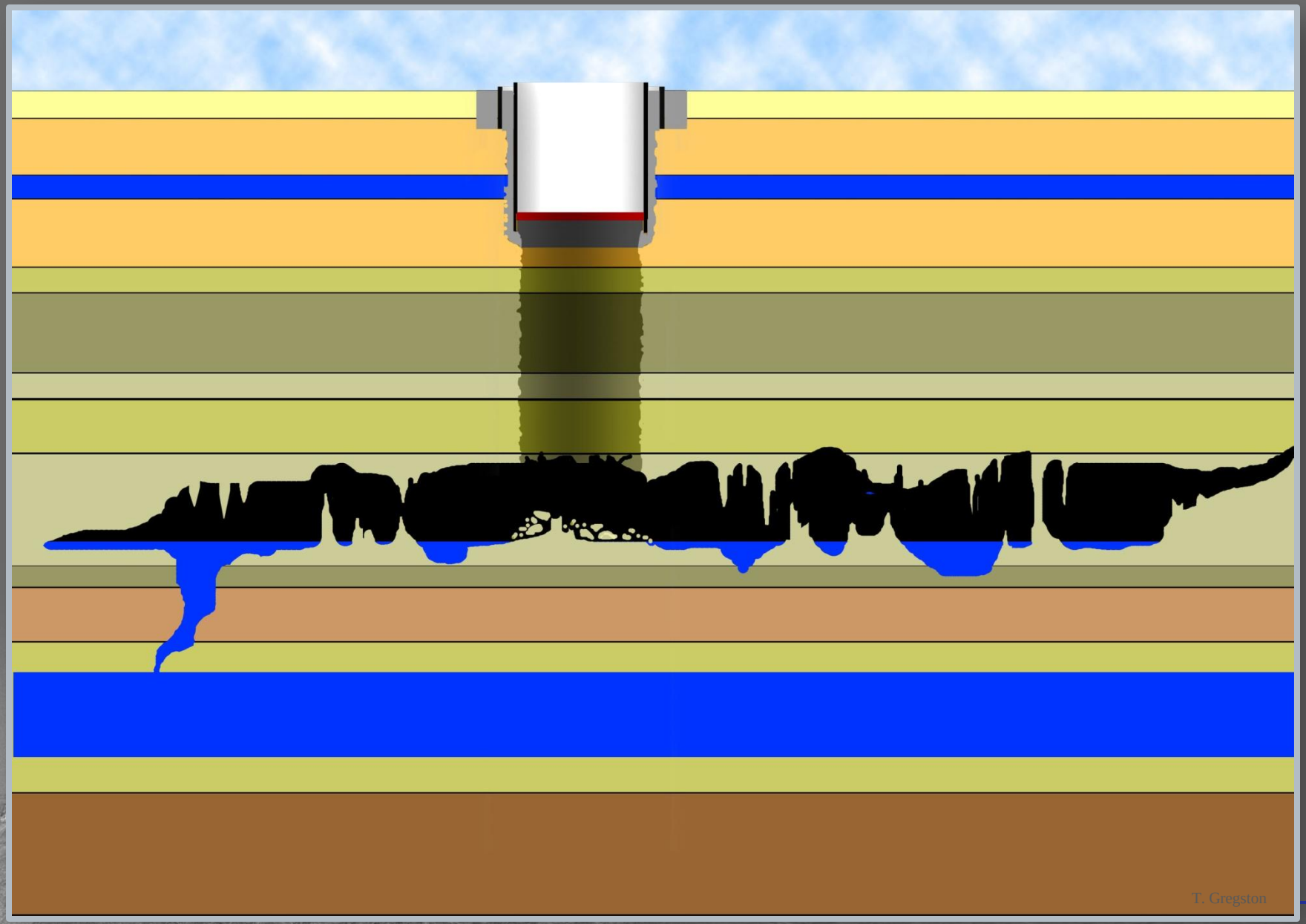

Conductor Casing and Cement
Note: drawing is not to scale!
T. Gregston

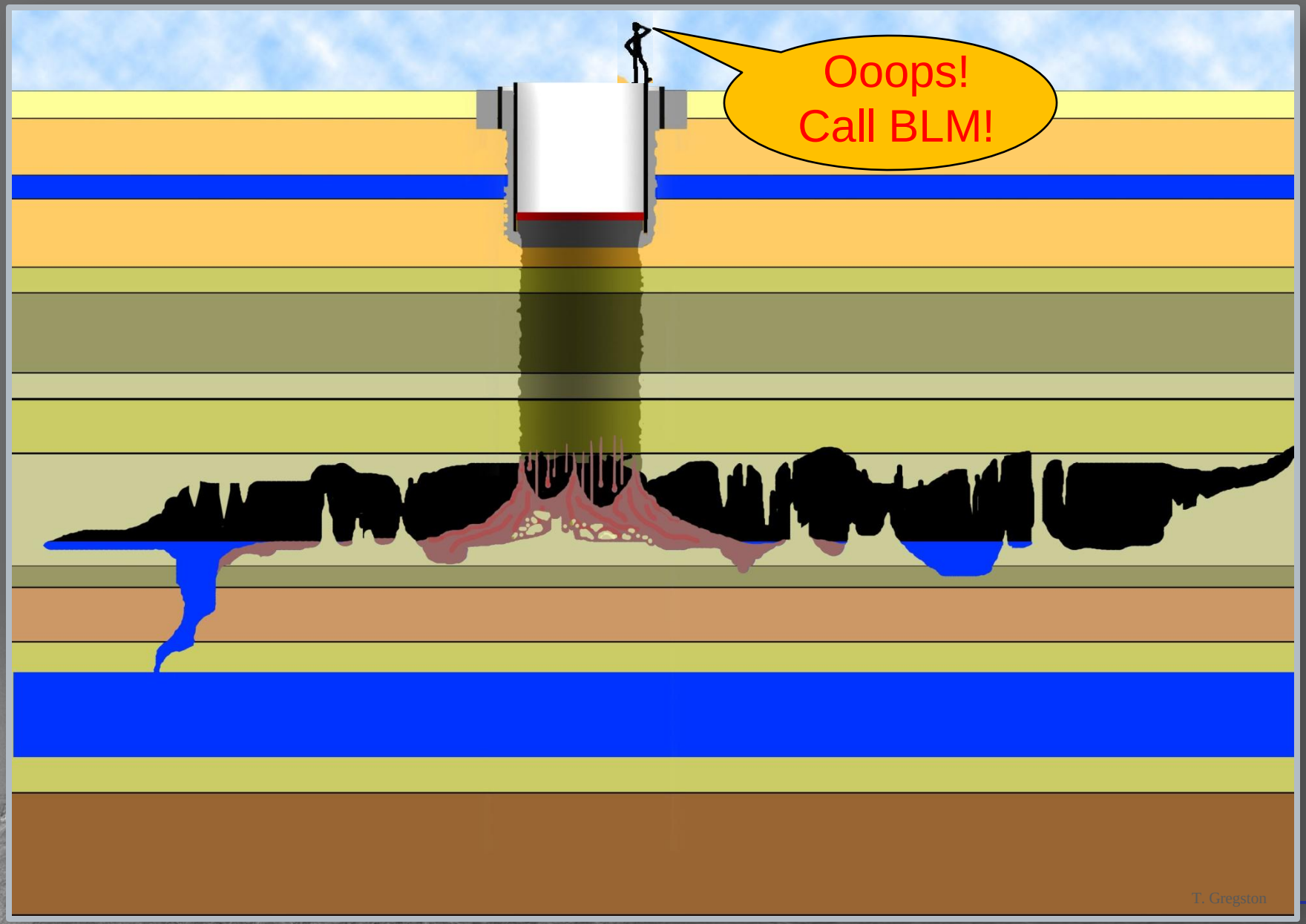

Surface Hole
T. Gregston

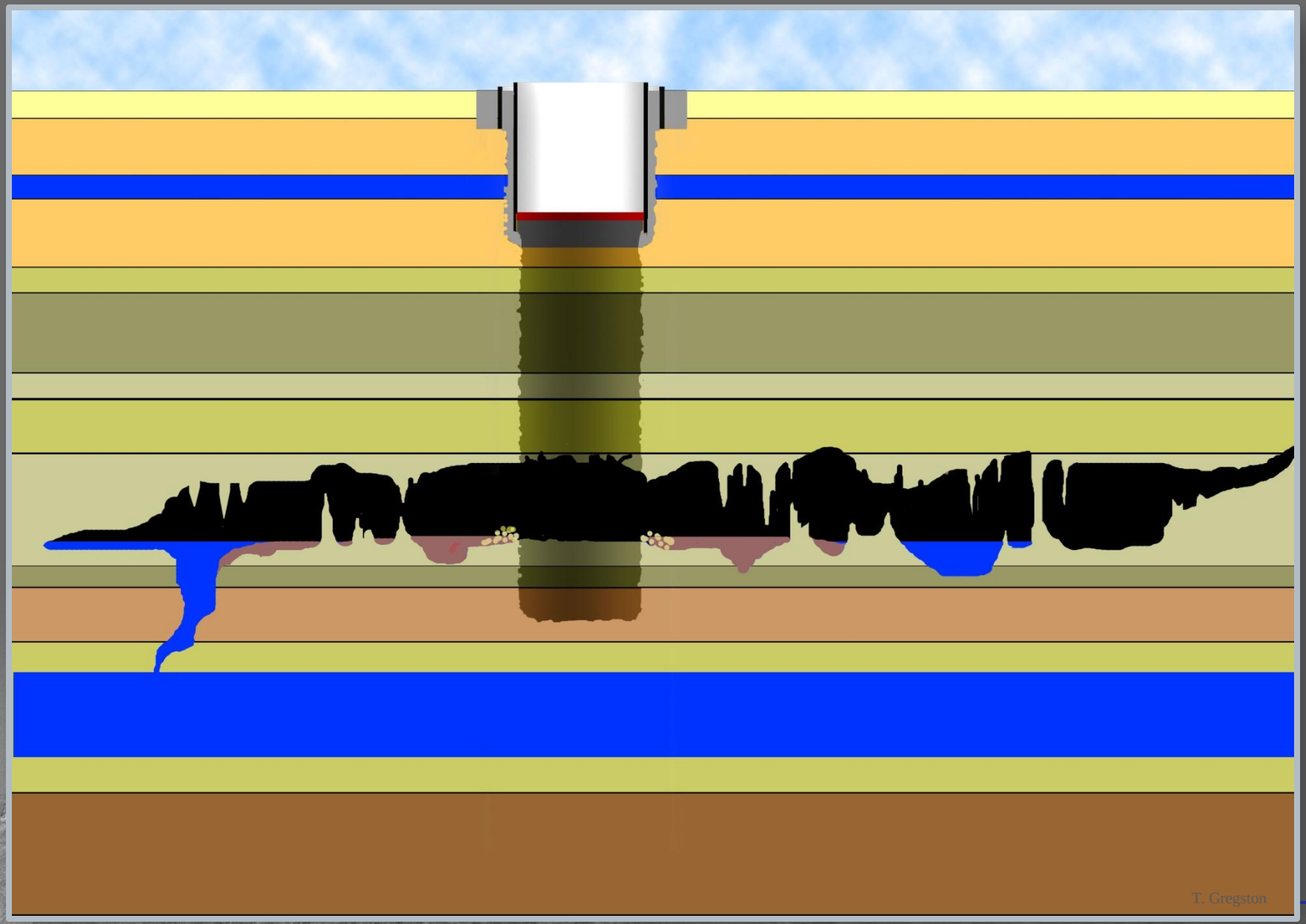

Surface Casing Set in
Competant Formation
T. Gregston

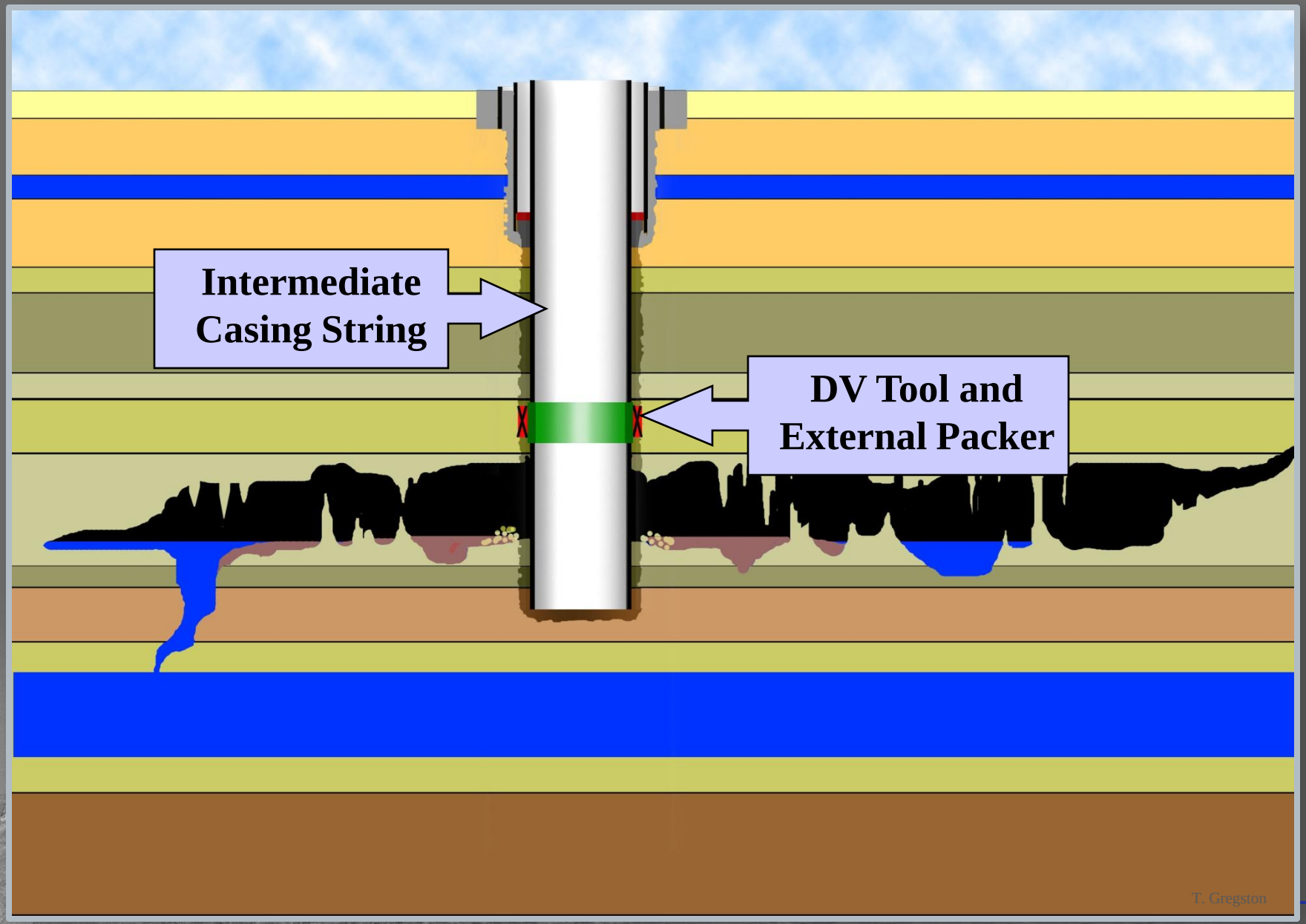

Casing Cemented
to Surface
T. Gregston

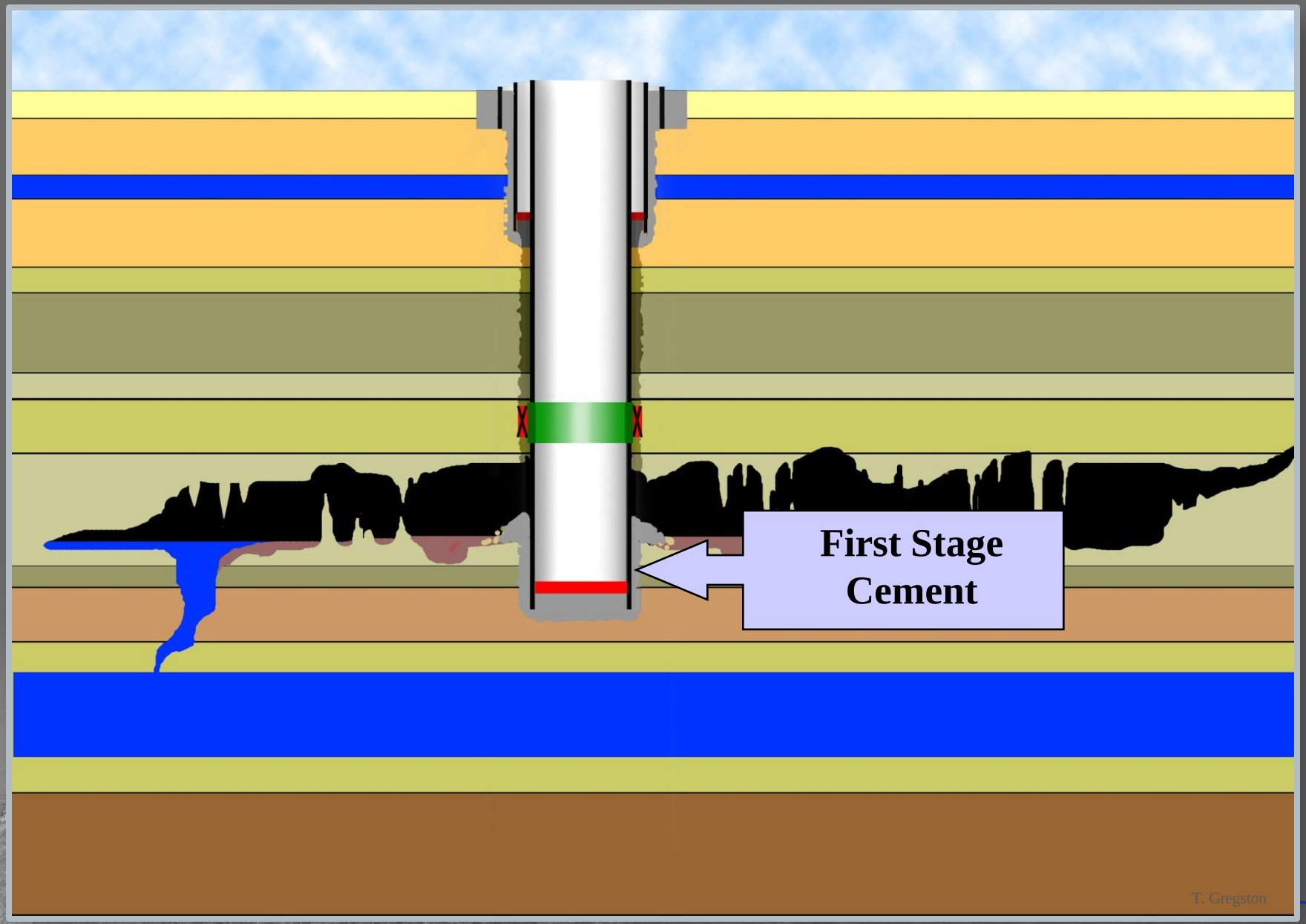

Intermediate
Hole
T. Gregston

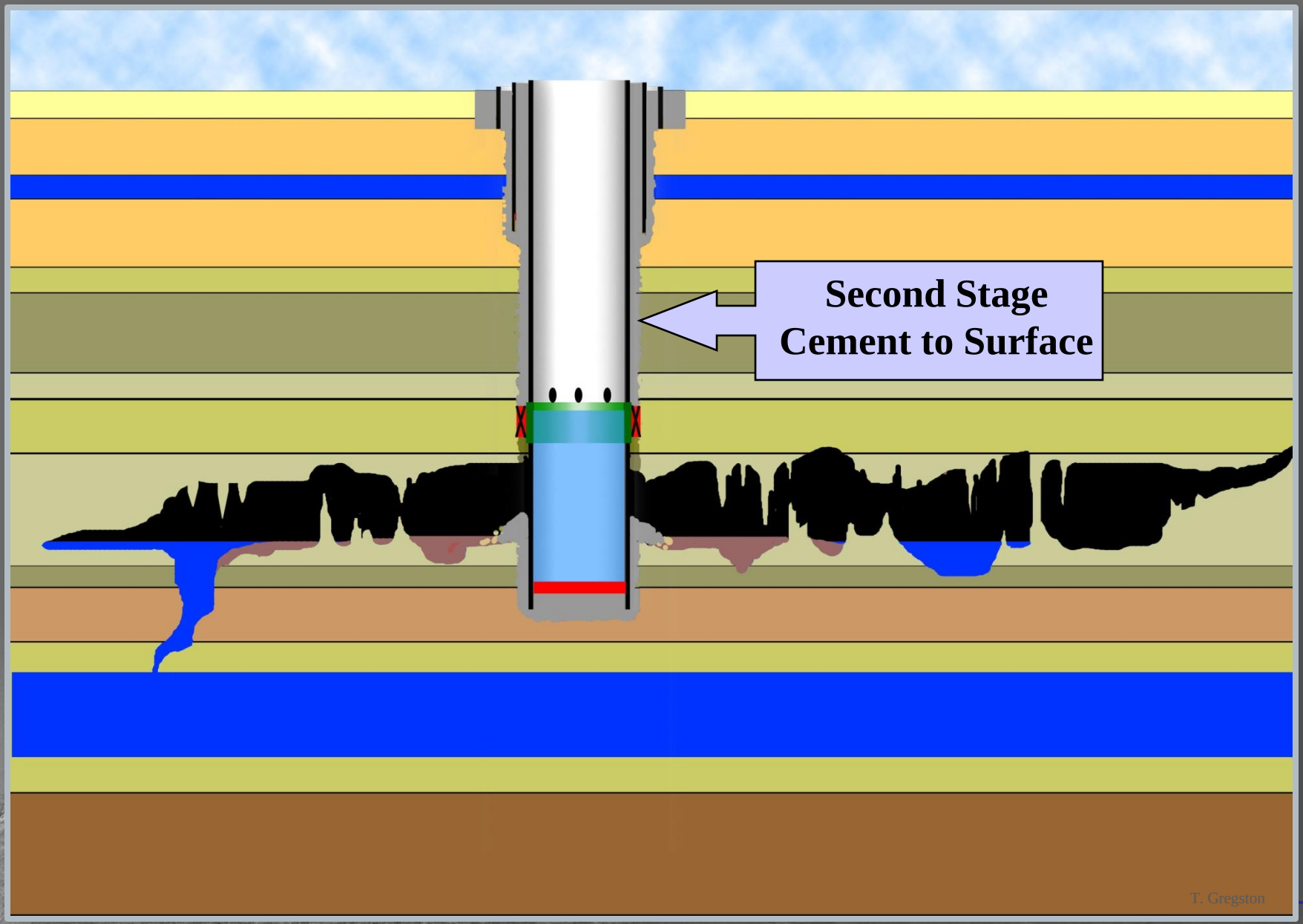

T. Gregston

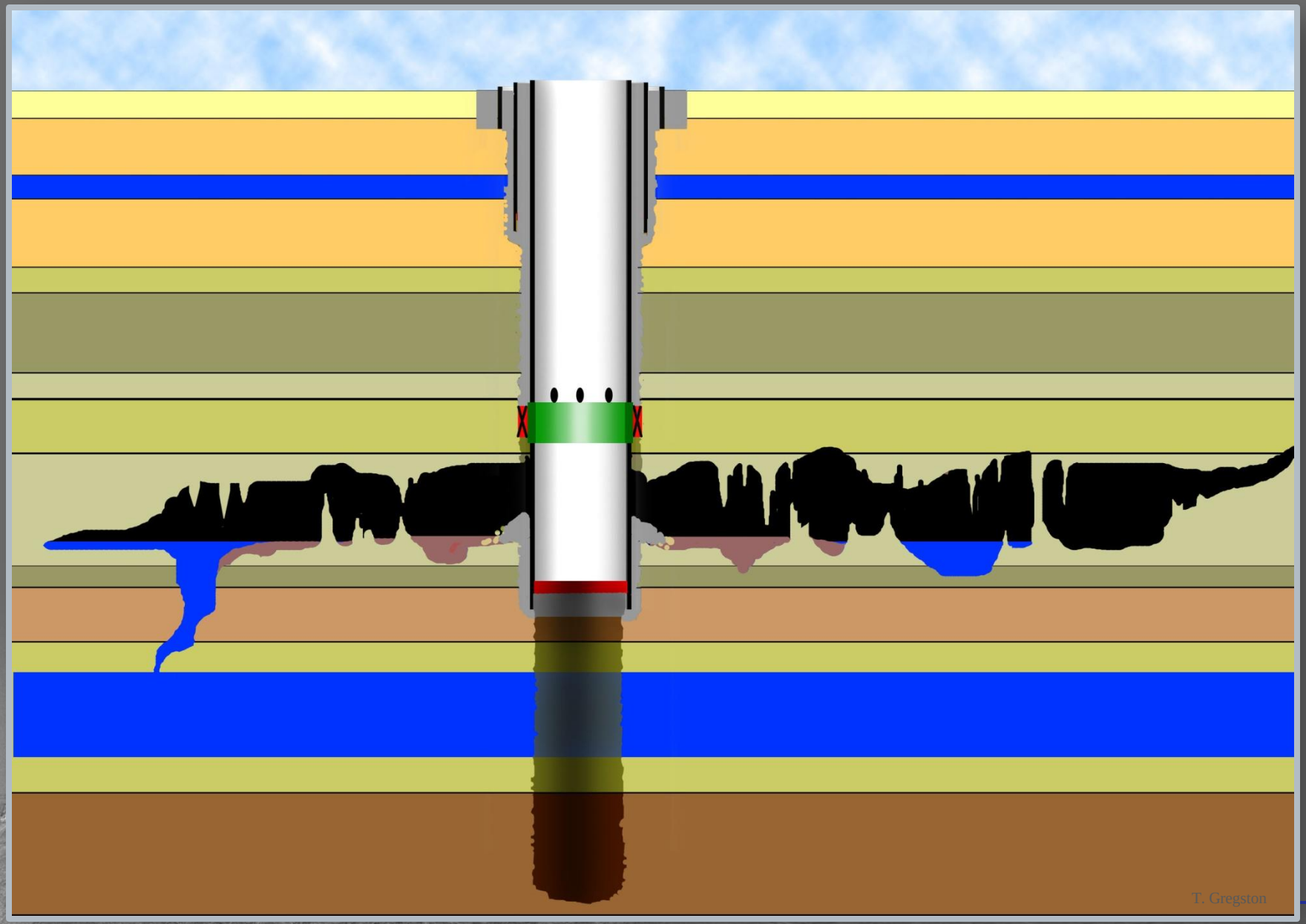

Ooops!
Call BLM!
T. Gregston

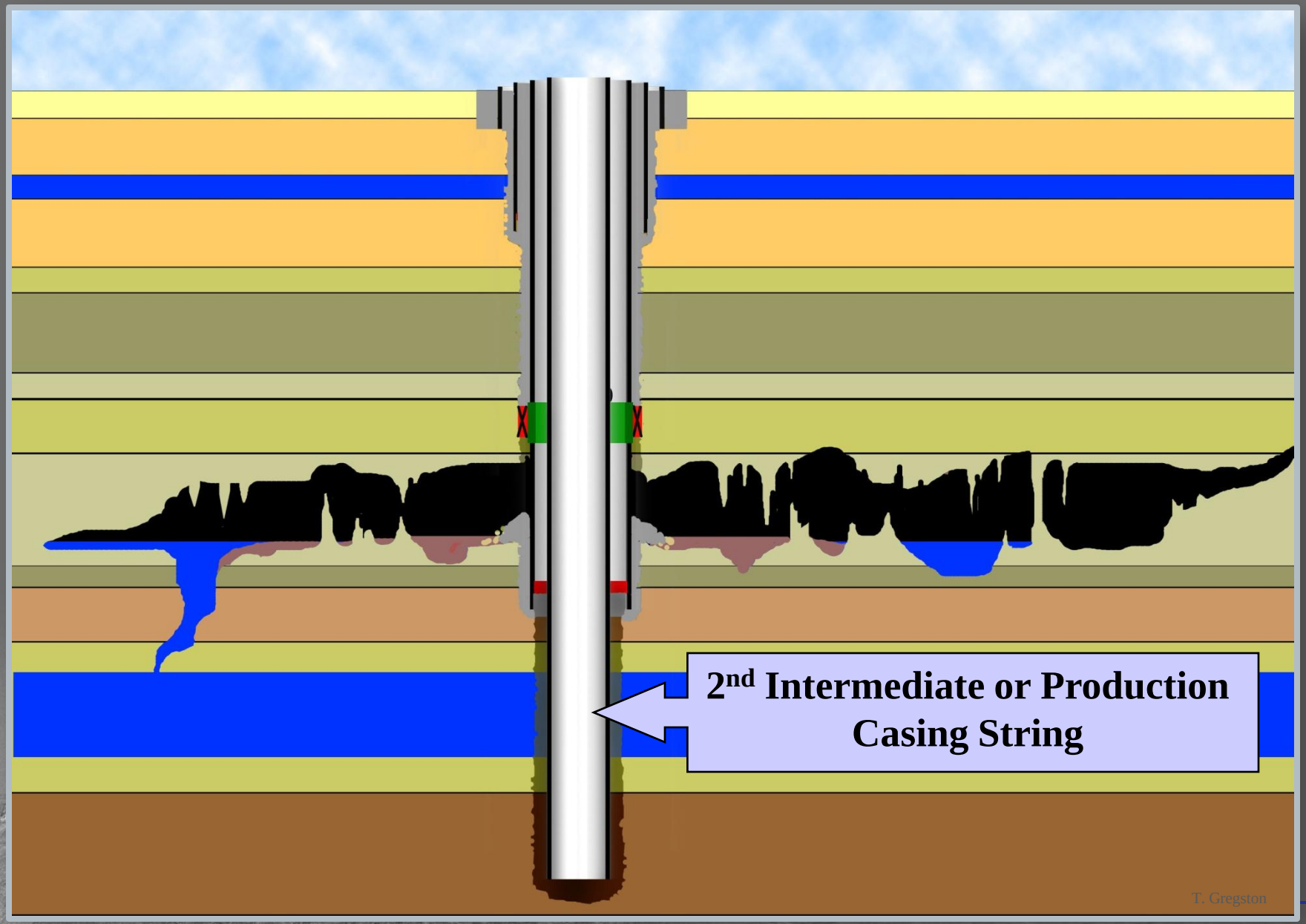

T. Gregston

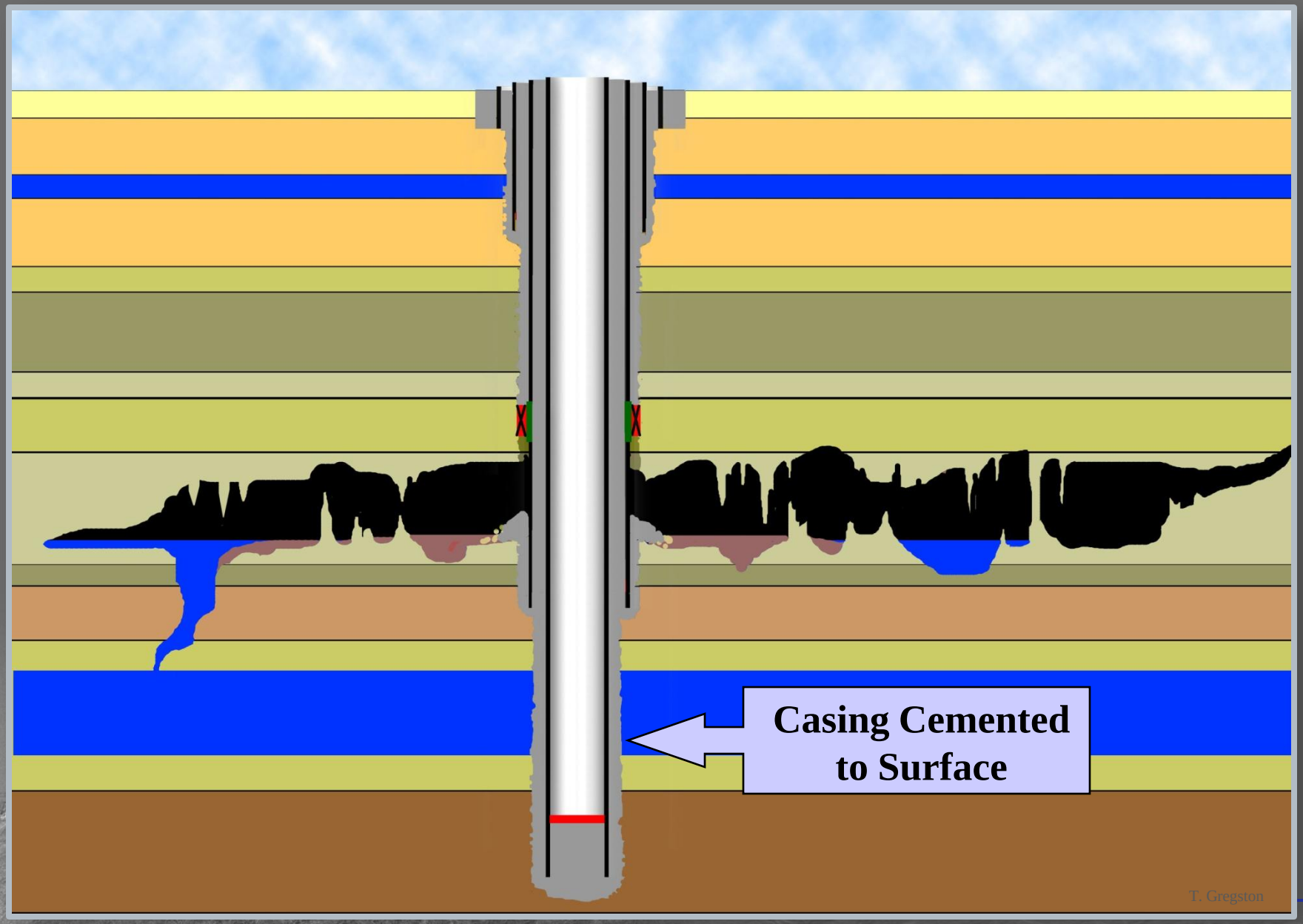

Intermediate
Casing String
DV Tool and
External Packer
T. Gregston

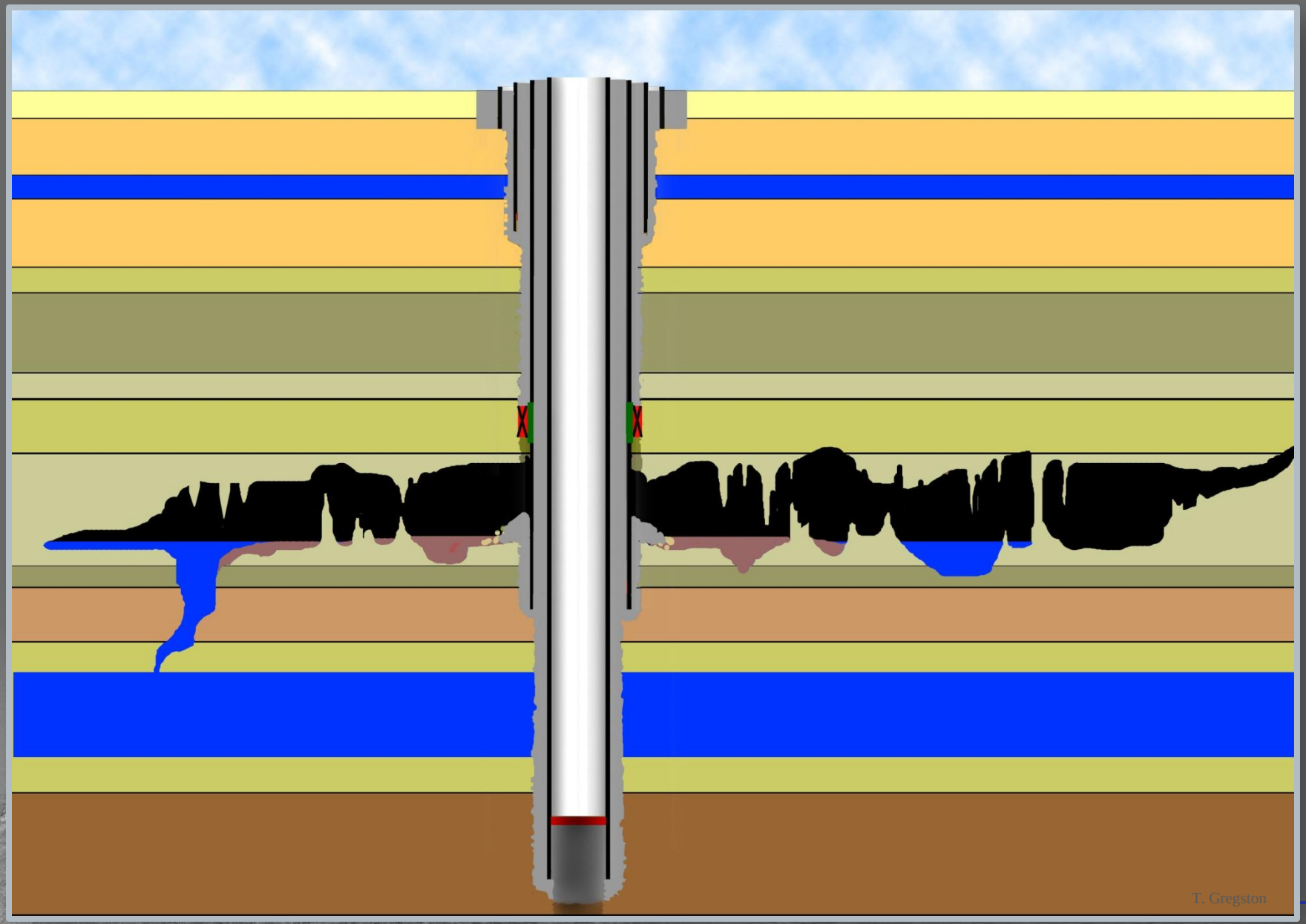

First Stage
Cement
T. Gregston

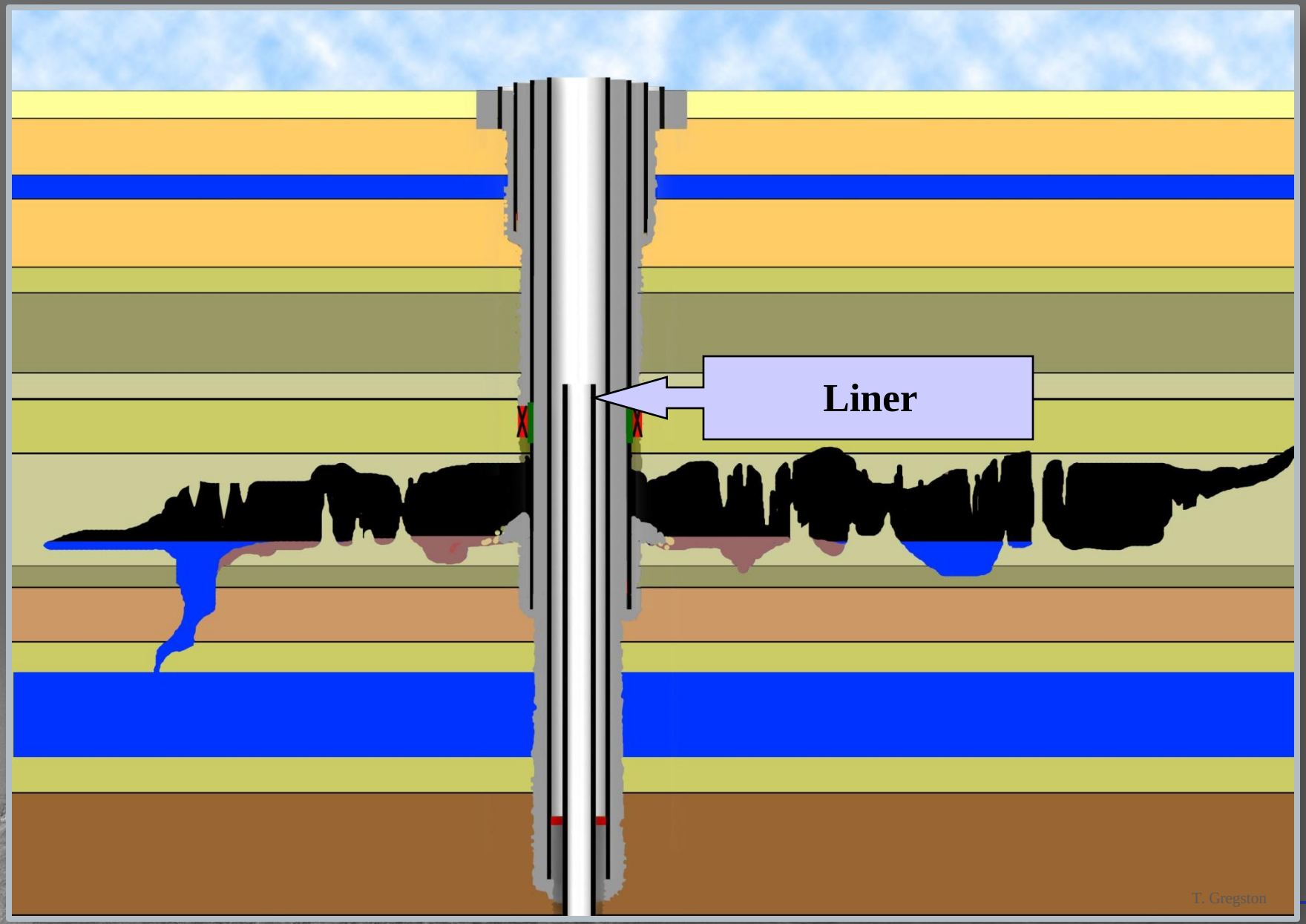

Second Stage
Cement to Surface
T. Gregston

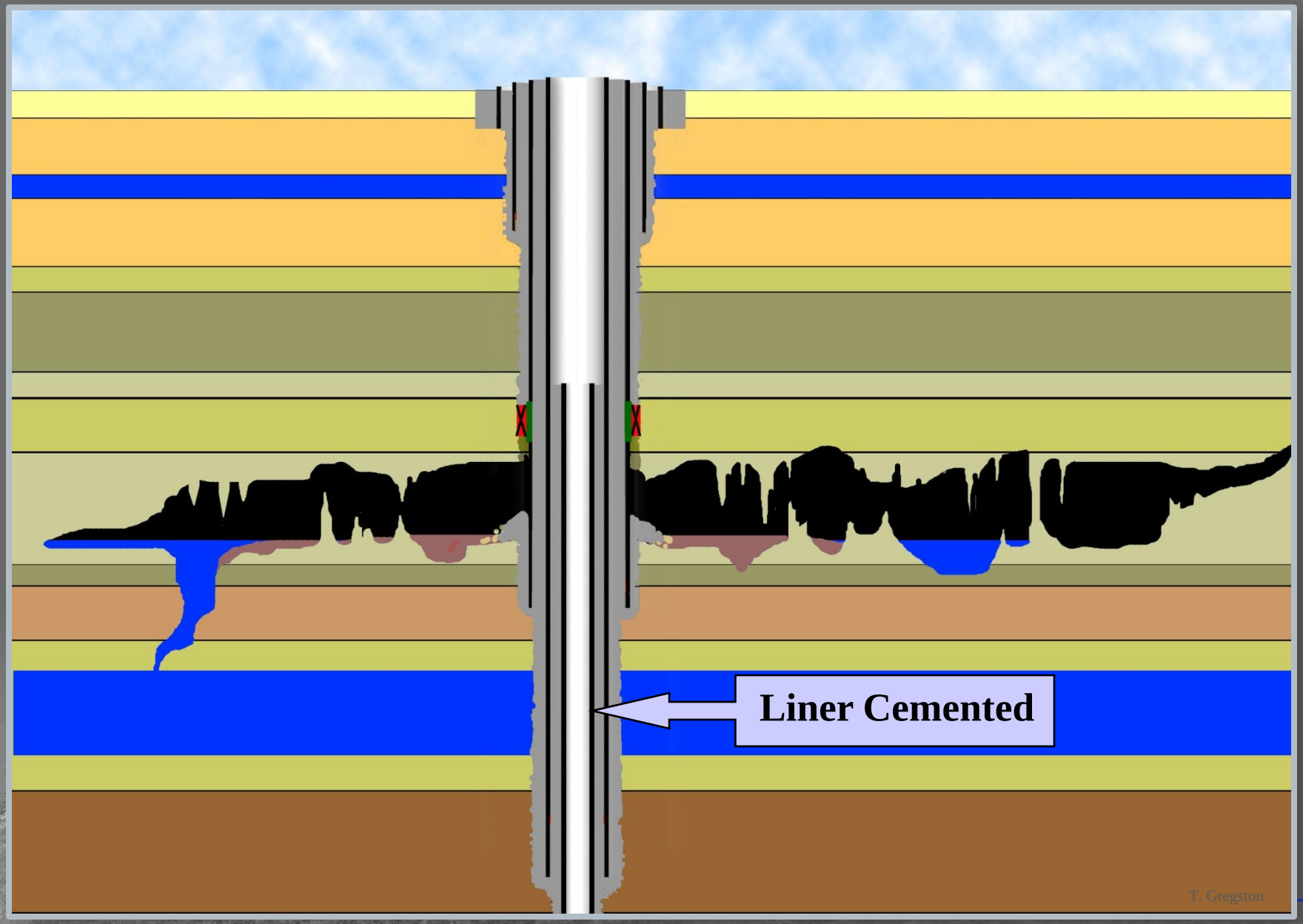

T. Gregston

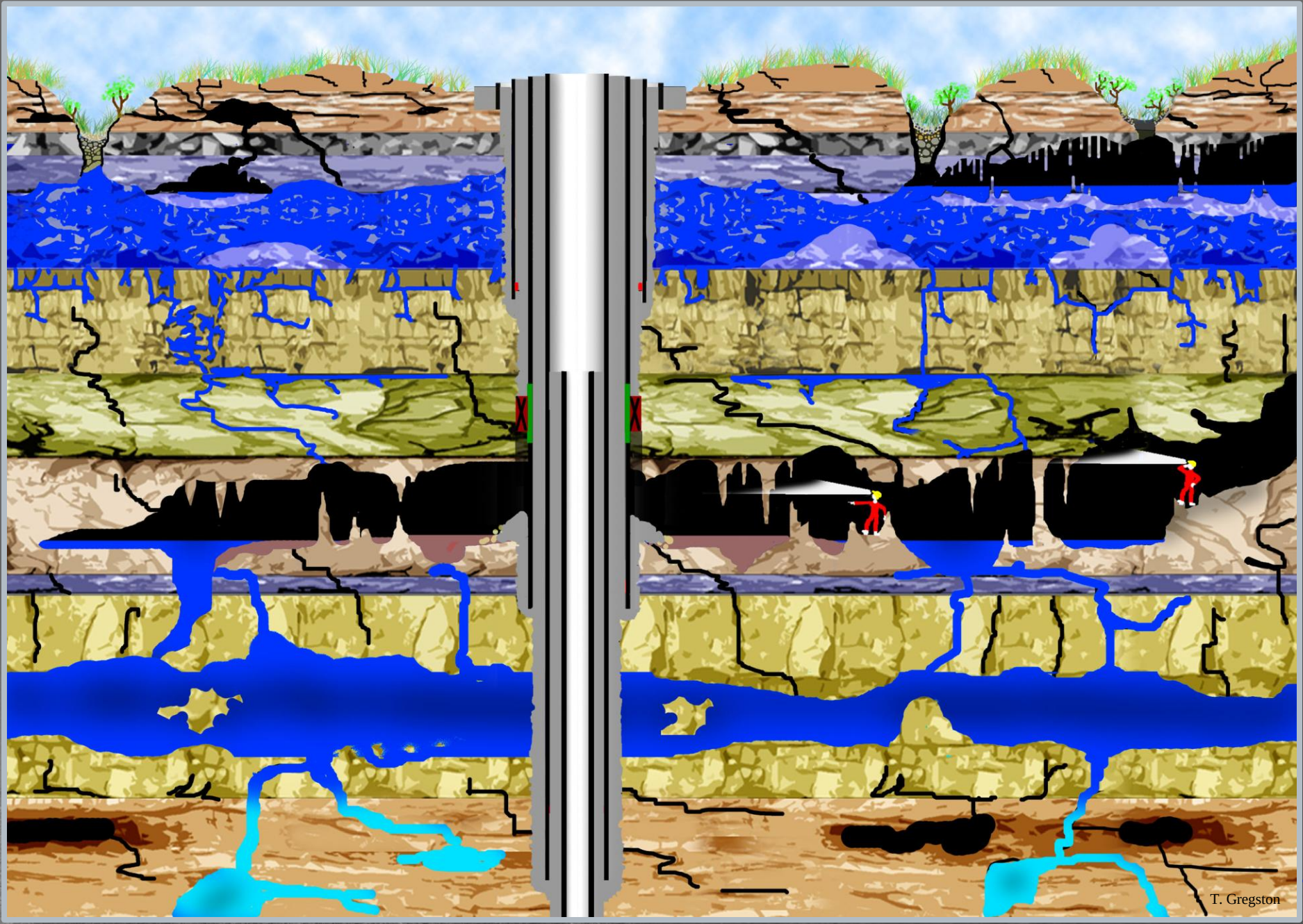

2nd Intermediate or Production Casing String
T. Gregston


Casing Cemented
to Surface
T. Gregston


T. Gregston


Liner
T. Gregston


Liner Cemented
T. Gregston


T. Gregston

Abandonment

- Plugging

Abandonment

- Reclamation

Monitoring

- Pressure tests

Monitoring

- Dye tracing

Monitoring

- Dye tracing

CRAWFORD HYDROLOGY LAB * CENTER FOR CAVE AND KARST STUDIES

Western Kentucky University

* *Hydrogeologists, Geologists, Environmental Scientists* * *Karst Geophysical Subsurface Investigations*

* *Karst Groundwater Investigations* * *Fluorescent Dye Analysis*

Bowling Green, KY 42101
(270) 745-9224
E-mail: caveandkarst@wku.edu

LABORATORY REPORT SHEET

FLUORIMETRIC ANALYSIS RESULTS

Bureau of Land Management

Analysis requested by:

Jim Goodbar

TINOPAL CBS-X	FLUORESCEIN	EOSINE	FD&C Red #3	RHODAMINE WT	SULPHORHODAMINE B
Fabric Brightening Agent 351	**Color Index:** Acid Yellow 73	**Color Index:** Acid Red 87	**Color Index:** Food Red 14	**Color Index:** Acid Red 388	**Color Index:** Acid Red 52
Dye Receptor: Activated Charcoal	**Dye Receptor:** Activated Charcoal	**Dye Receptor:** Activated Charcoal	**Dye Receptor:** Activated Charcoal	**Dye Receptor:** Activated Charcoal	**Dye Receptor:** Activated Charcoal
Analysis by: Spectrofluorophotometer	**Analysis by:** Spectrofluorophotometer	**Analysis by:** Spectrofluorophotometer	**Analysis by:** Spectrofluorophotometer	**Analysis by:** Spectrofluorophotometer	**Analysis by:** Spectrofluorophotometer

CHARCOAL SAMPLES

Code Number	Event	Date Collected	Feature Name	Peakfit	Comment	TINOPAL CBS-X Results	TINOPAL CBS-X Conc in ppb	FLUORESCEIN Results	FLUORESCEIN Conc in ppb	Eosine Results	Eosine Conc in ppb	FD&C RED #3 Results	FD&C RED #3 Conc in ppb	RHODAMINE WT Results	RHODAMINE WT Conc in ppb	SULPHORHODAMINE B Results	SULPHORHODAMINE B Conc in ppb
1			QA-ELUENT					ND		ND				ND			
2			QA-FLUORESCEIN						0.005	ND				ND			
3			QA-EOSINE OJ					ND			0.006			ND			
4			QA-RHODAMINE WT					ND		ND					0.005		
EL-001-0	02		Carlsbad Monitoring Well #1					ND		+?	0.563			ND			
EL-002-0	02		Jurnigan Spring #1					B	0.052	B	0.044			B	0.016		
EL-003-0	02		Able East Stock Tank #1					ND		+	1.160			ND			
EL-004-0	02		Blue Spring #4					B	0.068	ND				B	0.049		
EL-006-0	02		Black River (Beard) BRB-3					ND		ND				B	0.054		
1			QA-ELUENT					ND		ND				ND			
2			QA-FLUORESCEIN						0.005	ND				ND			
3			QA-EOSINE OJ					ND			0.006			ND			
4			QA-RHODAMINE WT					ND		ND					0.005		

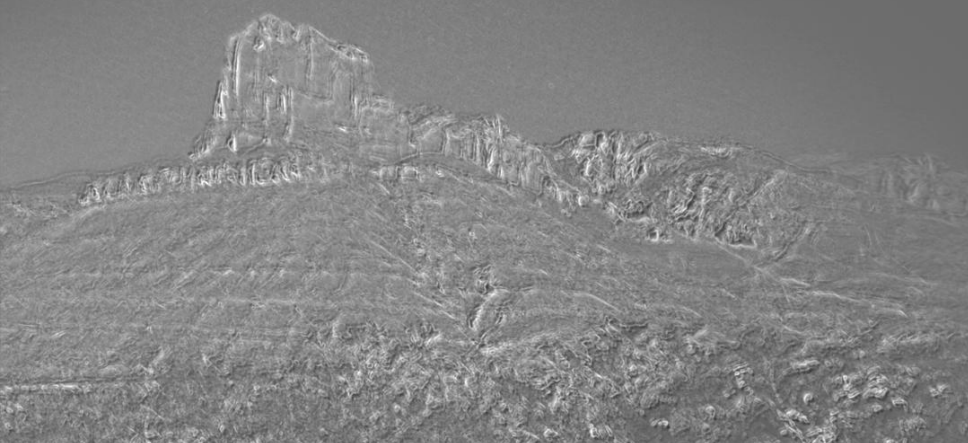
Analyzed by: Chad Martin on 11/8/2006

Comments: Eosine OJ,RWT,FL analysis

GS = Grab Sample

We have covered:

- Cave and karst terminology
- Cave and karst resources
- Impacts of drilling and production activities in karst areas
- BLM Best Management Practices:
  - Detection
  - Avoidance
  - Mitigation



Questions