HYPOGENIC KARST OF THE GREAT BASIN

A Virtual Field Trip for the GSA Cordilleran Section Meeting

10 May 2021

Louise D. Hose (UNR), Harvey R. DuChene (KWI), Daniel Jones (NMT & NCKRI), Gretchen Baker (NPS), Zoë Havlena (NMT), Donald Sweetkind (USGS), and Doug Powell (USFS)

INTRODUCTION

Introduction	0900 PDT: Louise Hose
Stop 1 – Cueva de Villa Luz	0910 PDT
Stop 2 – Frasassi Caves	0935 PDT
Stop 3 – Carlsbad Cavern	1000 PDT
Stop 4 – Lechuguilla Cave	1020 PDT
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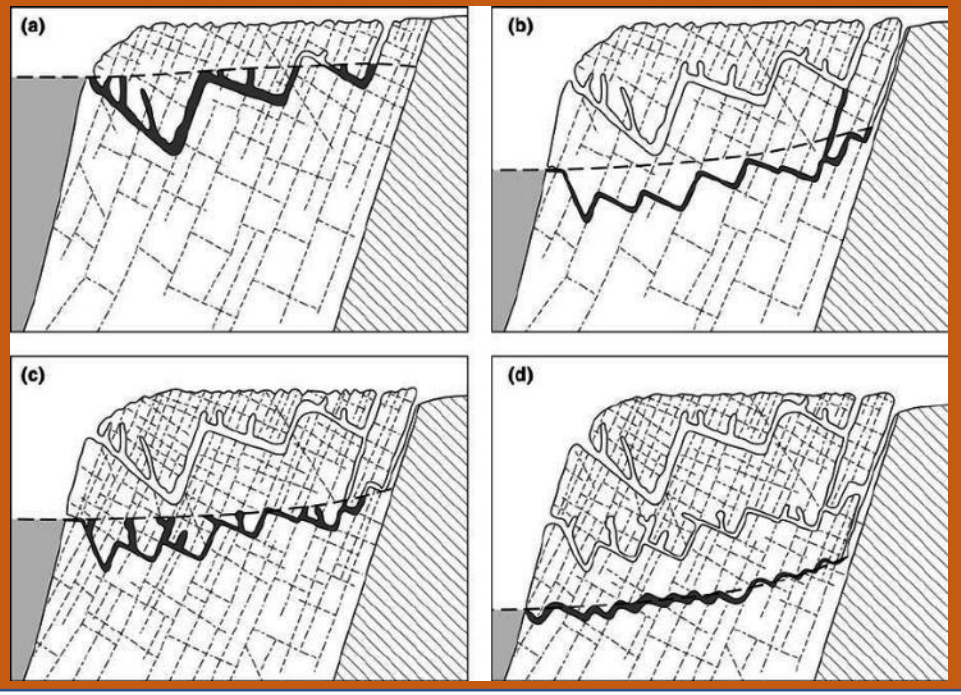
Stop 8 – Crystal Ball Cave	1305 PDT
Stop 9 - Pescio Cave	1315 PDT
Stop 10 – Discovery Cave	1325 PDT
Stop 11 – Old Mans Cave	1335 PDT
Summary and questions	1345 PDT

- Many (but certainly not all) eastern Nevada caves do NOT fit the "traditional" models of cave formation (speleogenesis)
  - Long understood to have formed under phreatic conditions



INTRODUCTION

- In the 1970s, speleologists began to understand the role of hypogenic (rising) groundwater flow along with sulfidic water.
  - Deep-seated artesian flow (e.g., J. Quinlan—Bottomless Lakes –cenotes, NM).
  - Also earlier workers proposed a role for sulfuric acid (e.g., S. Egemeier—Kane Caves, WY, & Carlsbad Cavern, NM).
  - Mostly viewed as real processes but isolated cases.

INTRODUCTION

- Mid-1980s: Discovery of Lechuguilla Cave, NM (paleo-sulfidic cave)
  - Spectacular and abundant gypsum deposits
  - Elemental sulfur deposits

INTRODUCTION

- Mid-1980s: Discovery of Cueva de Villa Luz (active, sulfidic cave), Mexico

INTRODUCTION

- Mid-1980s: Discovery of Frasassi caves (active and paleo-sulfidic caves), Italy.

INTRODUCTION

- What all these caves have in common during their active phases included:
  - Thermal, sulfidic waters rose from depth
  - Waters released H_2S and/or SO_2 as well as H_2O vapor at the top of the groundwater table. Probably also released CO_2.
  - Water vapor is/was warmer than bedrock, causing condensation.
    - Condensate absorbs the gases, forming H_2SO_4 (and probably H_2CO_3).
  - The sulfuric acid reacts with the calcite (limestone) to form gypsum.

INTRODUCTION

$$H_2S + 2O_2 \rightarrow H_2SO_4$$

Sulfuric Acid

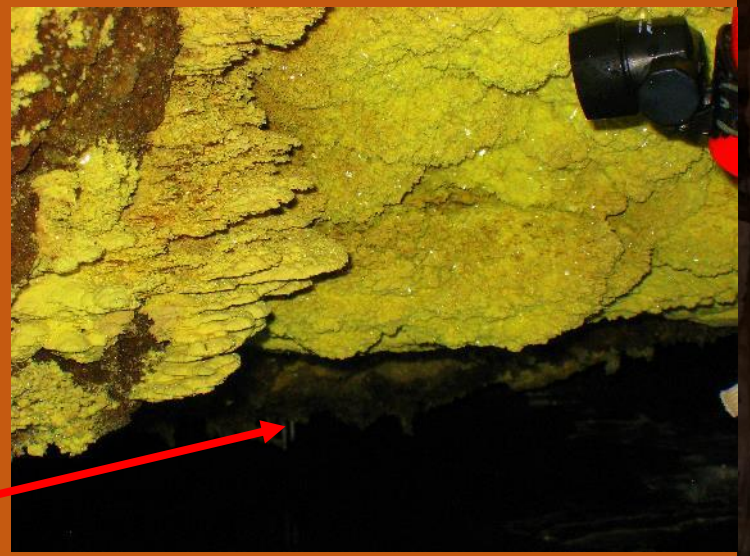
$$H_2SO_4 + CaCO_3 \rightarrow Ca^{2+} + SO_4^{2-} + CO_2 + H_2O \rightarrow CaSO_4 \cdot 2H_2O$$

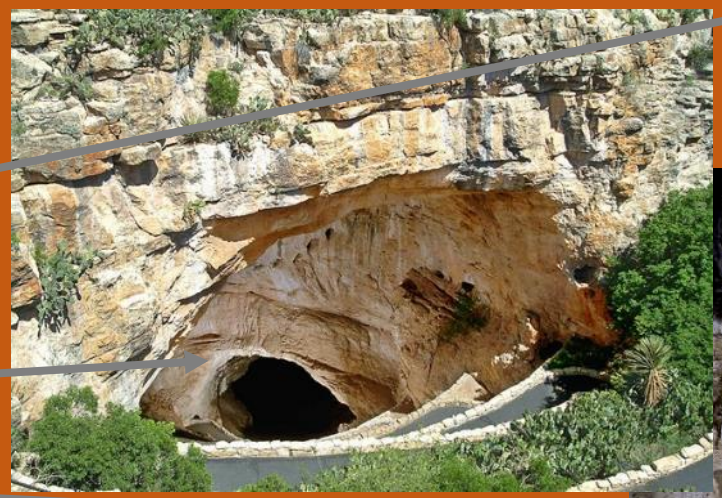
Calcite Gypsum

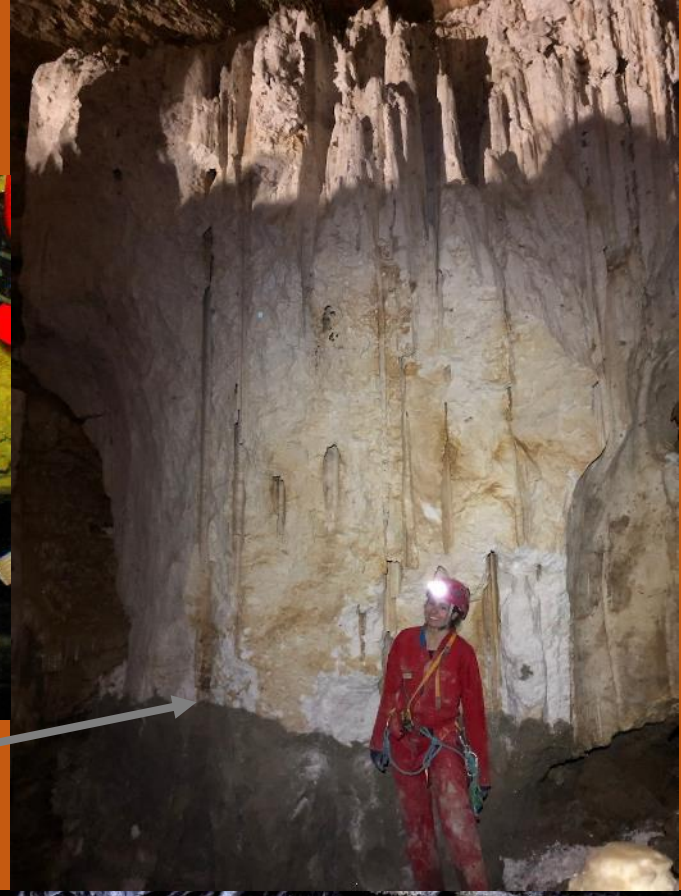
Microbes greatly facilitate these reactions

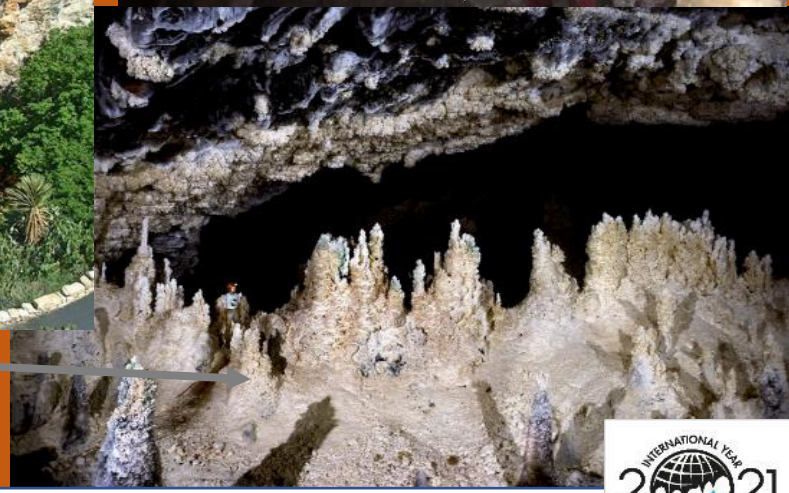
INTRODUCTION

- Field trip is organized in two parts
- Part I – Established, well-studied, hypogenic, sulfidic caves
  - Cueva de Villa Luz, Mexico (active)
  - Frasassi caves, Italy (active & paleo)
  - Carlsbad Cavern & Lechuguilla Cave, NM (paleo)









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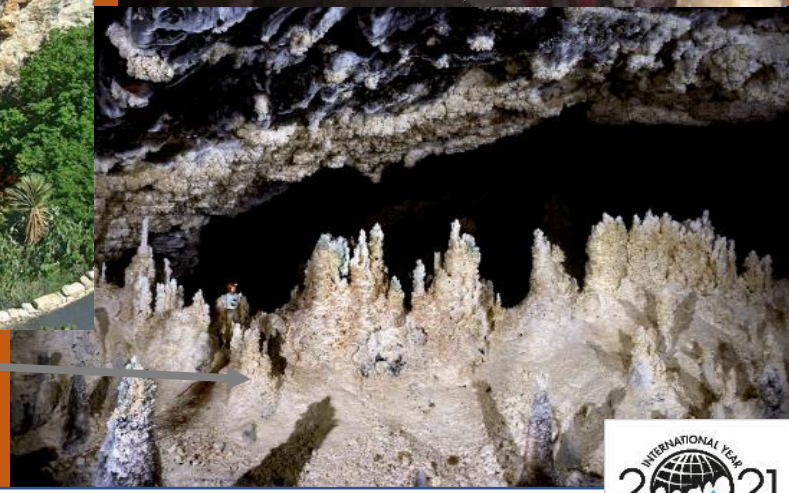

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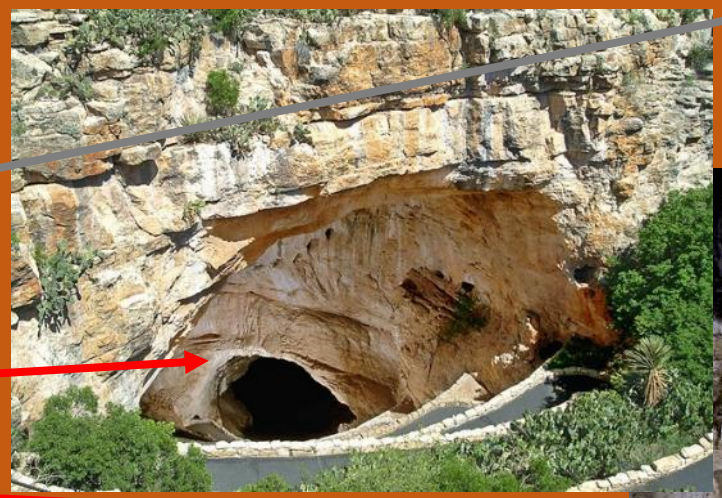
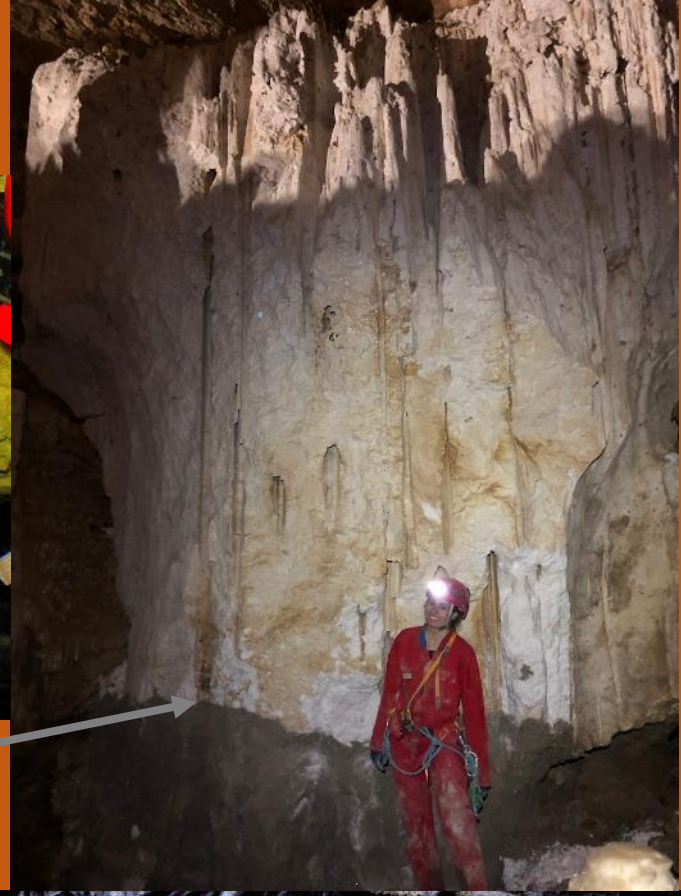
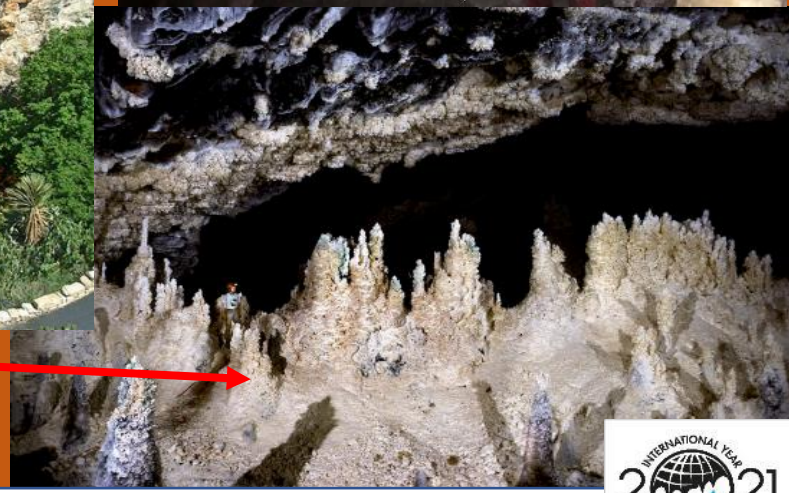
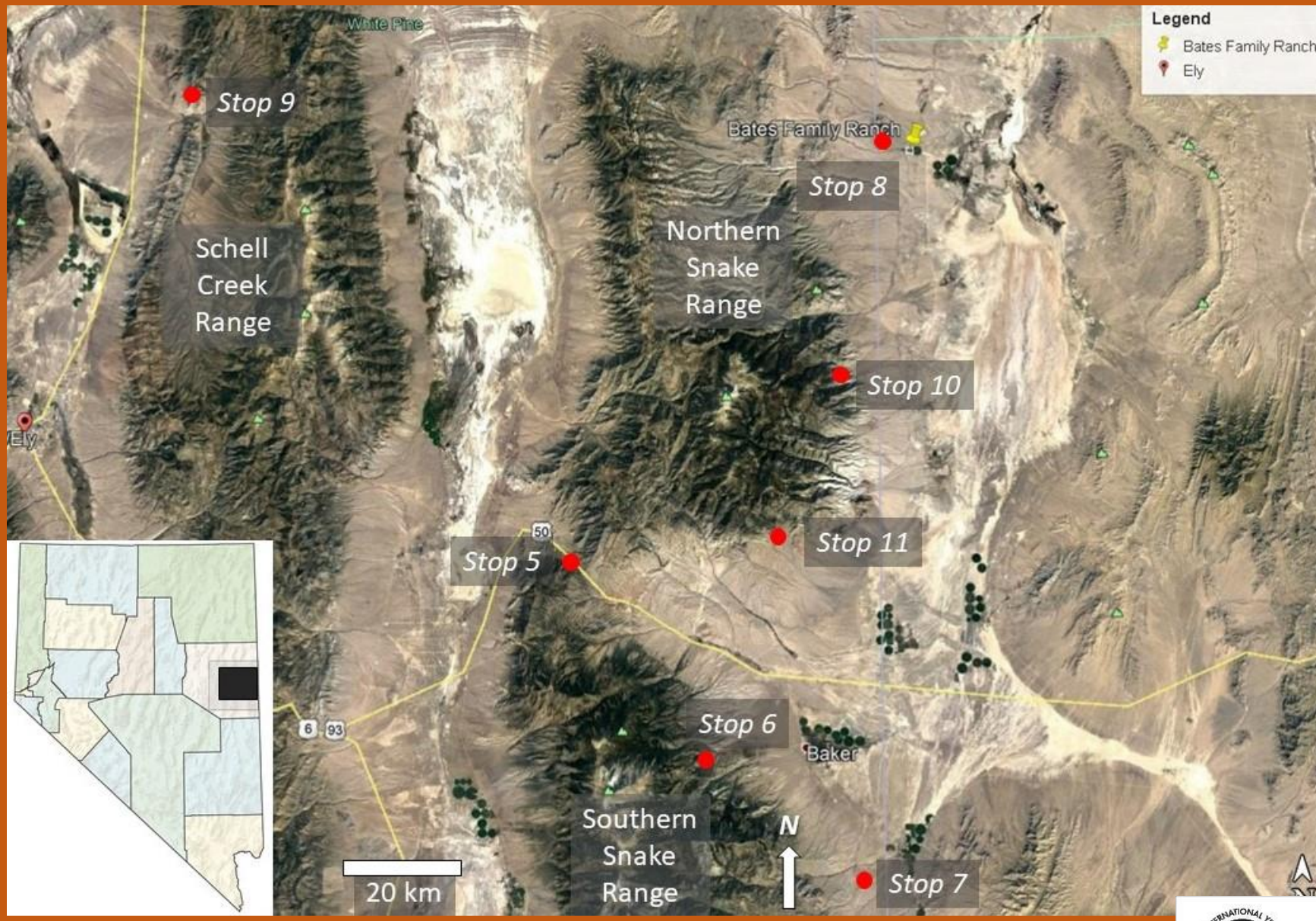






INTRODUCTION

- Part II – A few potential hypogenic, sulfidic caves in the Great Basin
  - Geologic setting – Sacramento Pass
  - Stop 6 – Lehman Caves
  - Stops 7-11 – Other suspected hypogenic, SAS caves



CUEVA DE VILLA LUZ

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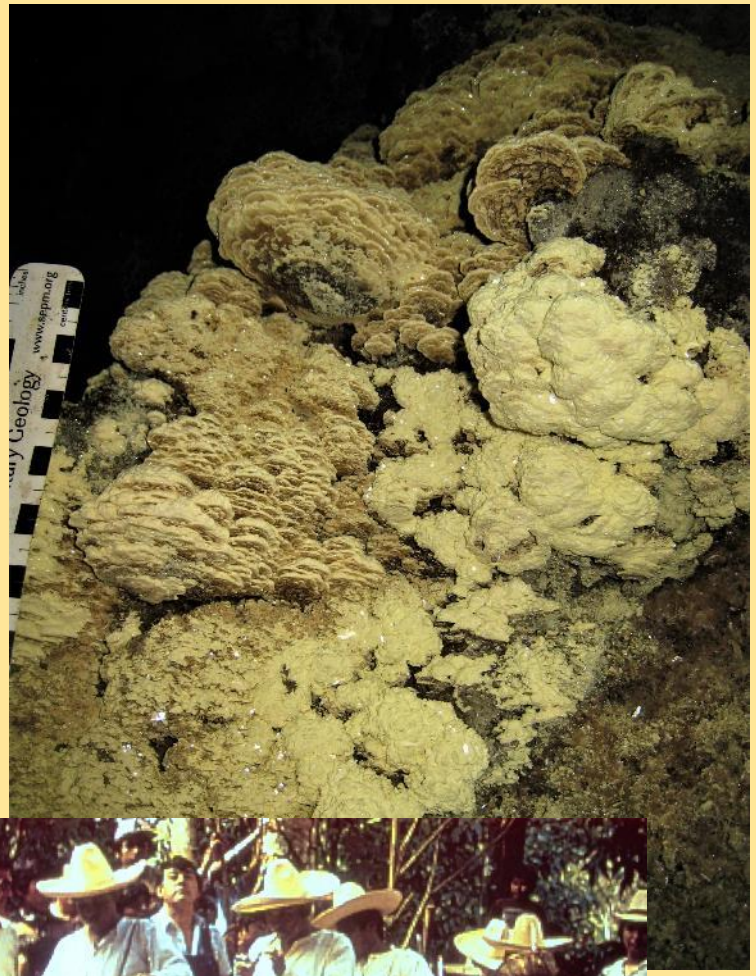
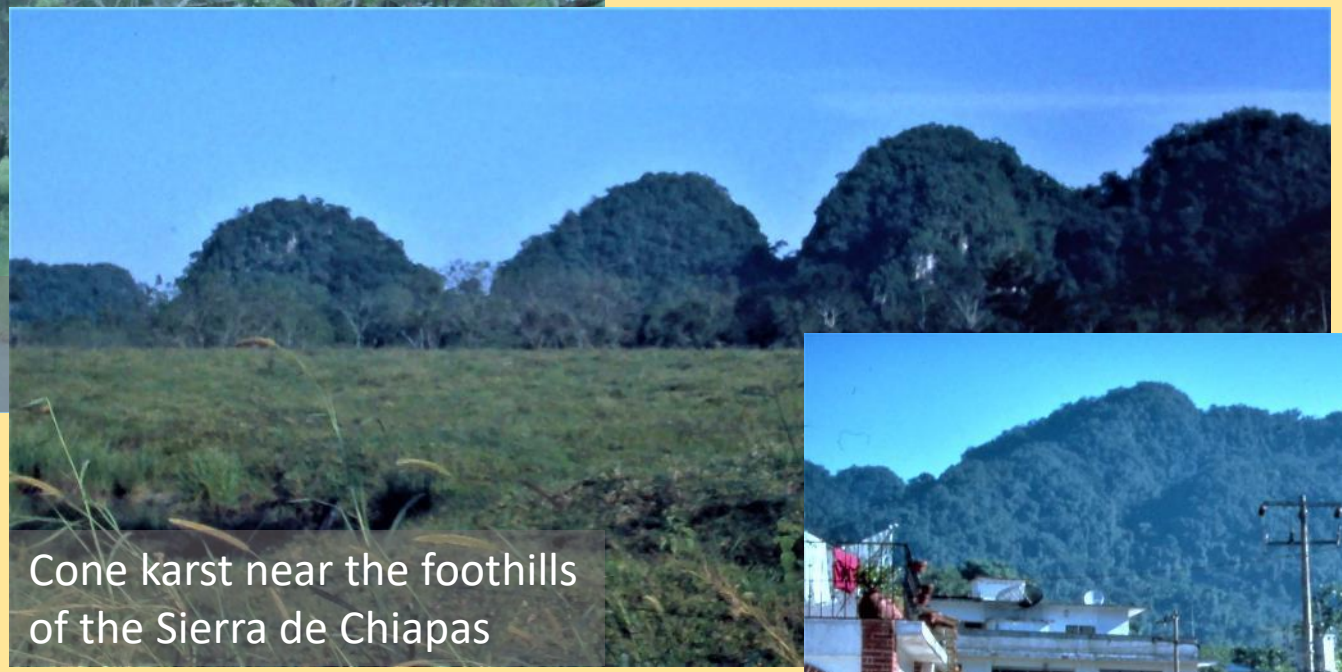


Ritual de la Pesca de la Sardina


of
Mexico
TAMAULIPAS
Ciudad Victoria
Ciudad Mante
Tampico
Ciudad Madero
San Luis Potosí
VERACRUZ-LLAVE
Cueva de Villa Luz
Progreso
Mérida
YUCATAN
Campeche
CHAMPECHE
QUINTANA ROO
Chetumal
Bahía de Campeche
Ciudad del Carmen
Querétaro
Peza Rica
Pachuca
Tulancingo
Jalapa
Veracruz
Mexico
Toluca
Cuernavaca
Puebla
Orizaba
Córdoba
TABASCO
Villahermosa
Coatzacoalcos
Minatitlán
Belize City
Belmopan
BELIZE
Tuxtla Gutiérrez
San Cristóbal de Las Casas
Chilpancingo
GUERRERO
Acapulco
Oaxaca
OAXACA
Inter-American Highway
Salina Cruz
Golfo de Tehuantepec
CHIAPAS
Puerto Barrios
GUATEMALA
HONDURAS

Living fence along the road from Villahermosa to Tapijulapa



Cone karst near the foothills of the Sierra de Chiapas

Village of Tapijulapa

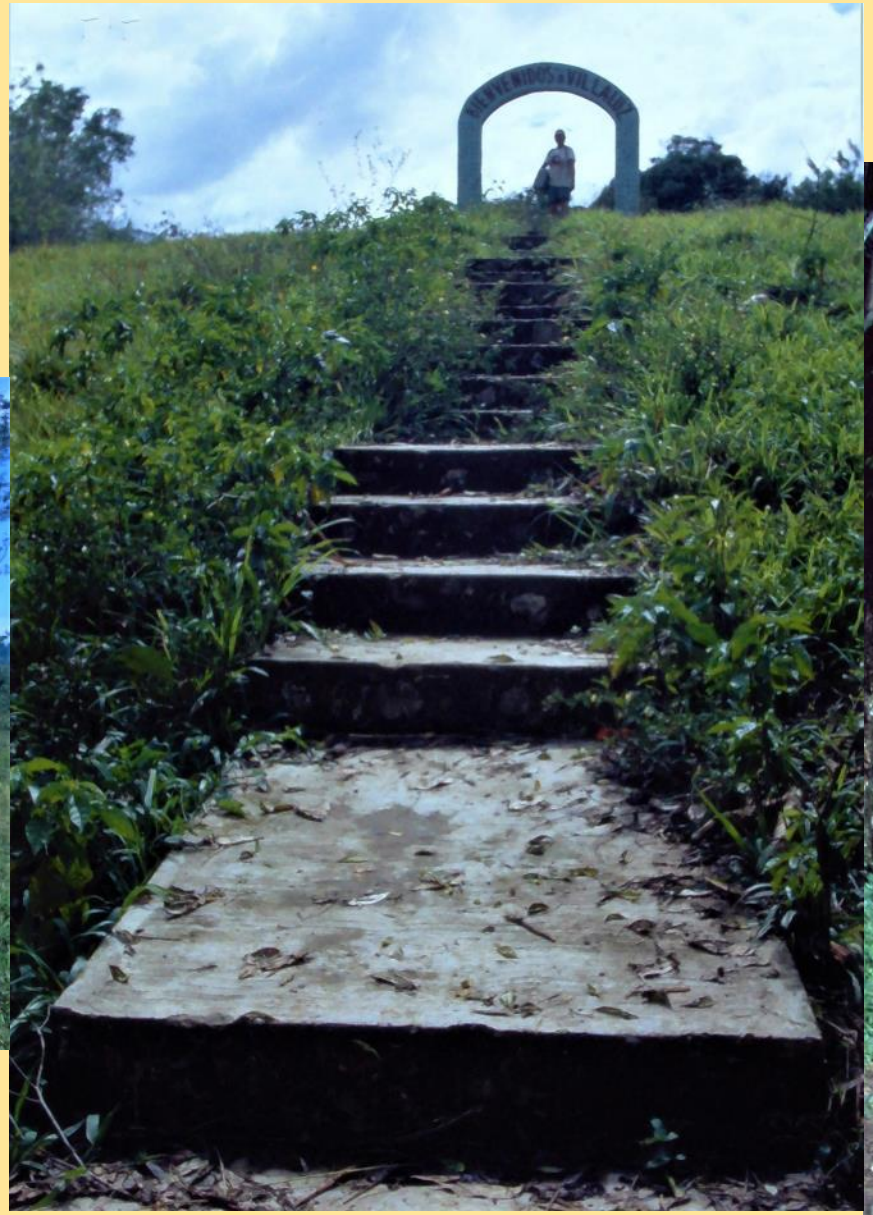
Rio Oxolotan

Rio Amatan

Boat Launch in Tapijulapa

Riding upstream on the Rio Oxolotan

Through pastureland (Rancho Villa Luz), up the stairs, and into Parque Villa Luz.



Sulfur- and gypsum-rich streams along the trail come out of Cueva de Villa Luz and sulfide-rich, surface springs.

Cueva de Villa Luz resurgence

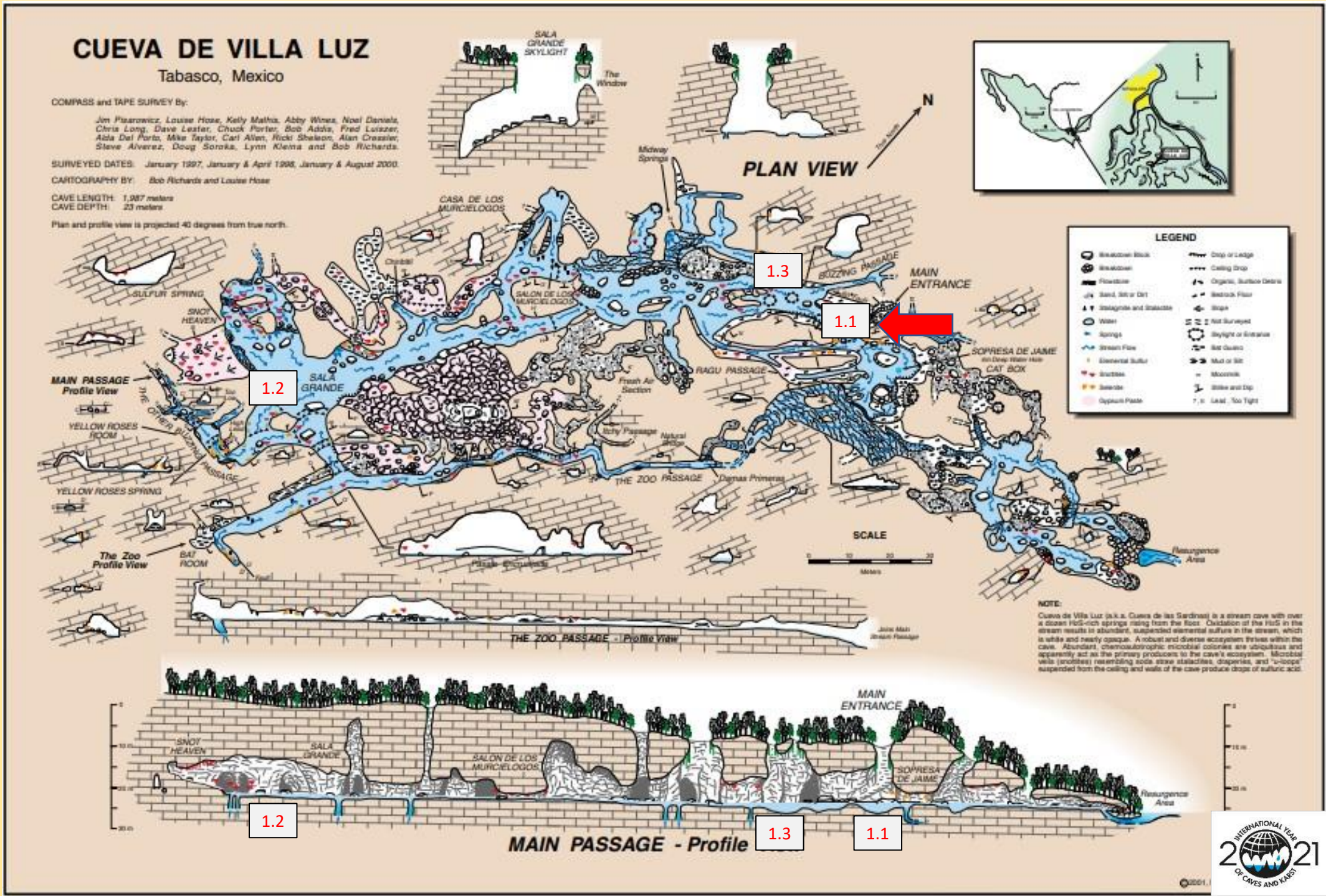
Stop 1.1

While we appreciate the geologic, hydrologic, and biological importance of the cave, the indigenous people have viewed the cave as a special, spiritual place. The tradition is honored every Palm Sunday with hundreds of participants.

Main entrance to Cueva de Villa Luz

La Pesca de las Sardinas dress rehearsal.

Stop 1.1


CUEVA DE VILLA LUZ
Tabasco, Mexico
COMPASS and TAPE SURVEY By:
Jim Pisarowicz, Louise Hose, Kelly Mathis, Abby Wines, Noel Daniels, Chris Long, Dave Lester, Chuck Porter, Bob Addis, Fred Luiszer, Aida Del Porto, Mike Taylor, Carl Allen, Ricki Sheleon, Alan Cressler, Steve Alverez, Doug Soroka, Lynn Kleina and Bob Richards.
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Plan and profile view is projected 40 degrees from true north.
SALA GRANDE SKYLIGHT
The Window
Midway Springs
PLAN VIEW
N
CASA DE LOS MURCIELOGOS
SULFUR SPRING
SNOT HEAVEN
SALON DE LOS MURCIELOGOS
BUZZING PASSAGE
MAIN ENTRANCE
1.3
1.1
1.2
MAIN PASSAGE Profile View
SALA GRANDE
Fresh Air Section
RAGU PASSAGE
SOPRESA DE JAIME
CAT BOX
YELLOW ROSES ROOM
YELLOW ROSES SPRING
Itchy Passage
Natural Bridge
THE ZOO PASSAGE
Damas Primeras
The Zoo Profile View
BAT ROOM
SCALE
Resurgence Area
LEGEND
THE ZOO PASSAGE - Profile View
NOTE:
MAIN ENTRANCE
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SALON DE LOS MURCIELOGOS
SOPRESA DE JAIME
Resurgence Area
1.2
1.3
1.1
MAIN PASSAGE - Profile

Stop 1.1

- H_2S at well-ventilated entrance is typically less than 10 ppm.
- Further in the cave, levels can peak >210 ppm.
- Occasionally, CO_2 can exceed 3%, O_2 has dropped to below 16%, and outgassing of CO.
- The opaque water and sharp rocks easily cut shins.

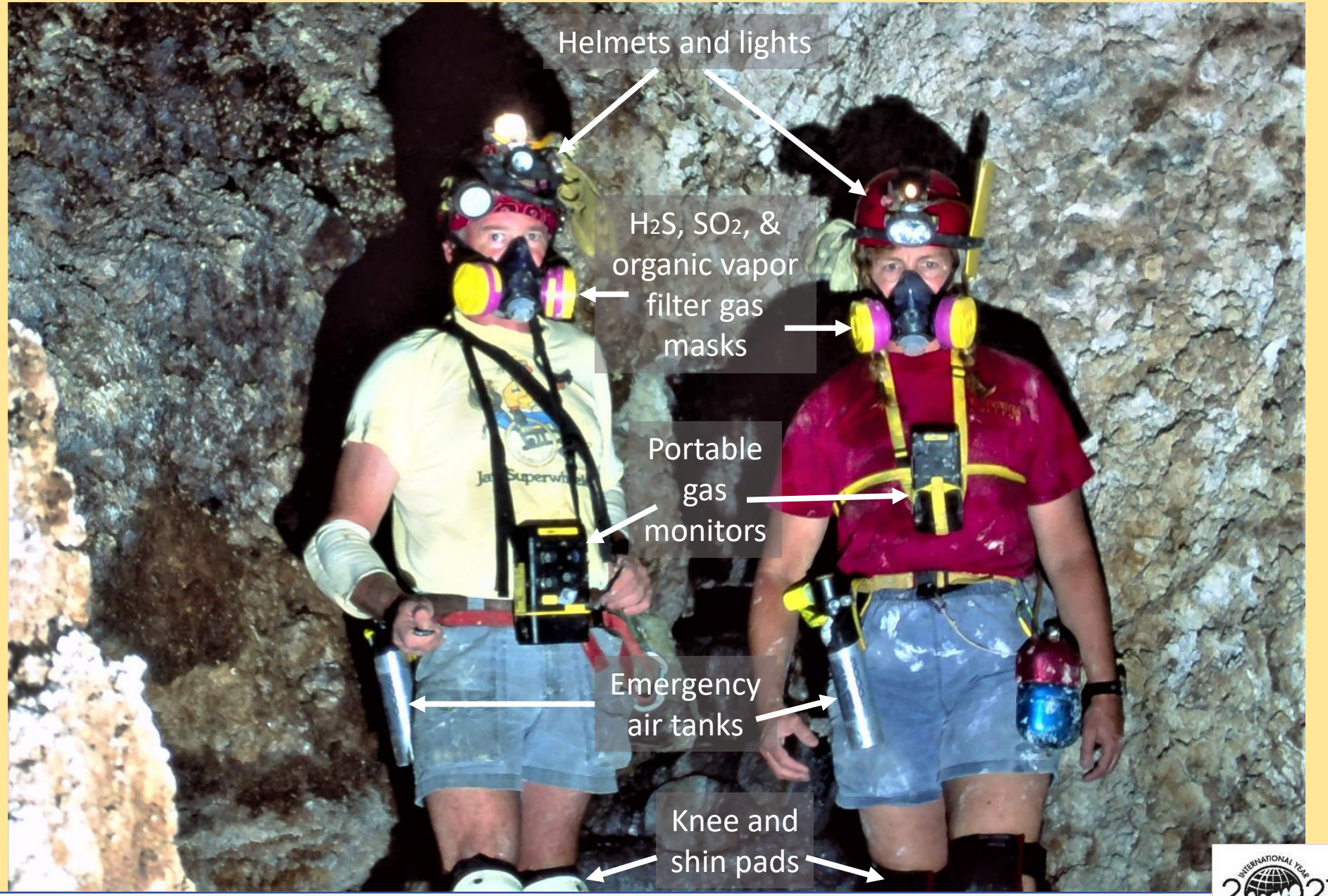


Photo by Stephen Alvarez

Pool near Main Entrance (Stop 1.3)

Crawlway in Main Passage

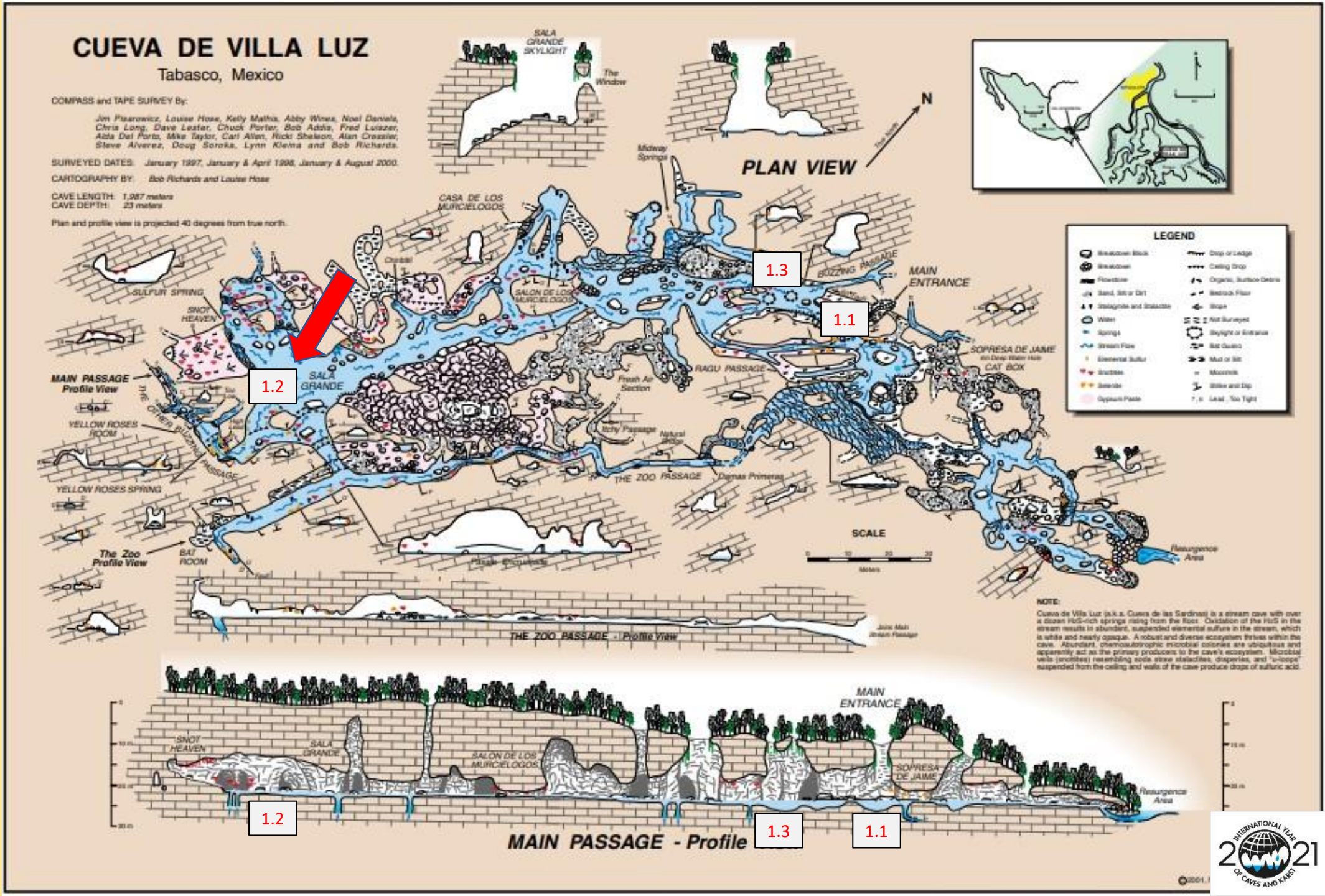
Main passage forms along a minor fault.

The cave has a couple of dozen skylights.

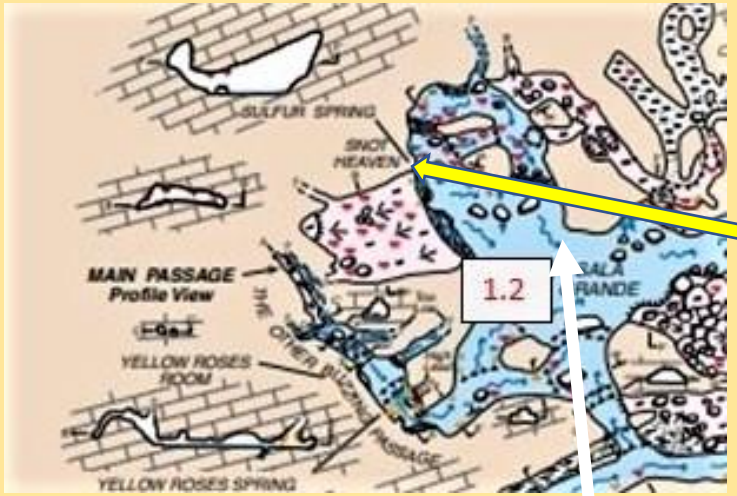
- Helps keep the H_2S and other toxic gases low
- Complicates the complex ecosystem

Stop 1.2

In the large Sala Grande, the lack of skylights and abundance of subterranean springs increases the risk of toxic air and the concentration of bizarre lifeforms.

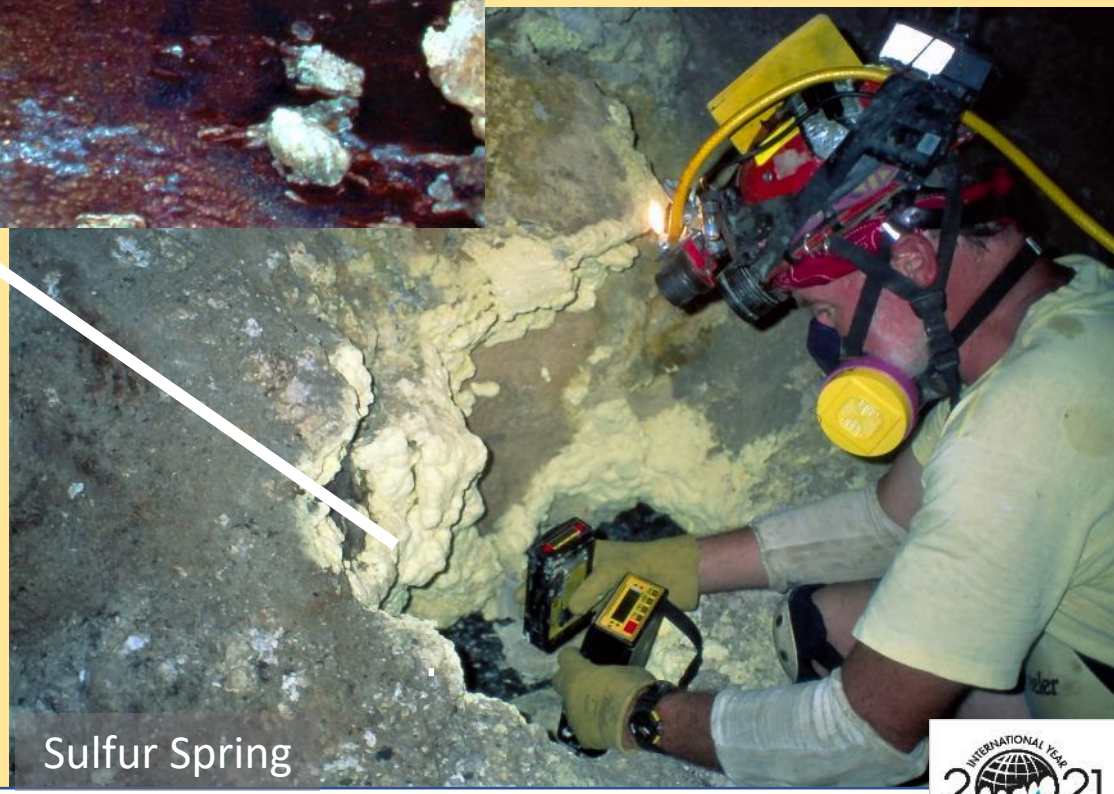


Stop 1.2

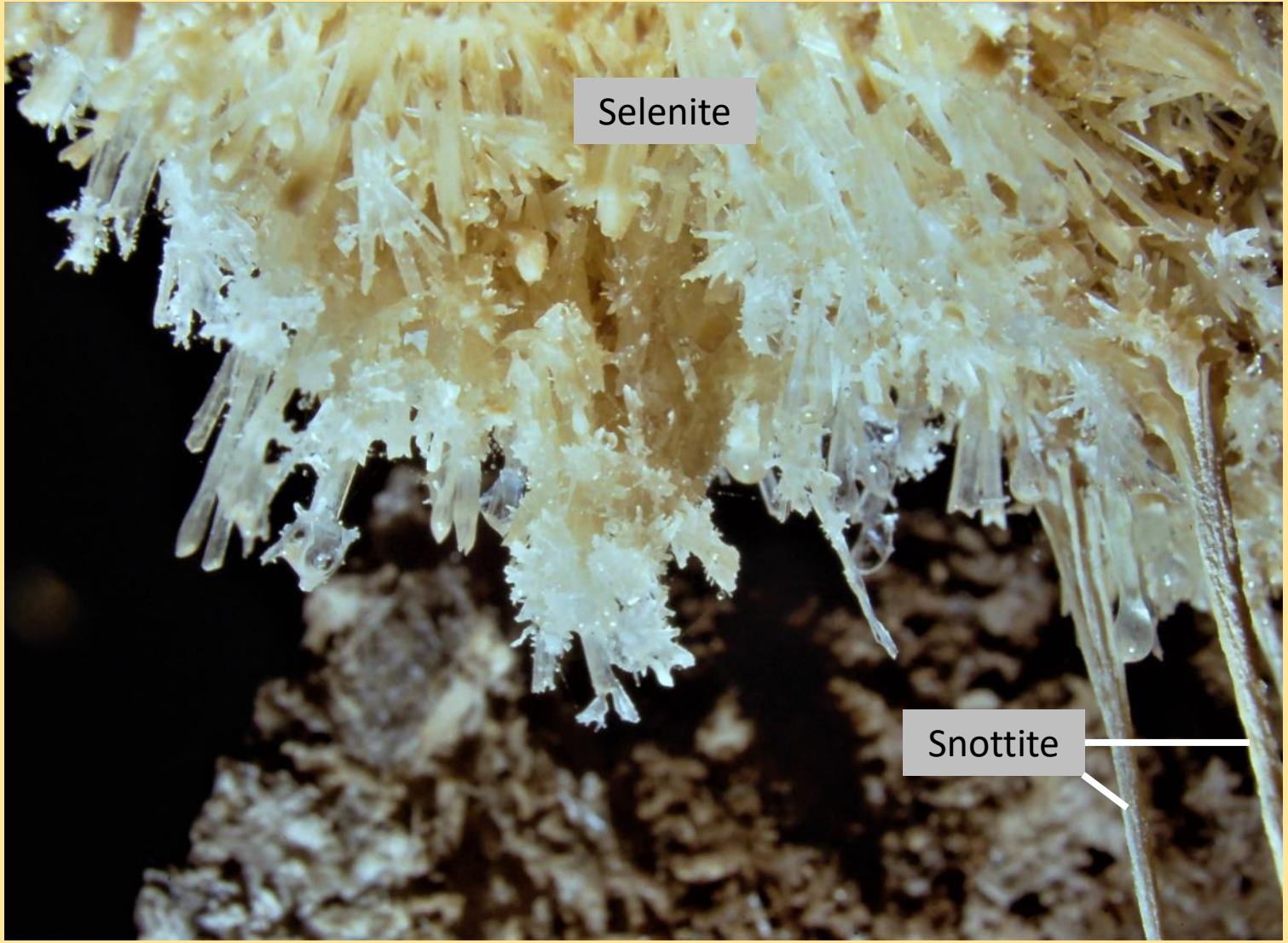


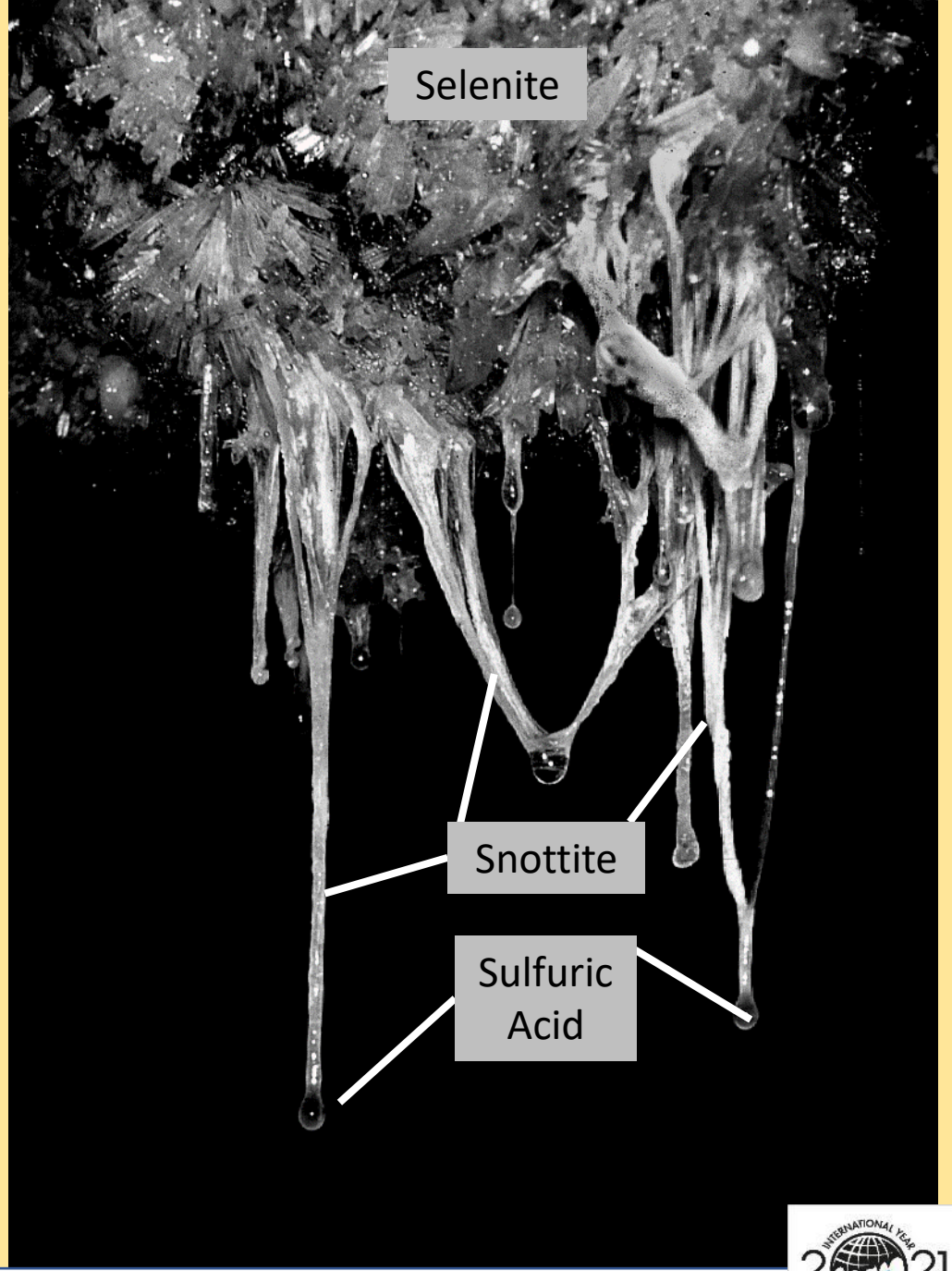
Red and white stream in Snot Heaven

Snot Heaven



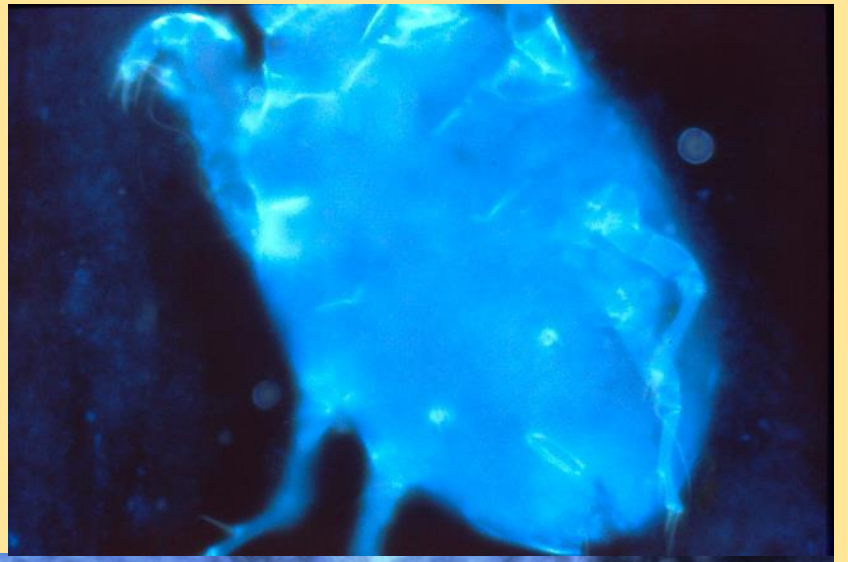
Sulfur Spring

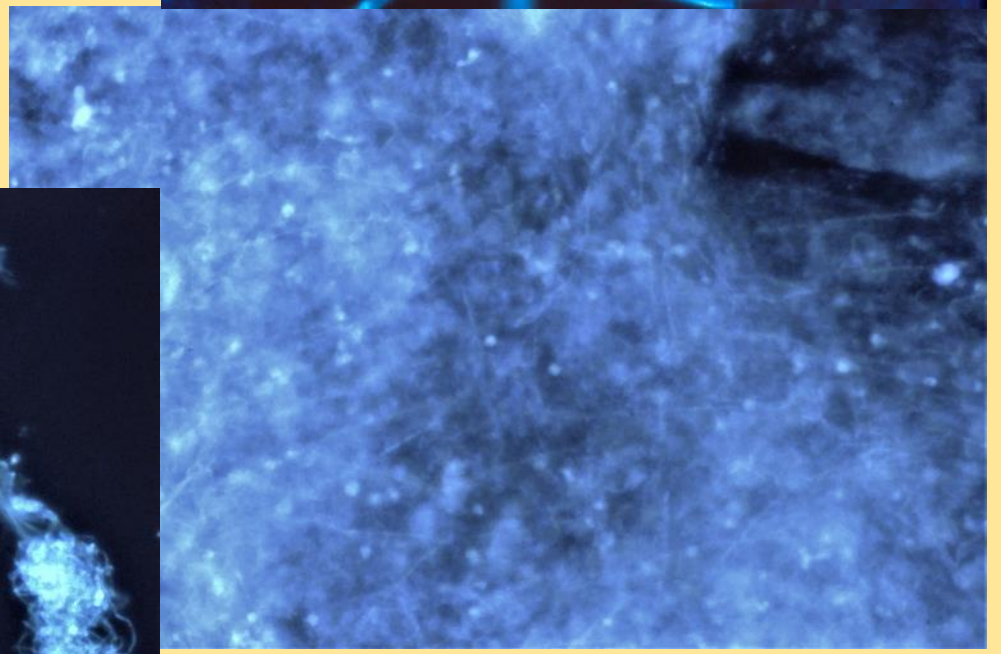


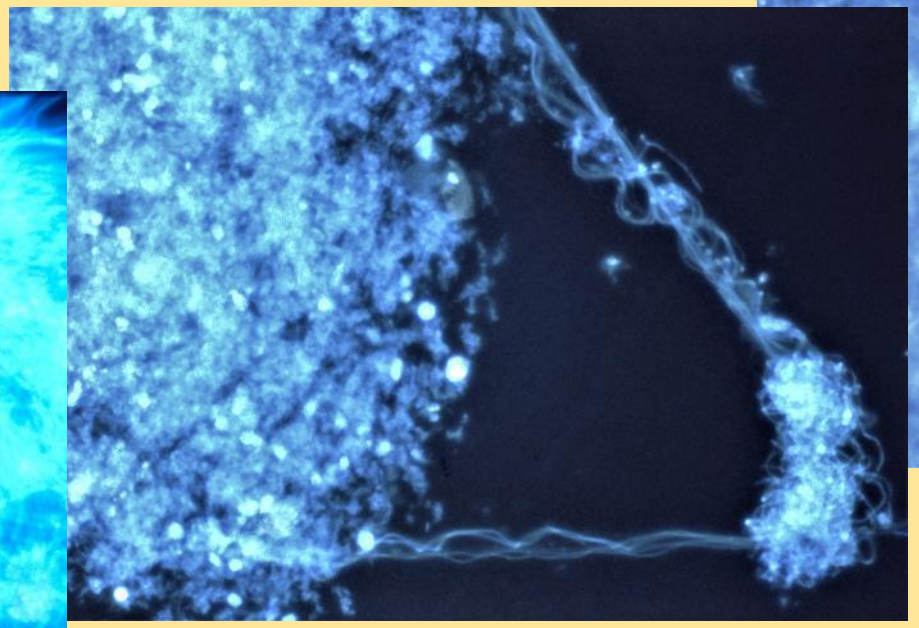


- Snottites produce and drip sulfuric acid (pH 0-3).
- They are rooted on gypsum to insulate the limestone bedrock.

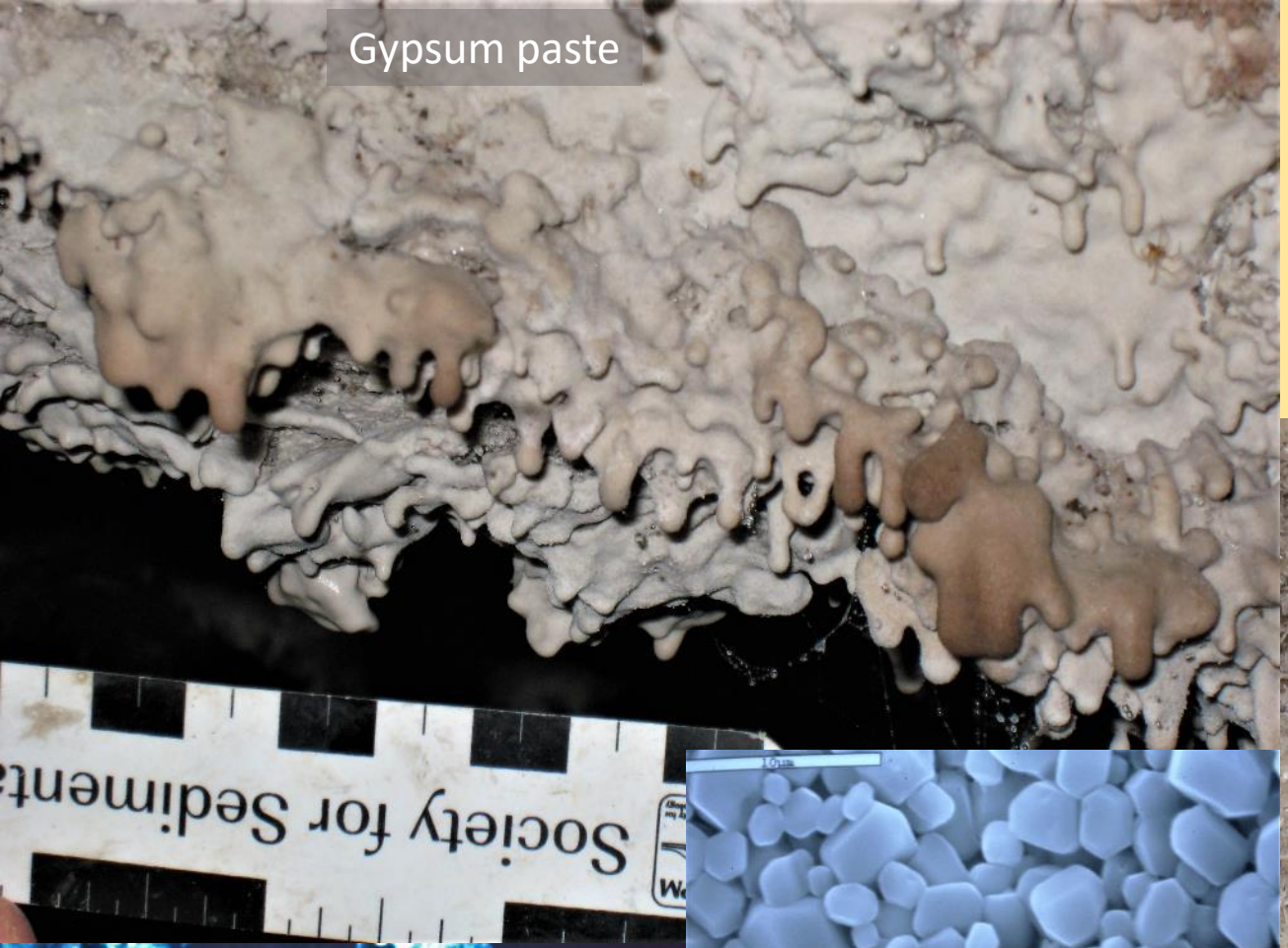
Snottites are colonies of sulfur-oxidizing and other bacteria as well as invertebrates that presumably graze on the snottites.

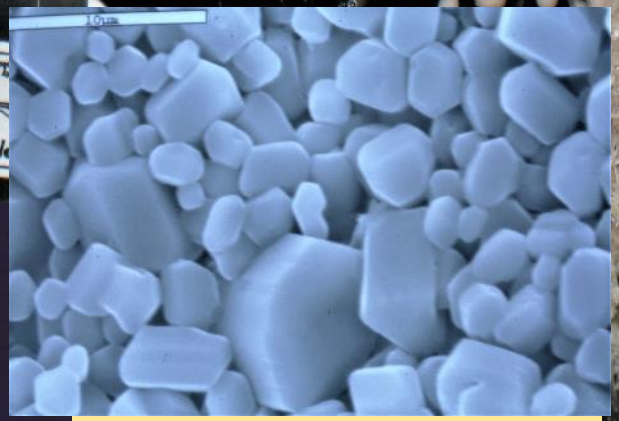


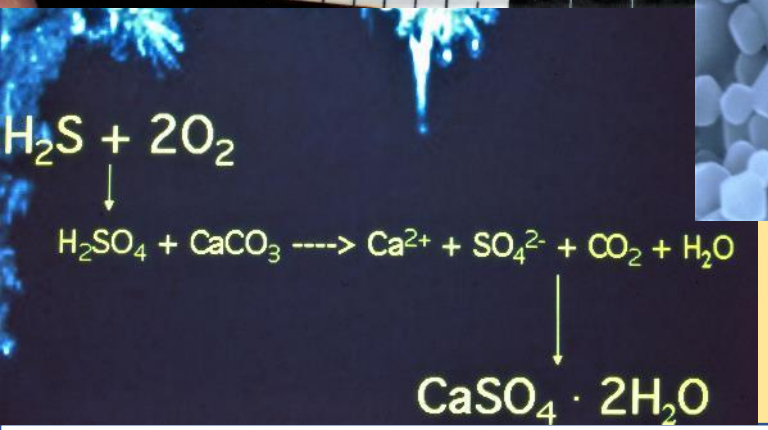




Gypsum paste



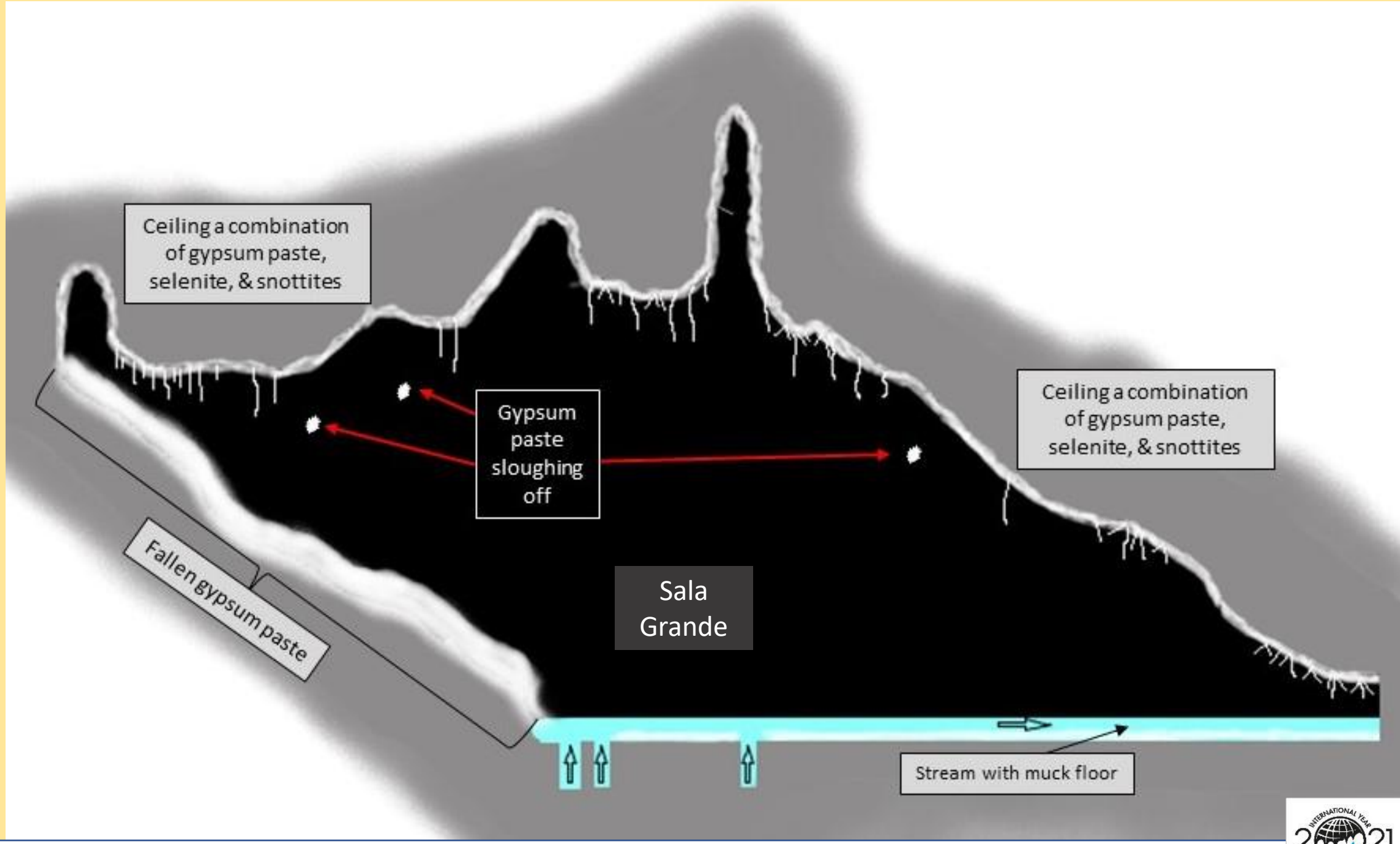


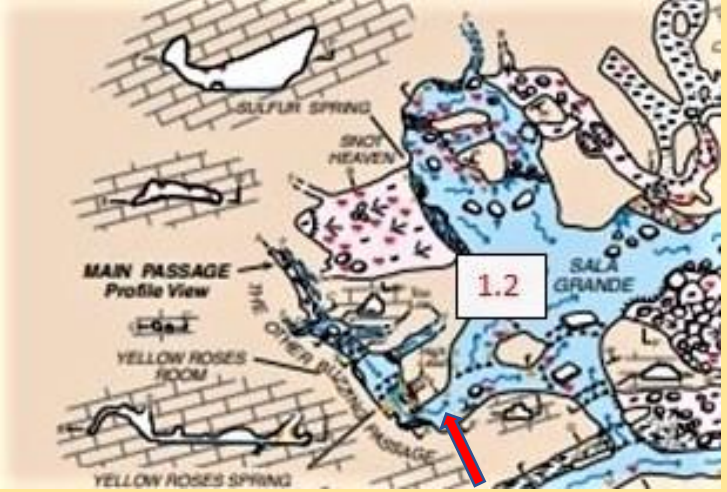


Warm water vapors in the cave air condense on the cooler walls. Water absorbs the H_2S gases and O_2 to form H_2SO_4. Bacteria facilitate. Acid plus calcite form gypsum.

Selenite

Stop 1.2


Ceiling a combination of gypsum paste, selenite, & snottites
Gypsum paste sloughing off
Ceiling a combination of gypsum paste, selenite, & snottites
Fallen gypsum paste
Sala Grande
Stream with muck floor



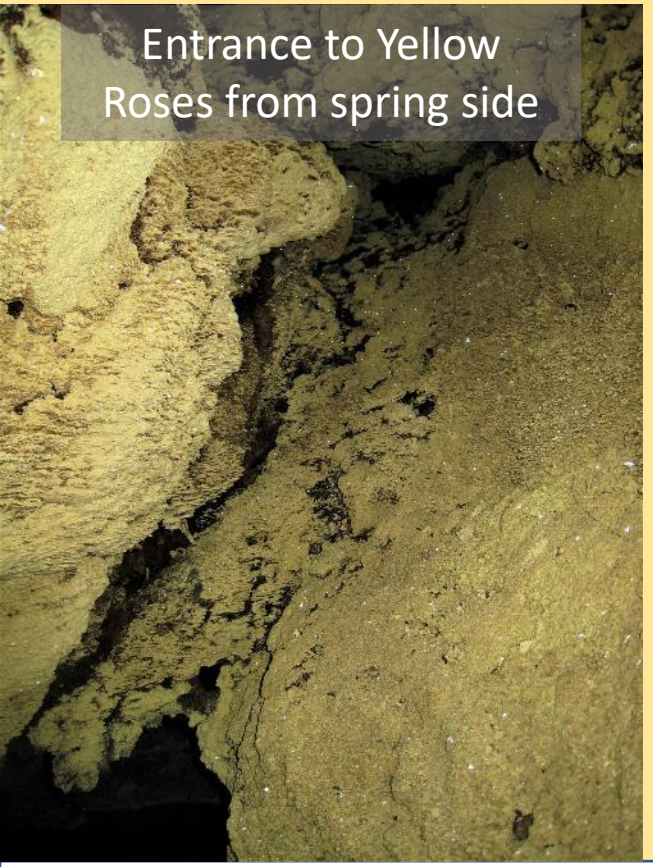
Sulfur folia are microbe-rich deposits of elemental sulfur.

Sulfur folia in Other Buzzing Passage

Crawlway into Other Buzzing Passage

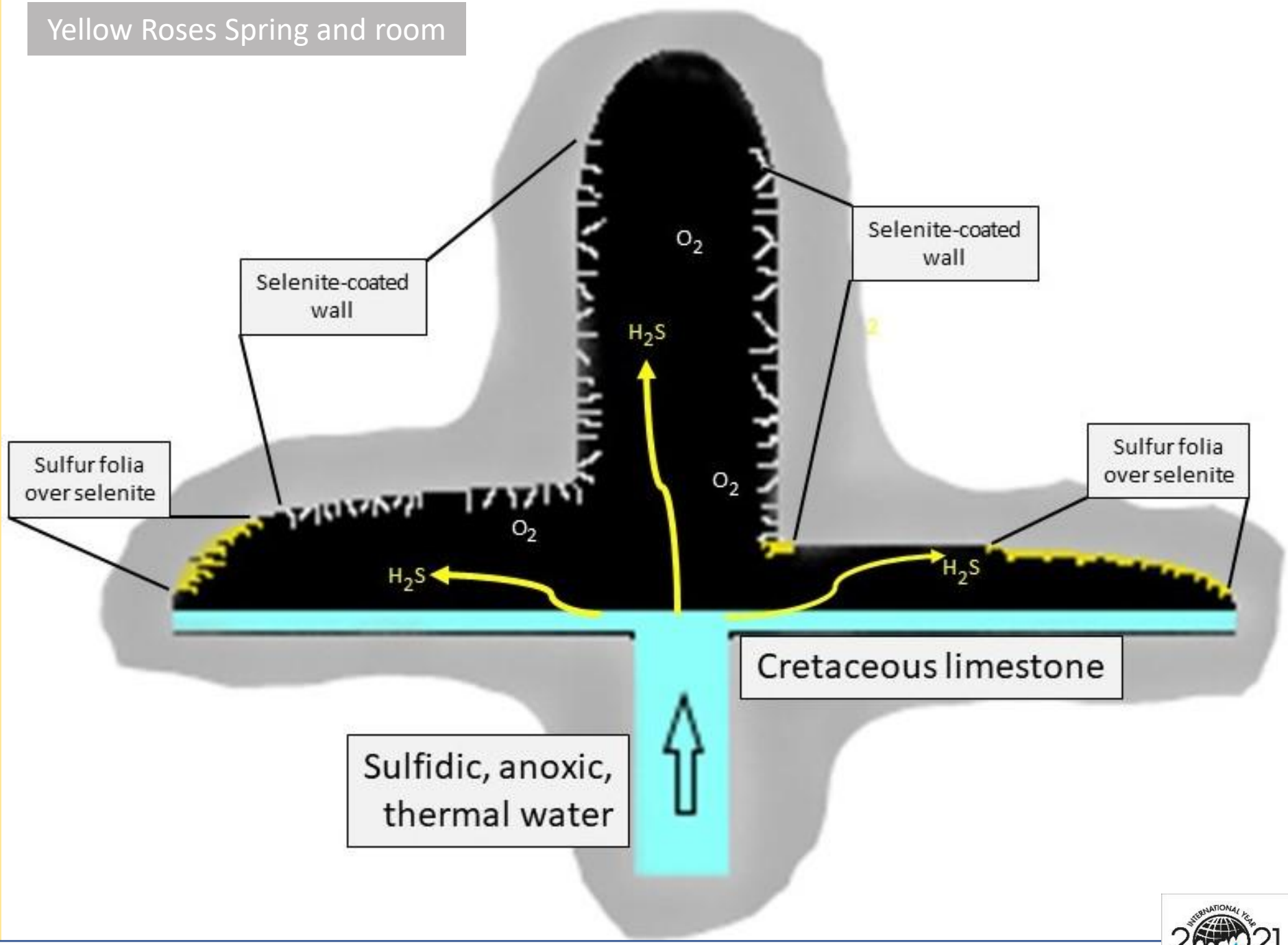
Sulfur folia in Cueva de Villa Luz are unique in the world.

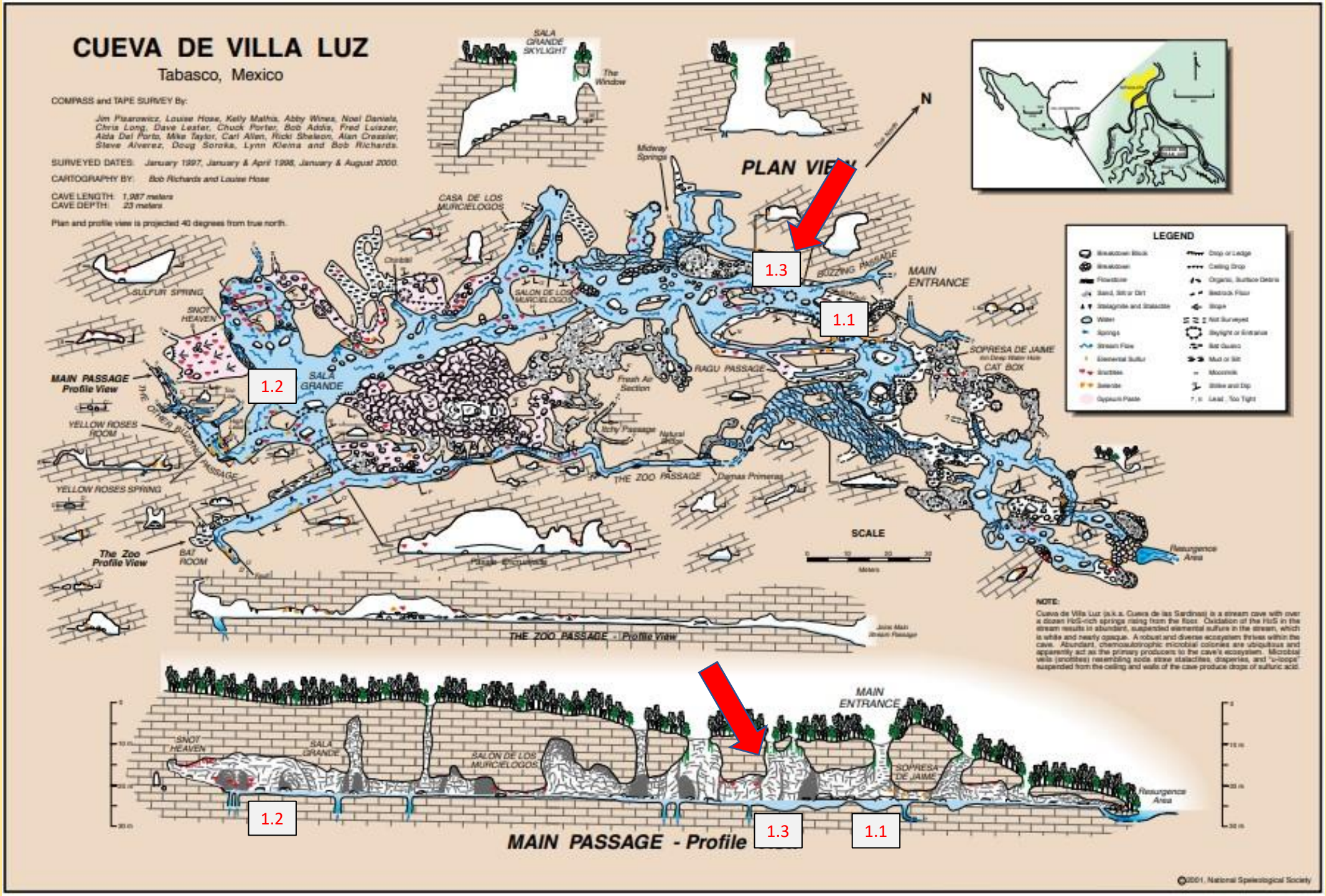
- Lake of the Yellow Roses room has the most hazardous atmosphere.
- These folia are clearly deposited sub-aerially on selenite.



Entrance to Yellow Roses from spring side

Yellow Roses Spring and room

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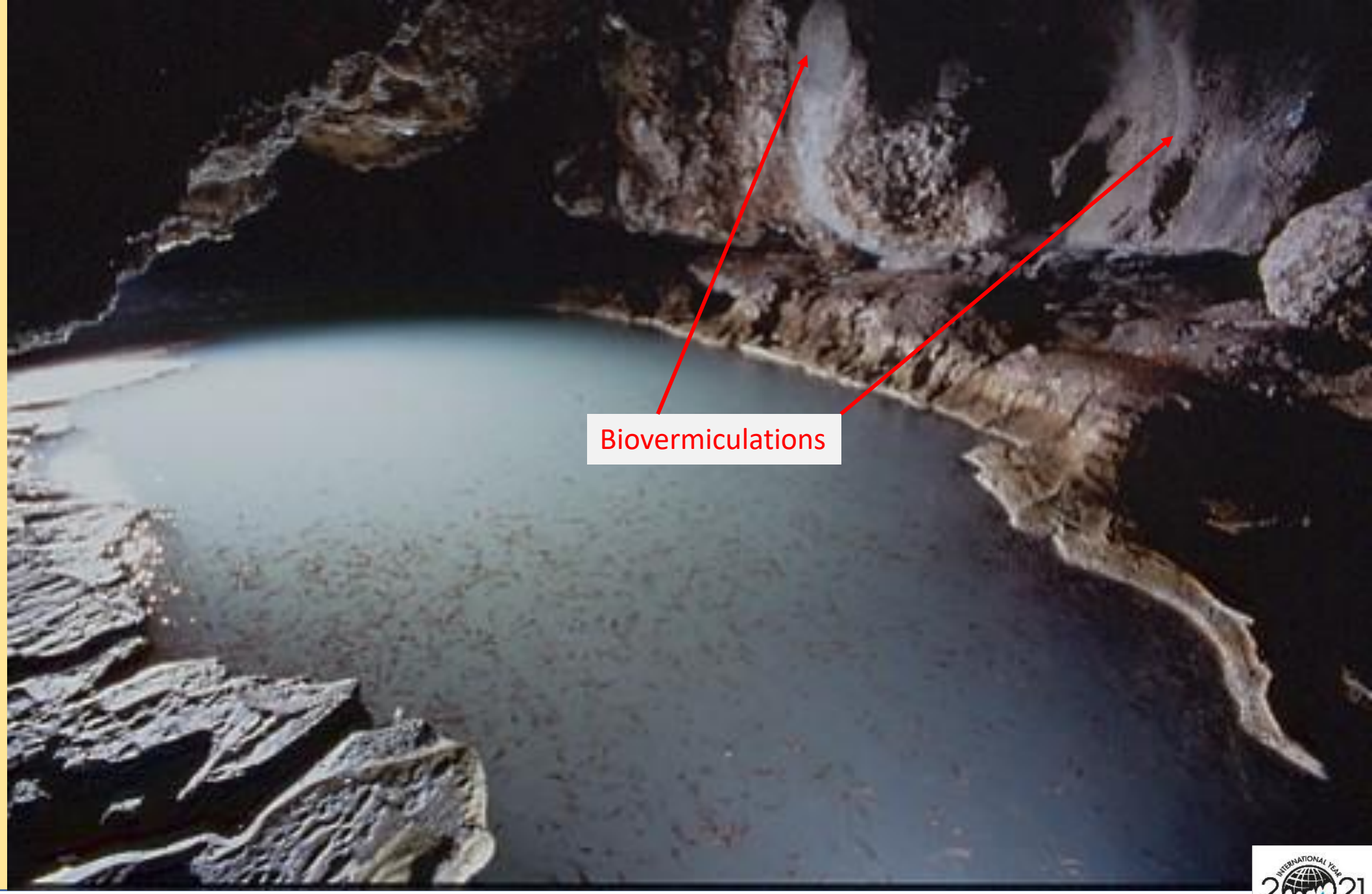
Fresh Air Section
MAIN PASSAGE Profile View
THE OTHER BUZZING PASSAGE
YELLOW ROSES ROOM
YELLOW ROSES SPRING
Itchy Passage
Natural Bridge
THE ZOO PASSAGE
Damas Primeras
The Zoo Profile View
BAT ROOM
Resurgence Area
SCALE
Meters
LEGEND
Breakdown Block
Breakdown
Flowstone
Sand, Silt or Dirt
Stalagmite and Stalactite
Water
Springs
Stream Flow
Elemental Sulfur
Bacteria
Selenite
Gypsum Paste
Drop or Ledge
Ceiling Drop
Organic, Surface Debris
Bedrock Floor
Slope
Not Surveyed
Skylight or Entrance
Bat Guano
Mud or Silt
Moonmilk
Strike and Dip
Level , Too Tight
NOTE:
Cueva de Villa Luz (a.k.a. Cueva de las Sardinas) is a stream cave with over a dozen H2S-rich springs rising from the floor. Oxidation of the H2S in the stream results in abundant, suspended elemental sulfure in the stream, which is white and nearly opaque. A robust and diverse ecosystem thrives within the cave. Abundant, chemoautotrophic microbial colonies are ubiquitous and apparently act as the primary producers to the cave's ecosystem. Microbial veils (snottites) resembling soda straw stalactites, draperies, and "u-loops" suspended from the ceiling and walls of the cave produce drops of sulfuric acid.
THE ZOO PASSAGE - Profile View
MAIN ENTRANCE
SNOT HEAVEN
SALA GRANDE
SALON DE LOS MURCIELOGOS
SOPRESA DE JAIME
Resurgence Area
MAIN PASSAGE - Profile
1.1
1.2
1.3
©2001, National Speleological Society

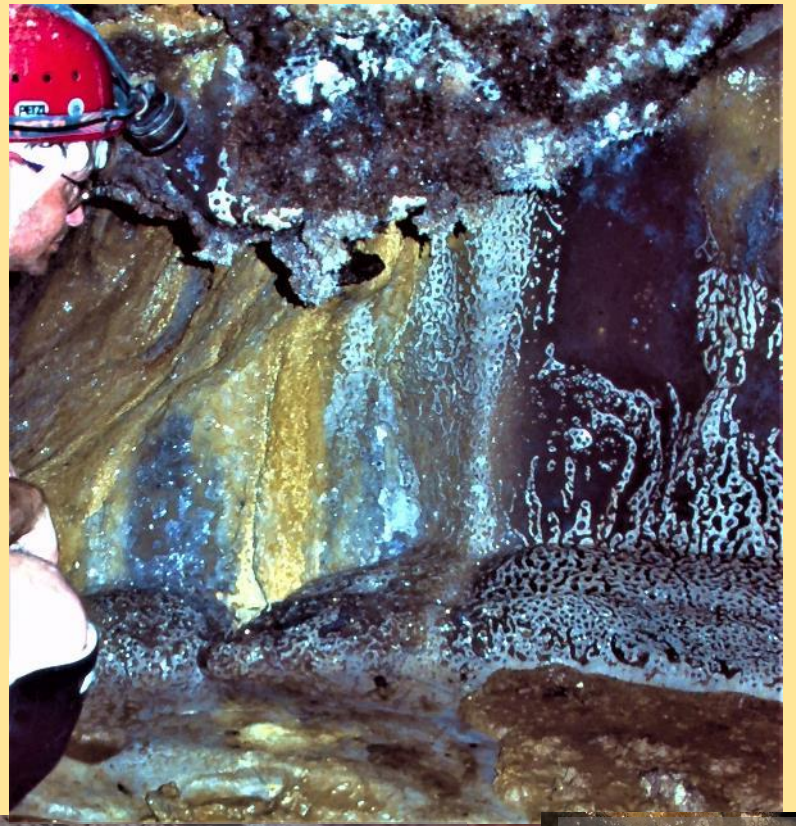
Stop 1.3

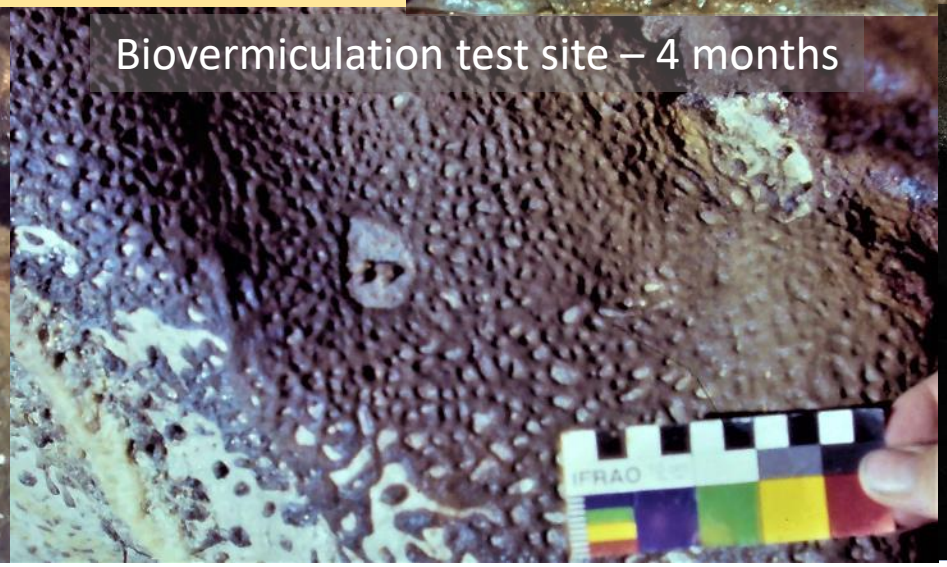
Biovermiculations



Biovermiculations are colonies of bacteria and fungi with captured detritus that grow on bare limestone.

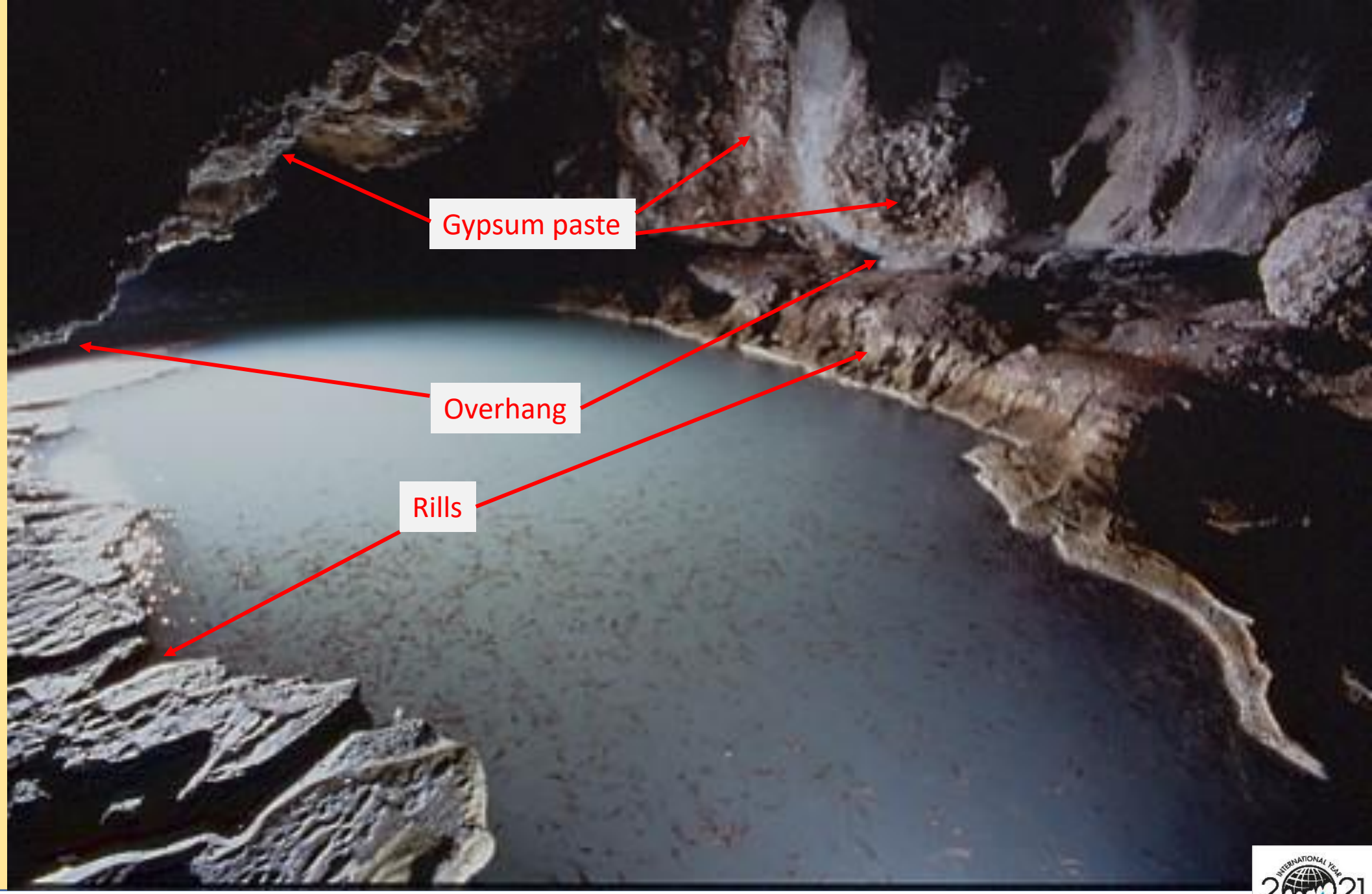
- They grow in the lower sulfidic areas.
- They have a variety of colors.
- In CVL, they seem to act as “pioneer organisms.”



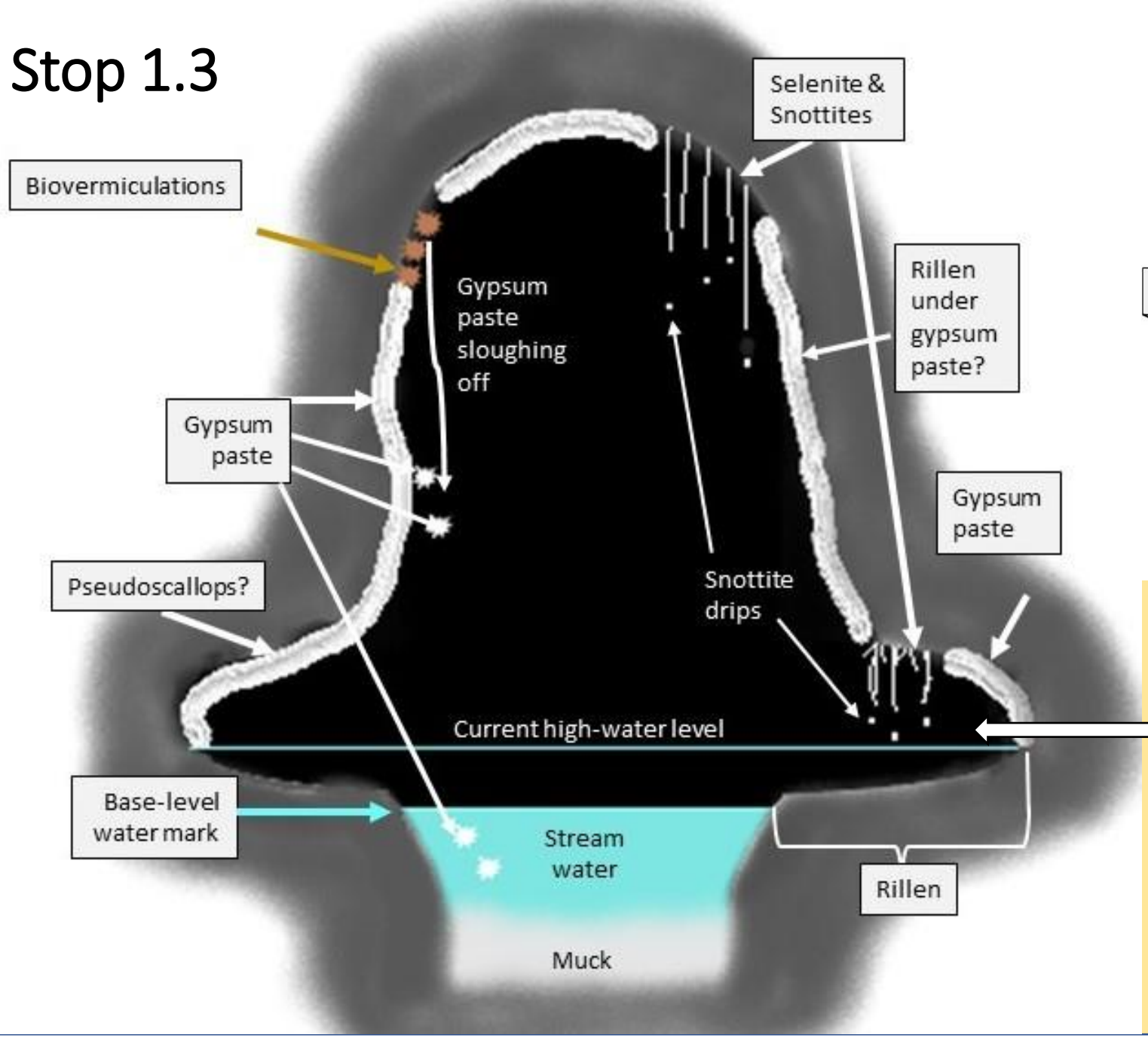


Stop 1.3

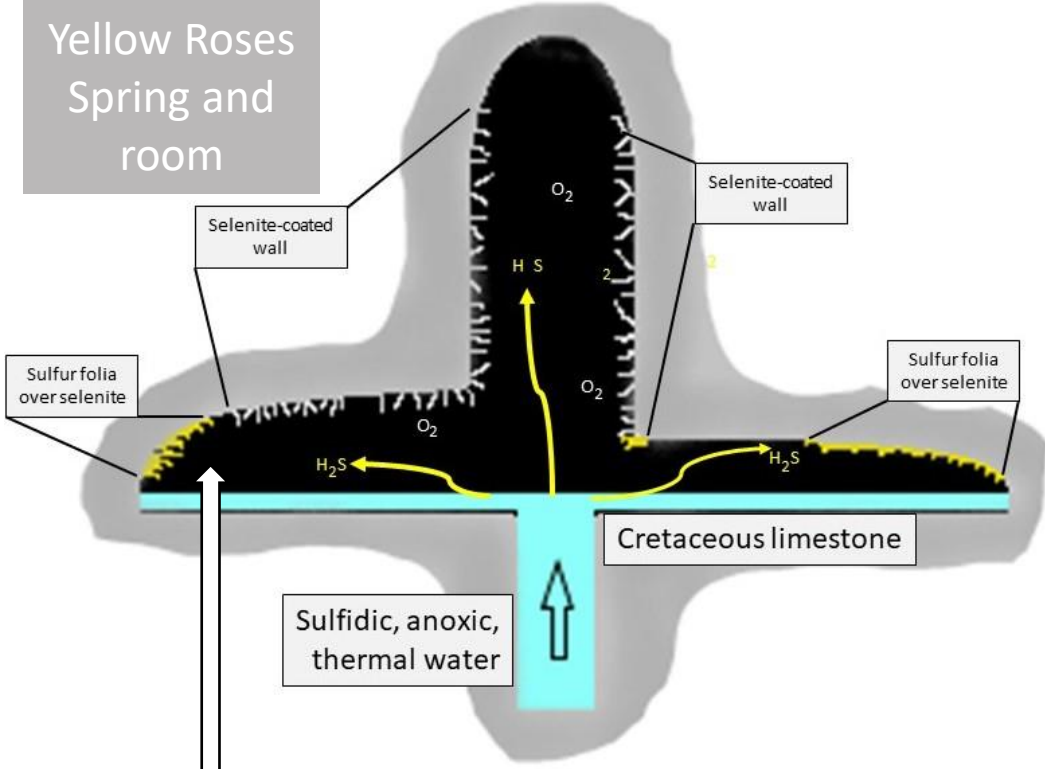
A classic acid pool



Stop 1.3



Yellow Roses Spring and room



Note the bare rock shelves with a notch above the pool/stream. We'll return to this morphology.

Remember this model as it appears in ancient, hypogenic, sulfidic caves later in the field trip.

Photo by James Pisarowicz

Note the bare rock shelves with a notch above the pool/stream. We'll return to this morphology.

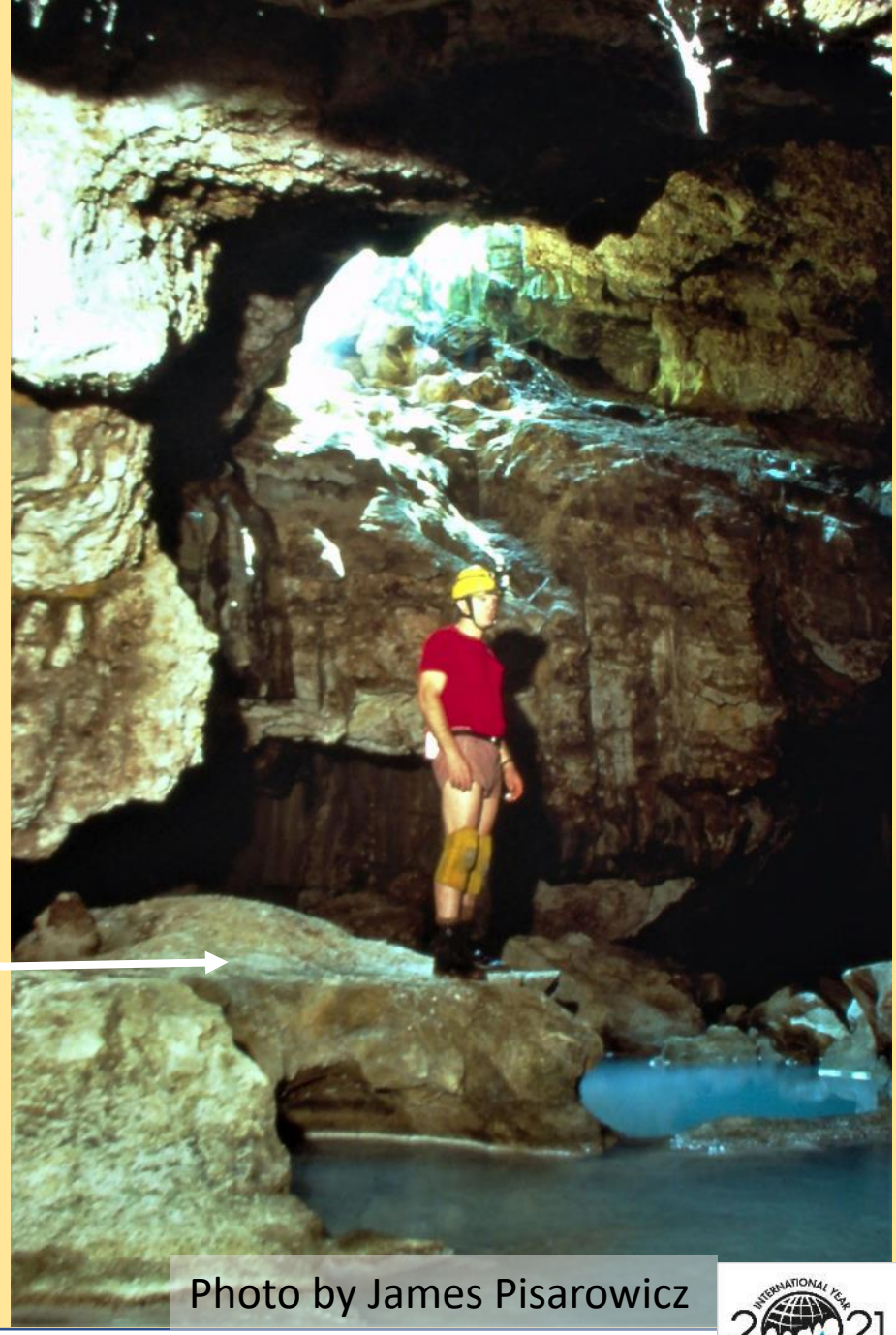
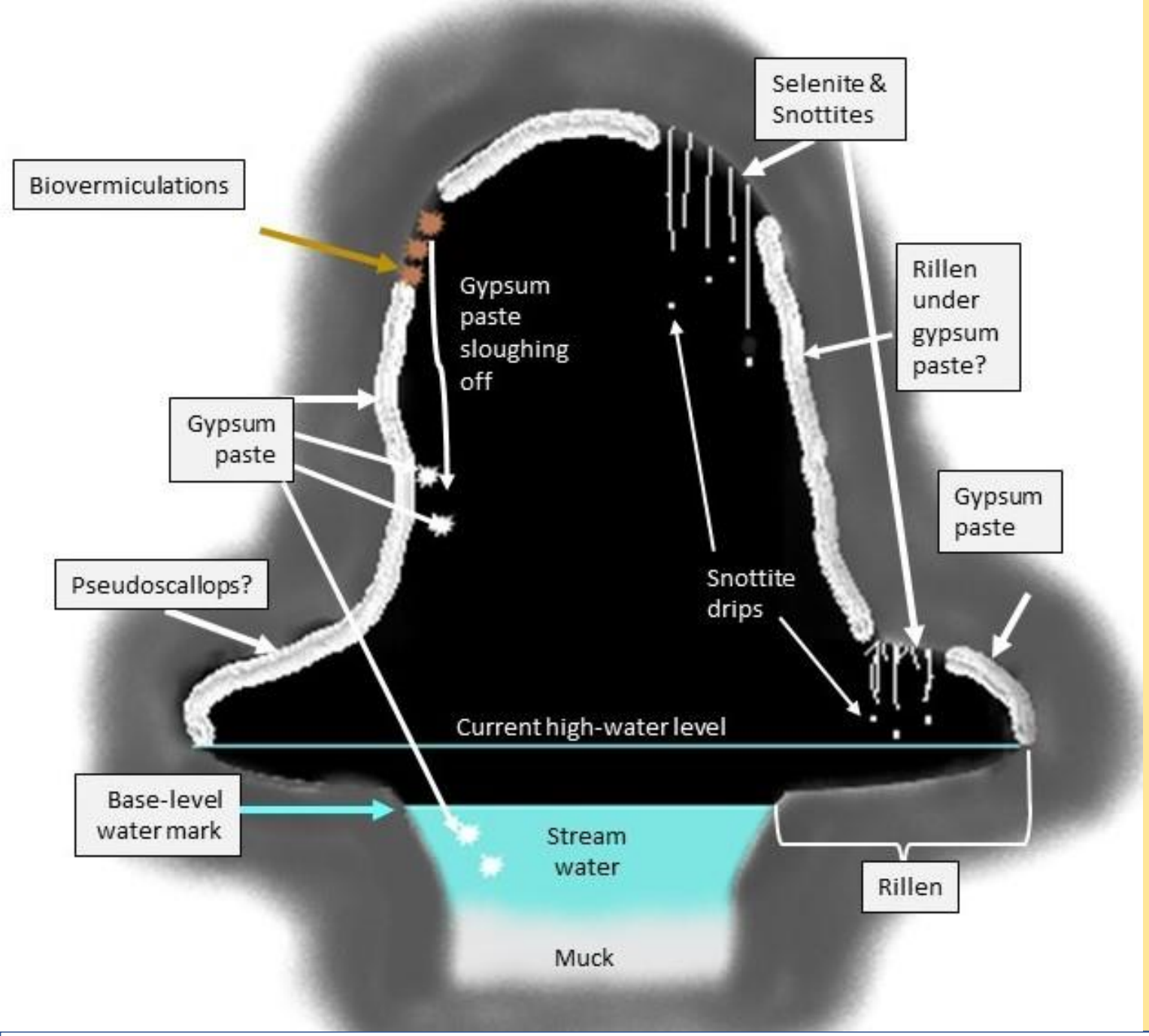


Photo by James Pisarowicz


Selenite &
Snottites
Biovermiculations
Gypsum
paste
sloughing
off
Rillen
under
gypsum
paste?
Gypsum
paste
Gypsum
paste
Pseudoscallops?
Snottite
drips
Current high-water level
Base-level
water mark
Stream
water
Rillen
Muck

QUESTIONS?

Frasassi Caves, Italy

- Introduction 0900 PDT
- Stop 1 – Cueva de Villa Luz 0905 PDT
- **Stop 2 – Frasassi Caves 0930 PDT**
  Dan Jones
- Stop 3 – Carlsbad Cavern 0955 PDT
- Stop 4 – Lechuguilla Cave 1015 PDT
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- Stop 10 – Discovery Cave 1325 PDT
- Stop 11 – Old Mans Cave 1335 PDT
- Summary and questions 1345 PDT

Daniel S. Jones
New Mexico Tech
Dept. of Earth and Environmental Science
Natl. Cave and Karst Research Inst. (NCKRI)
daniel.s.jones@nmt.edu, @geomicrobe

Most photos used for this fieldtrip were taken by Daniel Jones and Jennifer Macalady

The Frasassi Caves

The Frasassi caves are a sulfidic cave system

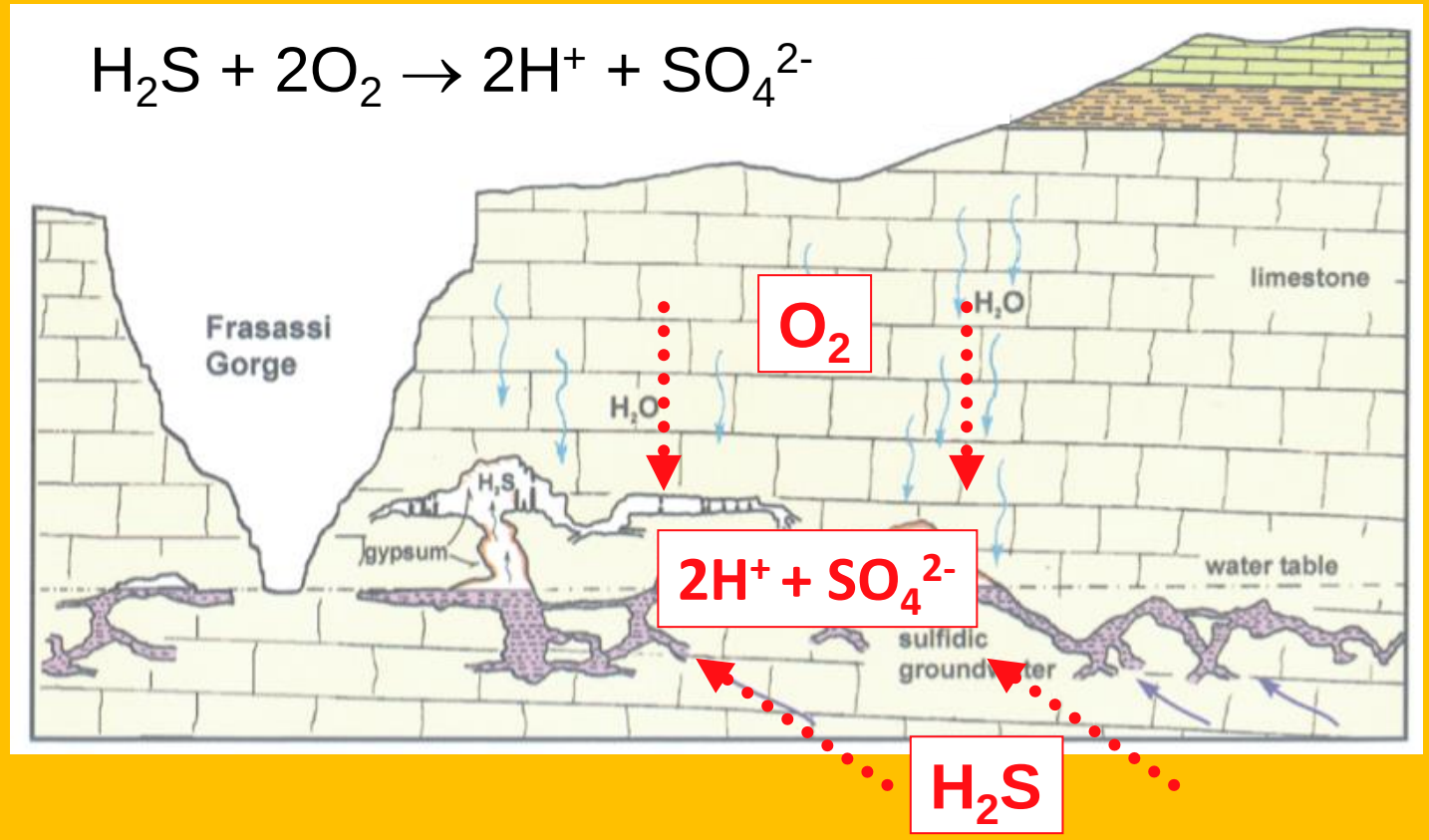
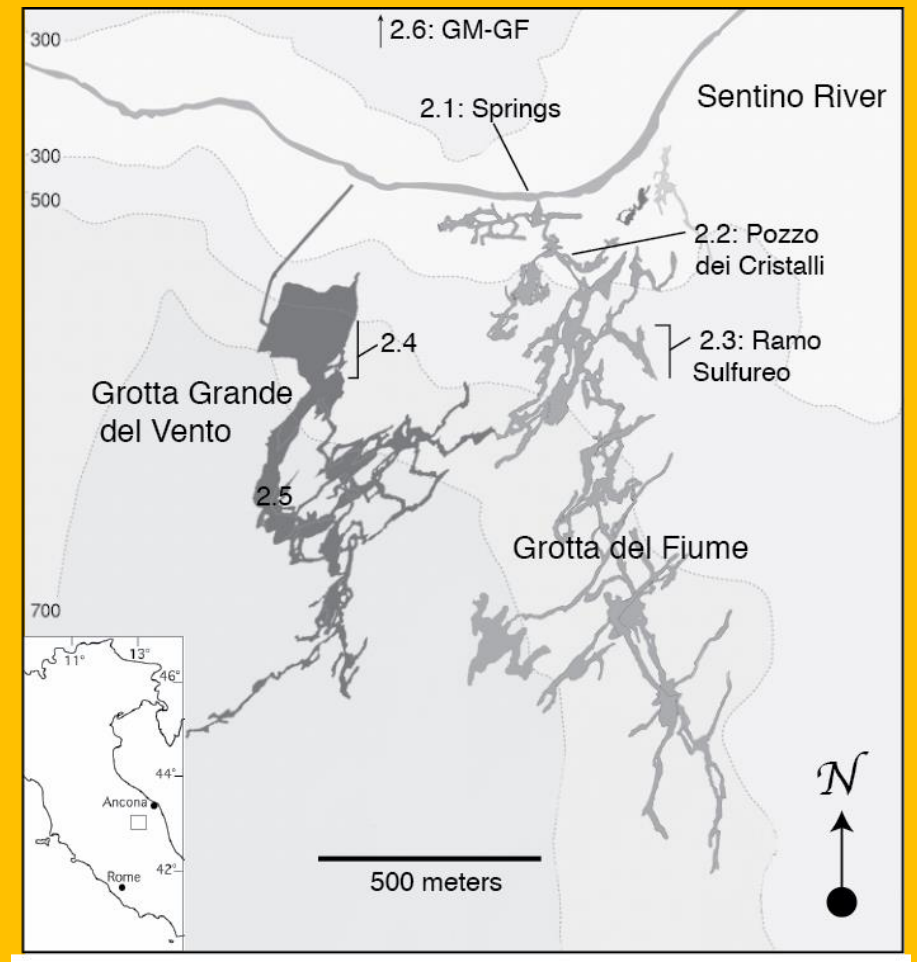
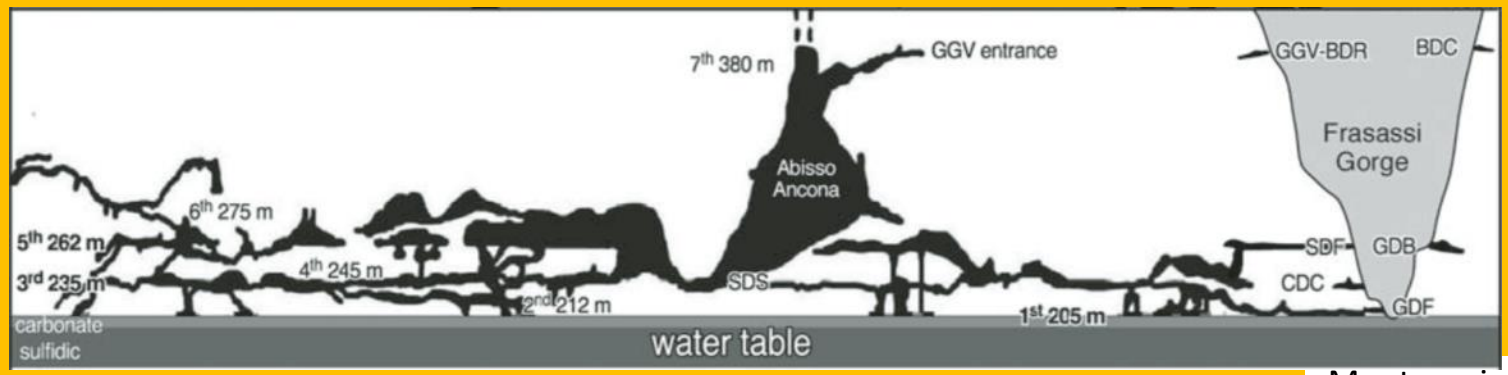


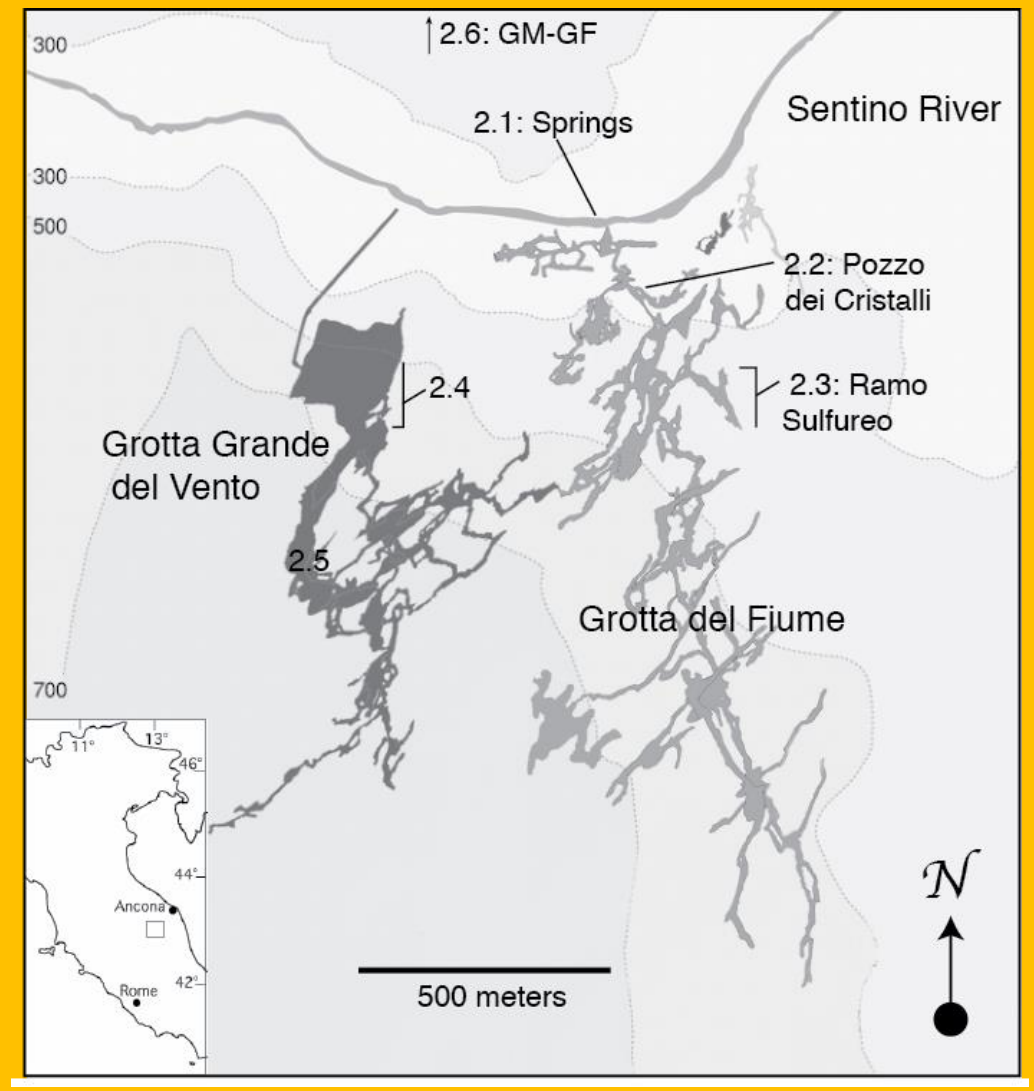
Image courtesy of Sandro Galdenzi





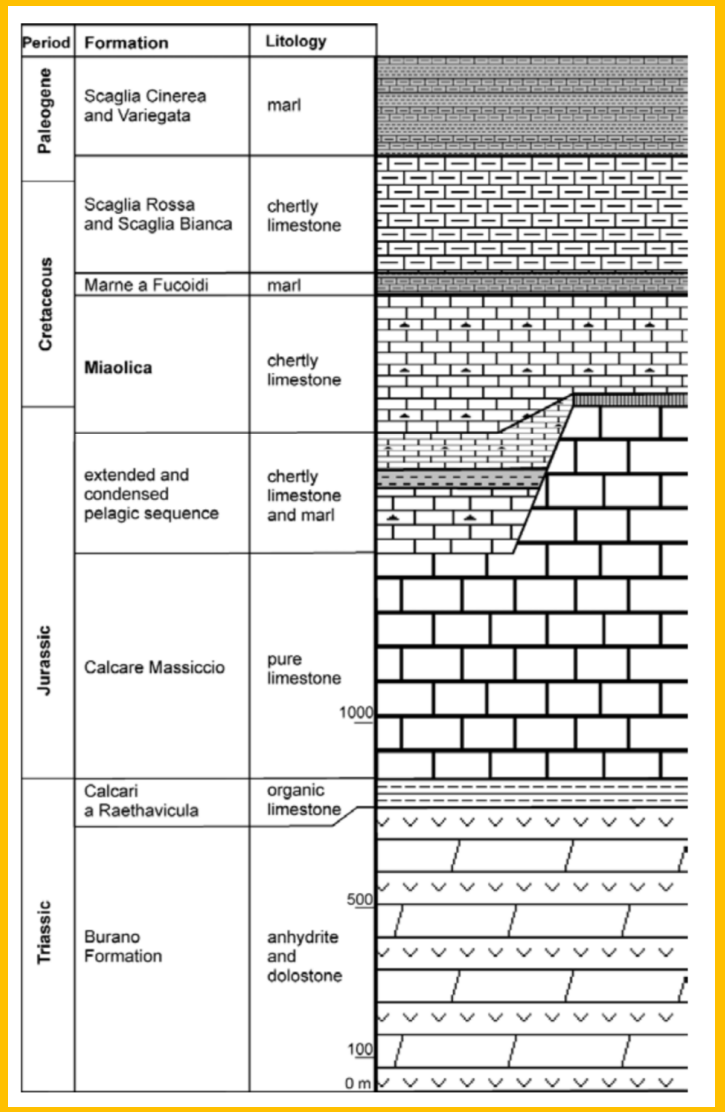
Montanari et al. (2019)

Trip overview and route to the caves

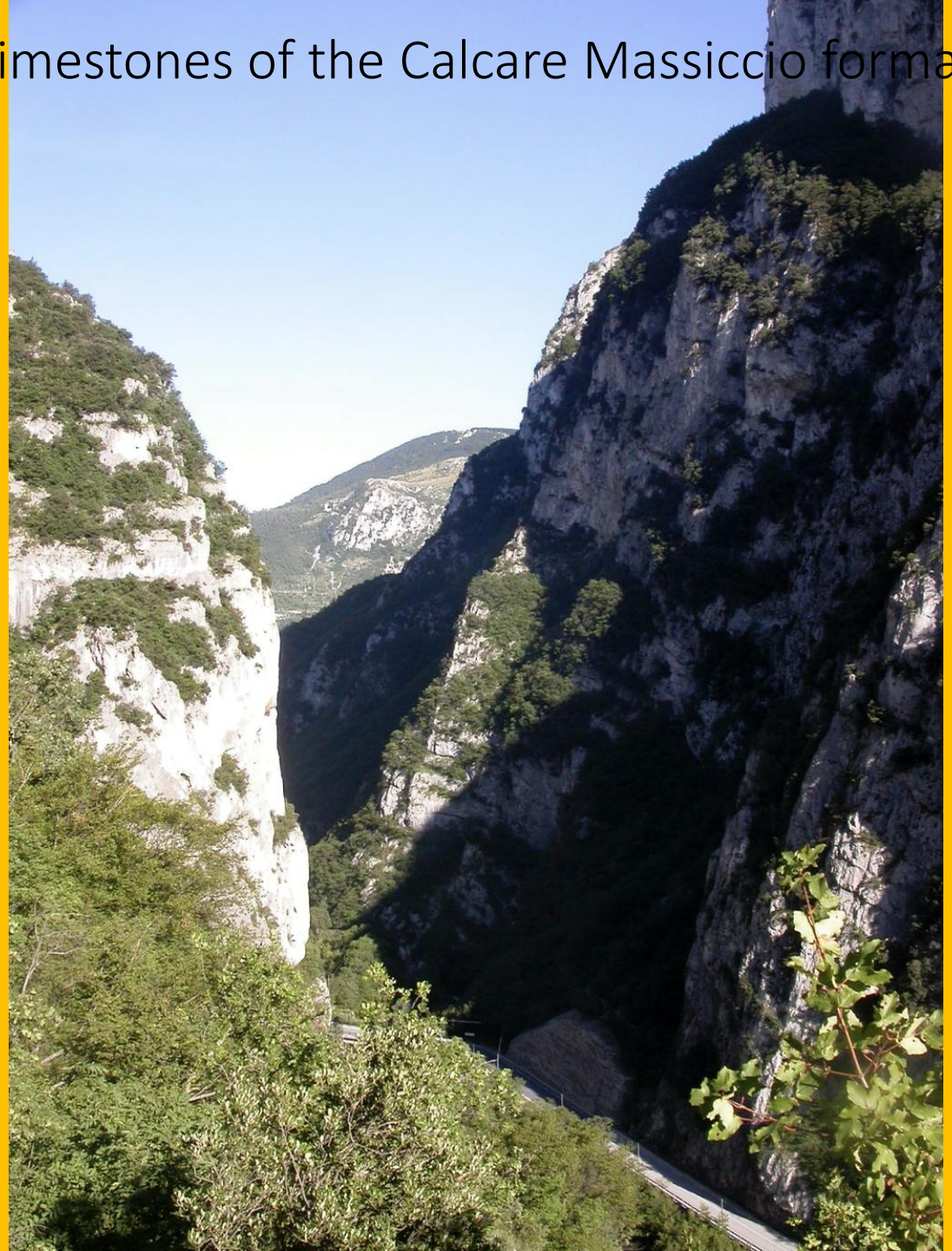



Explore

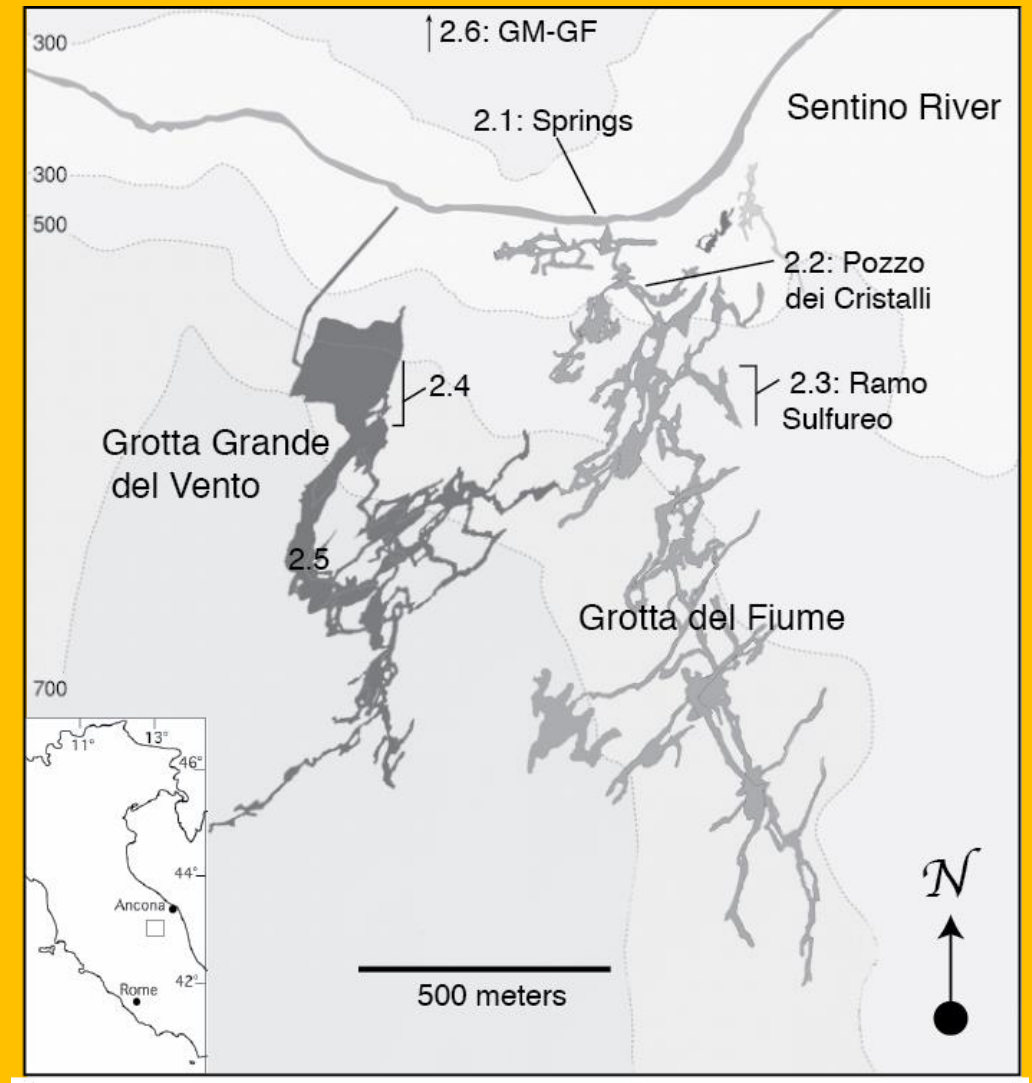
The caves are formed in the nearly pure limestones of the Calcare Massiccio formation



Galdenzi and Maruoka (2003)



Stop 1: Cave Springs

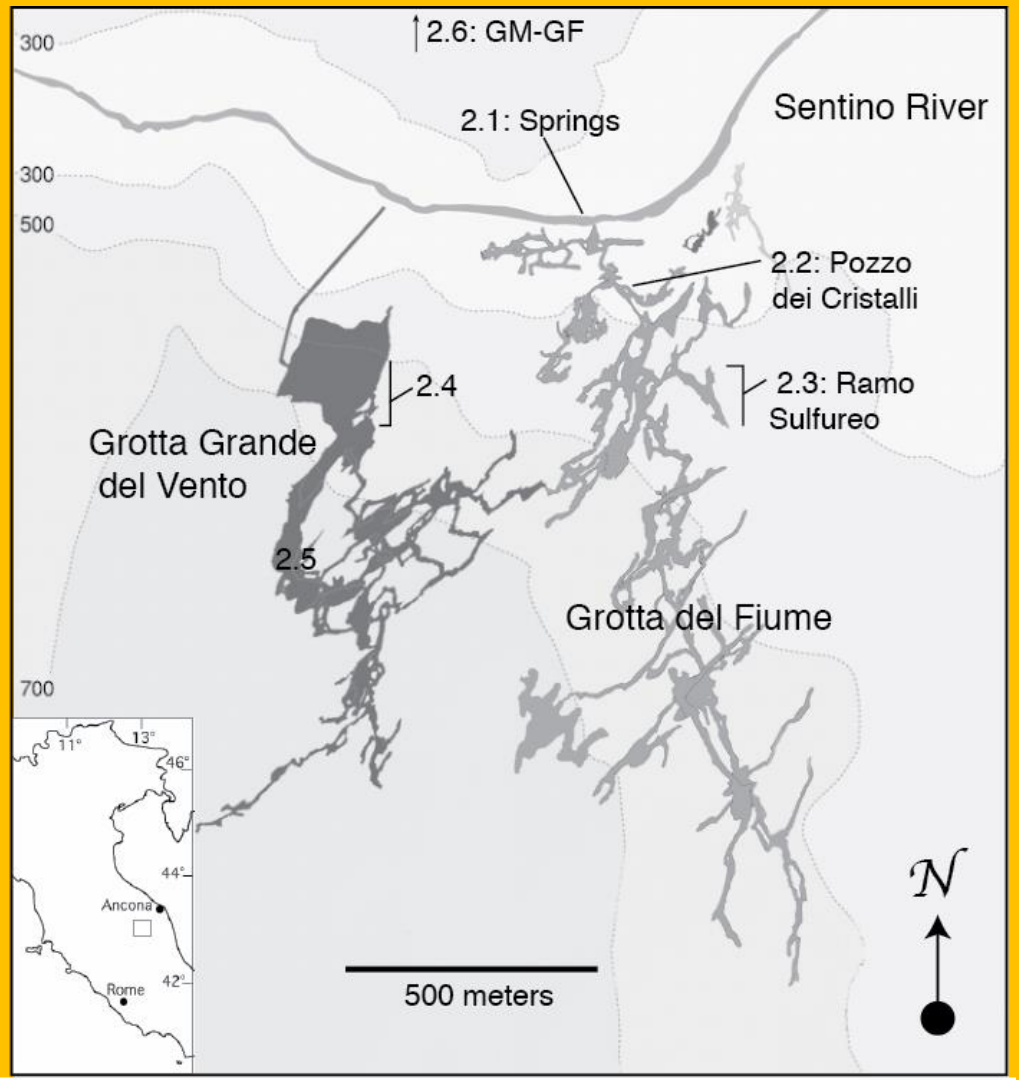



H_2S-rich water
~100-200 μM

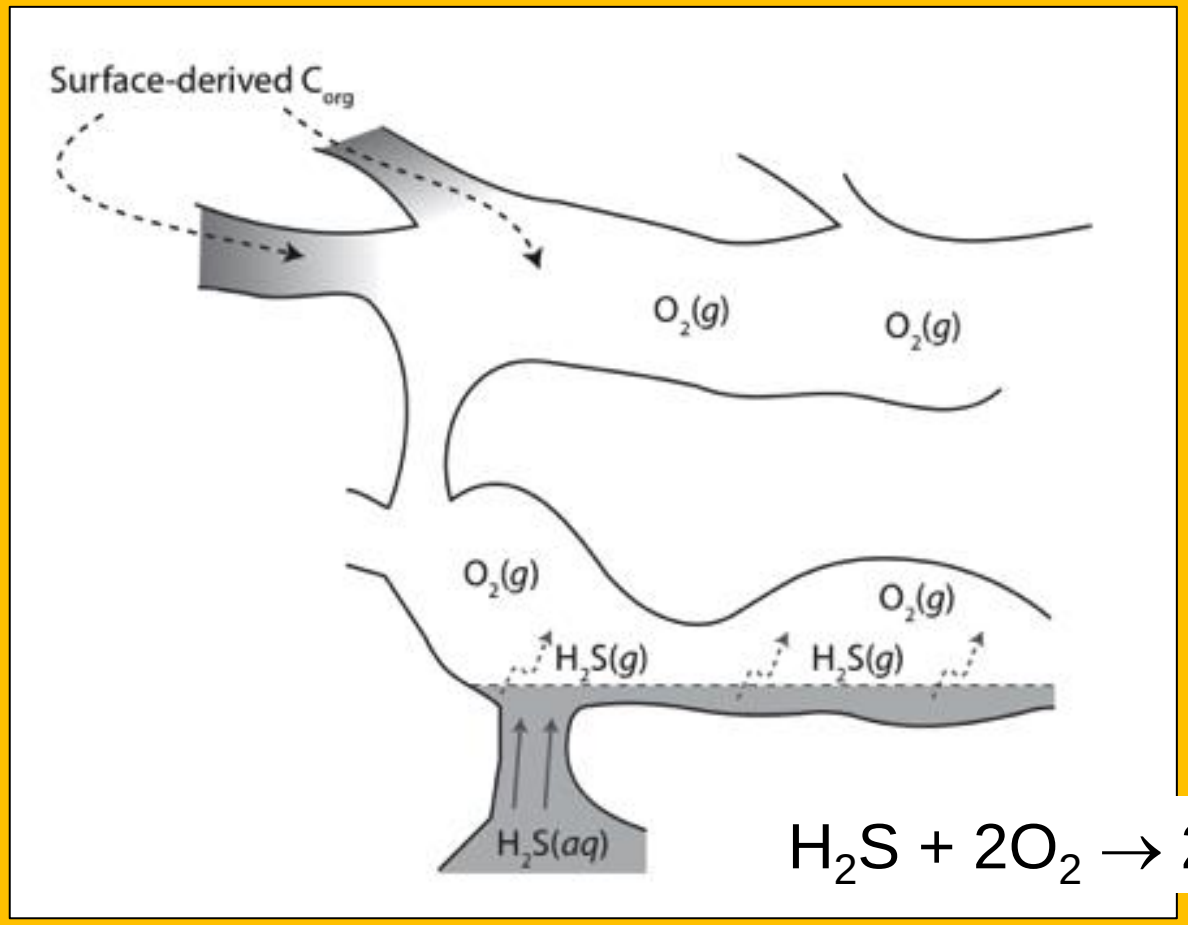
In 2013, a massive flood destroyed the springs… But they have re-emerged in slightly different locations

Photo from Nov. 2013, courtesy of Sandro Montanari

Cristalli (PC) and Ramo Sulfureo (RS)



In Frasassi, near cave entrances, biological activity is dependent on allochthonous organic matter from surface sources



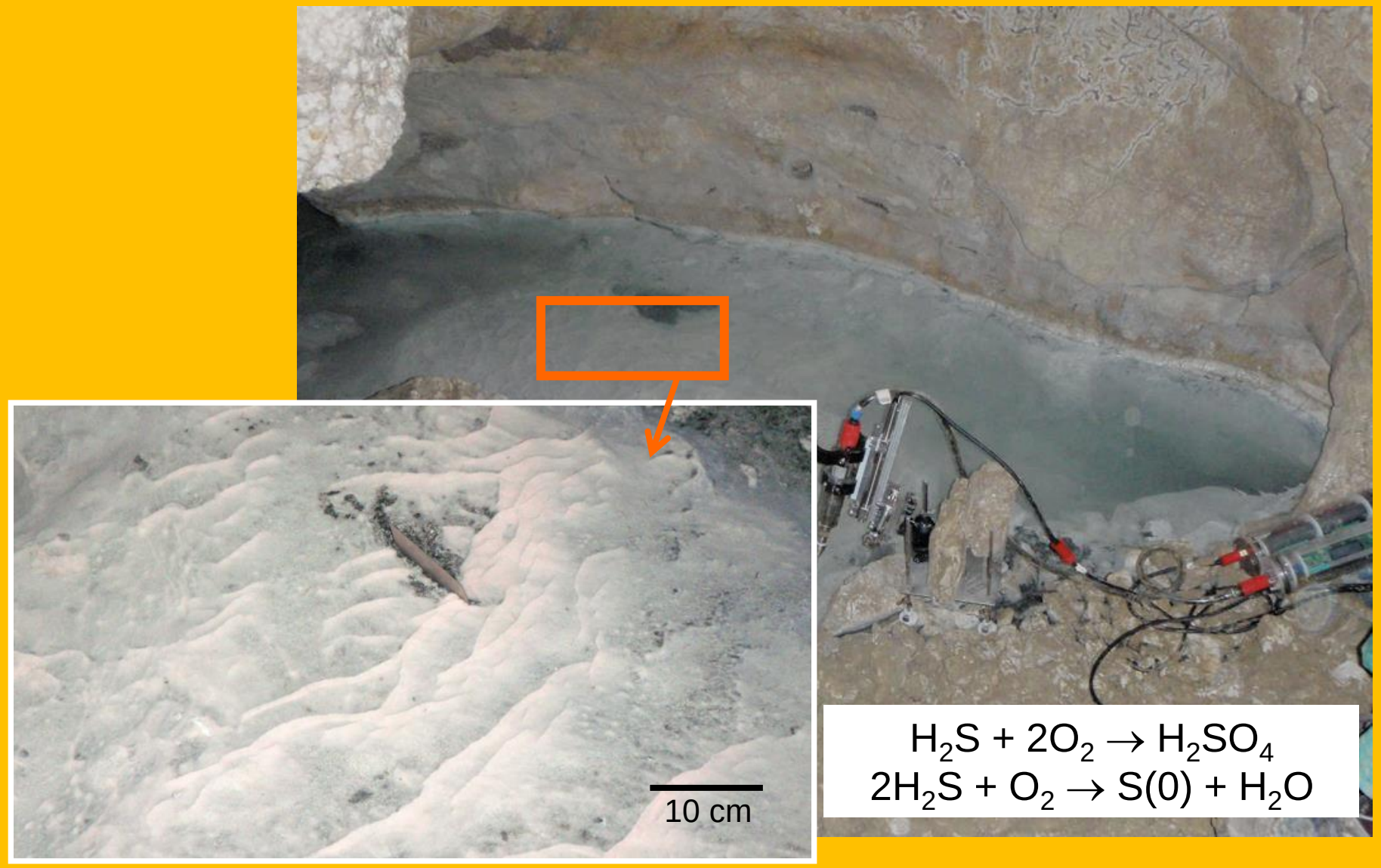
A robust chemosynthetic ecosystem occurs in the lower levels where chemical energy is plentiful

Jones and Macalady (2016)

Sulfidic streams are filled with white microbial mats created by sulfide-oxidizing bacteria

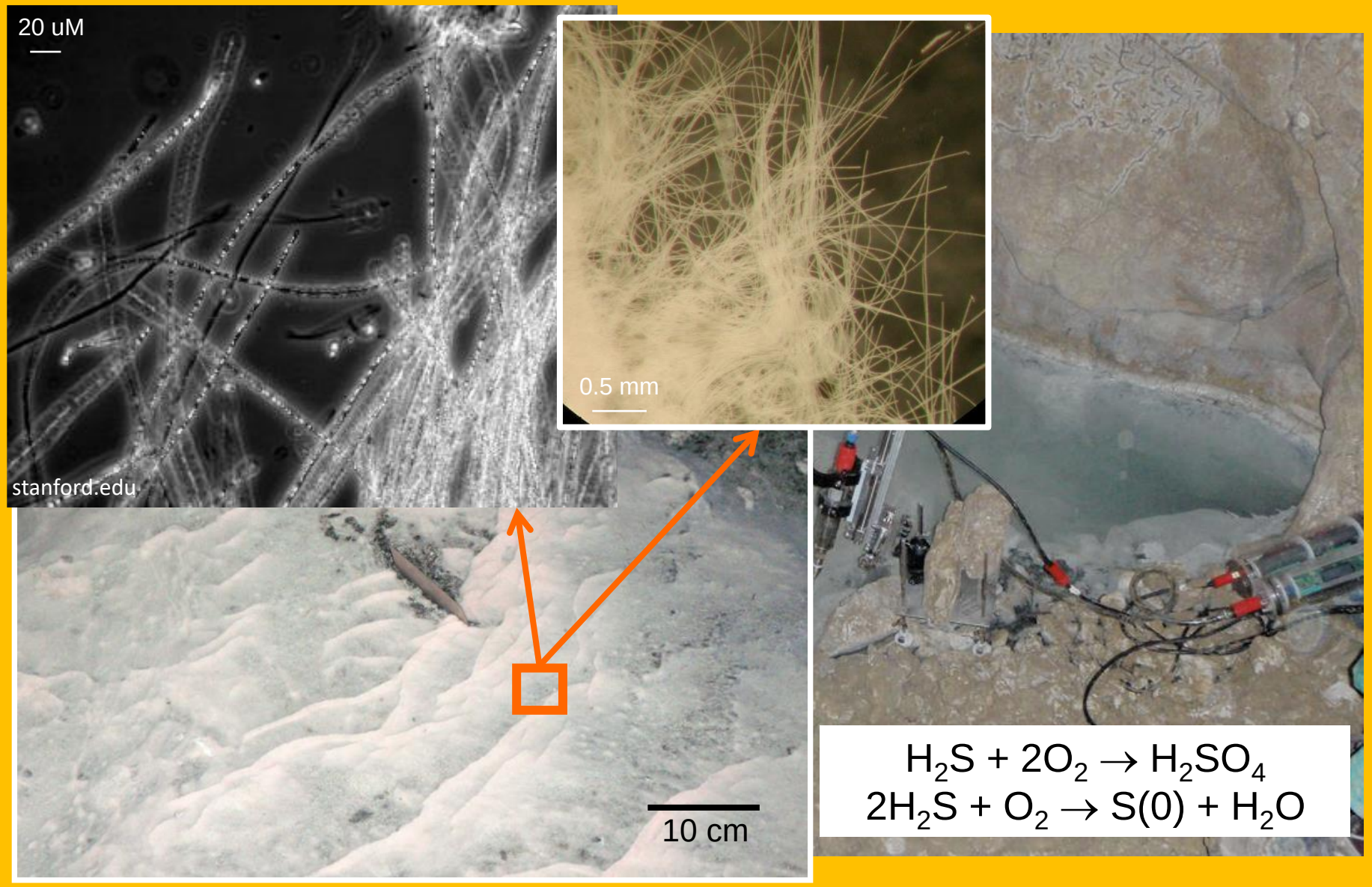
(Site GS)

Sulfidic streams are filled with white microbial mats created by sulfide-oxidizing bacteria



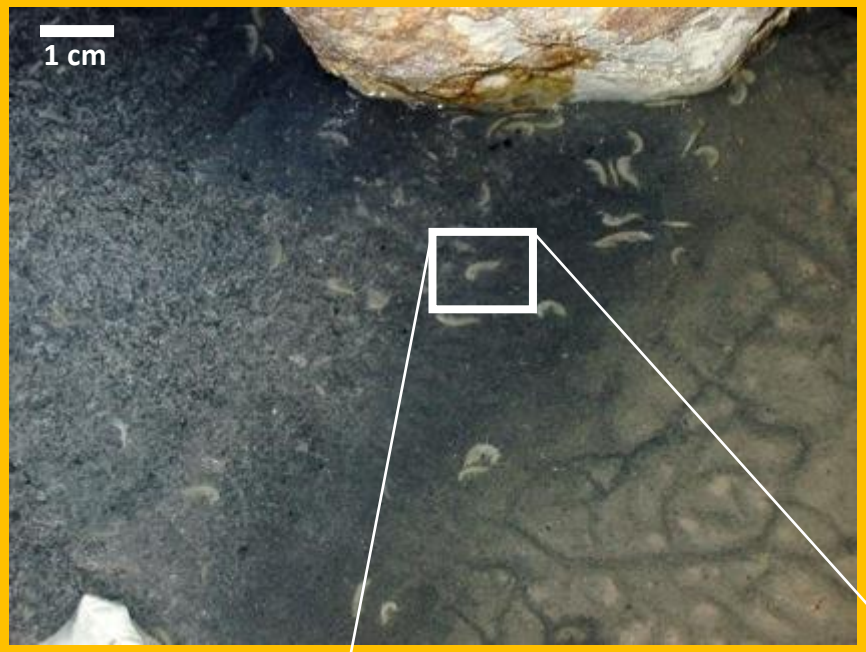
(Site GS)

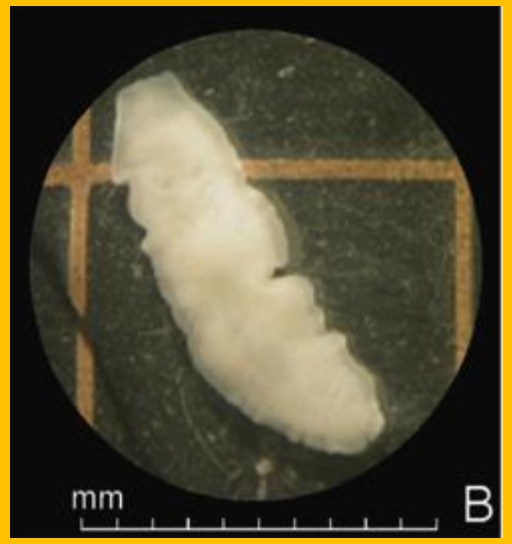
Sulfidic streams are filled with white microbial mats created by sulfide-oxidizing bacteria



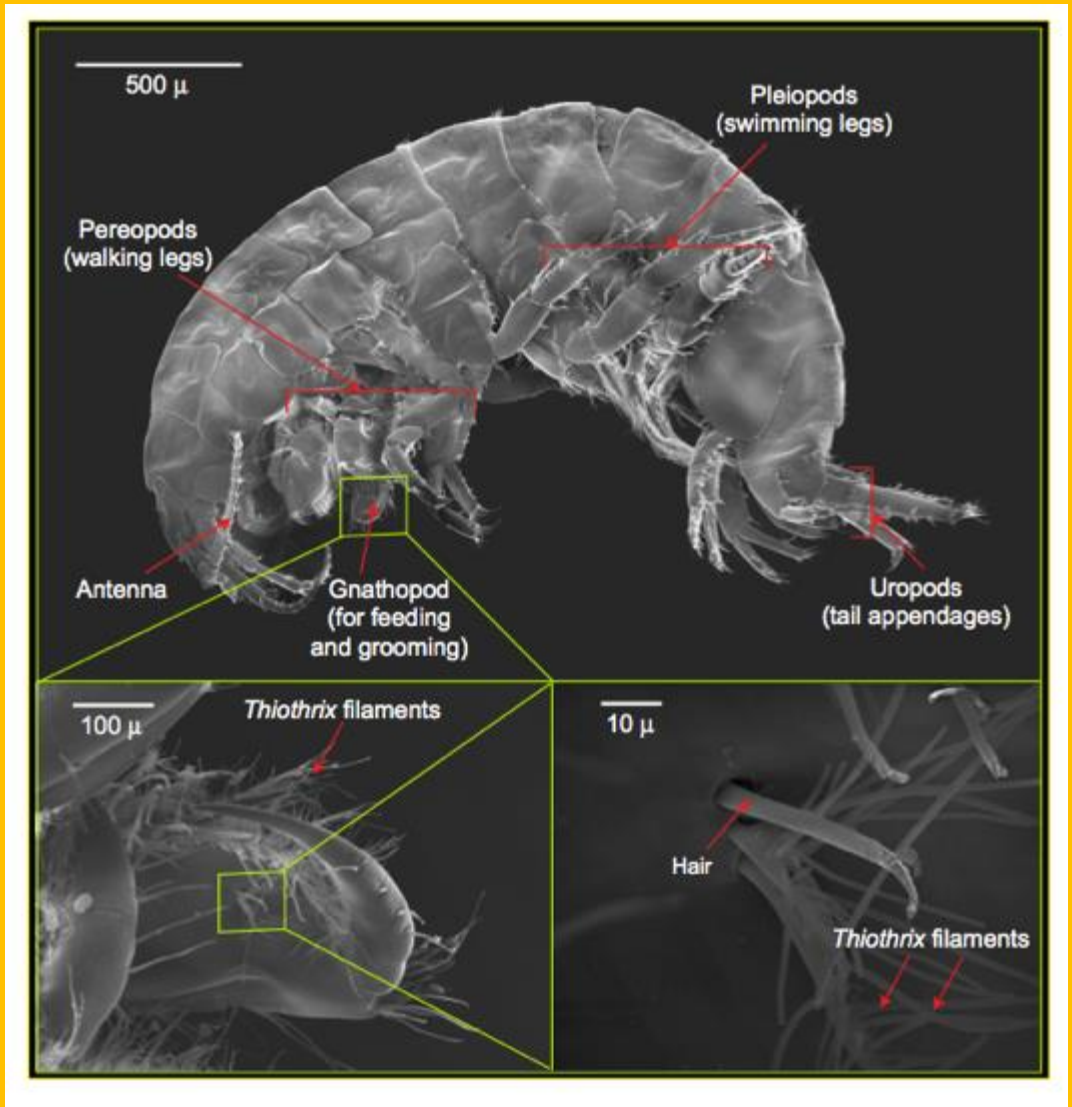
(Site GS)

Microbial biomass in the streams supports animal life





Including symbiotic associations among sulfur oxidizing bacteria and invertebrates



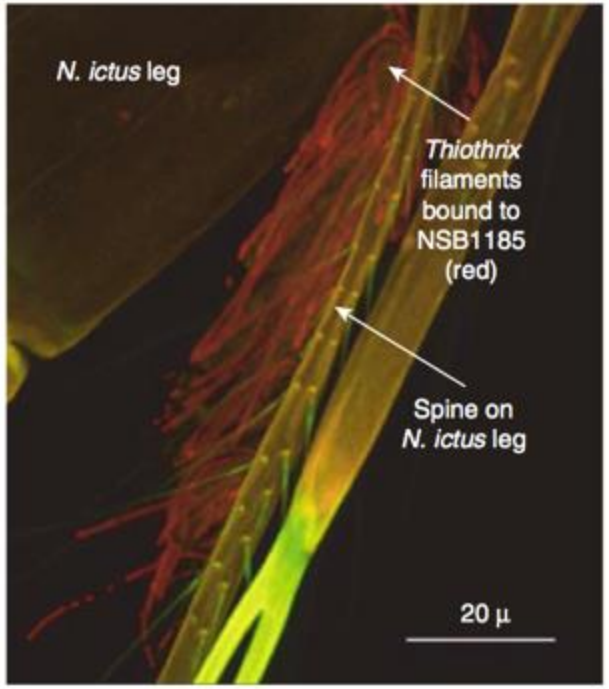
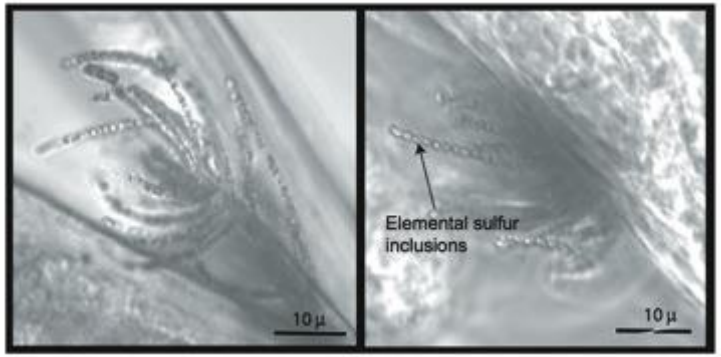


Figure 2 Confocal epifluorescence micrograph showing *Thiothrix* filaments bound to the NSB1185 probe (red) on a *N. ictus* leg spine (green and red autofluorescence).



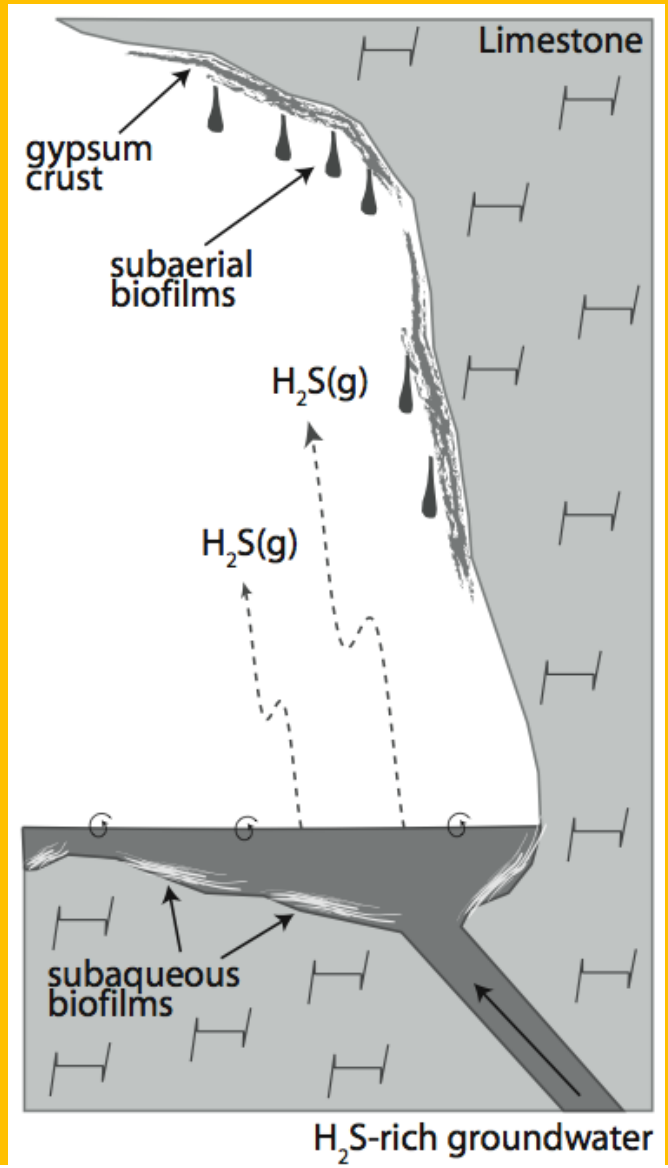
Dattagupta et al. (2009)

Ramo Sulfureo, Frasassi Caves


ENMET
0
0.0
13
20.3
0.0
5000
ENMET
SAPPHIRE


0
0.5
1.6
1.9
2.2

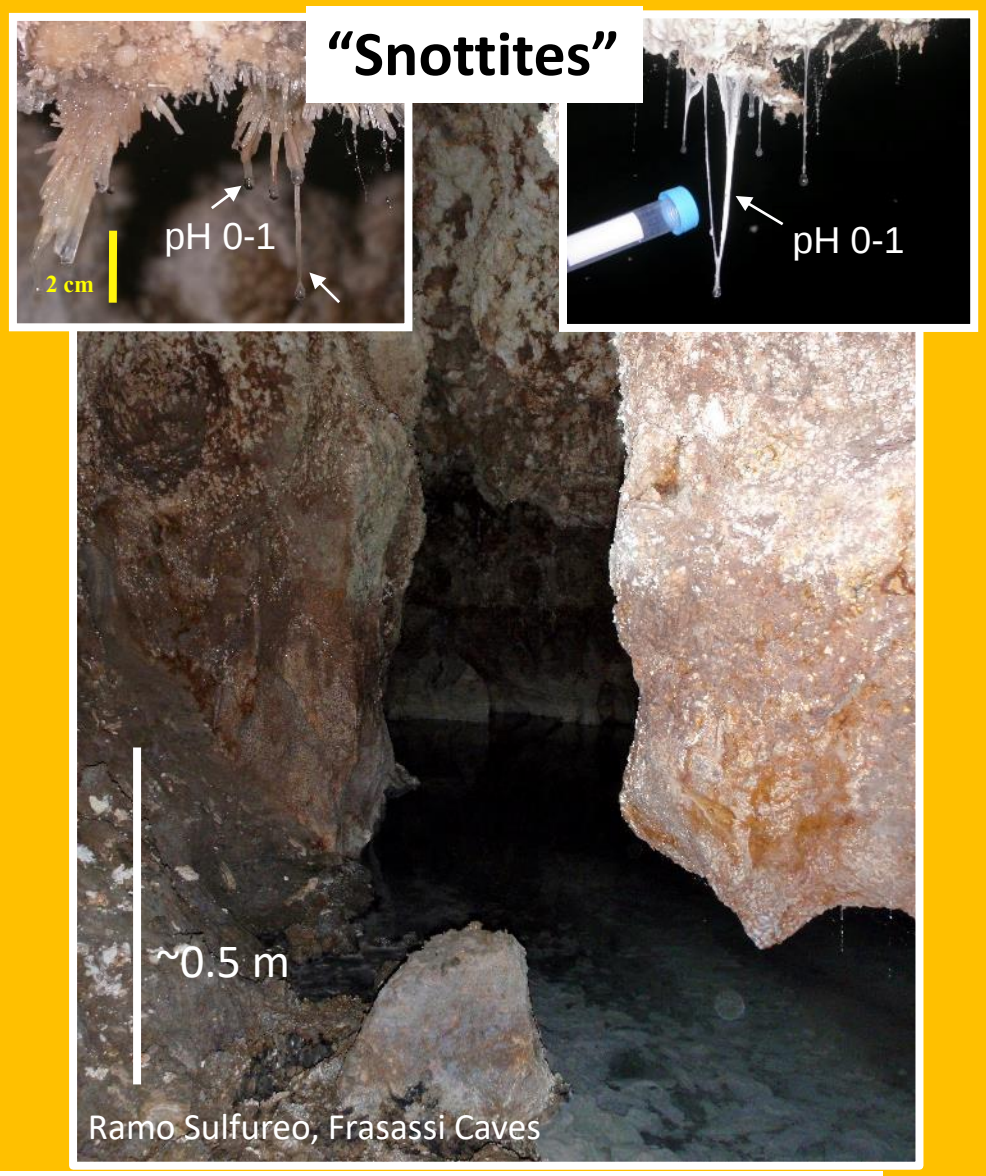
Extremely acidic biofilms and mineral deposits develop above the water table



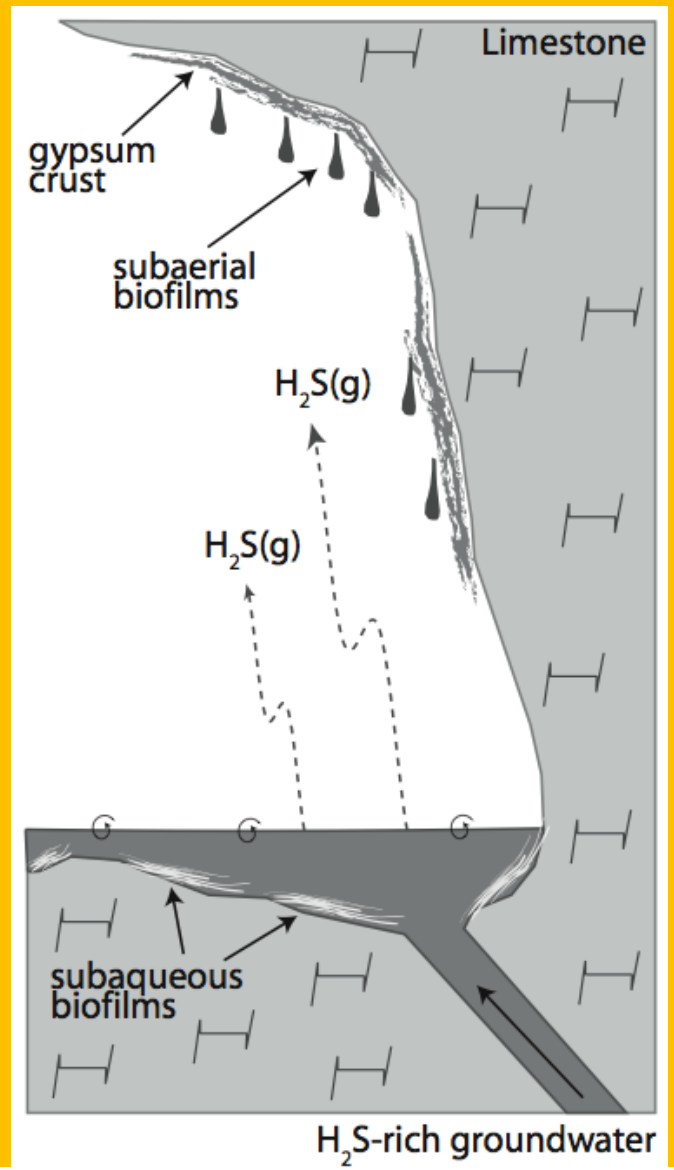
$$H_2SO_4 + CaCO_3 + H_2O \rightarrow CaSO_4 \bullet 2H_2O + CO_2$$

$$H_2S + 2O_2 \rightarrow 2H^+ + SO_4^{2-}$$

Extremely acidic biofilms and mineral deposits develop above the water table

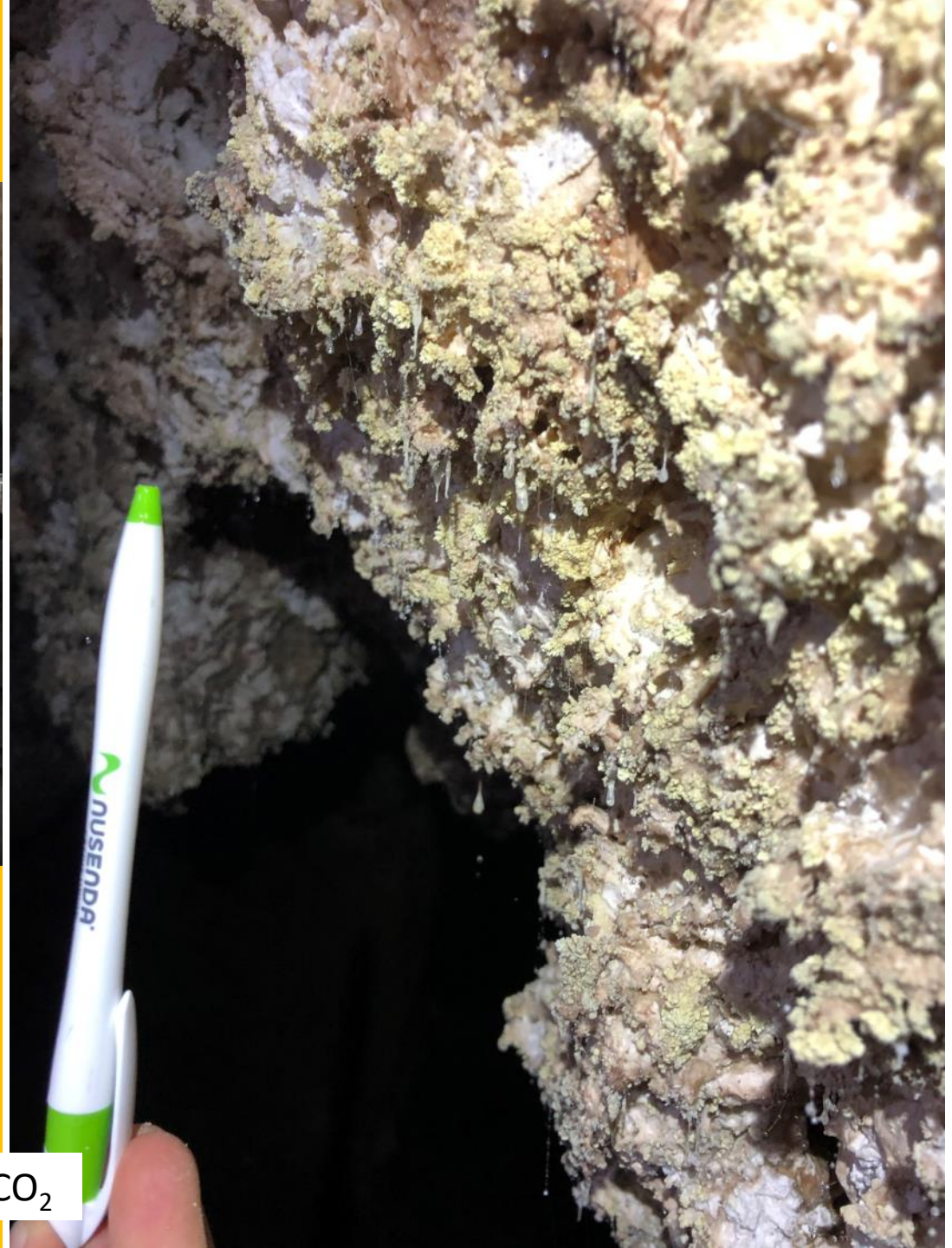


$H_2SO_4 + CaCO_3 + H_2O \rightarrow CaSO_4 \bullet 2H_2O + CO_2$



$H_2S + 2O_2 \rightarrow 2H^+ + SO_4^{2-}$

Acidic gypsum and elemental S deposits



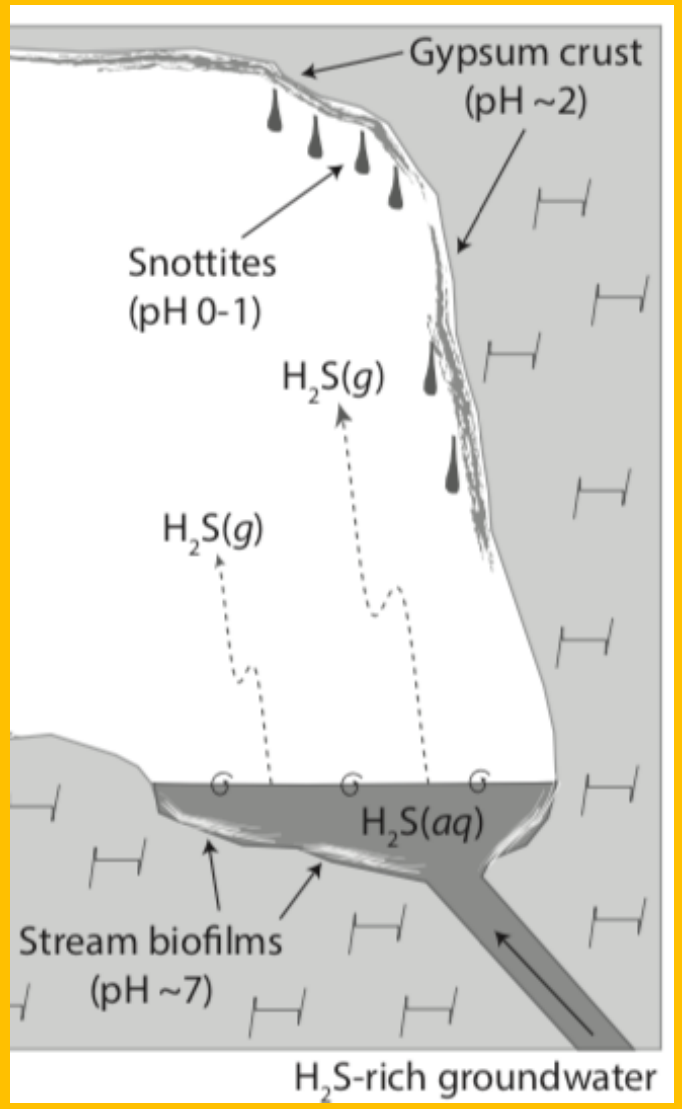
Sulfide oxidation

$$H_2S + 2O_2 \rightarrow H_2SO_4$$
$$2H_2S + O_2 \rightarrow S(0) + H_2O$$

Gypsum formation

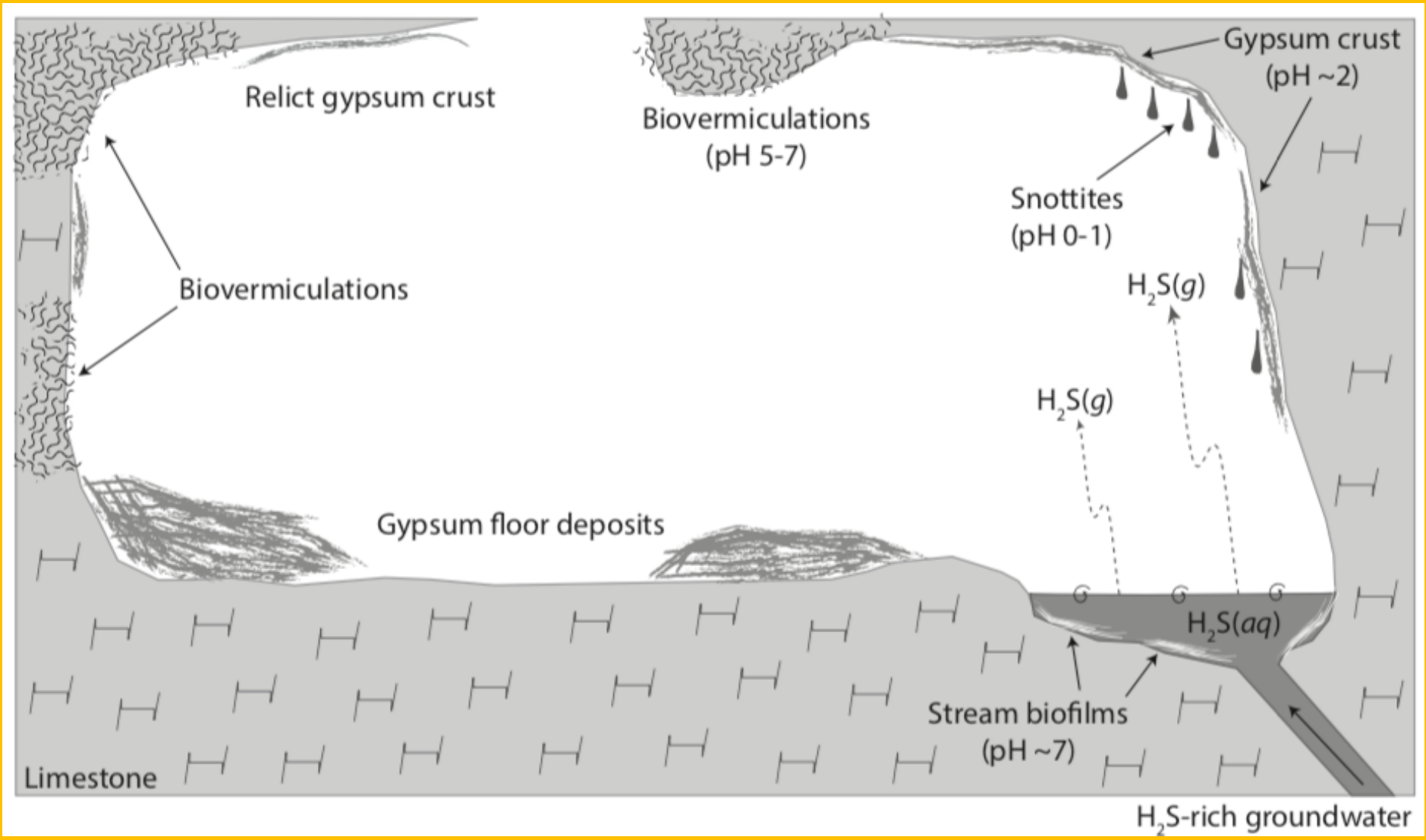
$$H_2SO_4 + CaCO_3 + H_2O \rightarrow CaSO_4 \bullet 2H_2O + CO_2$$

Things start to look different further from the H_2S source



Jones and Northup (in press)

Things start to look different further from the H_2S source



Jones and Northup (in press)

Biovermiculations cover exposed limestone surfaces farther from the H_2S degassing source

Grotta Sulfurea

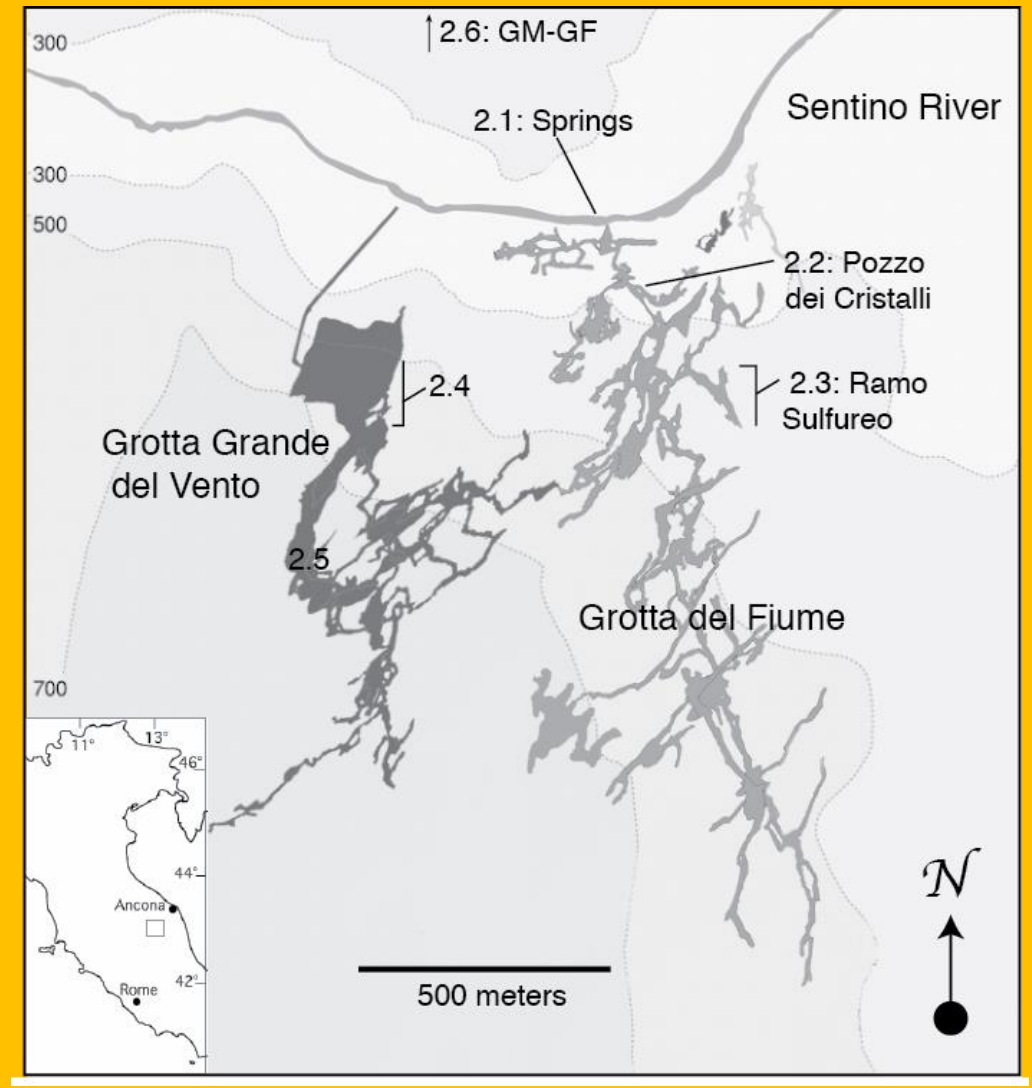
Photo by Ieva Perkons

Morphological evidence for abandoned sulfidic stream channels several meters above the current water table

“Bug” cave

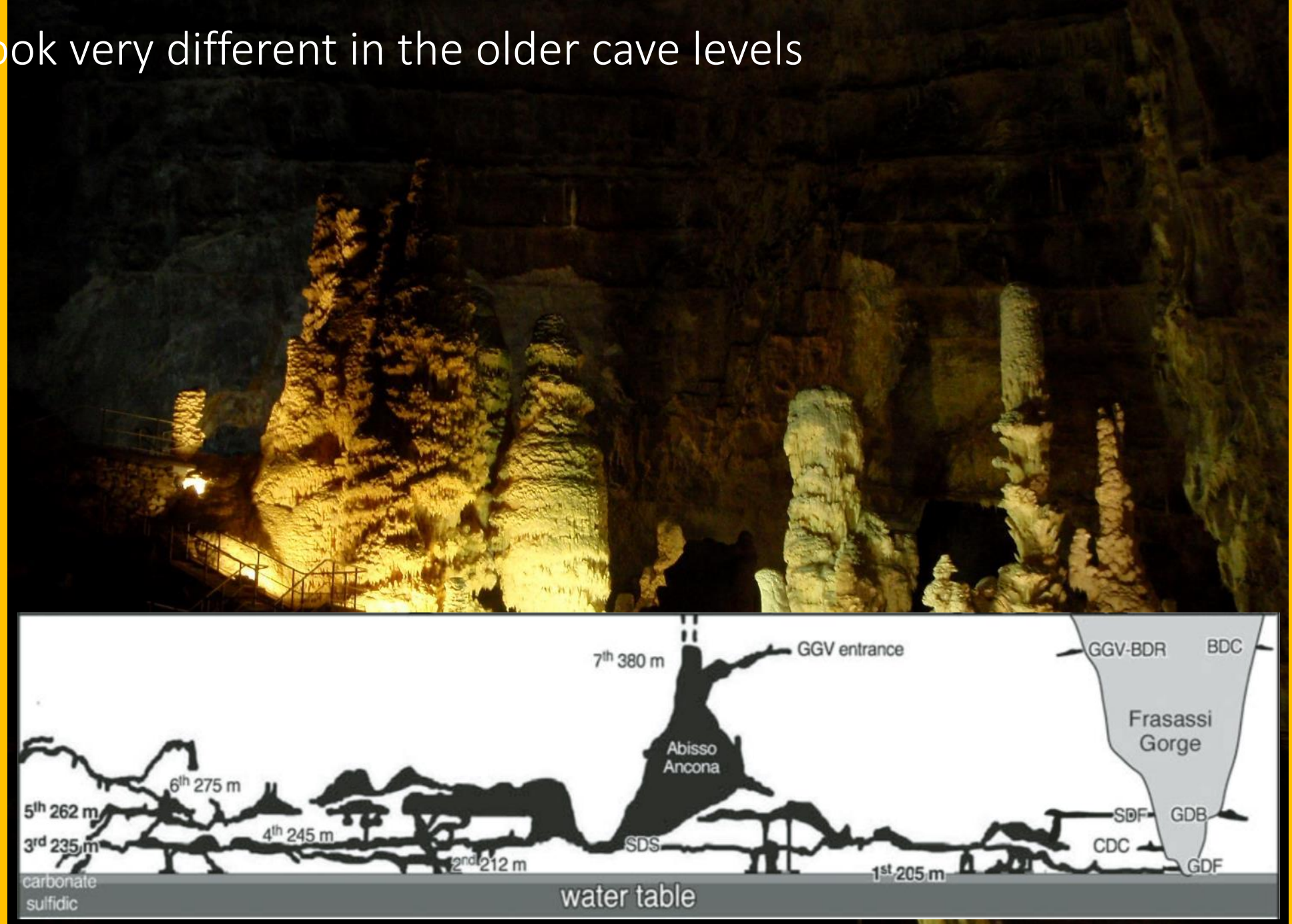
"Bug" cave

Stop 4: Abisso Ancona and the tourist route



Things look very different in the older cave levels

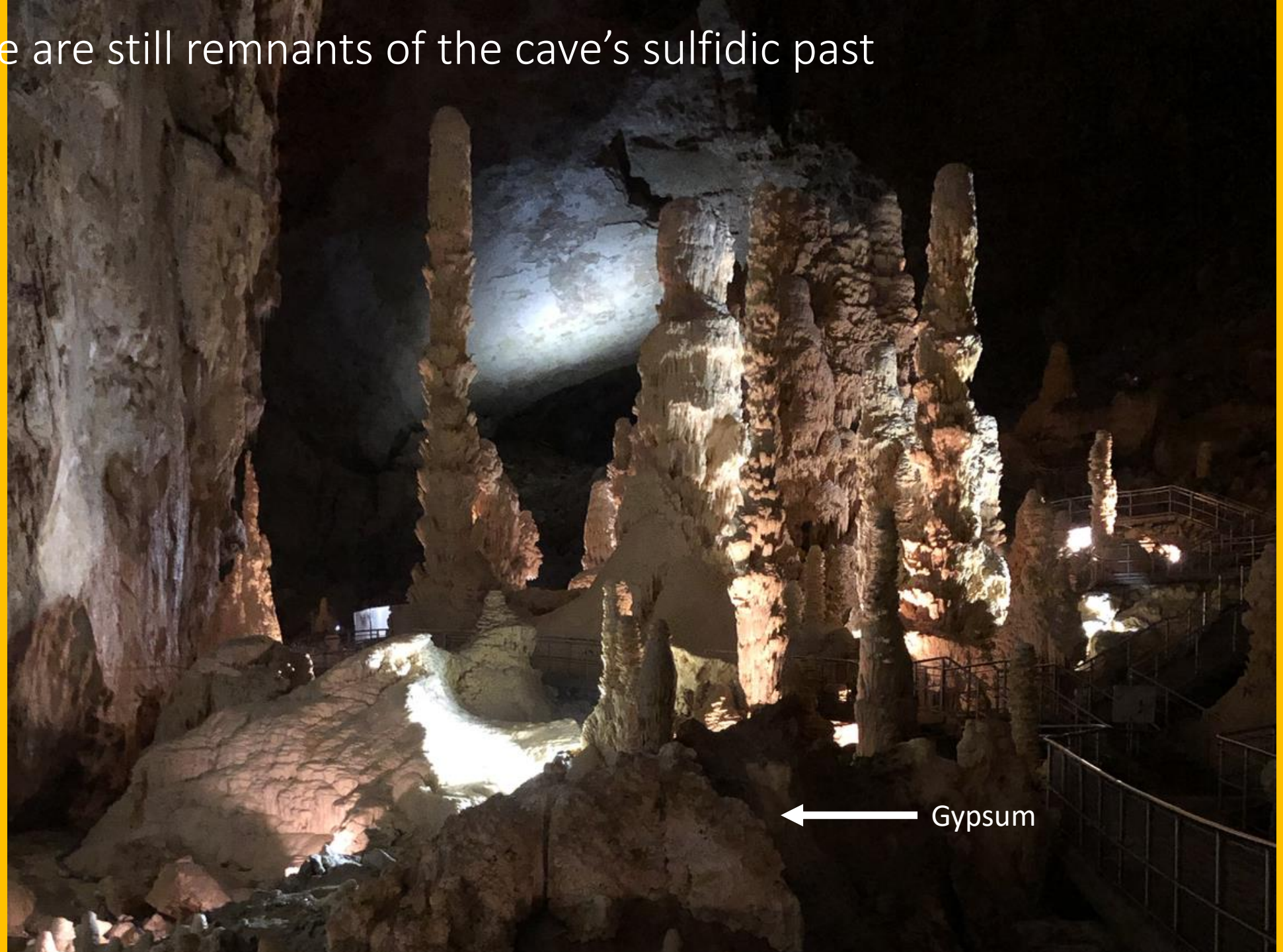
Things look very different in the older cave levels

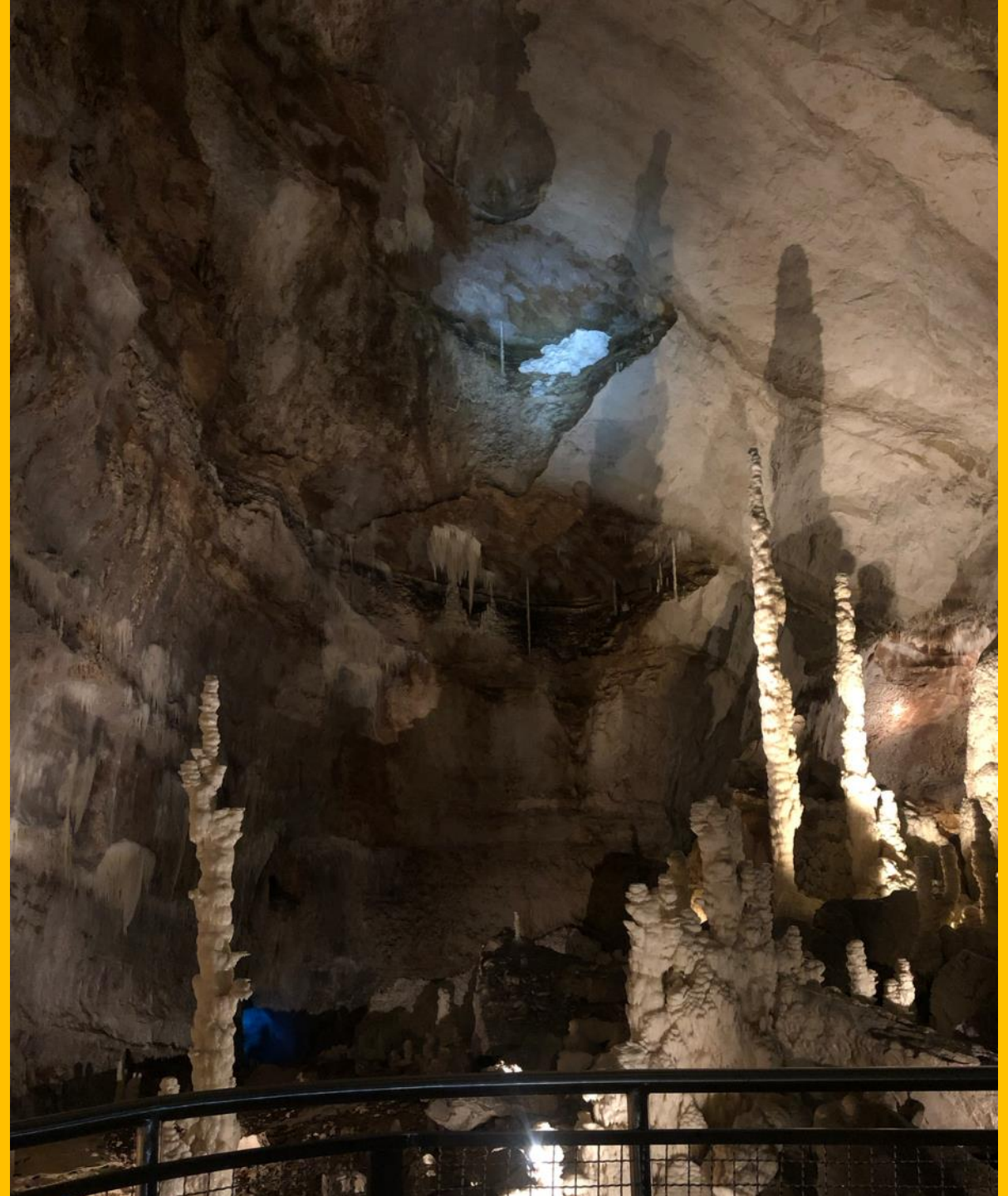


Montanari et al. (2019)

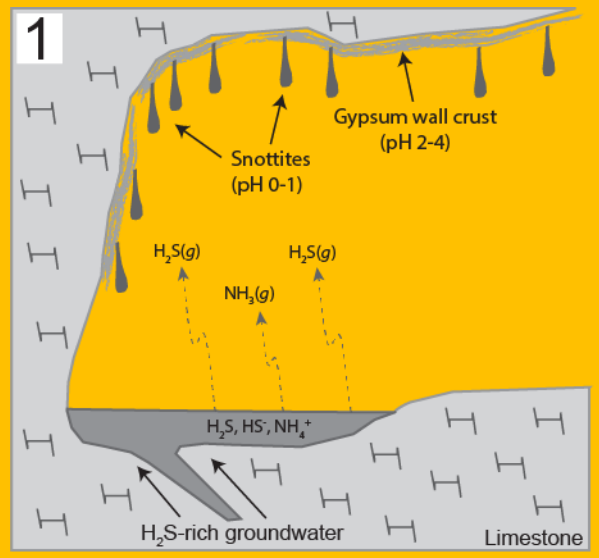
Things look very different in the older cave levels

But there are still remnants of the cave's sulfidic past

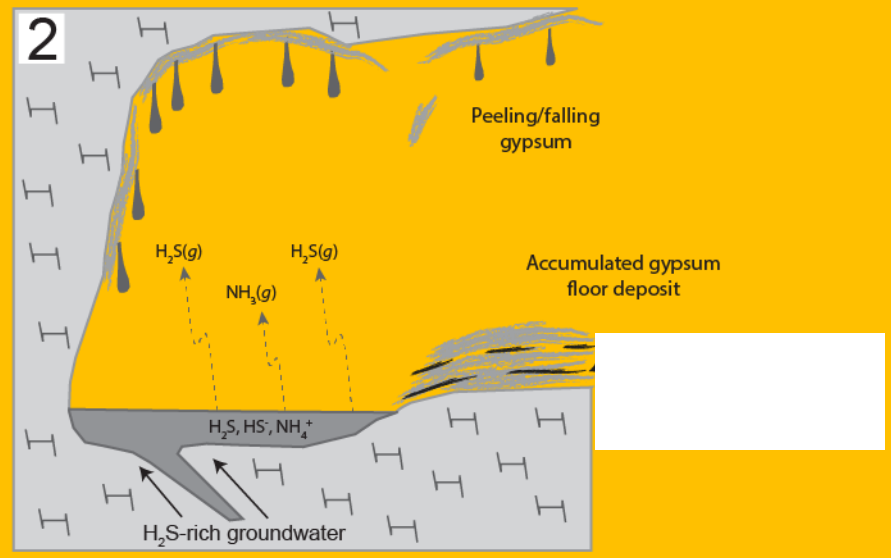




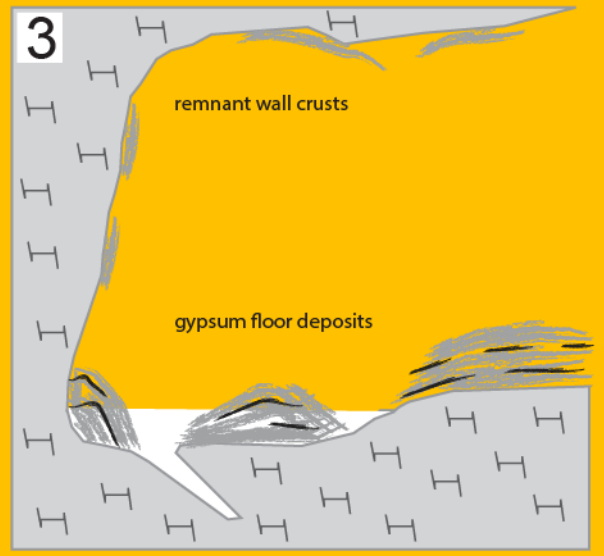
Evolution of the Frasassi Caves



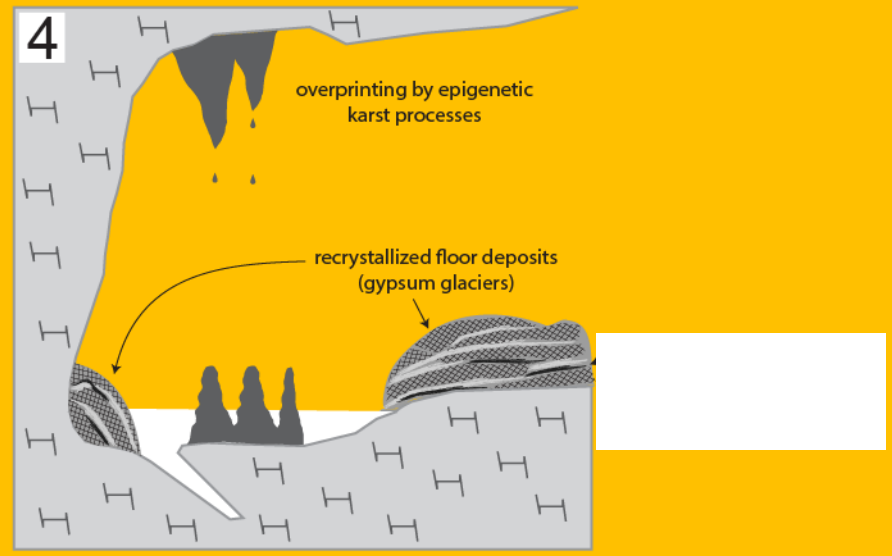
Time 1



Time 2: 10s to 1000s of yrs from time 1

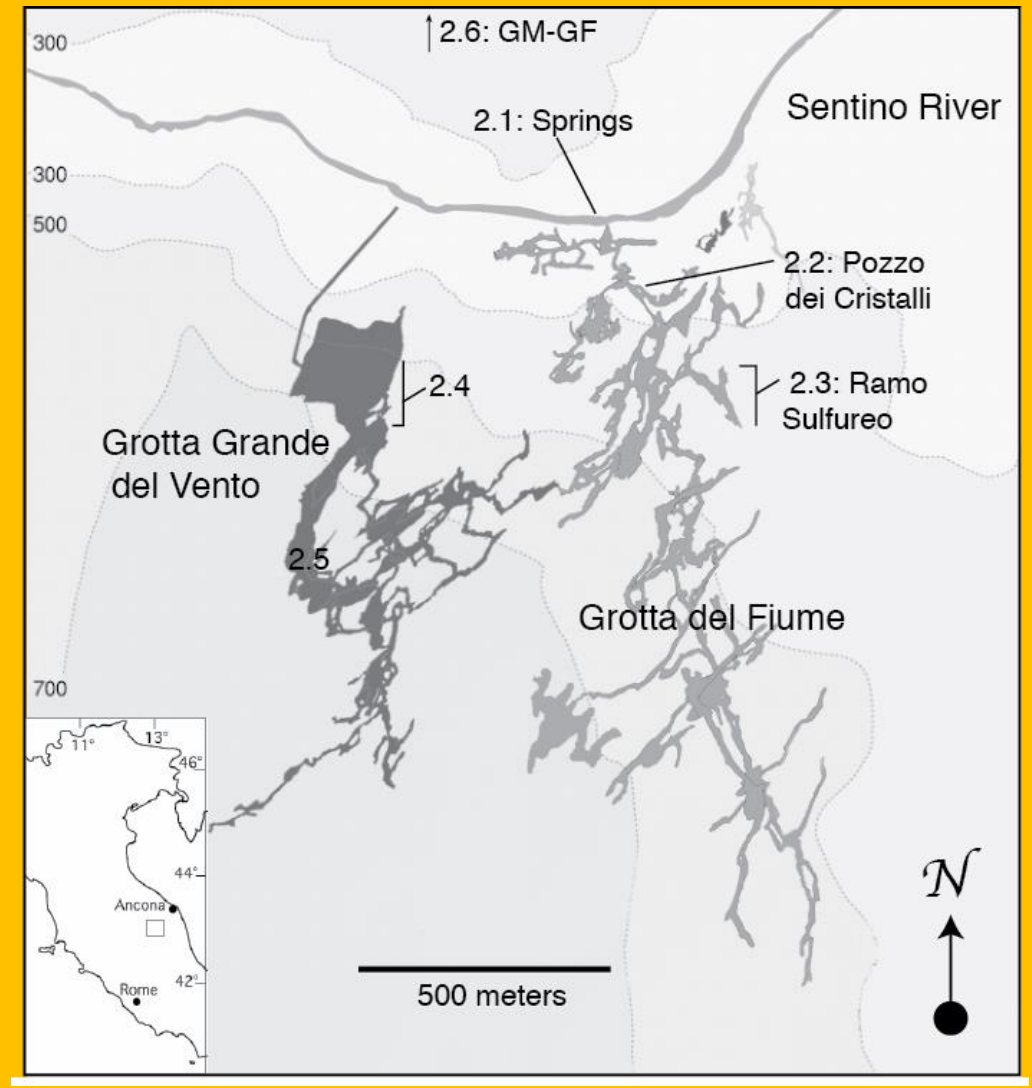


Time 3: 1,000s to 100,000s yrs from time 1



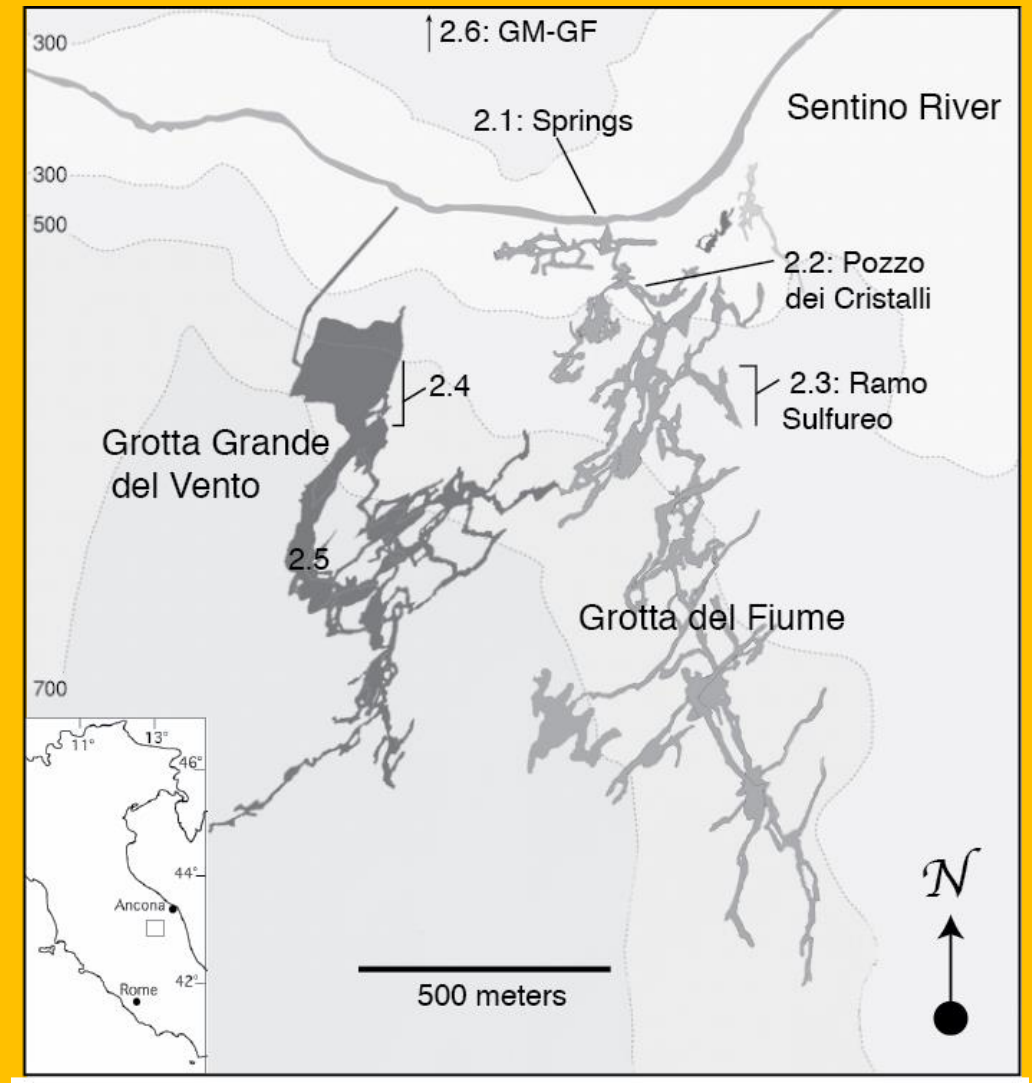
Time 4: 100,000s to millions yrs from time 1

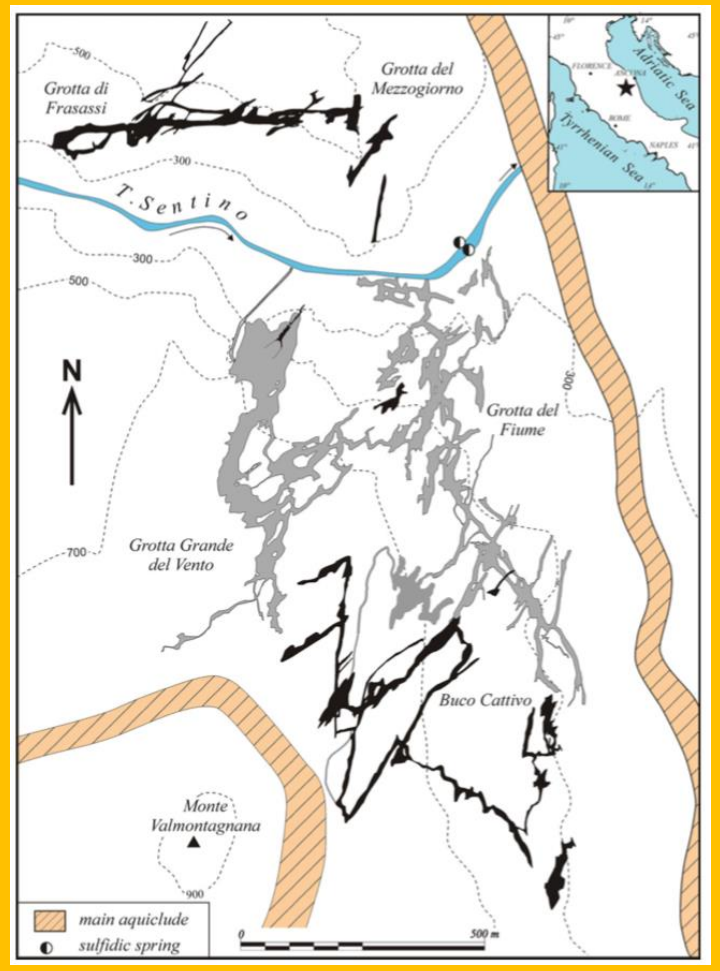
Stop 5: Artificial sulfidic spring along the tourist trail

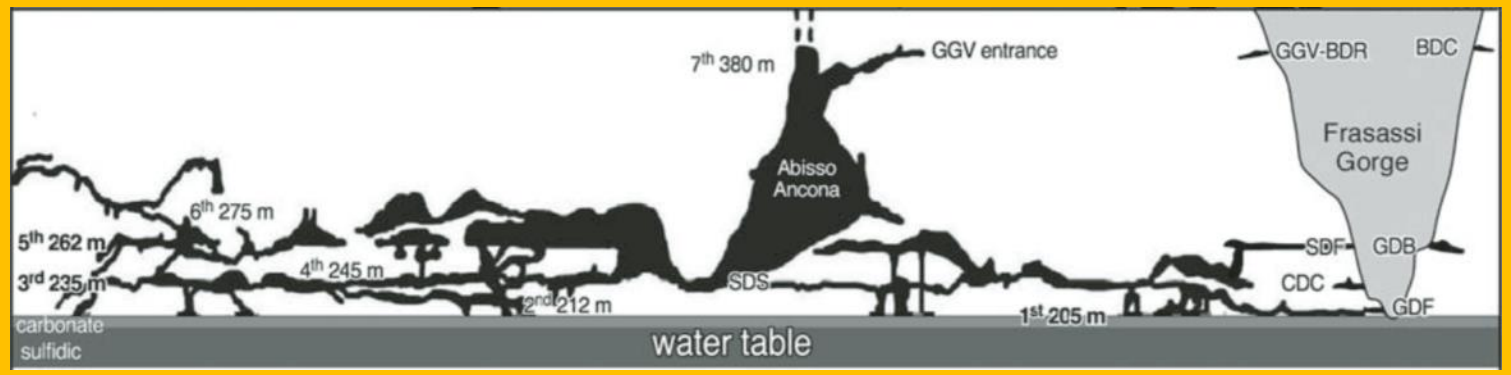



ADM
33
ADM
33

Stop 6: The oldest levels (Grotta del Mezzogiorno-Grotta di Frasassi)







Galdenzi and Jones (2017); Montanari et al. (2019)

CARLSBAD CAVERN, NEW MEXICO USA

- Introduction 0900 PDT
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- Stop 2 – Frasassi Caves 0930 PDT
- **Stop 3 – Carlsbad Cavern 0955 PDT**
  Harvey Duchene
- Stop 4 – Lechuguilla Cave 1015 PDT
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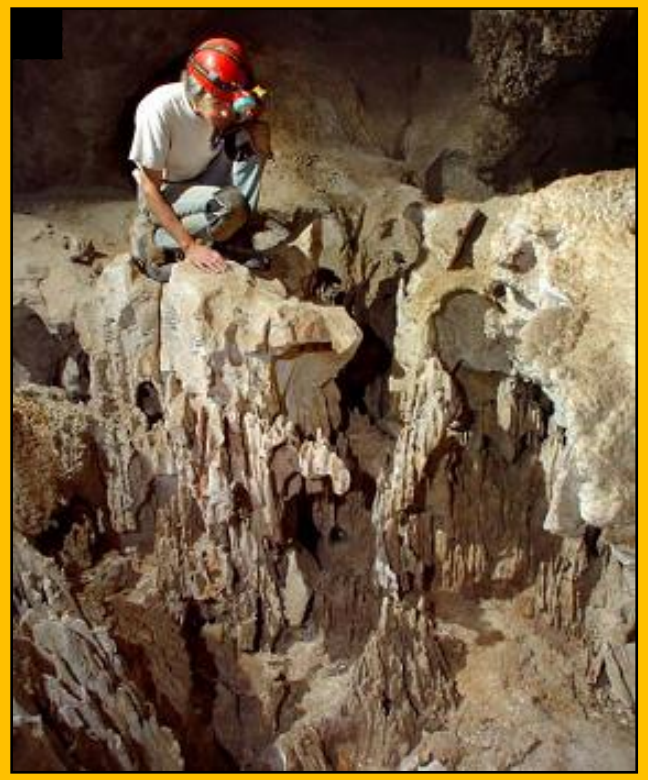
CARLSBAD CAVERN
NEW MEXICO USA



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INTERNATIONAL YEAR OF CAVES AND KARST 2021

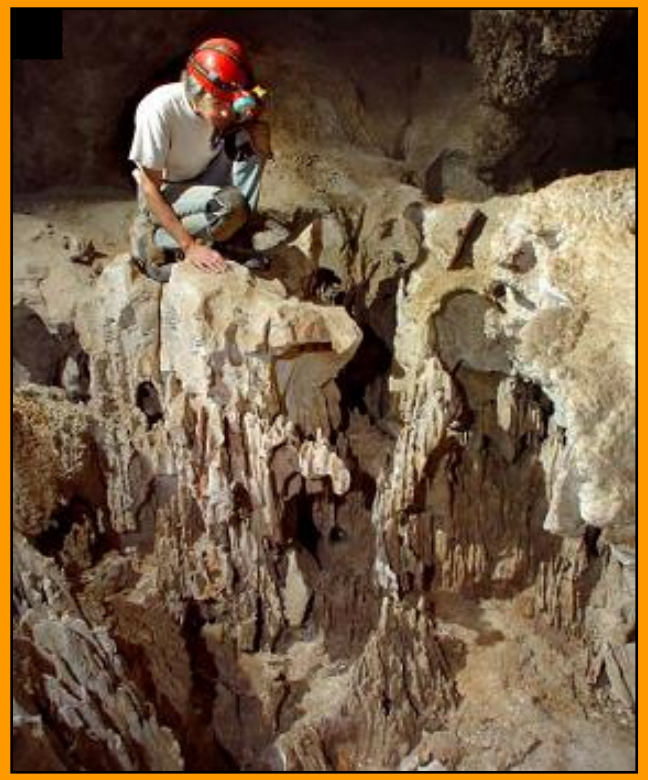
NATIONAL PARK SERVICE

NATIONAL CAVE & KARST RESEARCH INSTITUTE

KARST WATERS INSTITUTE

University of Nevada, Reno

CARLSBAD CAVERN
NEW MEXICO USA



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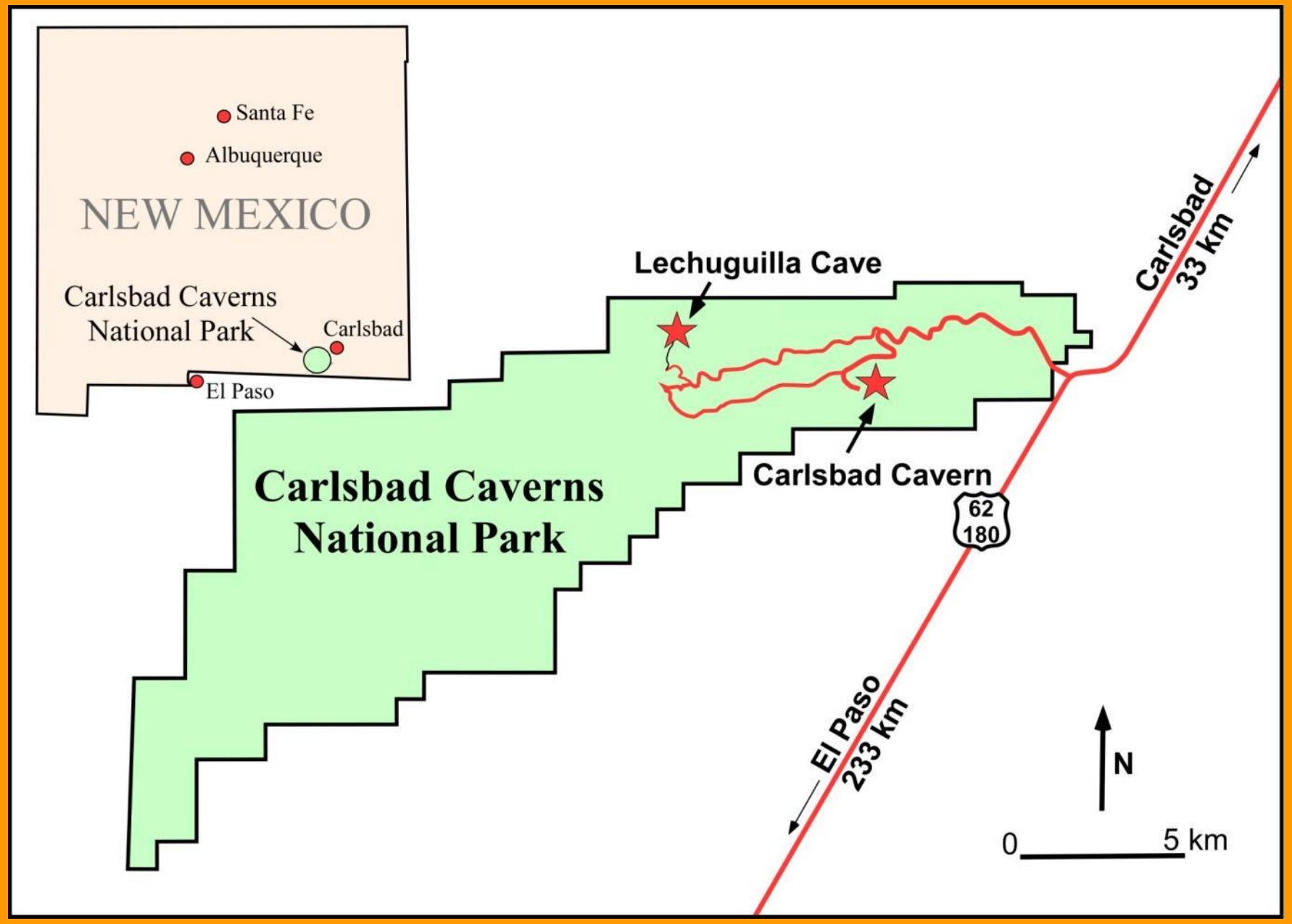
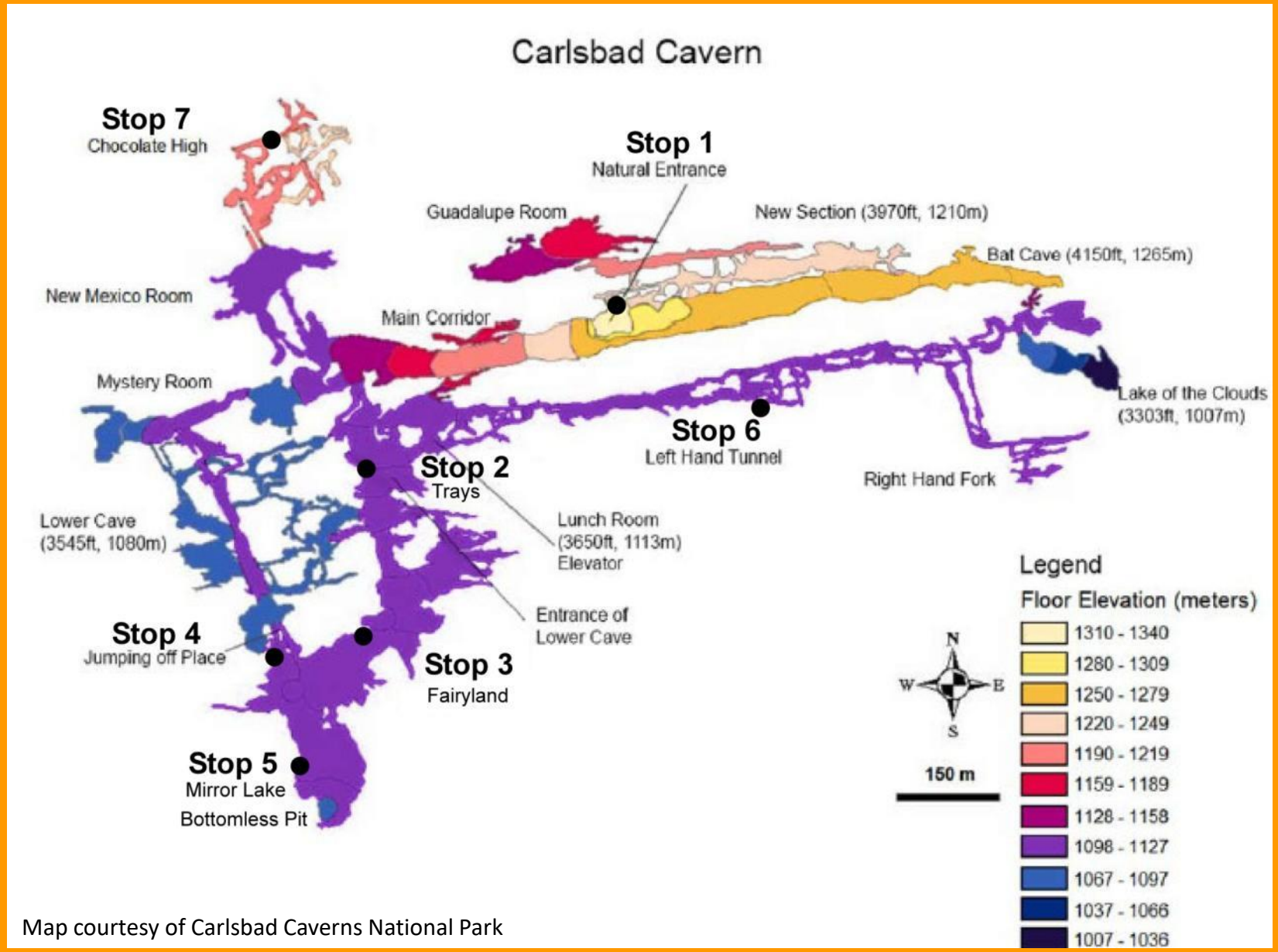
University of Nevada, Reno

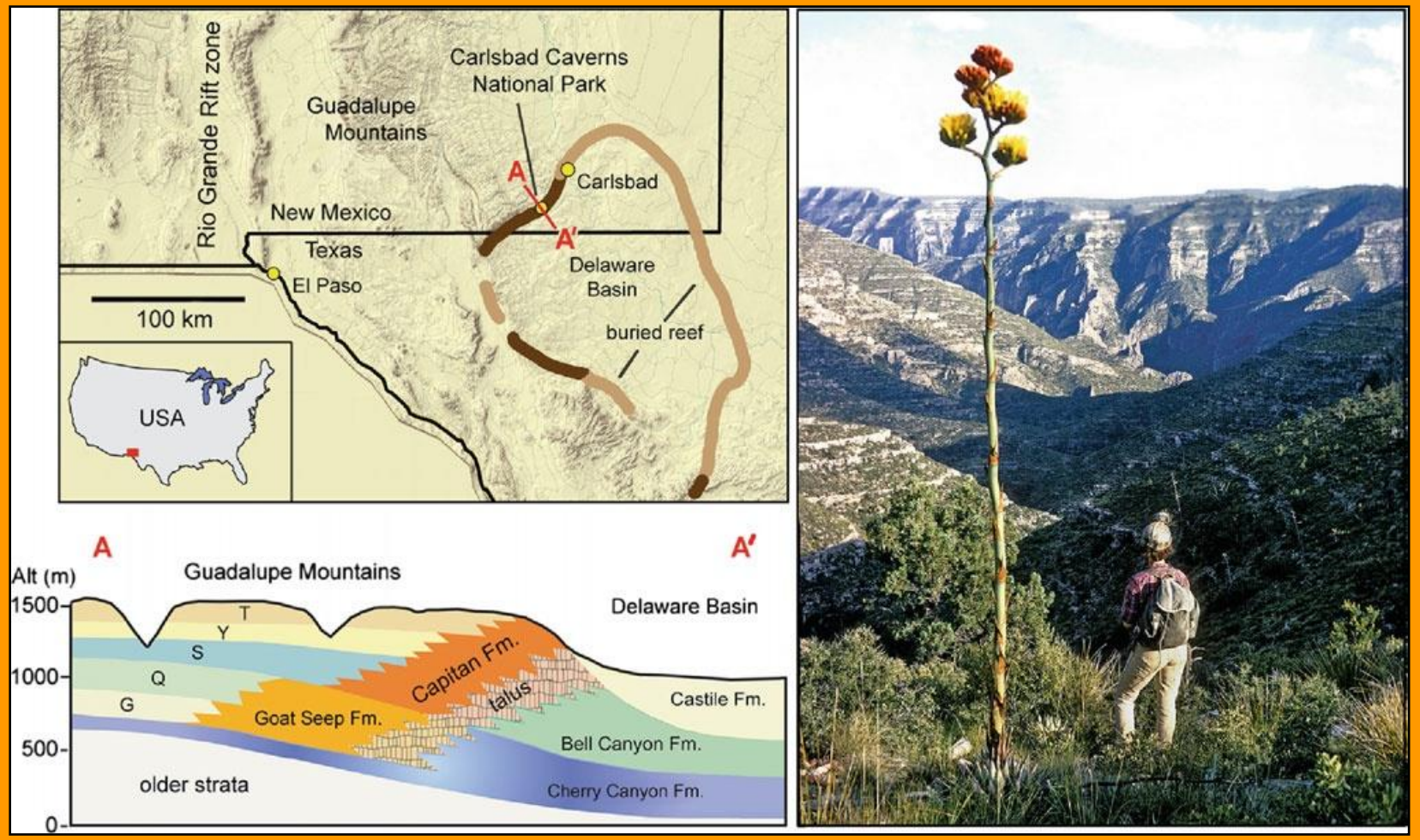


Hypogenic Caves of the Great Basin: Chapter 3, Carlsbad Cavern

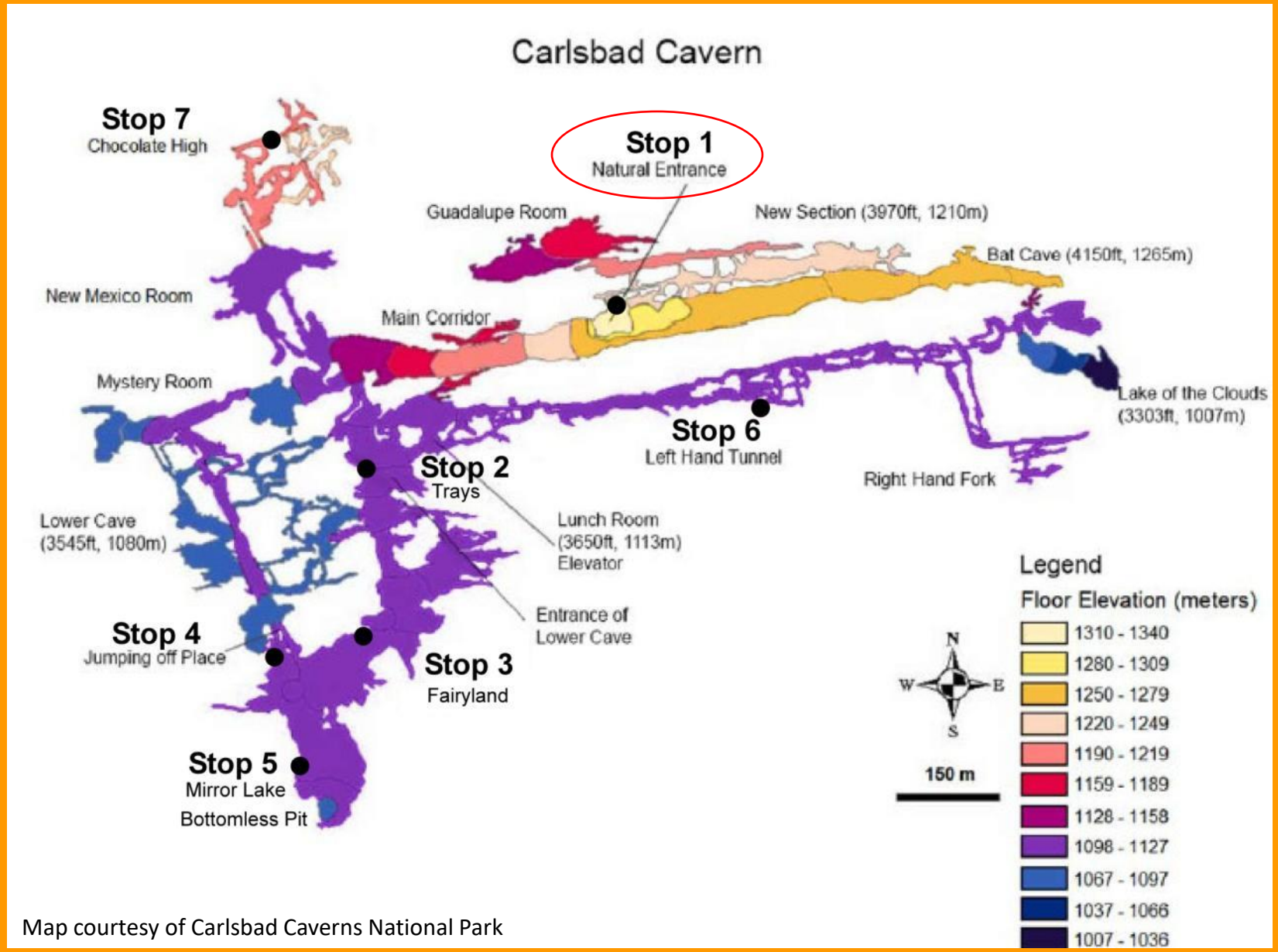


Map courtesy of Carlsbad Caverns National Park

Hypogenic Caves of the Great Basin: Chapter 3, Carlsbad Cavern



Location of the Capitan reef and Delaware Basin, with Rio Grande Rift to the west (modified from Harris et al. 1997). Backreef strata: G Grayburg, Q Queen, S Seven Rivers, Y Yates, T Tansill. Digital elevation map by Paul Burger. Cross section from Palmer and Palmer (2012). The photograph shows the gently dipping limestones and typical dissected plateau topography of the Guadalupes (Photograph and graphics by A. N. Palmer)



Map courtesy of Carlsbad Caverns National Park

Hypogenic Caves of the Great Basin: Chapter 3, Carlsbad Cavern

Stop 1. Entrance to Carlsbad Cavern

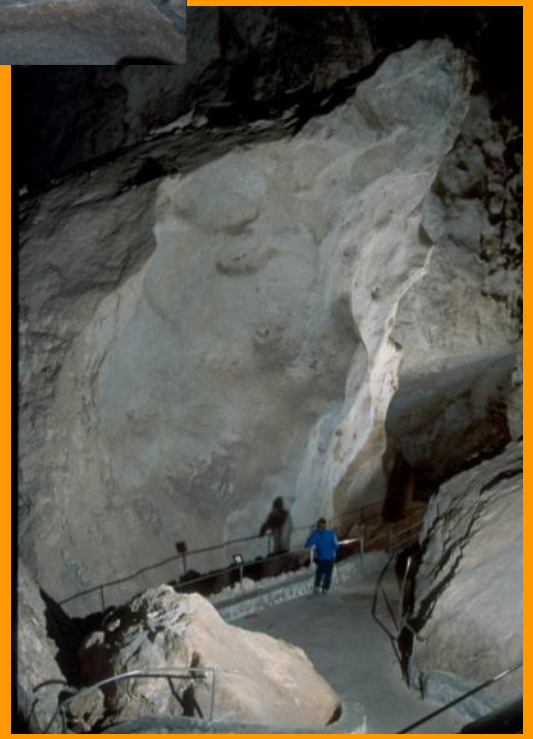
Hypogenic Caves of the Great Basin: Chapter 3, Carlsbad Cavern

Entrance during bat flight.

Switchbacks

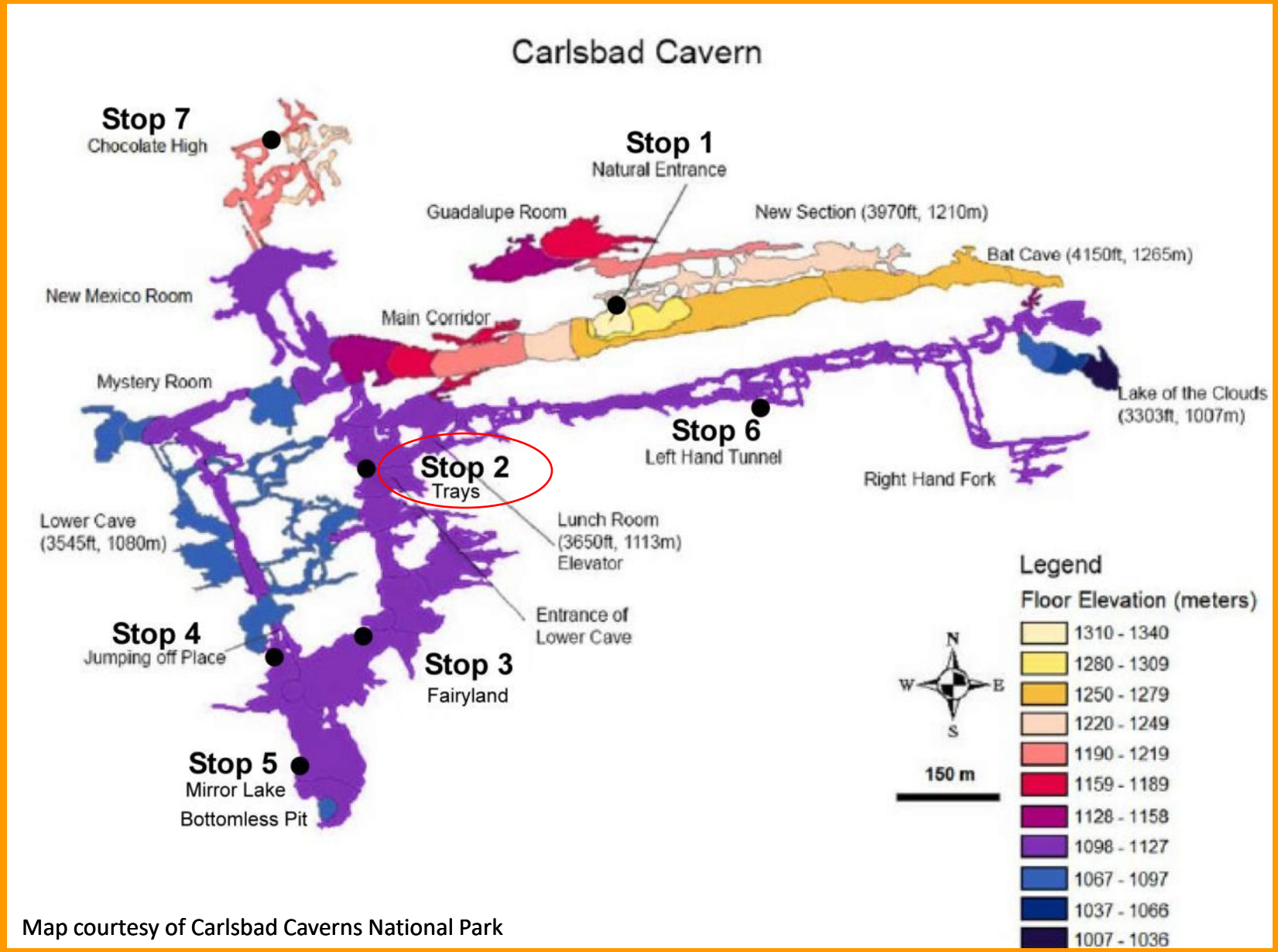
Trail below entrance

Views of the tourist trail from the entrance to the Big Room.



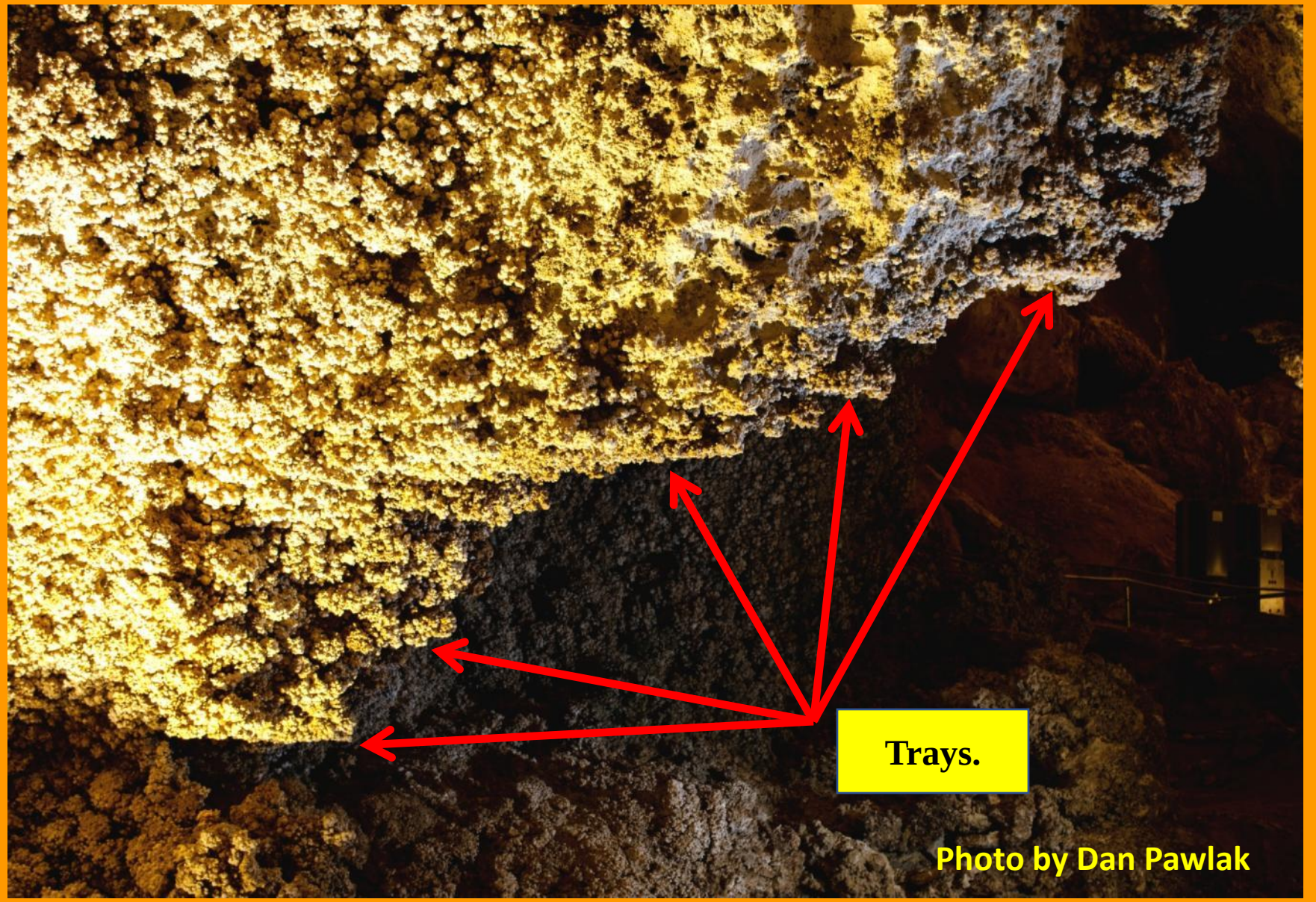
Iceberg Rock

Photos by Peter Jones

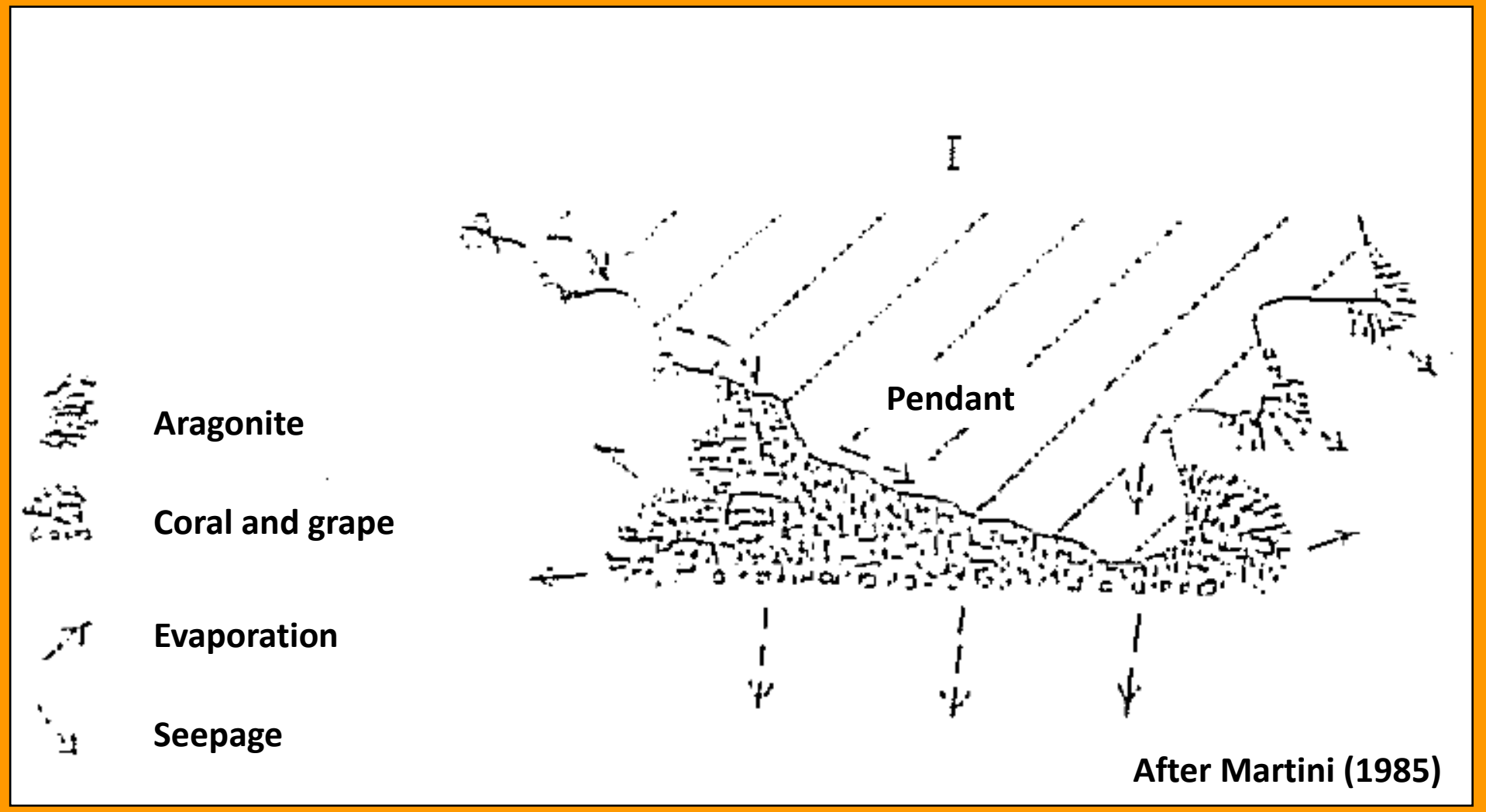


Map courtesy of Carlsbad Caverns National Park

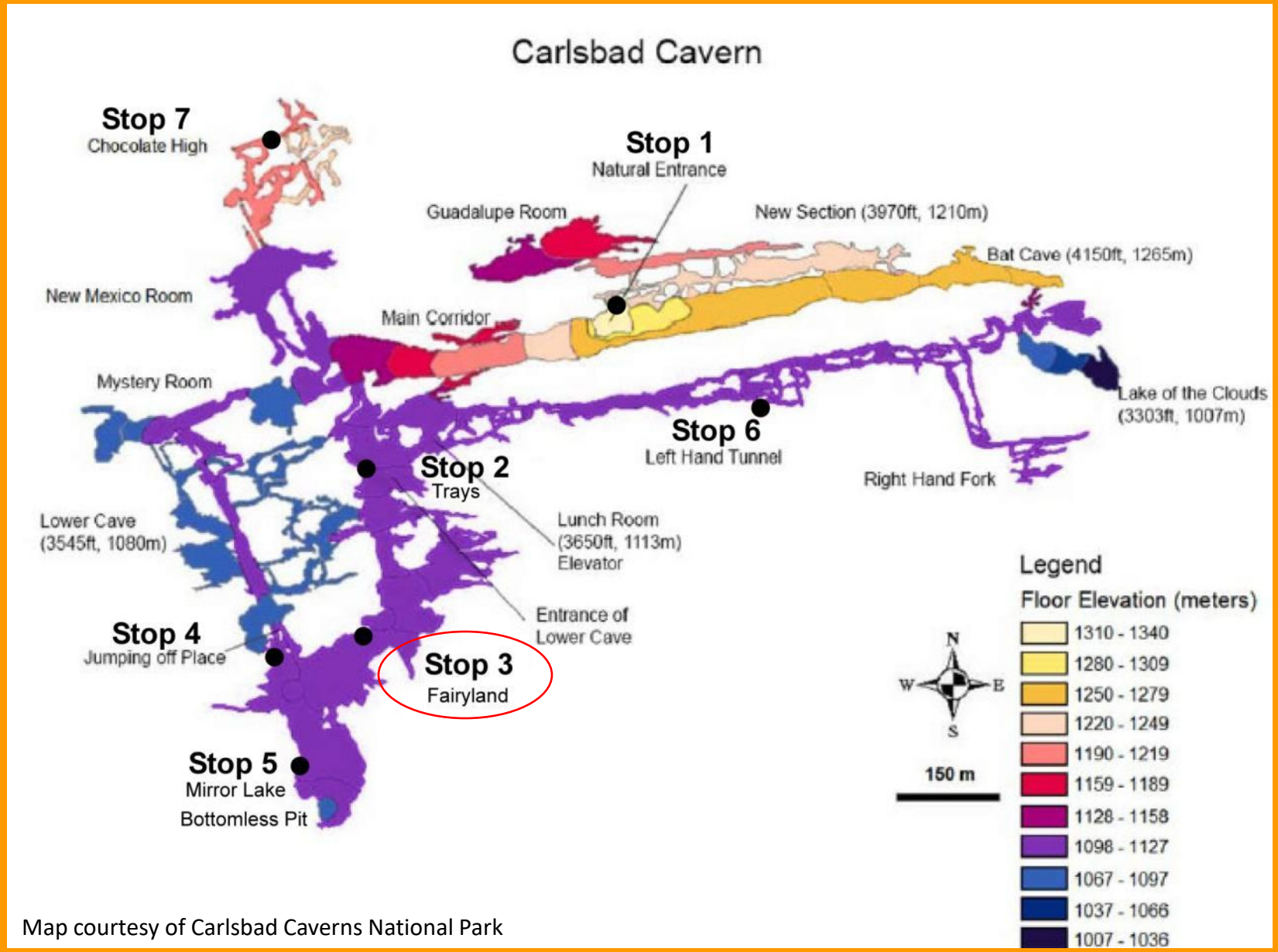
Hypogenic Caves of the Great Basin: Chapter 3, Carlsbad Cavern



Stop 2. Trays on wall next to Tourist Trail, Big Room, Carlsbad Cavern



Jacques Martini's explanation for tray development

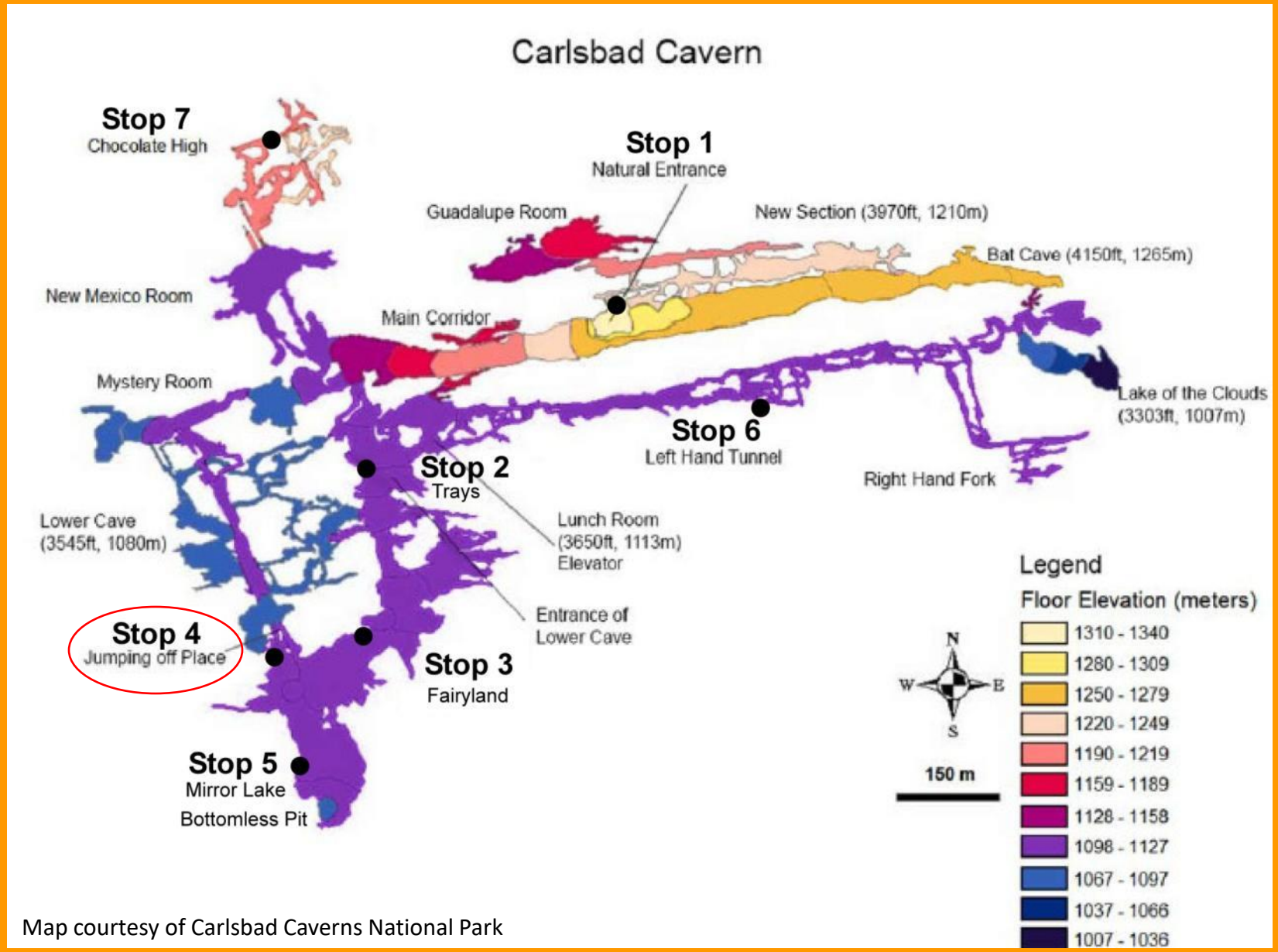


Map courtesy of Carlsbad Caverns National Park

Hypogenic Caves of the Great Basin: Chapter 3, Carlsbad Cavern

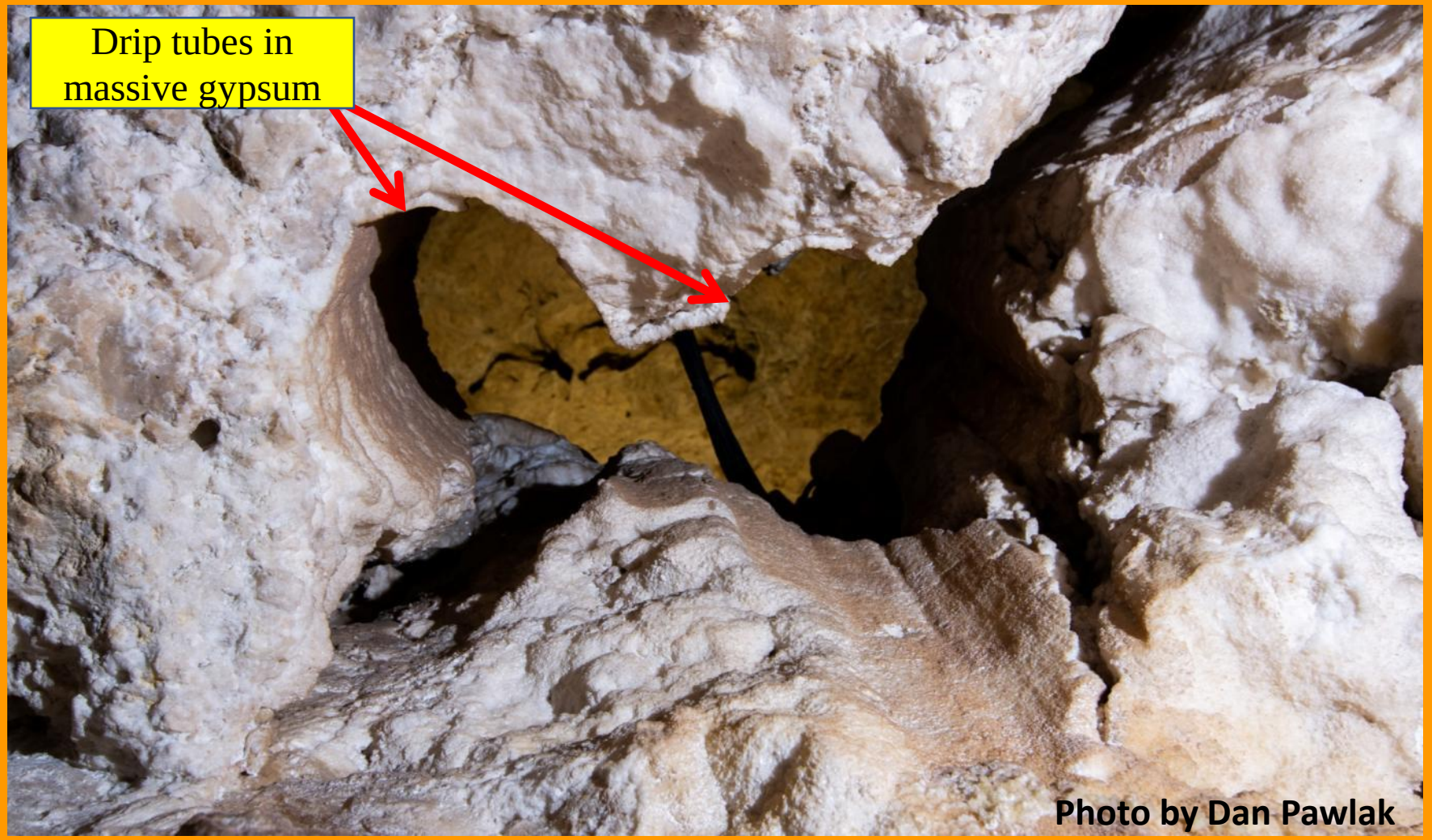
Coral-encrusted drip tube. Photo by David Harris, Harris Photographic.

Stop 3: Coral-encrusted drip tubes, Fairyland, along the trail through the Big Room of Carlsbad Cavern



Map courtesy of Carlsbad Caverns National Park

Hypogenic Caves of the Great Basin: Chapter 3, Carlsbad Cavern



Stop 4. Drip holes through gypsum mass near the Jumping Off Place, viewed from the bottom looking up.

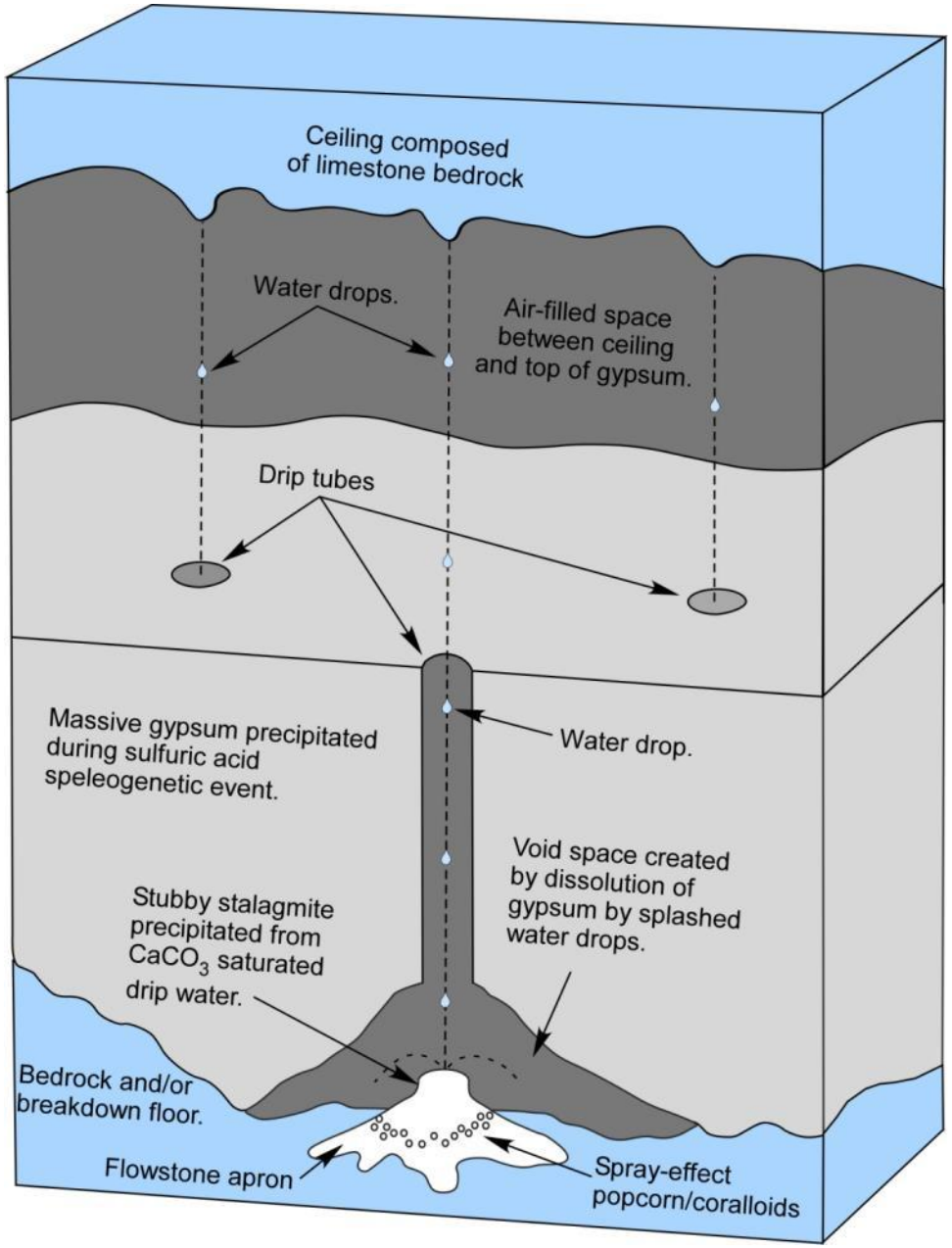
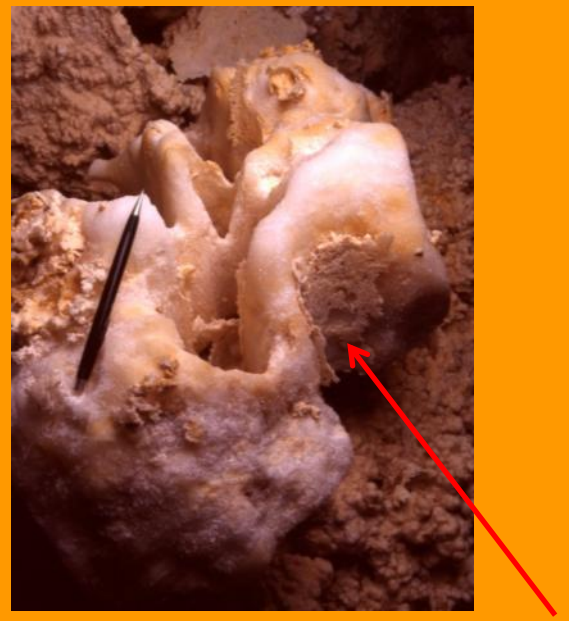
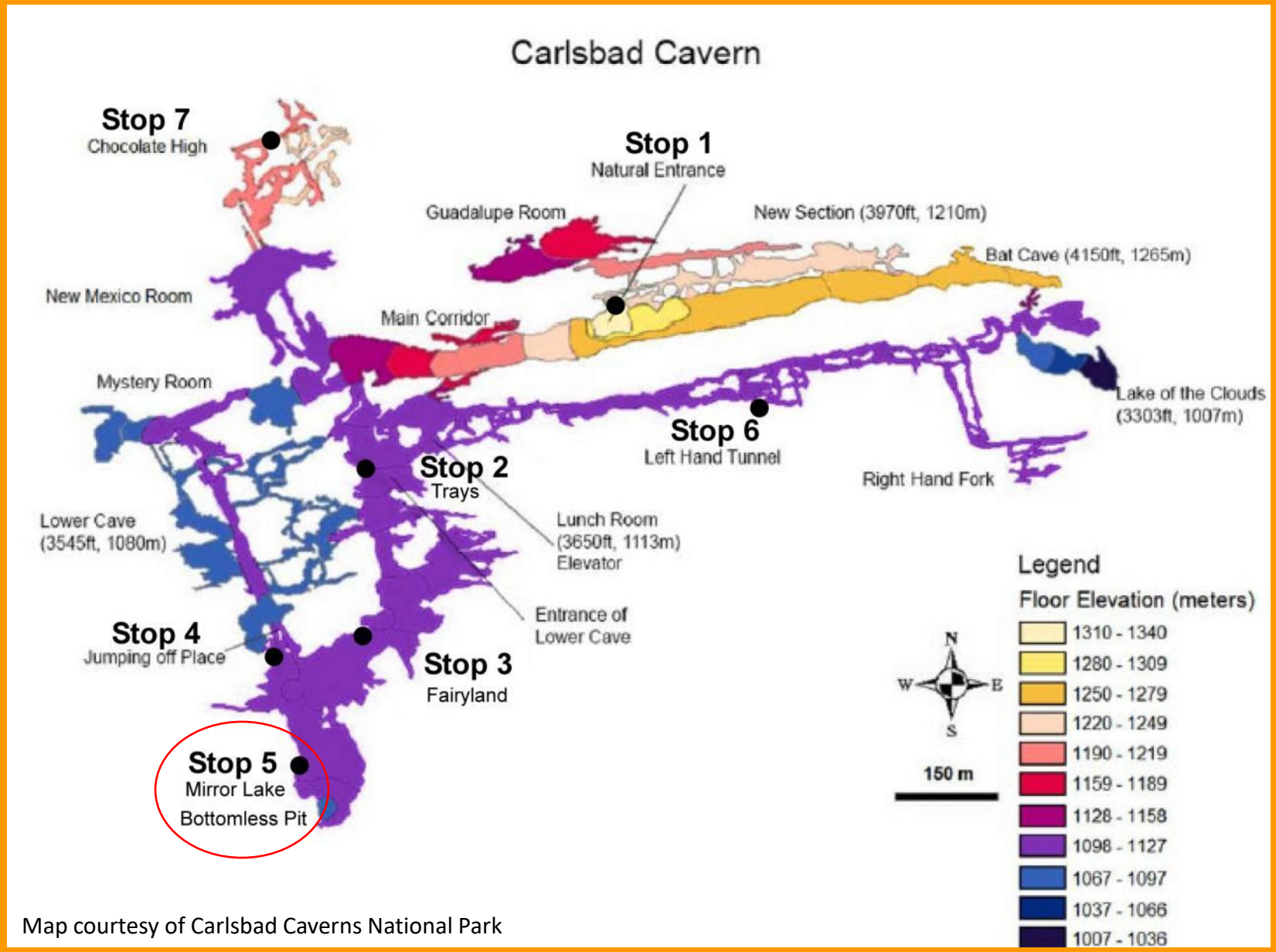


Diagram of a drip tube and associated features in a massive gypsum deposit. Tubes are commonly lined with common-ion effect calcite. Where tubes are coupled to the substrate, they may be preserved and develop into hollow corralloid-encrusted formations. Where the tubes are not coupled to the floor, they are destroyed when the gypsum mass dissolves.

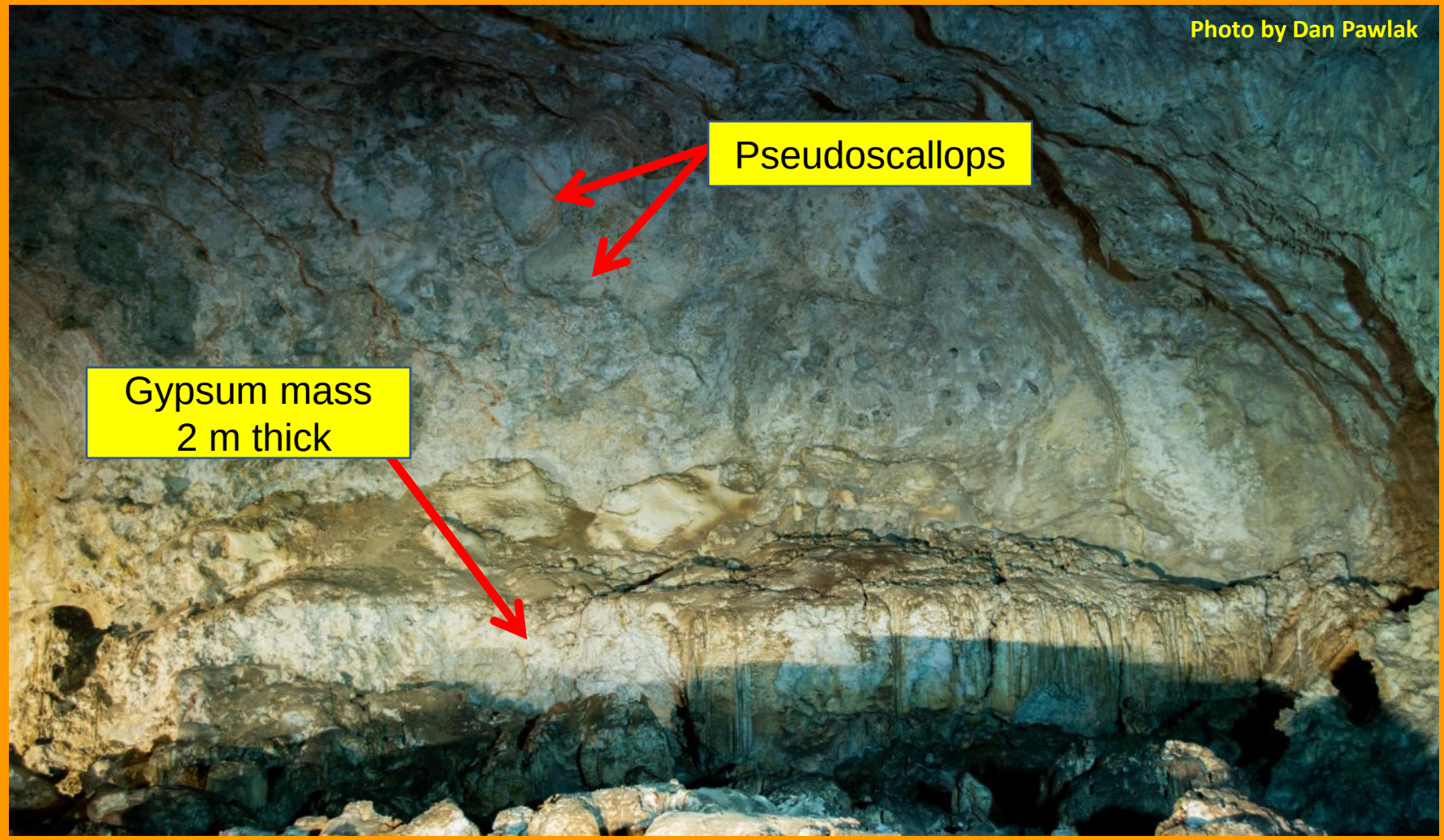


Gypsum remnant with remains of a calcite drip tube. Photo by David Harris, Harris Photographic.

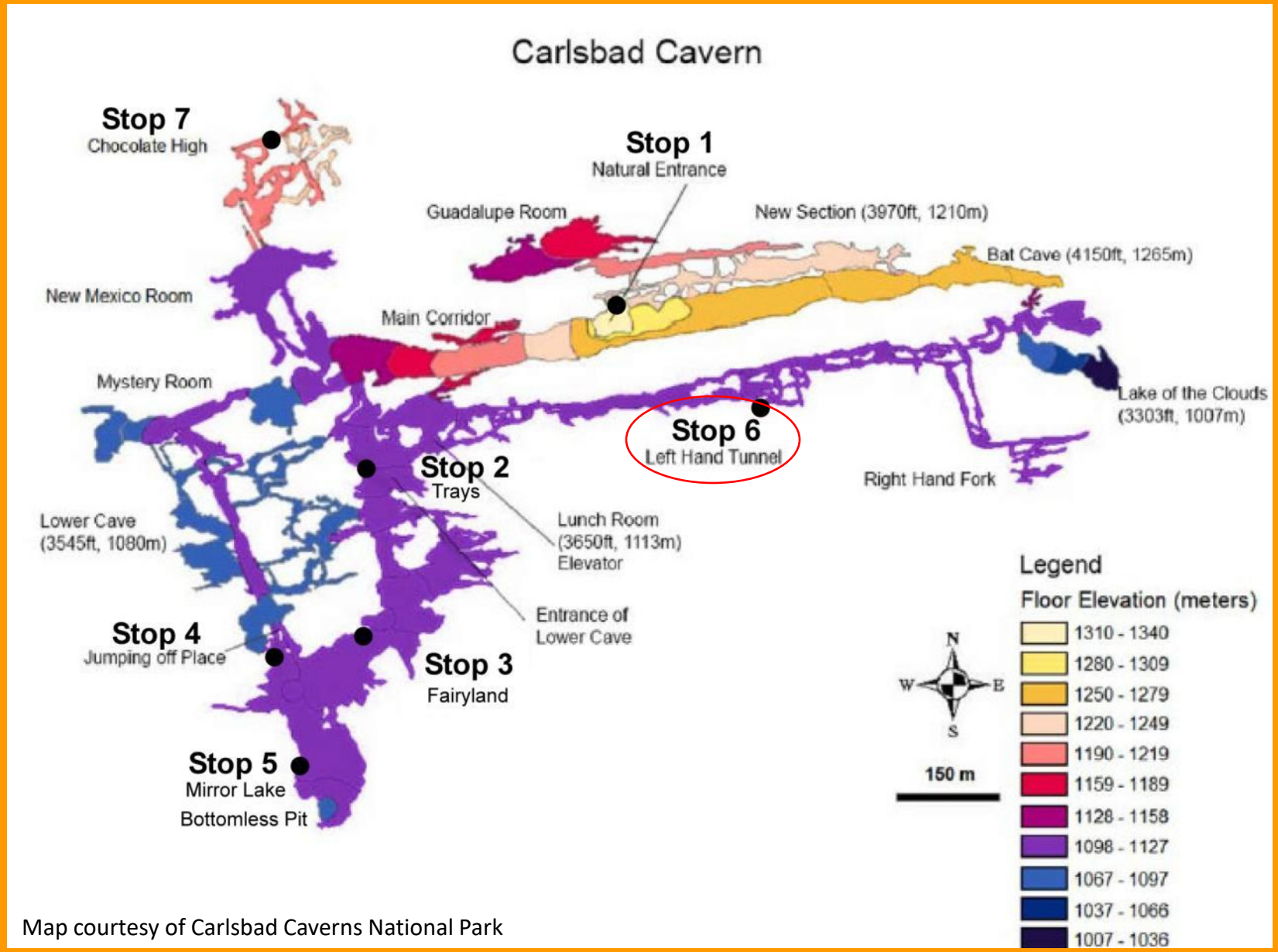


Map courtesy of Carlsbad Caverns National Park

Hypogenic Caves of the Great Basin: Chapter 3, Carlsbad Cavern

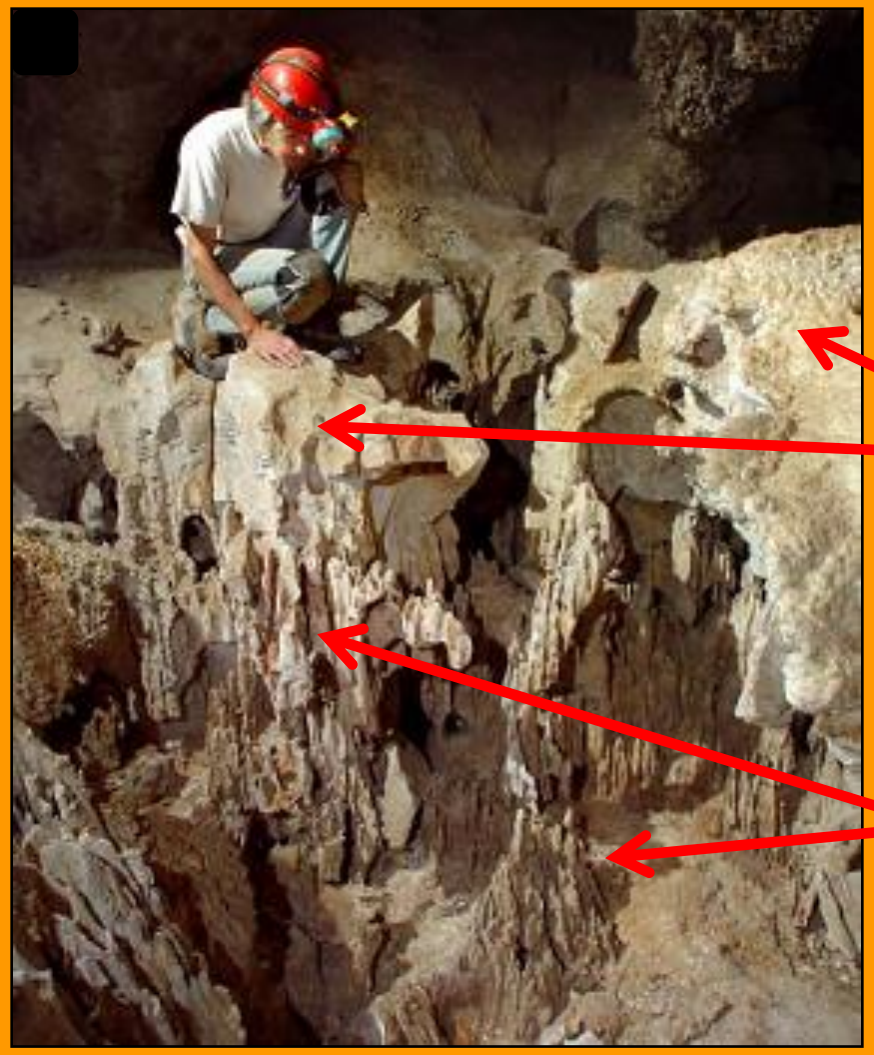


Stop 5. Massive precipitated gypsum near Mirror Lake, Big Room, Carlsbad Cavern. Mass is approximately 2 m thick.



Map courtesy of Carlsbad Caverns National Park

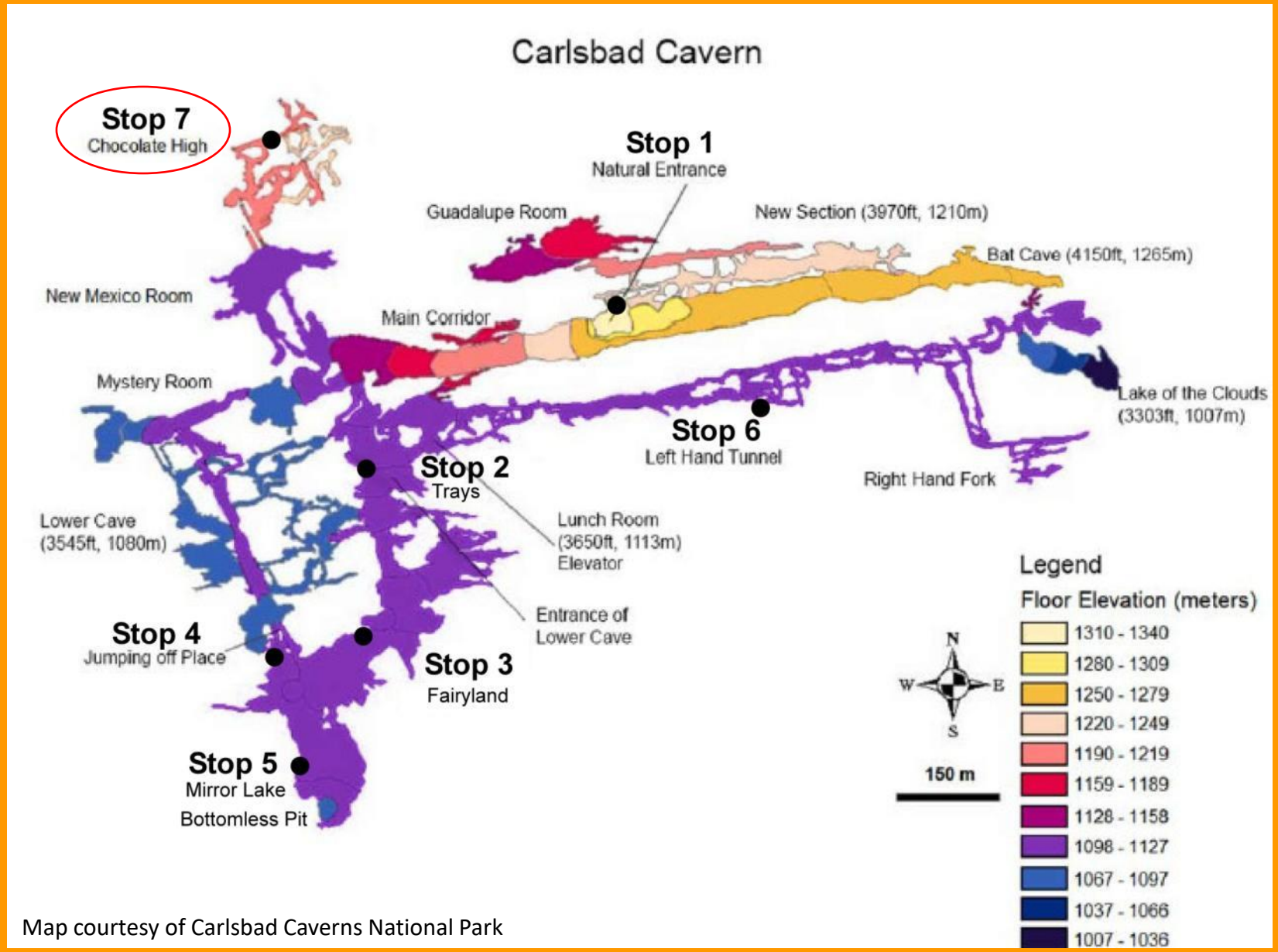
Hypogenic Caves of the Great Basin: Chapter 3, Carlsbad Cavern



Stop 6. Solution rills near Left Hand Tunnel, Carlsbad Cavern. Photo by Art Palmer

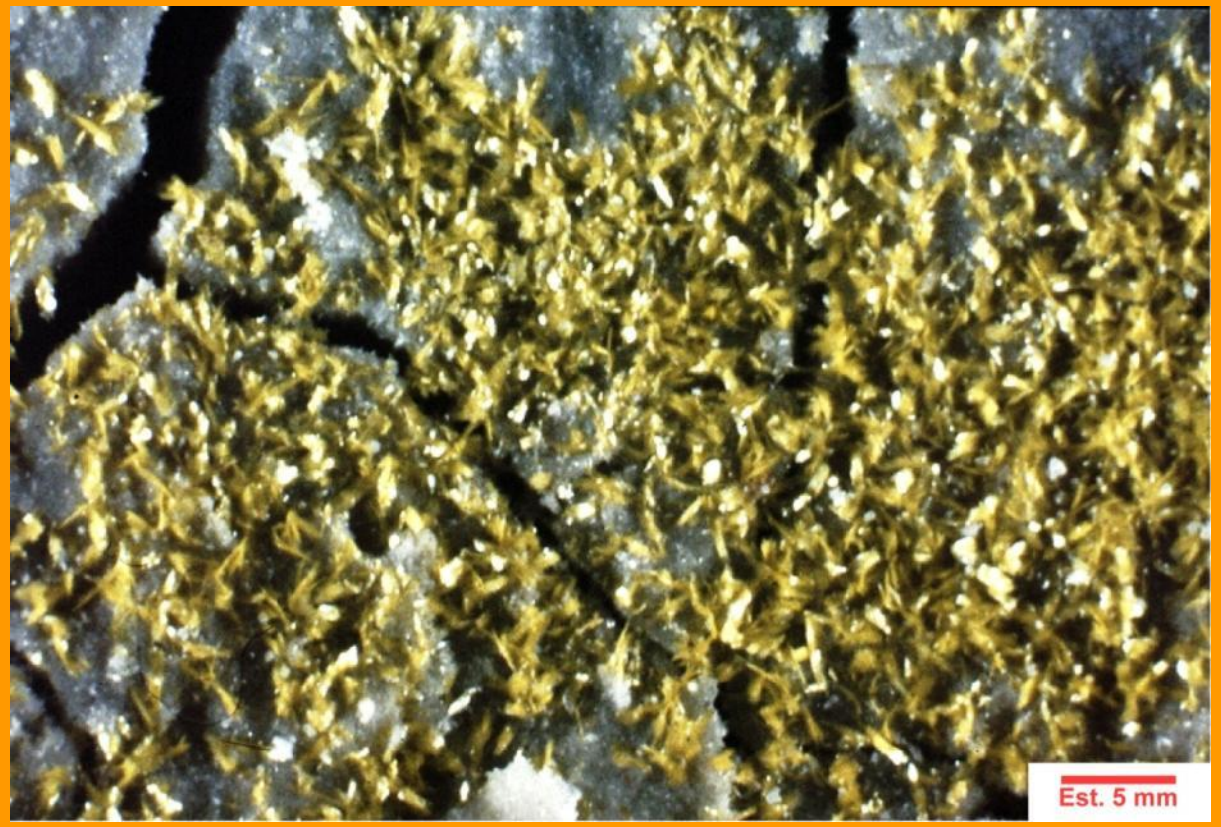
Smooth caps above rills were probably covered with gypsum paste at time rills were forming.

Rills were dissolved when acid seeped from gypsum cap and flowed downward by gravity.



Map courtesy of Carlsbad Caverns National Park

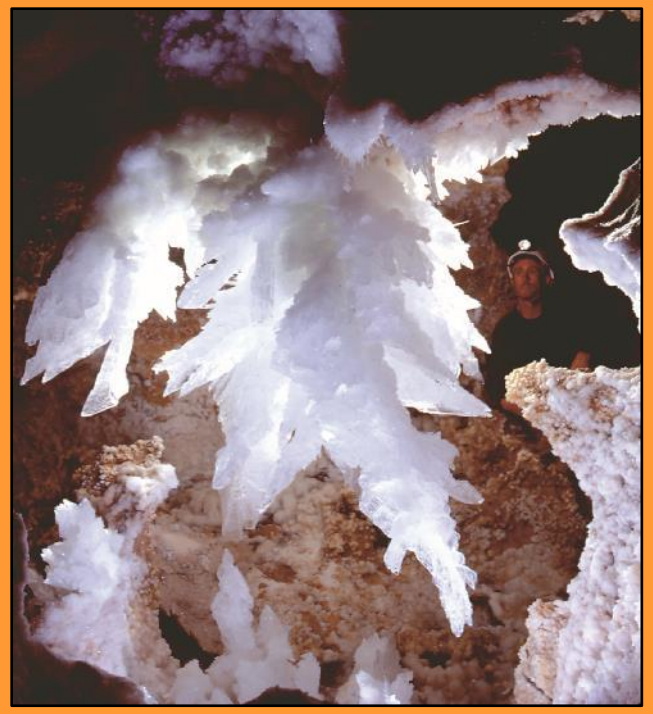
Hypogenic Caves of the Great Basin: Chapter 3, Carlsbad Cavern



Stop 7. Tyuyamunite or metatyuyamunite, Chocolate High, Carlsbad Cavern. The chemical composition of tyuyamunite is $Ca(UO_2)_2(VO_4)_2 \cdot 5\text{-}8H_2O$. Metatyuyamunite is the dehydrated variant composed of $Ca(UO_2)_2(VO_4)_2 \cdot 3H_2O$. Metatyuyamunite is more likely to be found in Guadalupe caves. Photo slightly out of focus.

LECHUGUILLA CAVE
NEW MEXICO USA

David Harris, Harris Photographic



David Harris, Harris Photographic

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SCIENCE • ENGINEERING • RESEARCH UNIVERSITY

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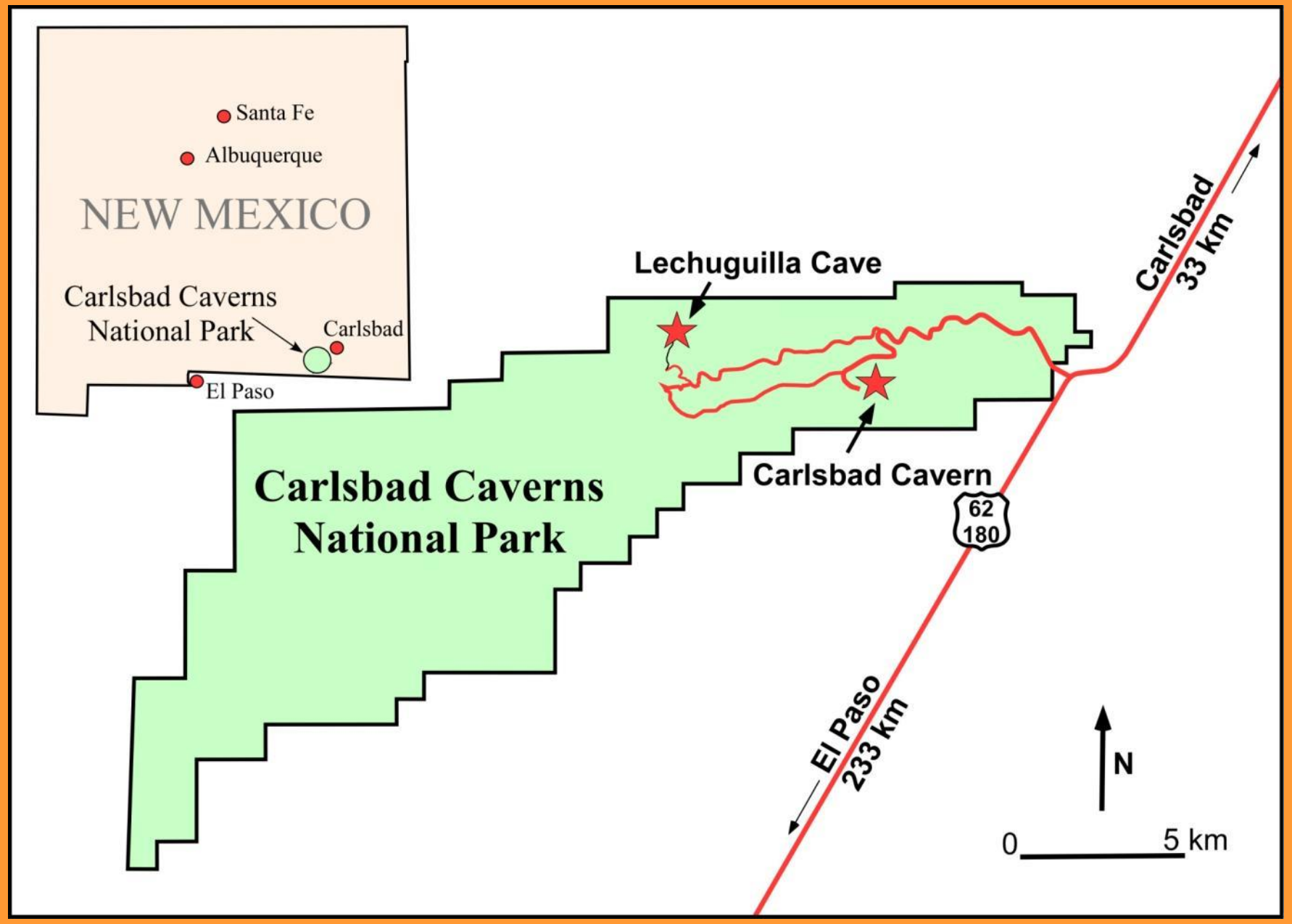
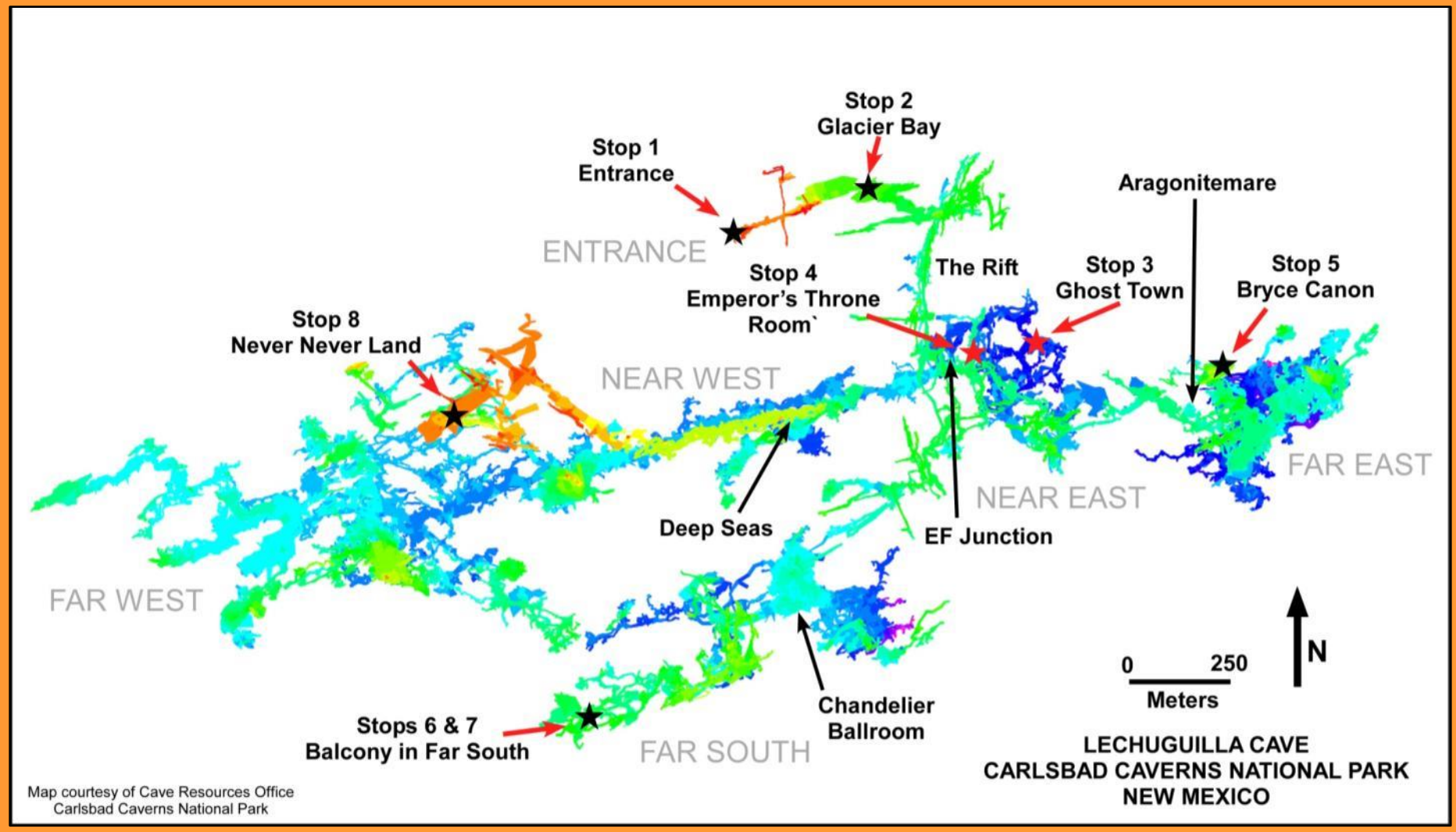
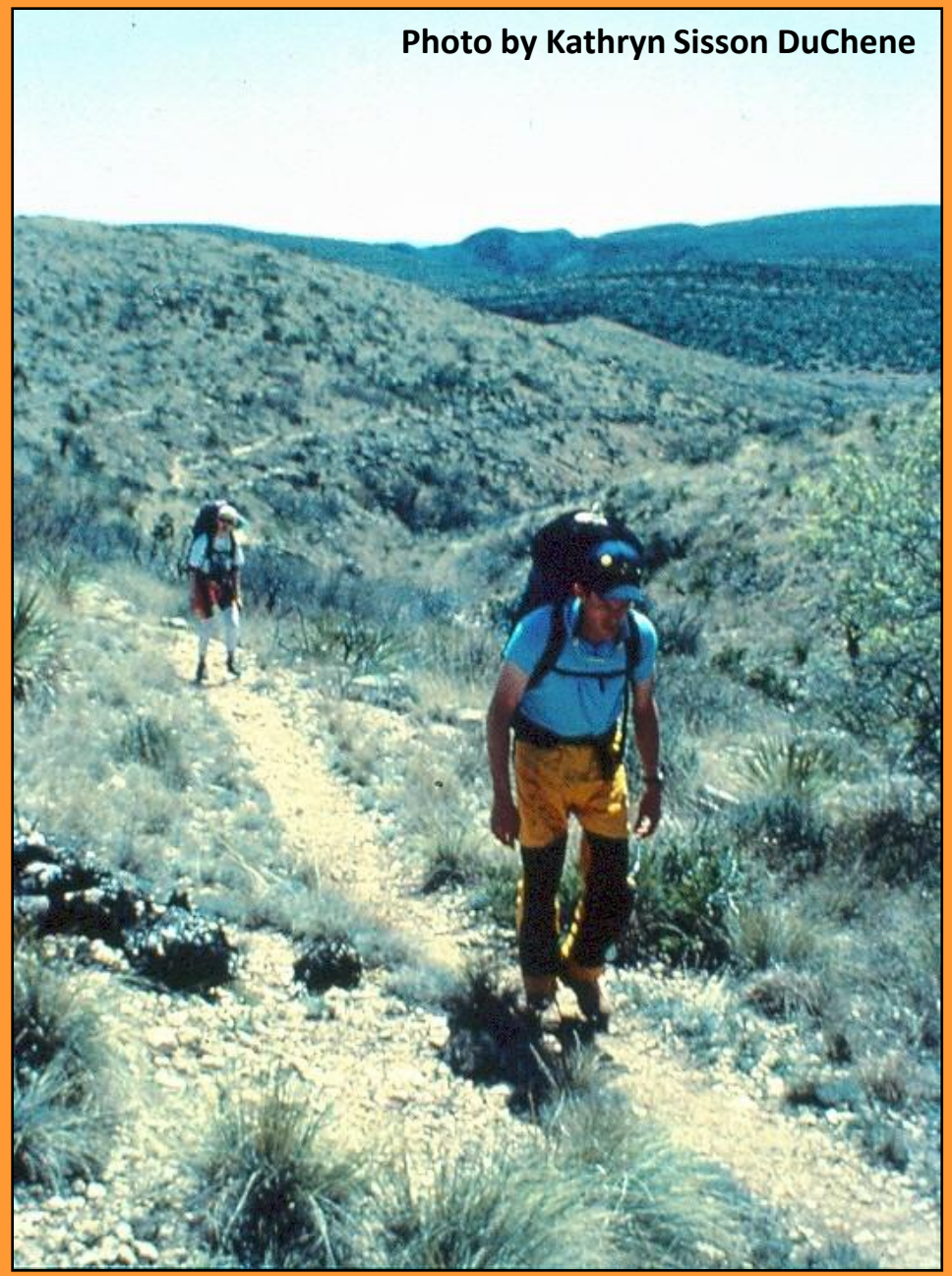
University of Nevada, Reno



Hypogenic Caves of the Great Basin: Chapter 4, Lechuguilla Cave

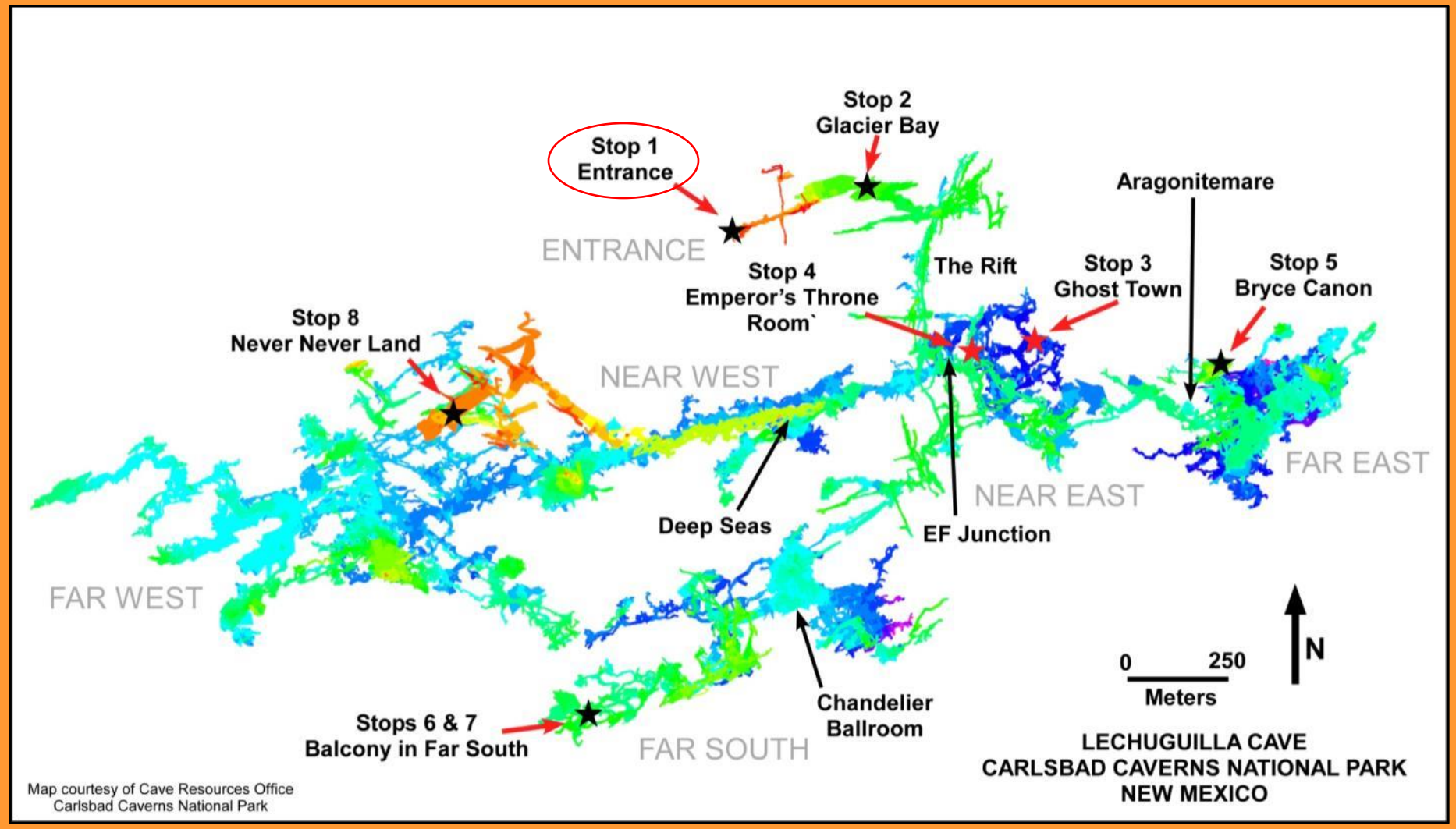


Lechuguilla Cave is a rectilinear, multi-level, 3-dimensional maze with 241 km of known passage and a depth of 489 m. Highest level passages are shown in red and orange; lowest levels are blue and purple.



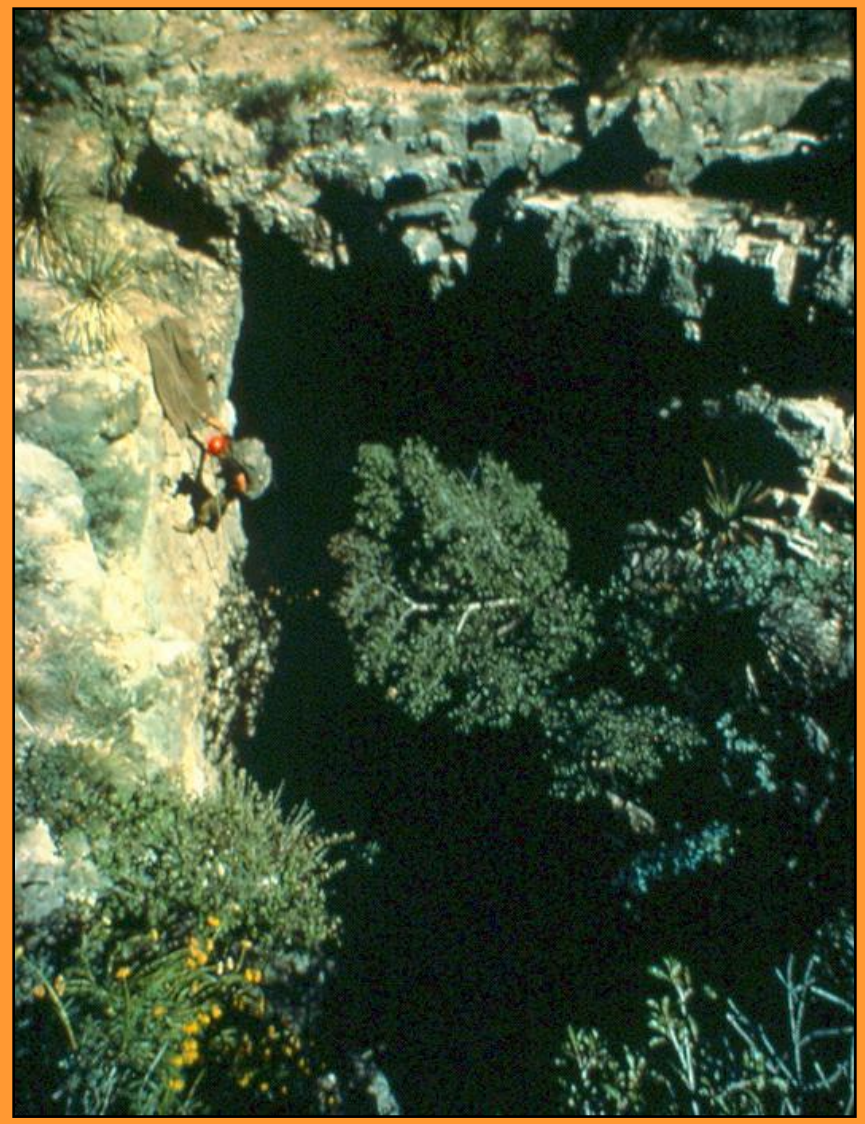
Everything needed for an underground camping expedition must be carried into and out of the cave in 45 to 70 lb backpacks

Entrance to Lechuguilla Cave

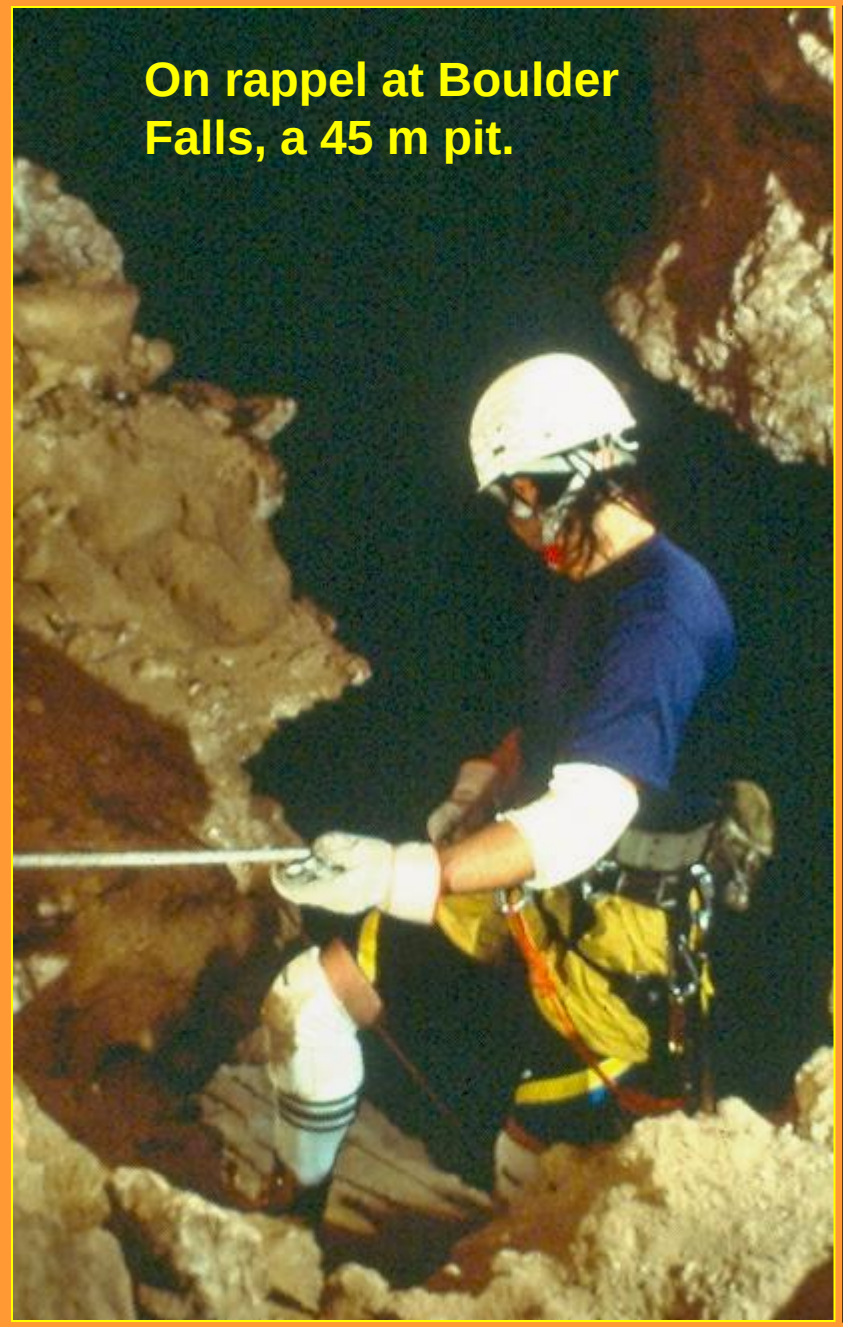


Stop 4.1: Entrance
Deep-seated speleogenesis

Hypogenic Caves of the Great Basin: Chapter 4, Lechuguilla Cave



I was once asked "How far can you go in Lechuguilla before you need rope?" Well, the first step is 30 meters.


On rappel at Boulder Falls, a 45 m pit.

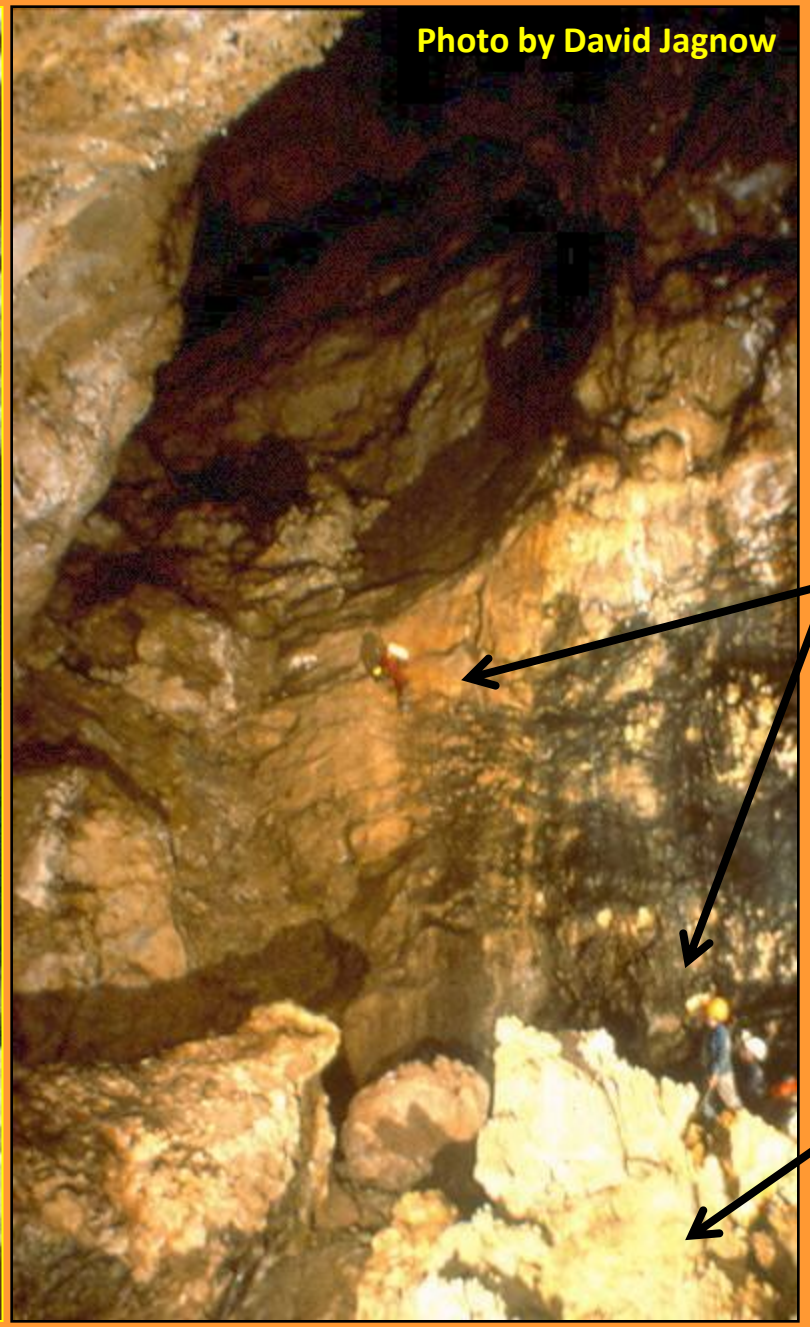
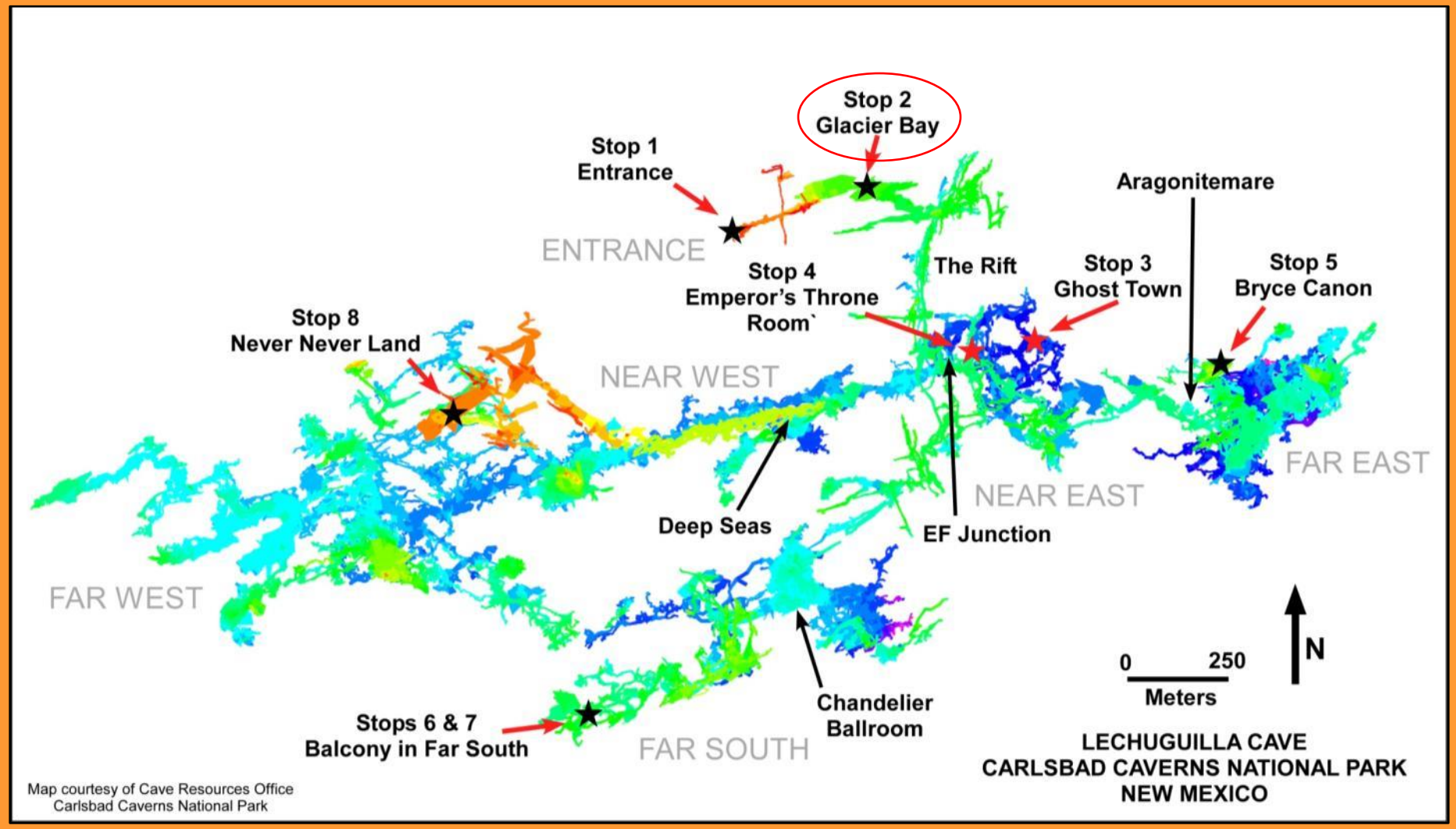
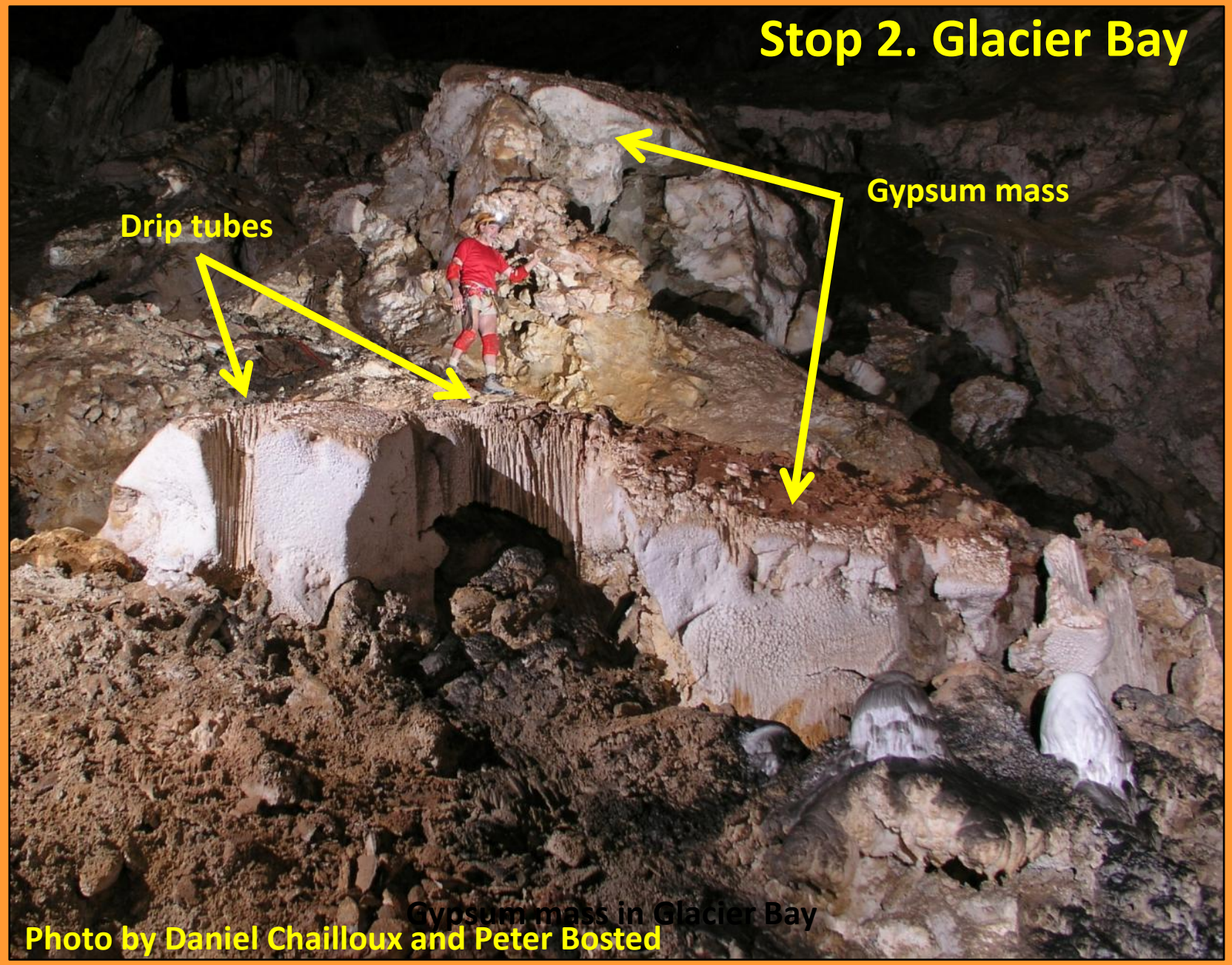


Photo by David Jagnow
People for scale
First remnant gypsum blocks seen in the cave



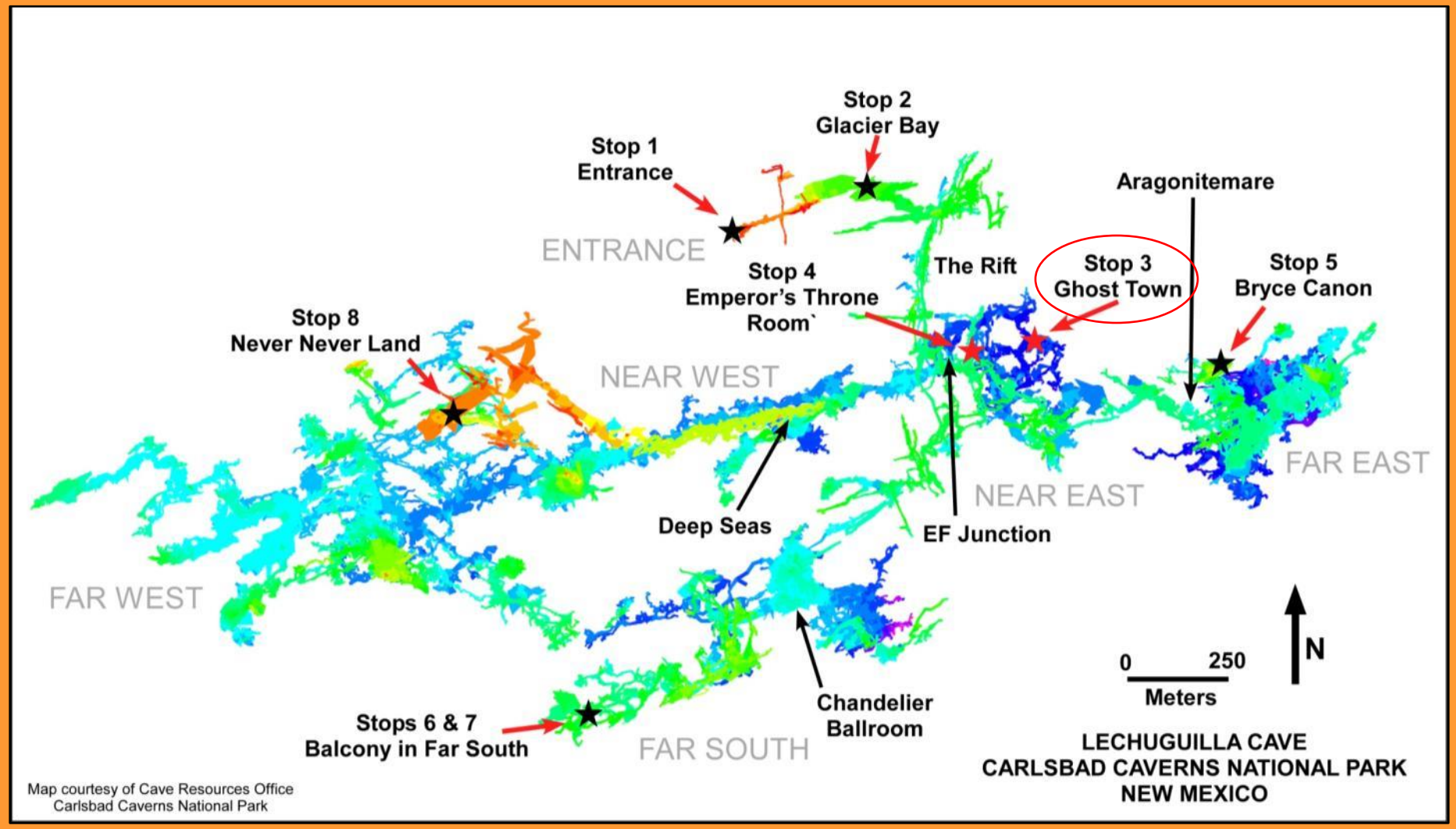
Stop 4.2: Glacier Bay
Massive gypsum

Hypogenic Caves of the Great Basin: Chapter 4, Lechuguilla Cave


Stop 2. Glacier Bay
Drip tubes
Gypsum mass
Gypsum mass in Glacier Bay
Photo by Daniel Chailloux and Peter Bosted

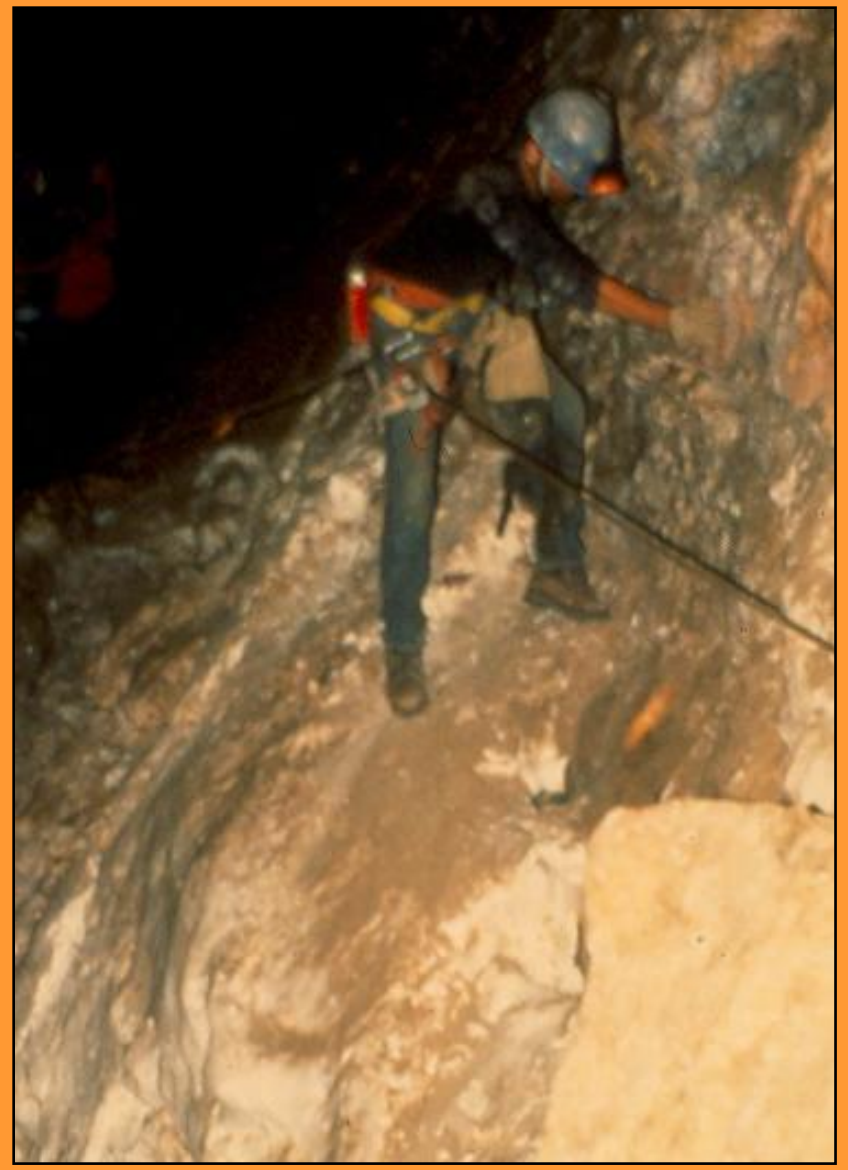
Note multiple orientations of drip tubes due to settling of gypsum.

Hypogenic Caves of the Great Basin: Chapter 4, Lechuguilla Cave

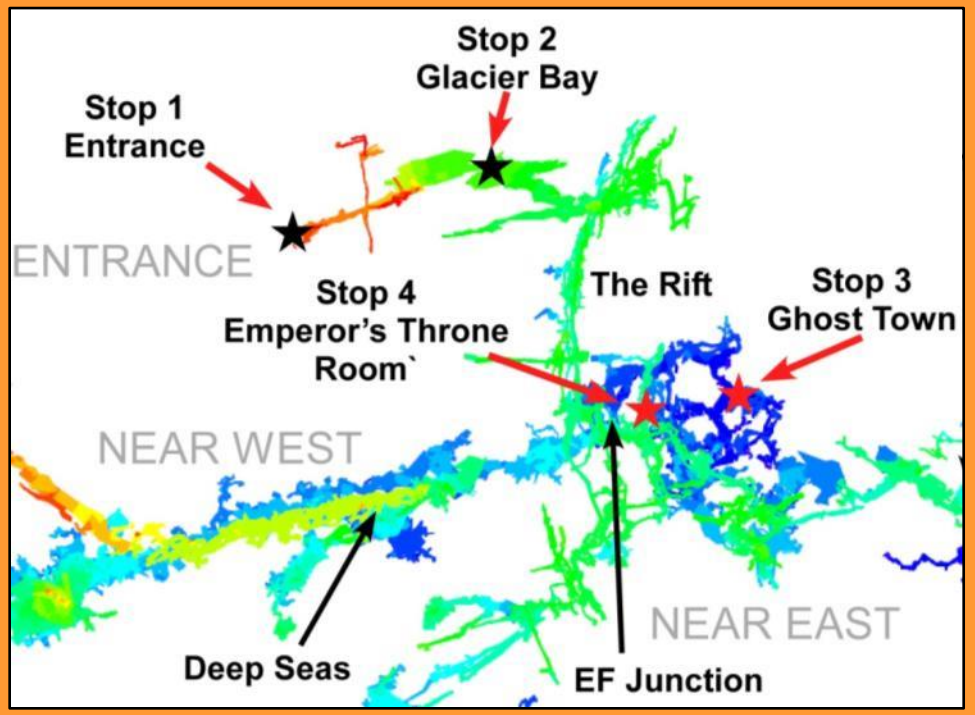


Stop 4.3: Ghost Town
Sulfur and gypsum

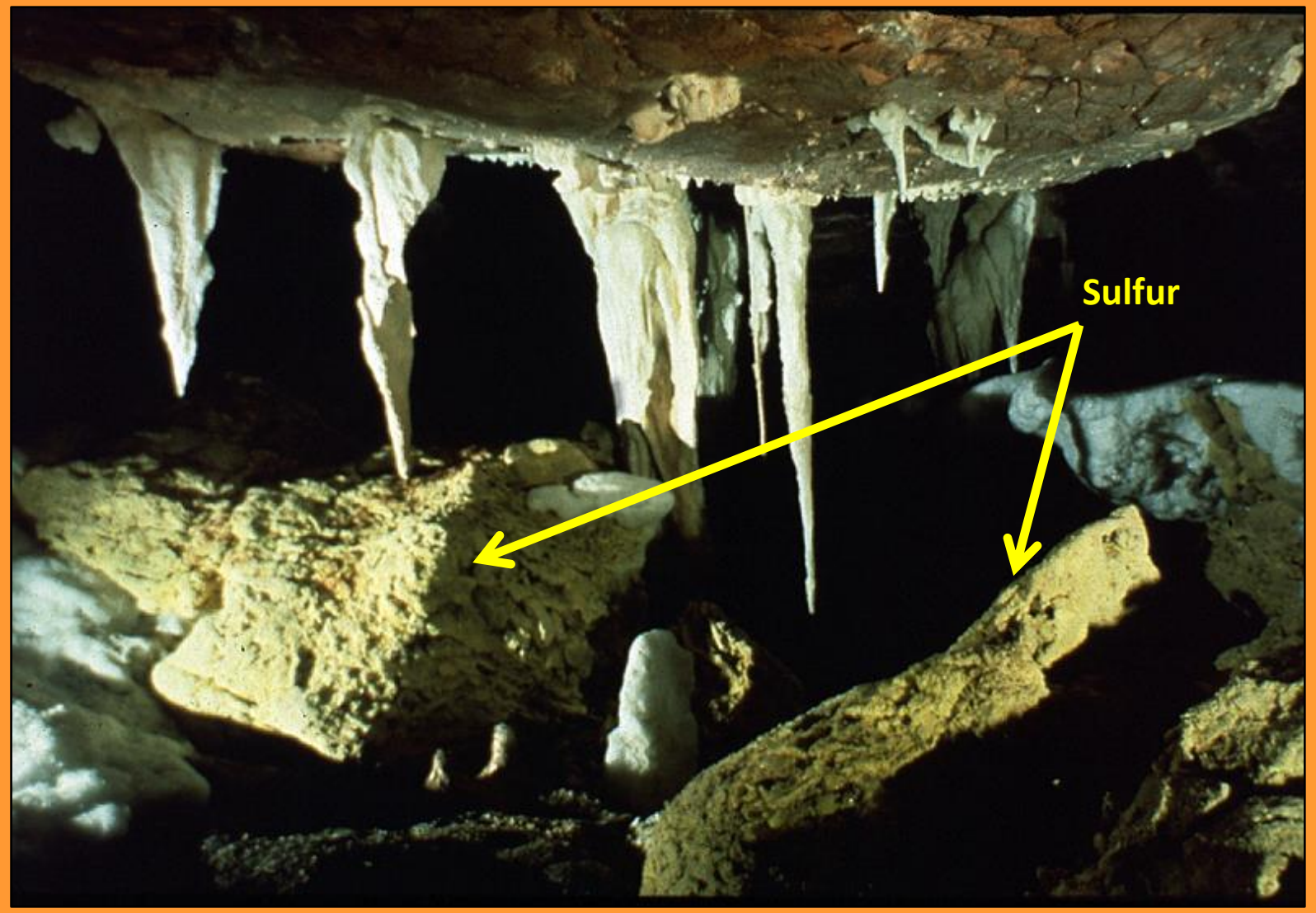
Hypogenic Caves of the Great Basin: Chapter 4, Lechuguilla Cave



Traversing a narrow ledge above a 50 m drop in The Overpass part of The Rift on the way to EF Junction where routes to all known parts of the cave converge.



Negotiating a 24 cm high constriction in the S&M Crawl on the way to Ghost Town



Massive sulfur and gypsum, GDVB Passage, Ghost Town, Lechuguilla Cave.
Ceiling bedrock is a siltstone bed.

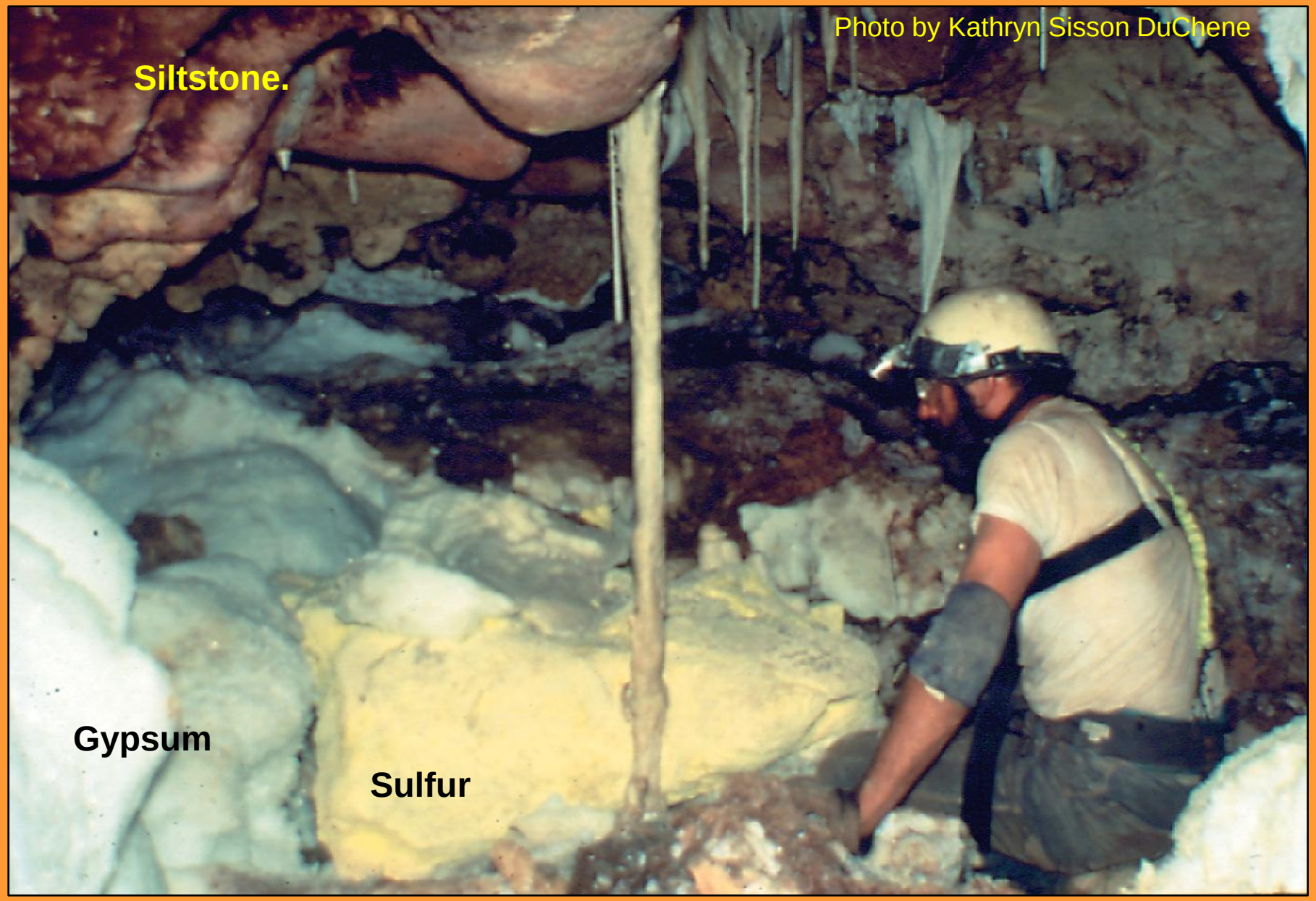
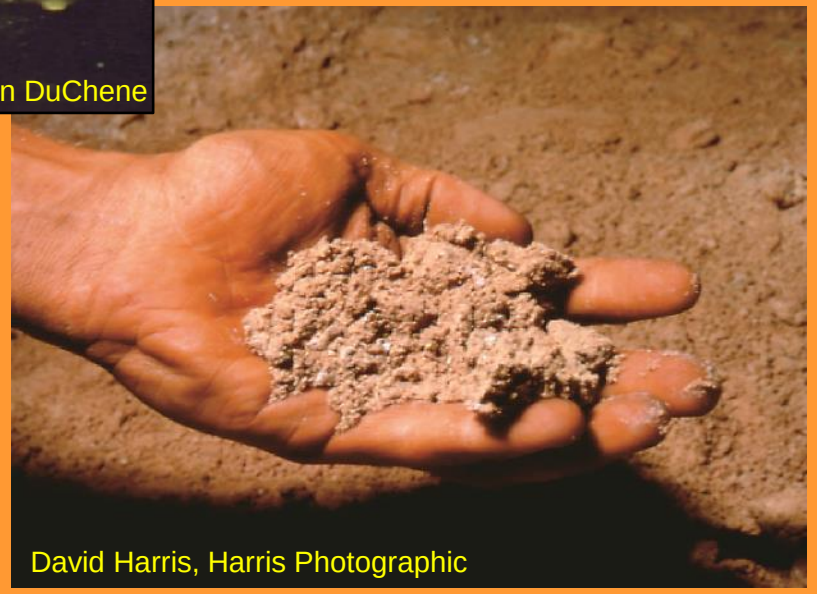


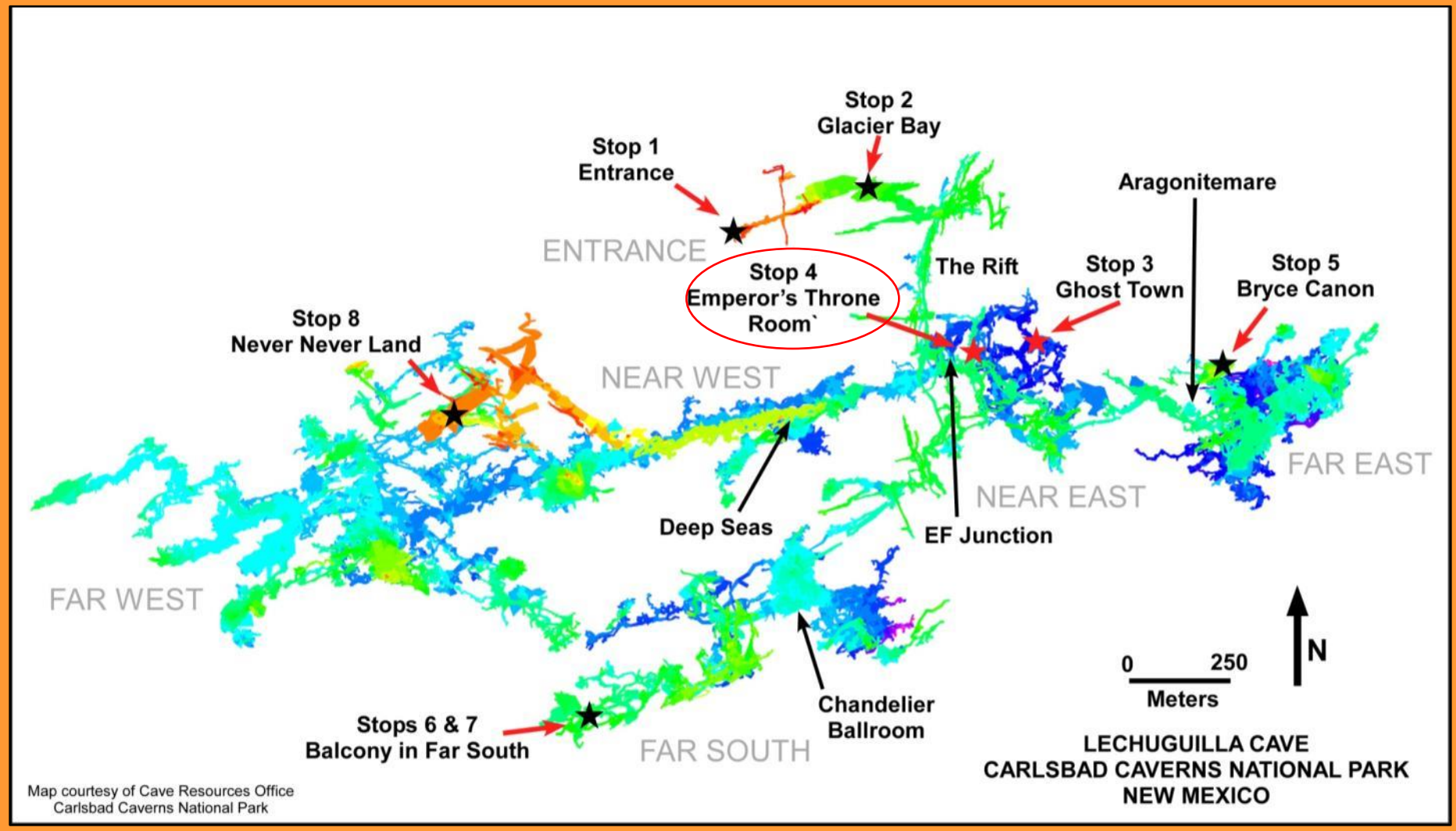
Photo by Kathryn Sisson DuChene
Siltstone.
Gypsum
Sulfur

Sulfur in gypsum.
Barite Boulevard near Blanca
Navidad Hall

Sulfur on siltstone, The Void, Lechuguilla Cave.

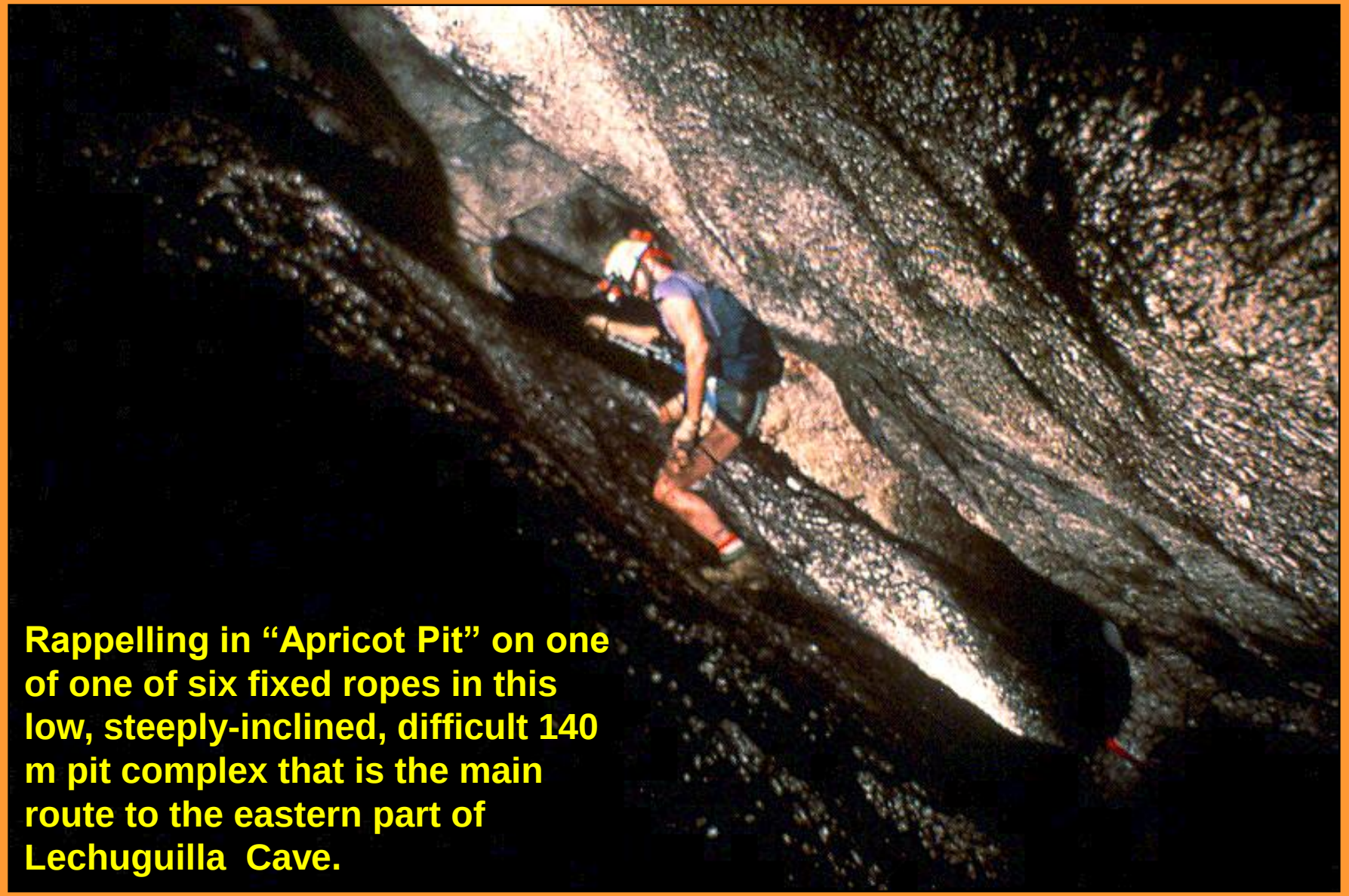


Unconsolidated silt, The Void

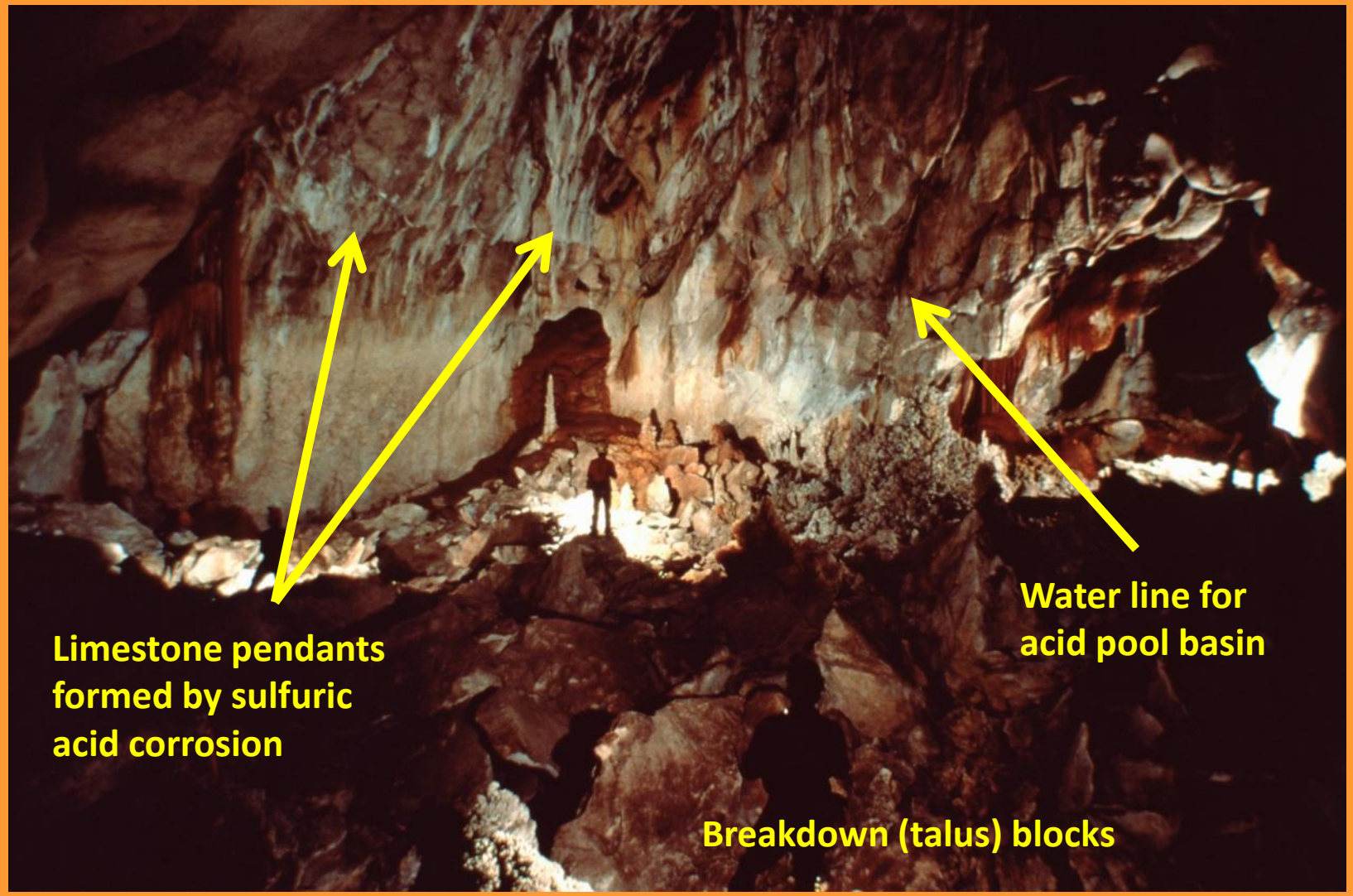


Stop 4.4: Emperor's Throne Room
Acid pool basin

Hypogenic Caves of the Great Basin: Chapter 4, Lechuguilla Cave

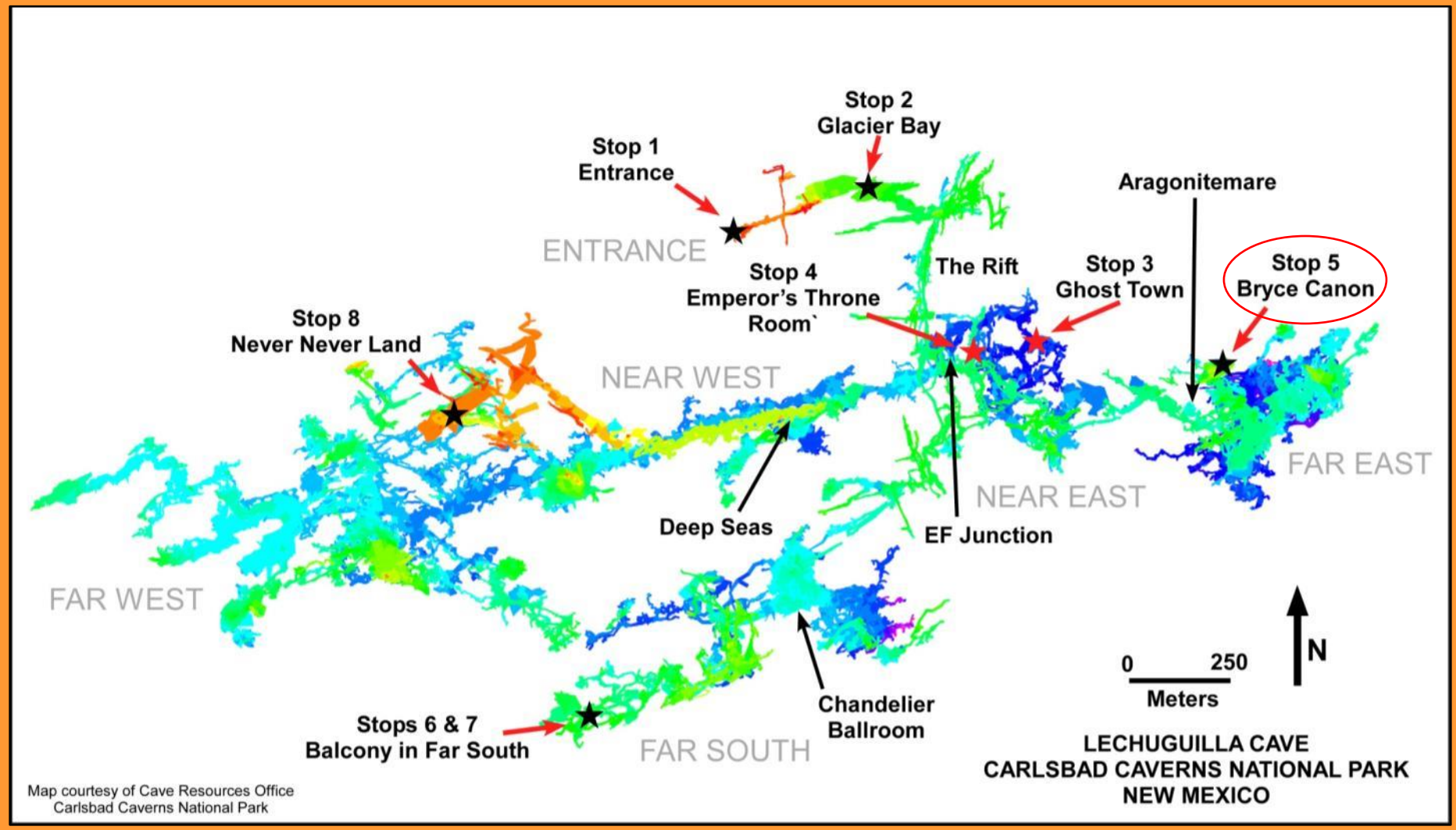


Rappelling in “Apricot Pit” on one of one of six fixed ropes in this low, steeply-inclined, difficult 140 m pit complex that is the main route to the eastern part of Lechuguilla Cave.



Condensation-corrosion pendants, acid pool basin water line and breakdown (talus) floor, Emperor's Throne room, Near East, Lechuguilla

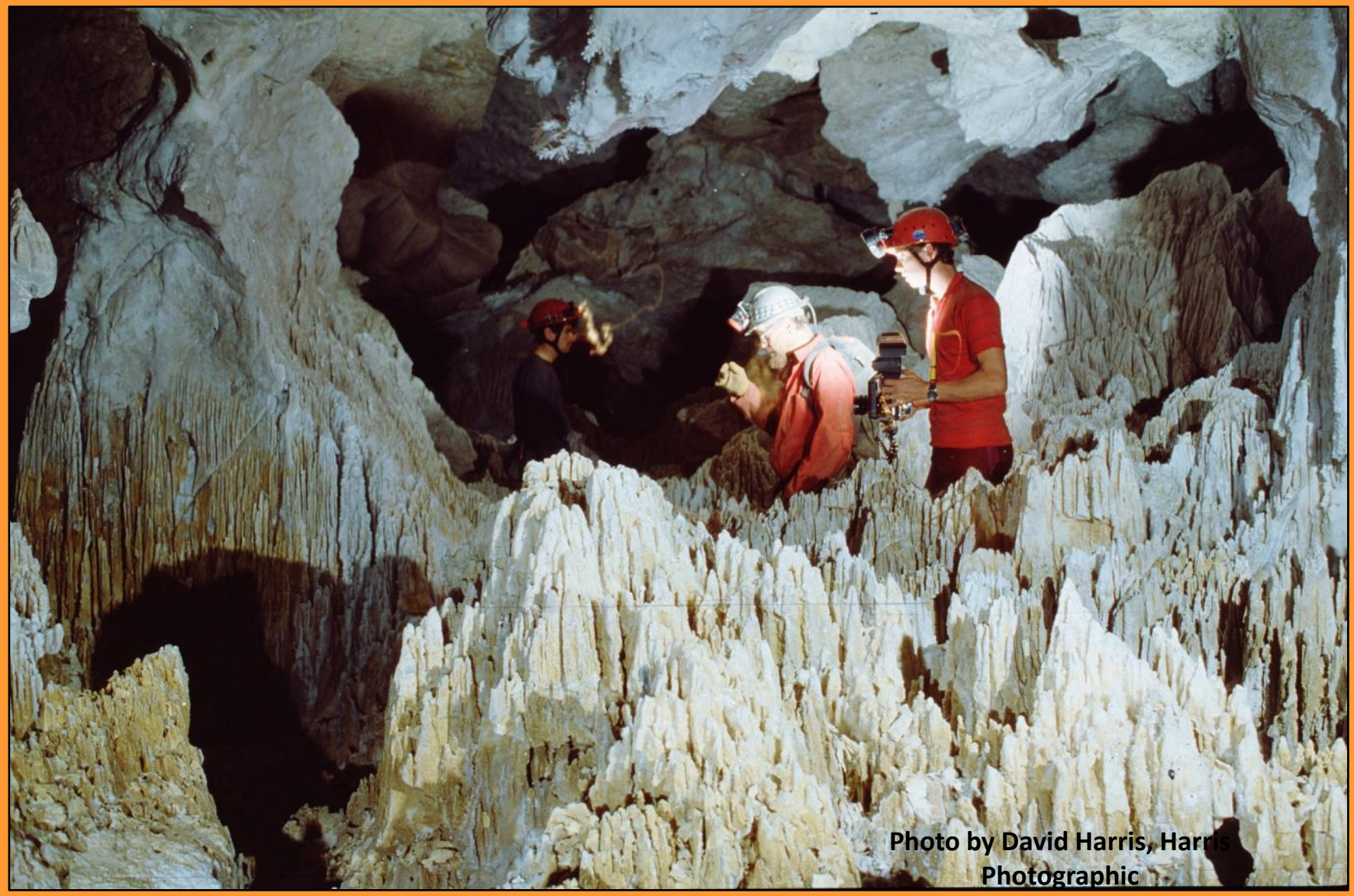
Sharp water line with speleogenetic gypsum above and none below.



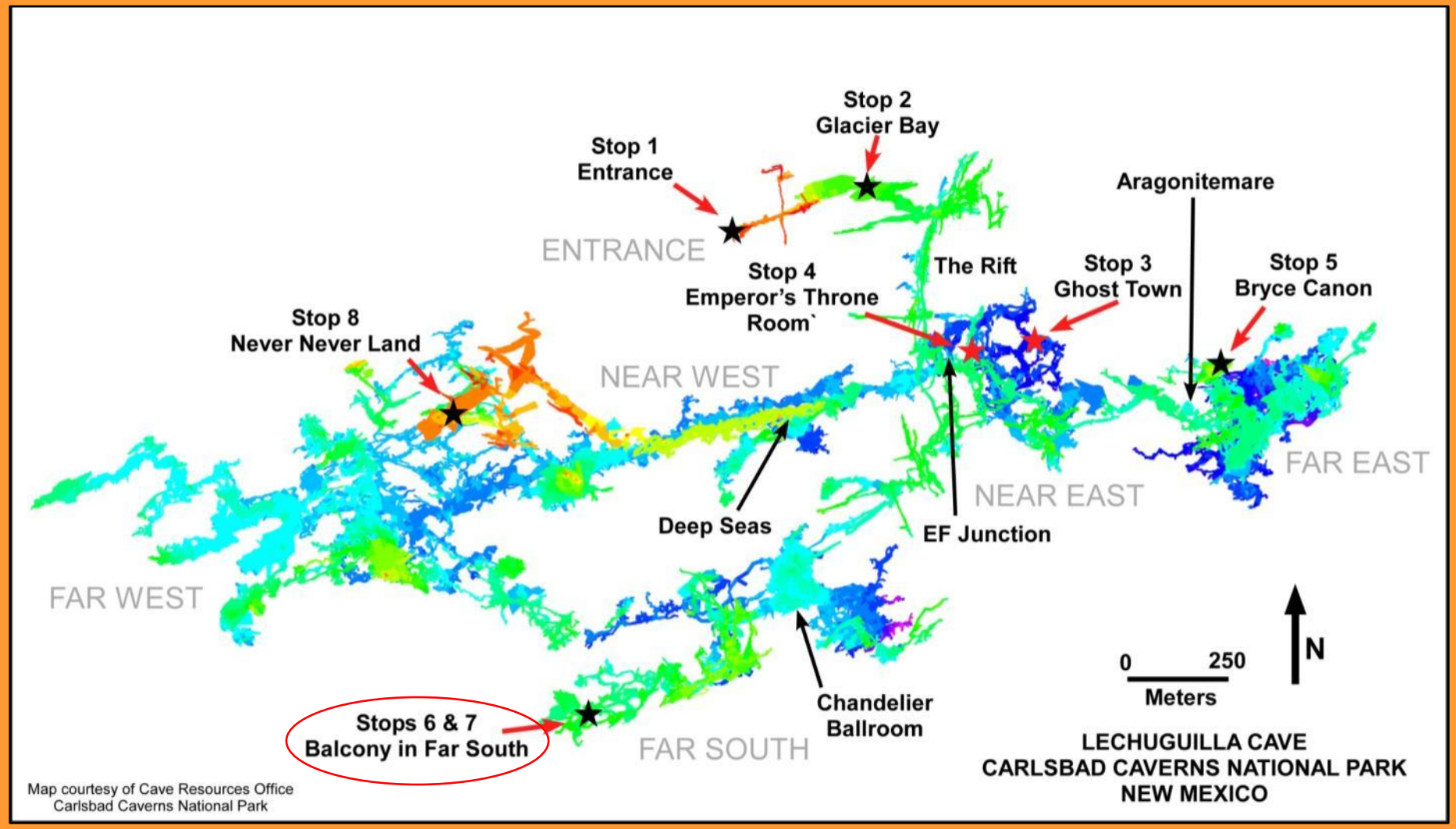
Stop 4.5: Bryce Canyon, Far East.
Acid pool basin and rills

Hypogenic Caves of the Great Basin: Chapter 4, Lechuguilla Cave

Acid Pool Basin – Far East, Lechuguilla



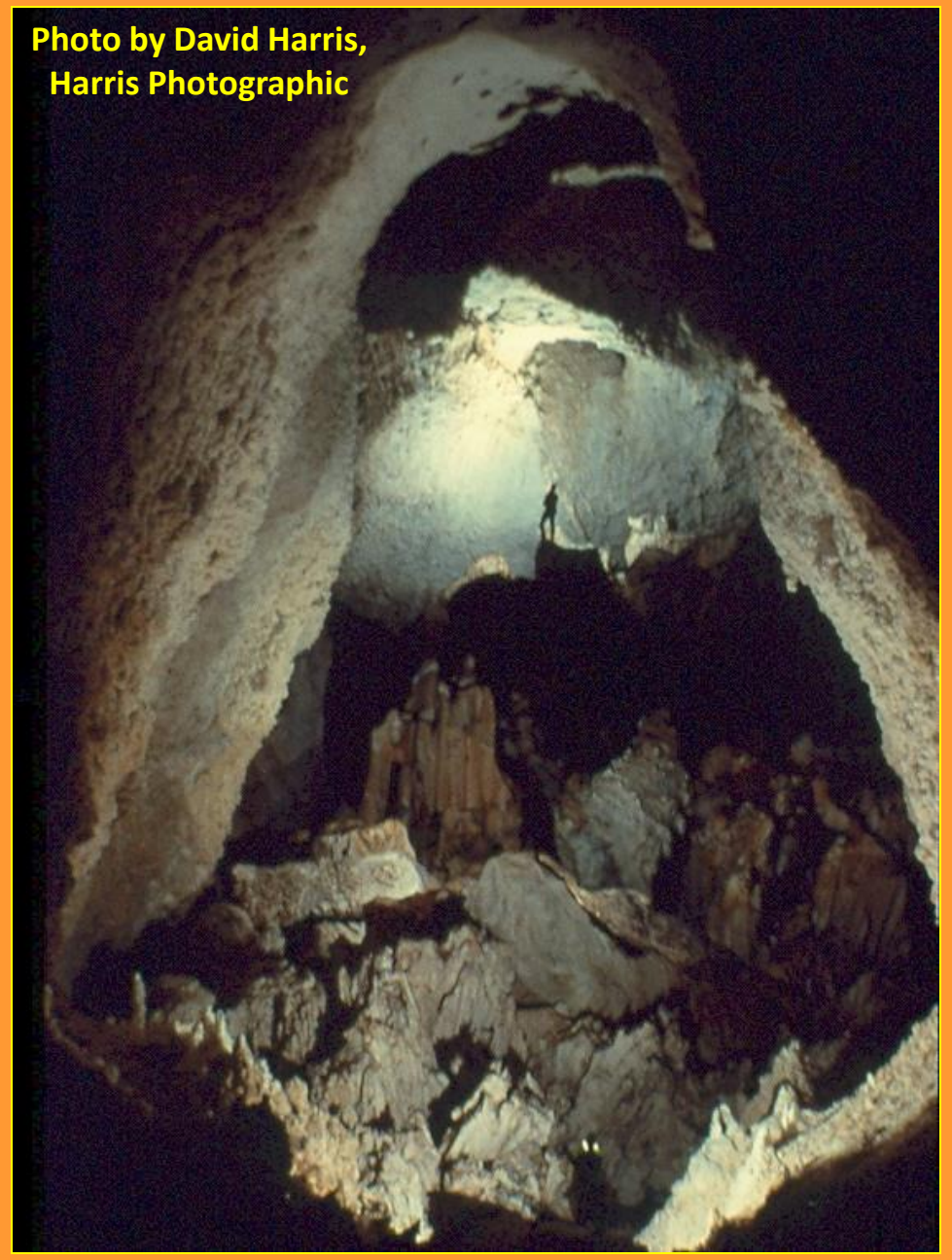
Exceptional display of corroded bedrock, Bryce Canyon, Far East, Lechuguilla Cave



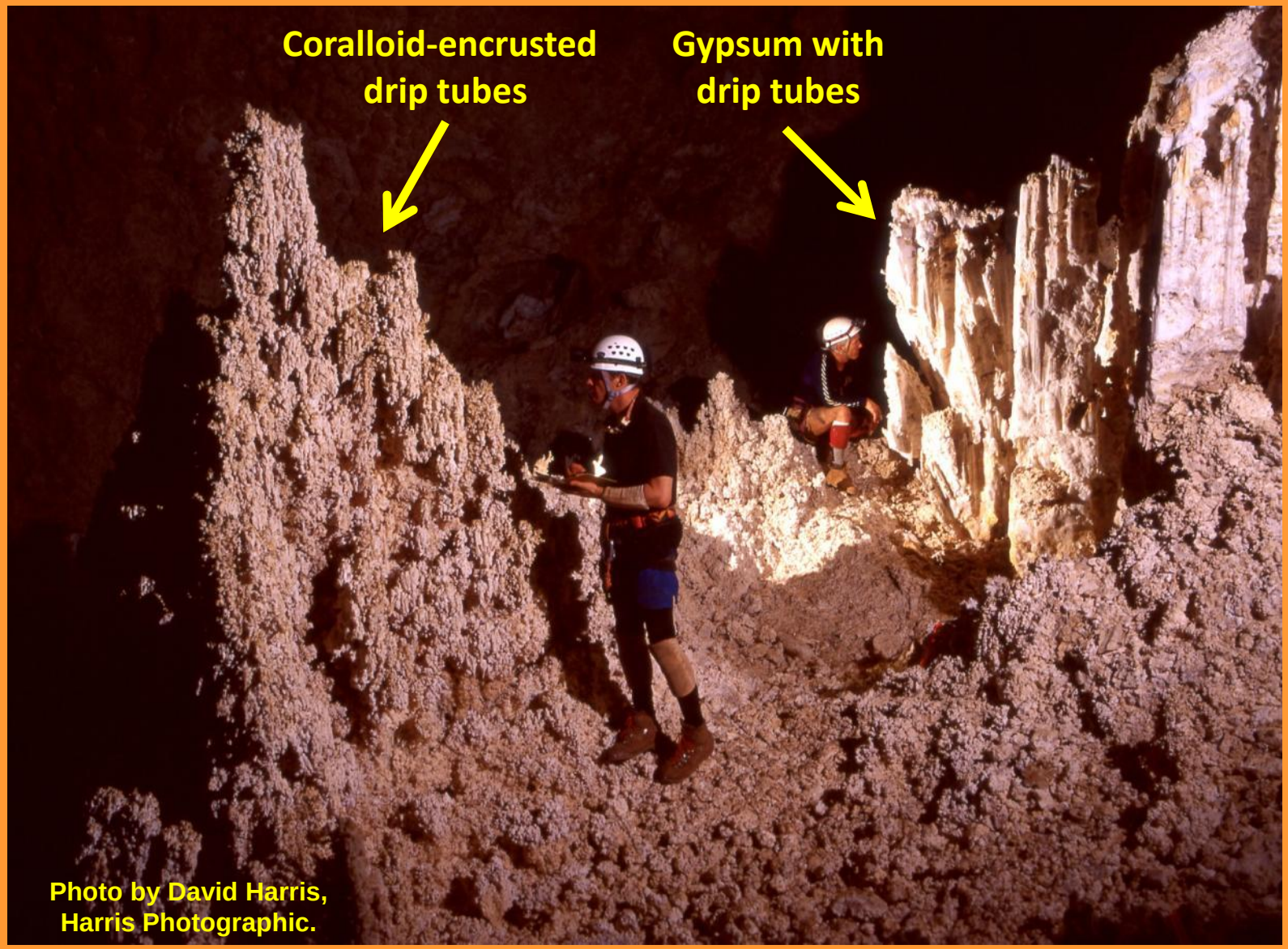
Stop 4.6 & 4.7: Balcony, Far South
Drip tubes and metatyuyamunite

Hypogenic Caves of the Great Basin: Chapter 4, Lechuguilla Cave

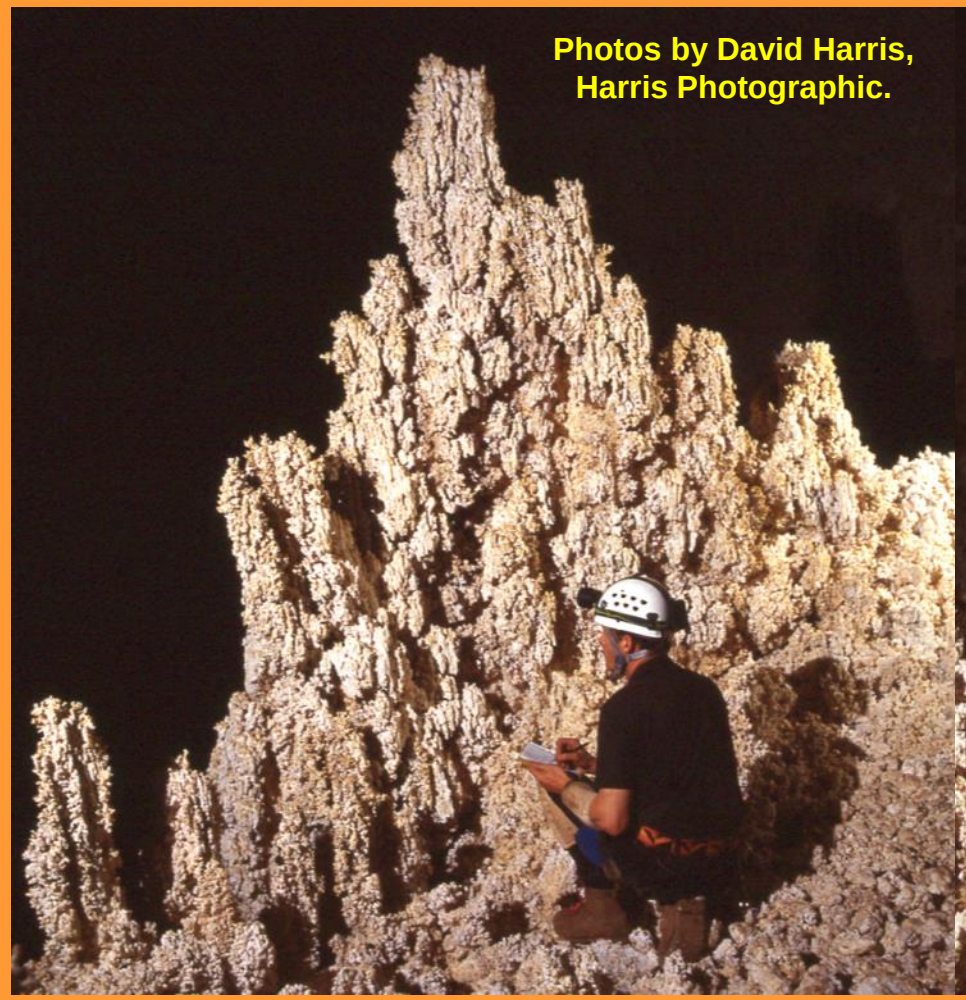
Gypsum chandeliers, Chandelier Ballroom.



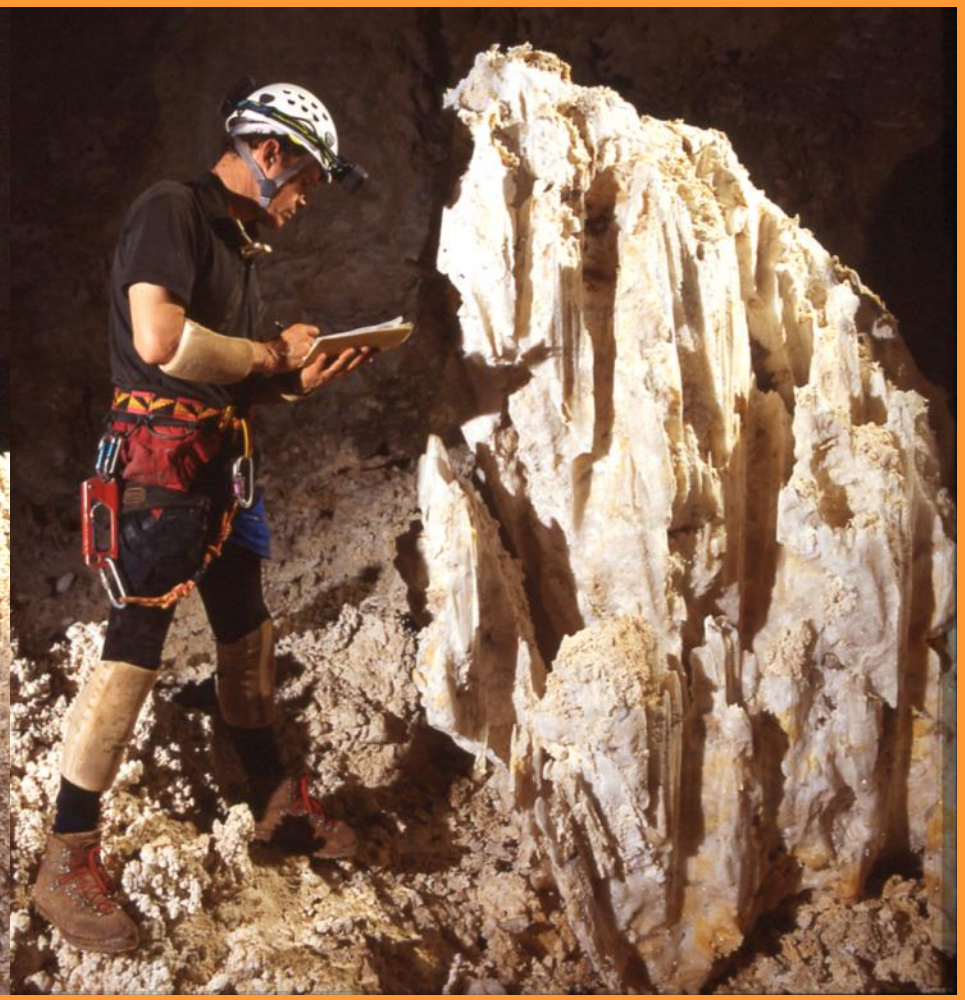
West end of the Prickly Ice Cube Room, a huge chamber beyond the Chandelier Ballroom. The large blocks on the floor are gypsum. Note cavers at bottom center and in upper center of photo for scale.



Hypogenic Caves of the Great Basin: Chapter 4, Lechuguilla Cave

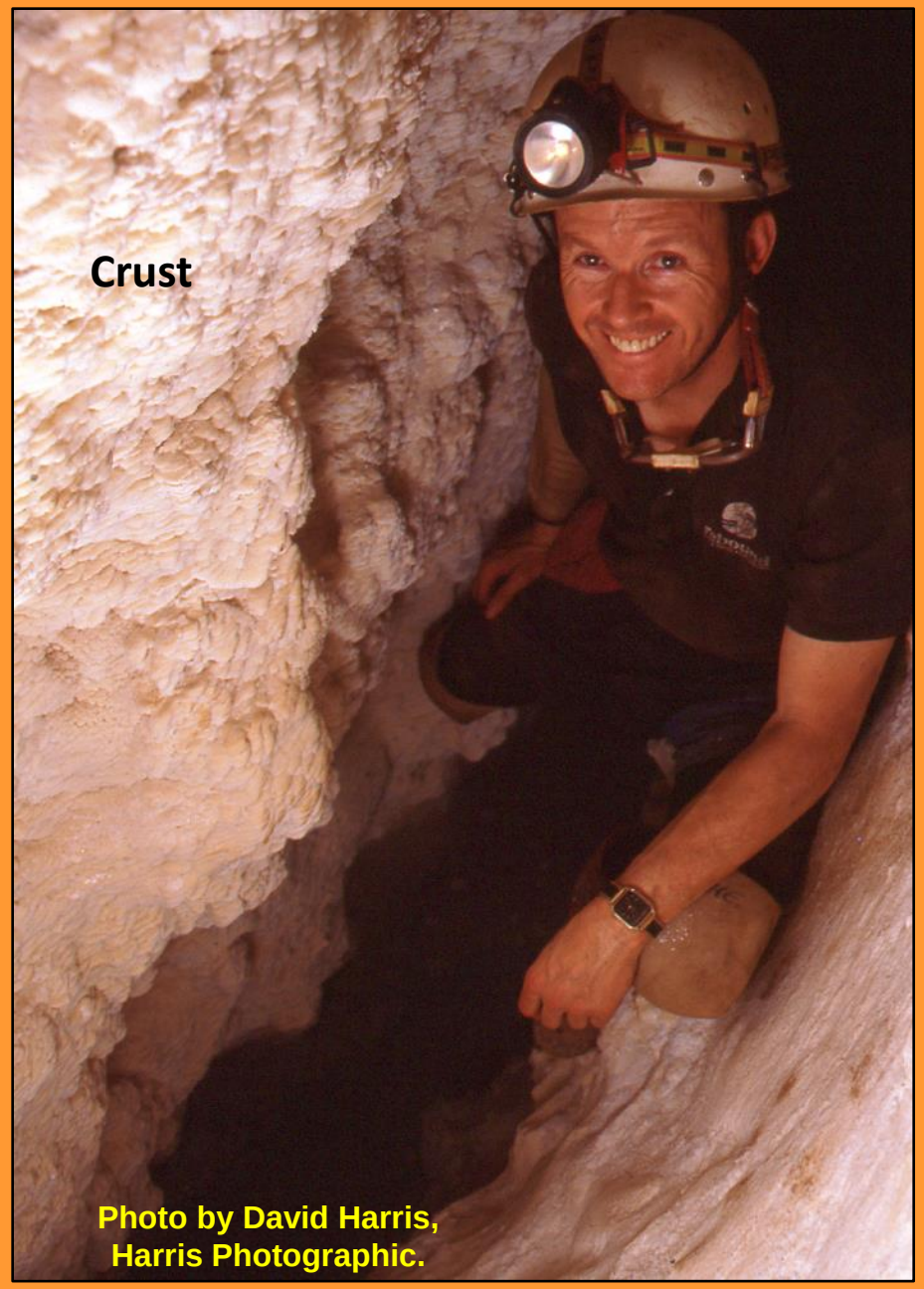


Coralloid-encrusted drip holes.



Remnant block of gypsum with drip holes

Note the drip tube morphology similarity between left and right.



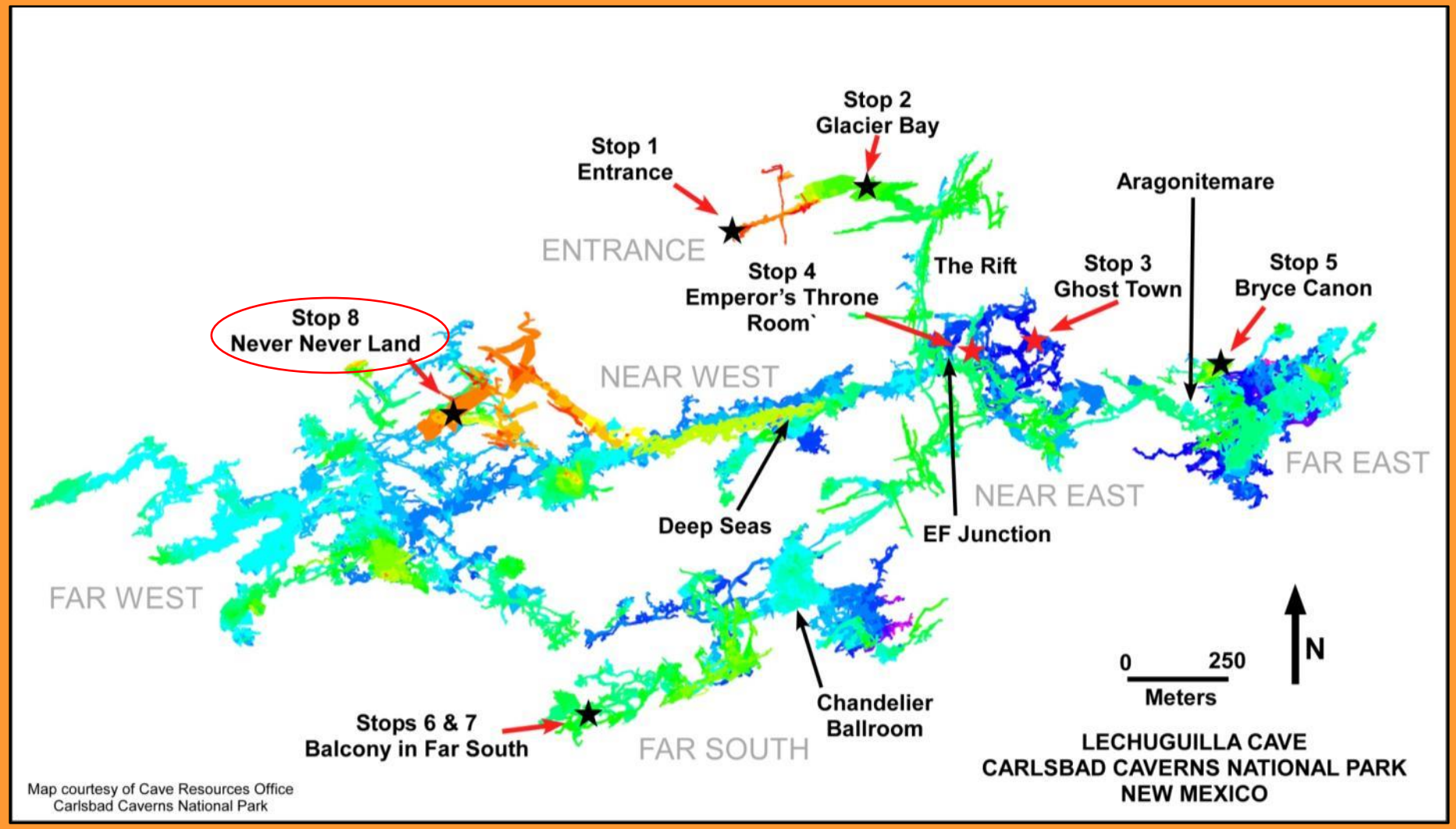
Crusts:

They can be composed of calcite, hydrocalcite, hydromagnesite, gypsum, and rarely quartz.

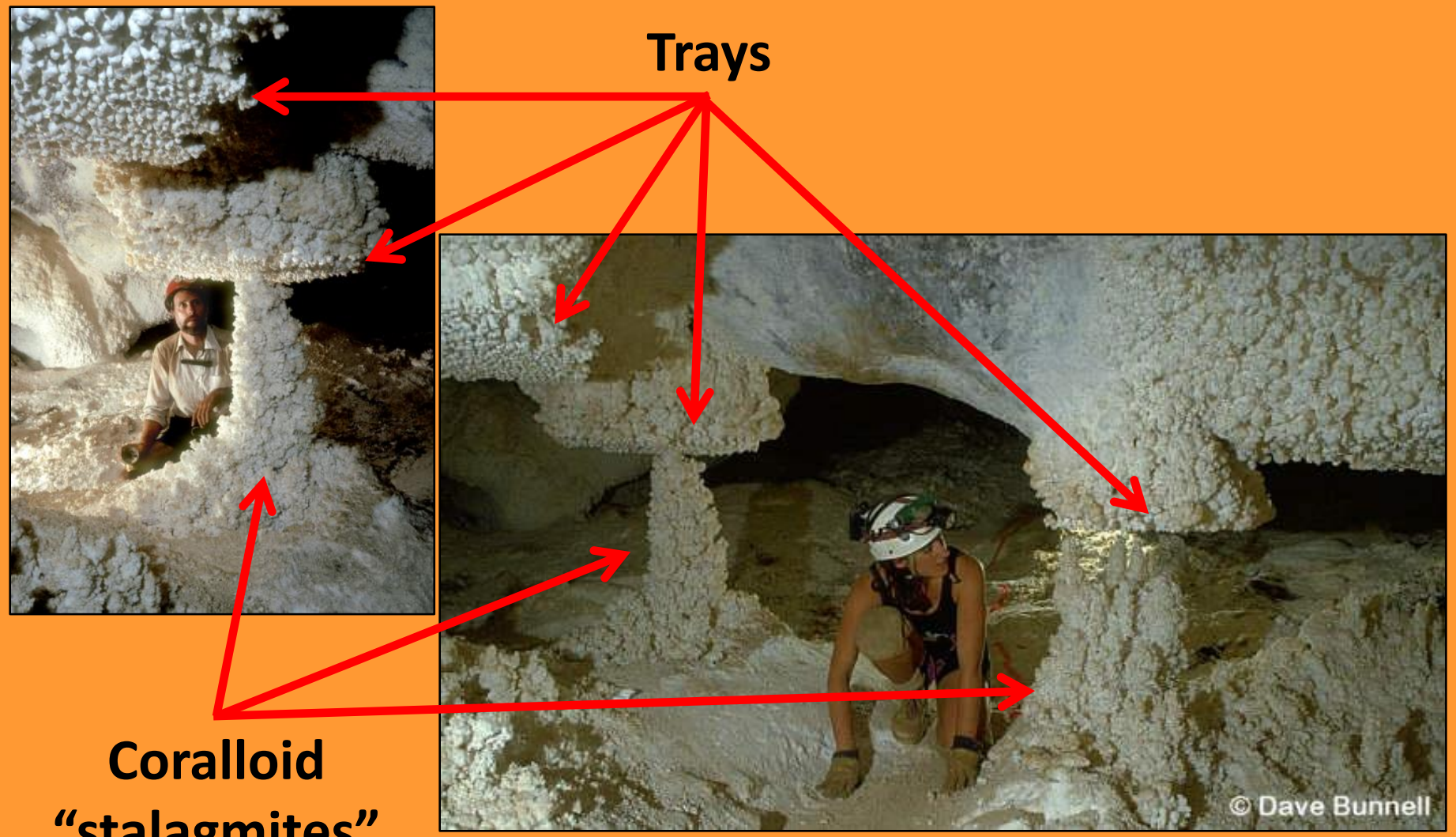
They can also contain rarer cave minerals, including fluorite, celestine, tyuyamunite and metatyuyamunite.

Tyuyamunite (yellow) on quartz in a wall crust.

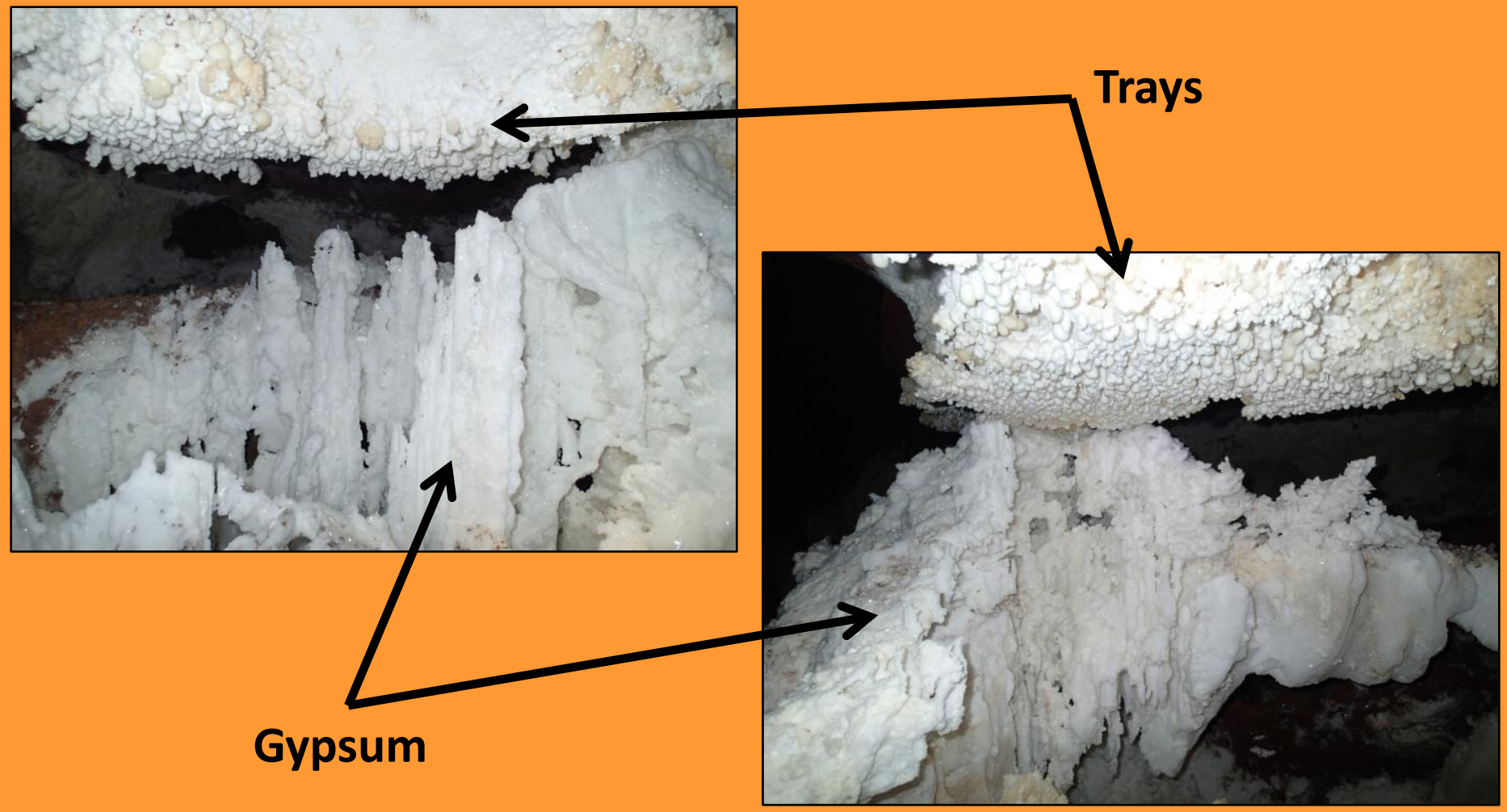
Tyuyamunite (yellow) on fluorite (dark purple) and quartz. Yellow mass is ~ 1mm across.



Stop 4.8: Never Never Land Trays

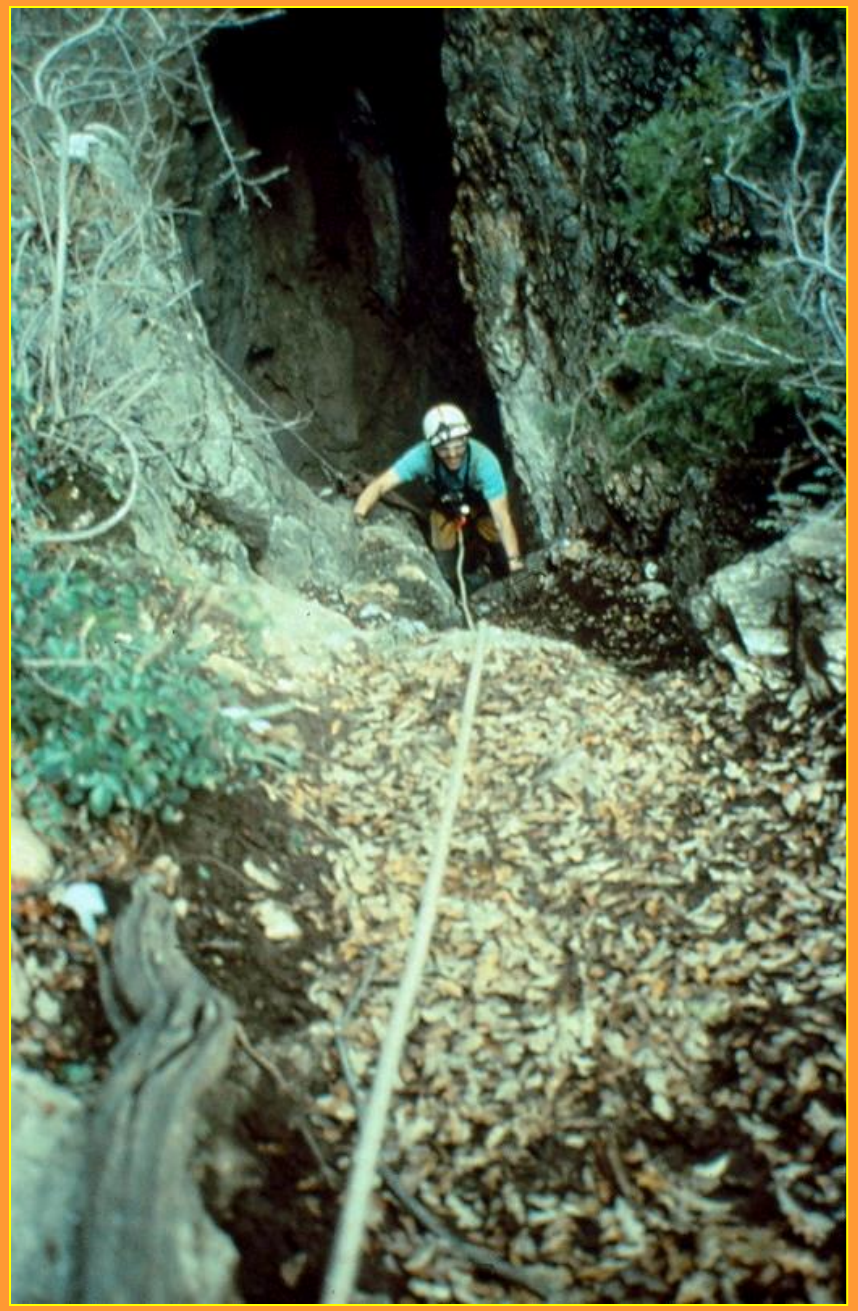


Trays and corraloid “stalagmites”, Deep Seas area, Western Borehole



Photos by Art Fortini

Is there a relationship between the flat bottoms of trays and underlying gypsum masses?



Daylight at last!