Cartography beyond the Planimetric

Alaska Trek, Hang Son Doong, and El Capitan

Martin Gamache
National Geographic Magazine

MIDDLEBURY COLLEGE, 2011

ALASKA TREK

March 2011

Circling Alaska in 176 Days

Nobody had ever done it before: Hike, ski, and raft 4,679 miles through eight national parks, dozens of mountain ranges, and the length of the Yukon territory. Then along came Andrew Skurka.

DENALI NATIONAL PARK, APRIL 27, 2010
"Skiing over this unnamed pass made me nervous," says extreme trekker Andrew Skurka. "I was worrying about an avalanche due to the warm and sunny spring weather." With 1,120 miles behind him, he still had 3,559 to go.


KOTZEBUE, ALASKA
Sept. 15, 2010
Scheduled arrival
MARCH 14, 2010
Departure
REMAINING
BROOKS RANGE
Anaktuvuk
Coldfoot
RICHARDSON MTNS.
IDITAROD TRAIL
OGILVIE MTNS.
ALASKA RANGE
Photo coverage
COMPLETED
YUKON RIVER
WRANGELL-ST.ELIAS
May 27
Cordova, ALASKA
Mi 1816, Day 74
(On schedule)
Photo coverage
Photo coverage
JUNE 25,2010
WHITEHORSE, YUKON
Mile 2617, Day 104
(Scheduled June, 30)
JUNE 20,2010
HAINES ALASKA
Mid-point: Mile 2480, Day 99
(Scheduled June, 25)
LOST COAST
INSIDE PASSAGE
Alaska


KOTZEBUE, ALASKA
MARCH 14, 2010
Departure
SEPT. 5, 2010
Completion
BROOKS RANGE
Photo coverage Aug.11-25
RICHARDSON MTNS.
IDITAROD TRAIL
OGILVIE MTNS.
ALASKA RANGE
Photo coverage
YUKON RIVER
WRANGELL-ST.ELIAS
Photo coverage
Photo coverage
LOST COAST
INSIDE PASSAGE
Alaska
RUSSIA
BEAUFORT SEA
CHUKCHI SEA
NORTHWEST TERRITORIES
YUKON TERRITORY
BRITISH COLUMBIA
BERING SEA
GULF OF ALASKA
BRISTOL BAY
ALEUTIAN ISLANDS
ALEUTIAN BASIN
ALEXANDER ARCHIPELAGO
QUEEN CHARLOTTE ISLANDS

ALASKA THE LONG WAY

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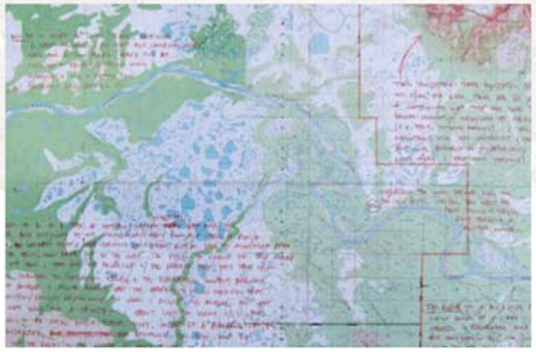


Mapping it out
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Aenean commodo ligula eget dolor. Aenean massa. Cum sociis natoque penatibus et magnis dis

Map note 1
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Aenean

Map note 2
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Aenean

Map note 2
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Aenean

Map note 3
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Aenean

Area of map shown at left

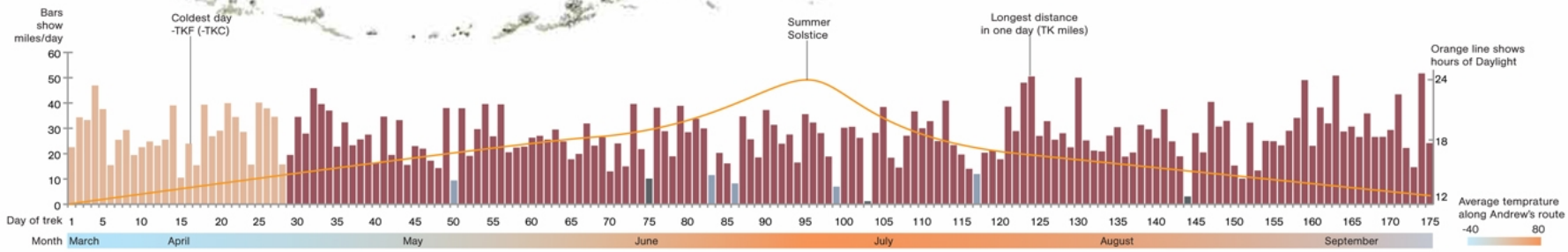
500 miles
3/20/2010
day18

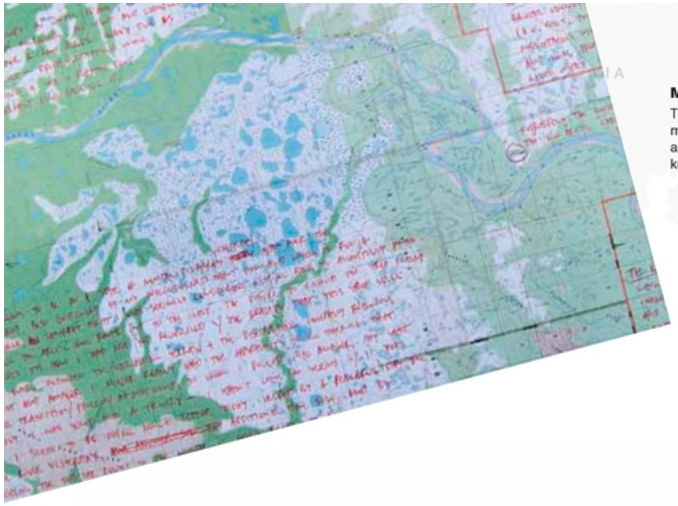
1000 miles
4/18/2010
day 39

UNITED STATES
ALASKA
CANADA
YUKON
BRITISH COLUMBIA

How Andrew travelled
Corem Ipsum Dolor Sit Amet, Consectetuer Adipiscing Elit. Aenean

- Ski
- Pack raft
- Walking
- Resupply Day / Point





Mapping it out

This is a note about all the maps Andrew prepared and used to navigate and keep his journal .

ALASKA DAY BY DAY

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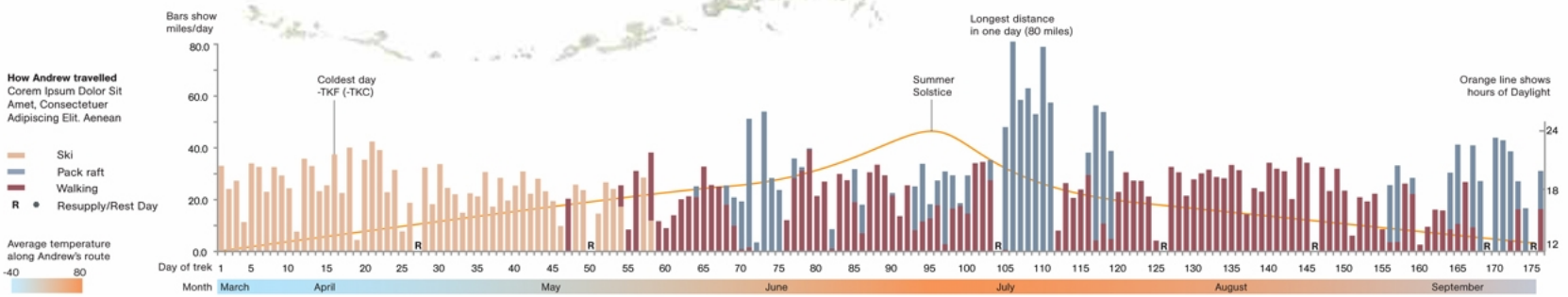
What Andrew Carries

Average Pack Weight: TK pds
Pack Raft and paddle: TK pds
Tent: TK pds
Pack: TK pds
Sleeping gear: TK pds
10 days of Food: avg TK pds max TK pds



Mapping it out
"Floated 11 pm-2 am under a magical full moon," Skurka scribbled on a map of the Copper River (left), one of 249 he used to plan his route.

Heavy load
In the final 1,700 miles Skurka passed just two roads and a few villages, forcing him to carry more than 30 pounds of food.

Speedy rafting
Skurka covered 500 miles on the Yukon River in just ten days, nearly double his average pace for the trip.

Iditarod chill
Setting off on skis, Skurka endured mostly below-freezing temperatures along the Iditarod Trail. As spring arrived, the snowpack turned wet and rotten.

Risky coastline
His route along the sandy coast was "mostly easy walking punctuated by moments of terror," Skurka says. The most dangerous part: paddling across open-ocean bays.

HOW SKURKA'S GEAR MEASURED UP

GEAR WEIGHT (POUNDS)	SUMMER	WINTER
Clothing worn and footwear	4.2	9.2
Sleeping gear	1.2	4.0
Shelter	1.9	1.2
Ski or pack-raft equipment	7.0	7.3
Other gear in pack	8.5	11.6
Total	**22.8**	**33.3**

One day of food (all seasons): 2.1 pounds; 4,760 calories

DAY-TO-DAY CHALLENGE

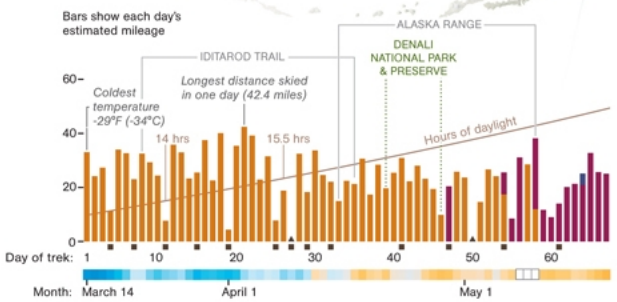
"This trip wasn't a race. It was 178 back-to-back marathons," Andrew Skurka says. "Some miles whizzed by, like when I was rafting the Yukon River. Others seemed to go on forever, such as when I was wallowing in rotten snow and tangled up in alder in the Alaska Range. I learned quickly that I couldn't force it. If nature had other plans, I had to adjust."

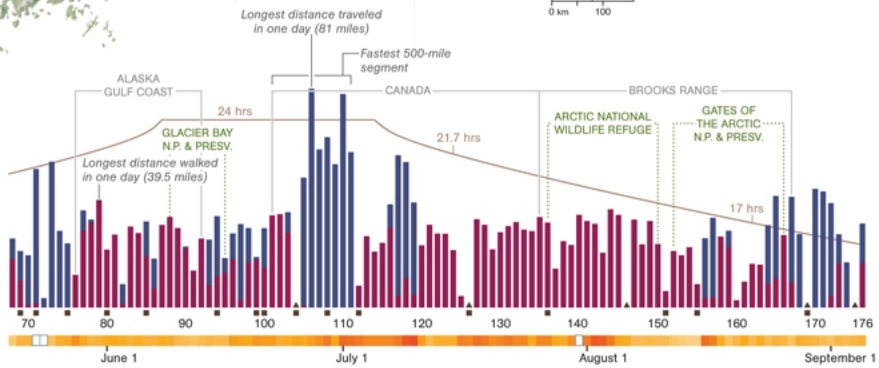
How Skurka traveled
Andrew was self-propelled the whole way, whether skiing, paddling, or hiking. Occasionally he hitchhiked into towns off his route to stock up on supplies.

Skiing	1,317.3 miles
Paddling	1,269.3 mi
Hiking	2,092.2 mi
Total	**4,678.8 mi**

■ Food or gear resupply
▲ Rest day

Average daily temperature (°F) along Skurka's route
-25 32 68 No data





MARTIN GAMACHE, NGM STAFF; COLTER SIKORA. PHOTO: REBECCA HALE, NGM STAFF
SOURCES: HEATHER ANGELOFF, ALASKA CLIMATE RESEARCH CENTER; MICHAEL ROSS, RER ENERGY; ANDREW SKURKA

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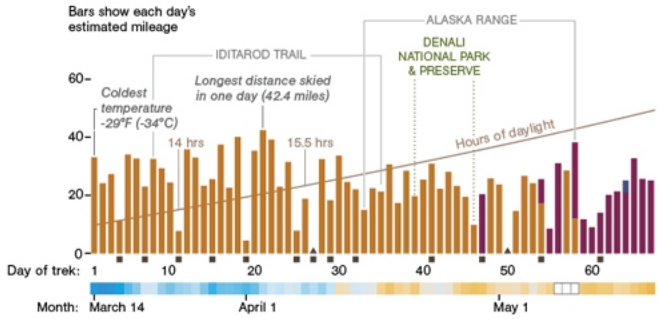

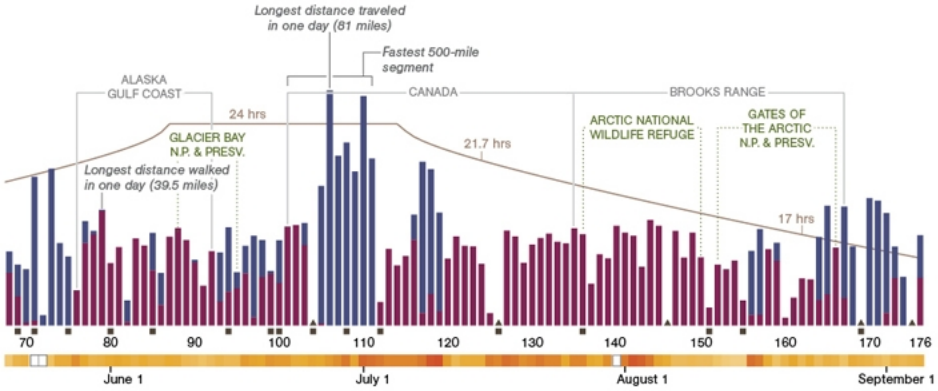

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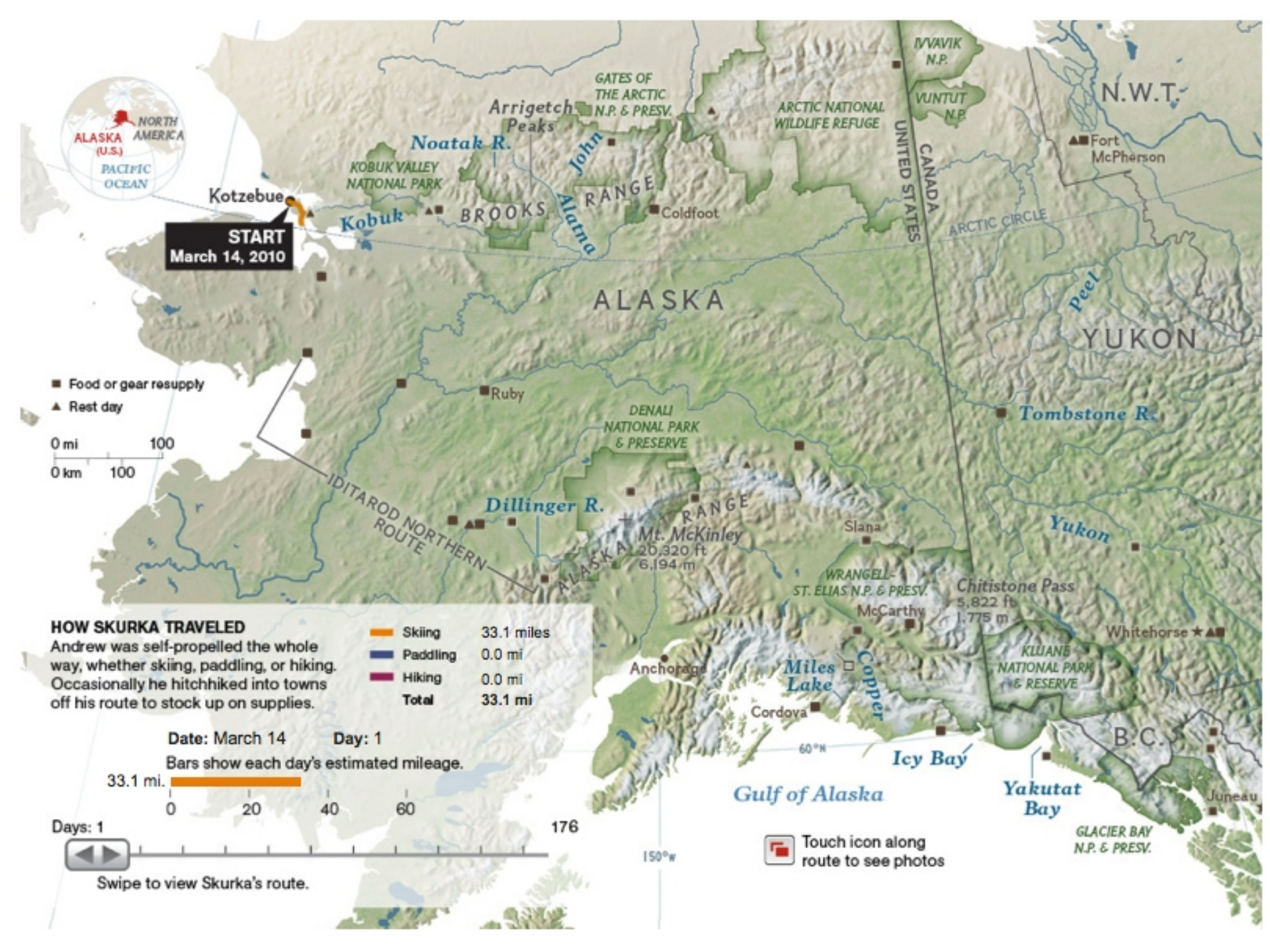

ALASKA (U.S.)
NORTH AMERICA
PACIFIC OCEAN
Kotzebue
START
March 14, 2010
Food or gear resupply
Rest day
0 mi 100
0 km 100
Noatak R.
KOBUK VALLEY NATIONAL PARK
Kobuk
BROOKS RANGE
Arrigetch Peaks
GATES OF THE ARCTIC N.P. & PRESV.
John
Alatna
Coldfoot
ARCTIC NATIONAL WILDLIFE REFUGE
IVVAVIK N.P.
VUNTUT N.P.
UNITED STATES
CANADA
N.W.T.
Fort McPherson
ARCTIC CIRCLE
ALASKA
Peel
YUKON
Ruby
DENALI NATIONAL PARK & PRESERVE
Tombstone R.
IDITAROD NORTHERN ROUTE
Dillinger R.
ALASKA RANGE
Mt. McKinley
20,320 ft
6,194 m
Slana
Yukon
WRANGELL-ST. ELIAS N.P. & PRESV.
Chitistone Pass
5,822 ft
1,775 m
McCarthy
Whitehorse
Anchorage
Miles Lake
Copper
KLUANE NATIONAL PARK & RESERVE
Cordova
B.C.
60°N
Icy Bay
Gulf of Alaska
Yakutat Bay
Juneau
GLACIER BAY N.P. & PRESV.
150°W
HOW SKURKA TRAVELED
Andrew was self-propelled the whole way, whether skiing, paddling, or hiking. Occasionally he hitchhiked into towns off his route to stock up on supplies.
Skiing 33.1 miles
Paddling 0.0 mi
Hiking 0.0 mi
Total 33.1 mi
Date: March 14 Day: 1
Bars show each day's estimated mileage.
33.1 mi.
0 20 40 60
Days: 1 176
Swipe to view Skurka's route.
Touch icon along route to see photos

LARGEST CAVE

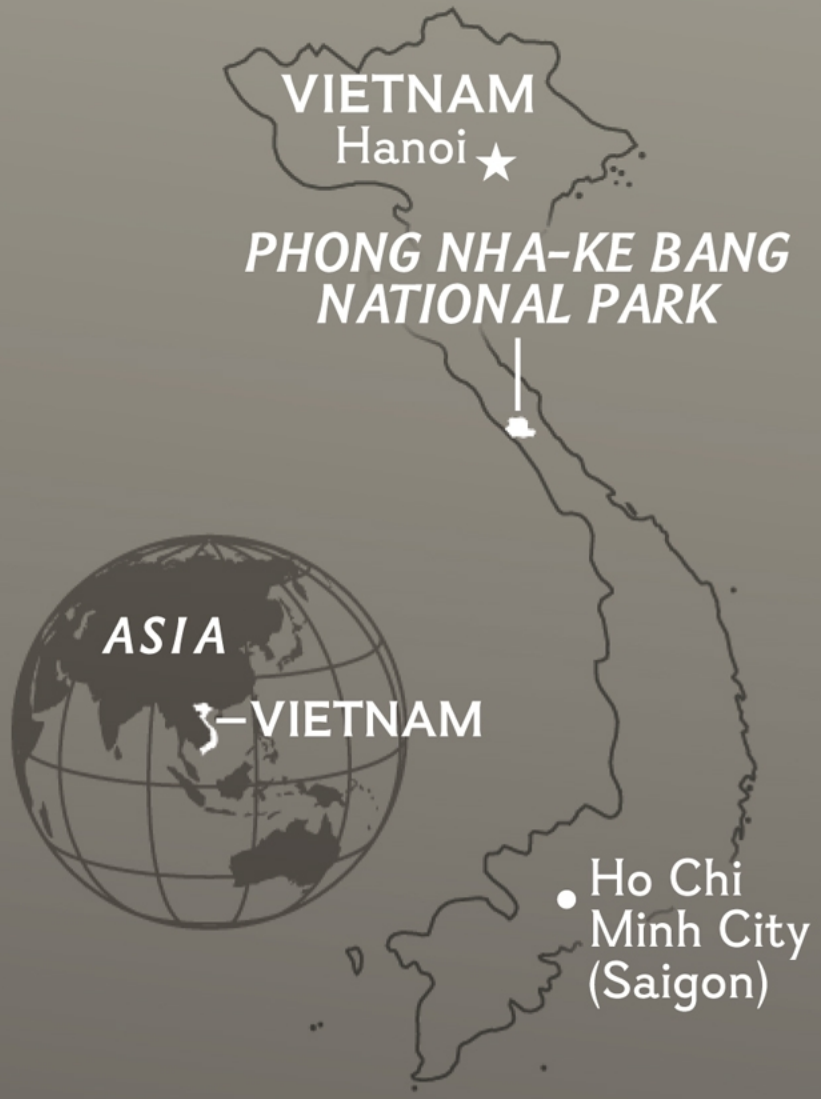
Hang Son Doong
Vietnam

January 2011

CONQUERING AN INFINITE CAVE

There's a jungle inside Vietnam's mammoth cavern. A skyscraper could fit too. And the end is out of sight.

A half-mile block of 40-story buildings could fit inside this lit stretch of Hang Son Doong, which may be the world's biggest subterranean passage. In nearby Loong Con (left), a climber ascends a shaft of sunlight.

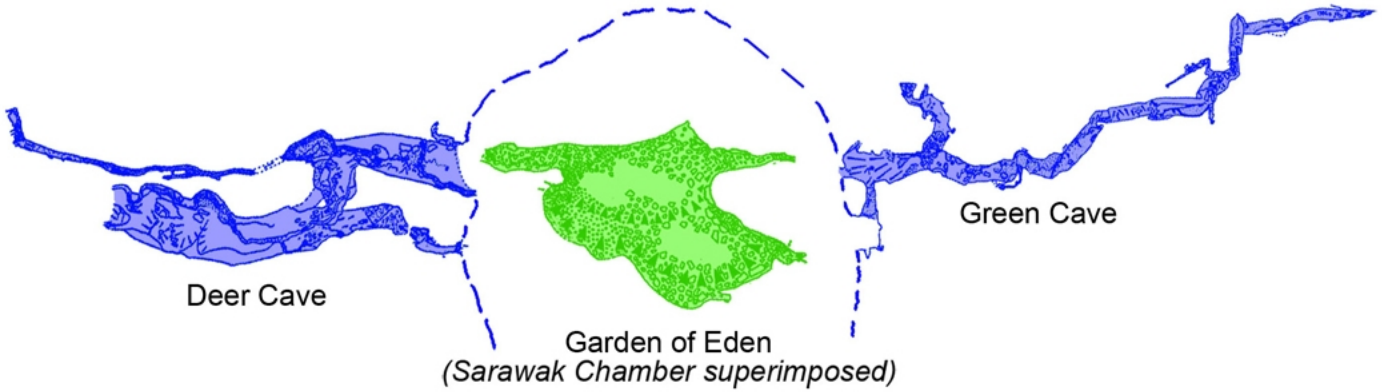

VIETNAM
Hanoi
PHONG NHA-KE BANG
NATIONAL PARK
ASIA
VIETNAM
Ho Chi
Minh City
(Saigon)

The largest caves in the world

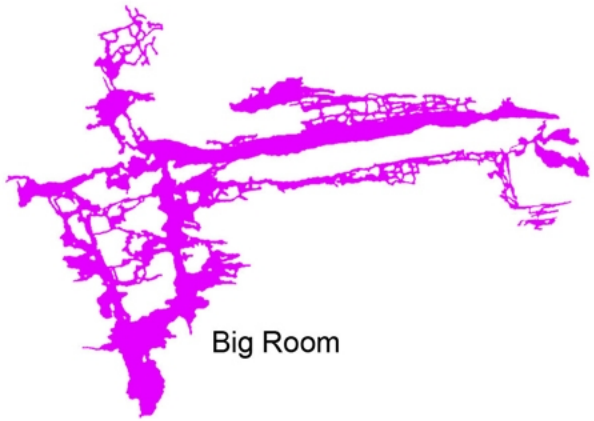
all drawn to the same scale

0 metres 1000

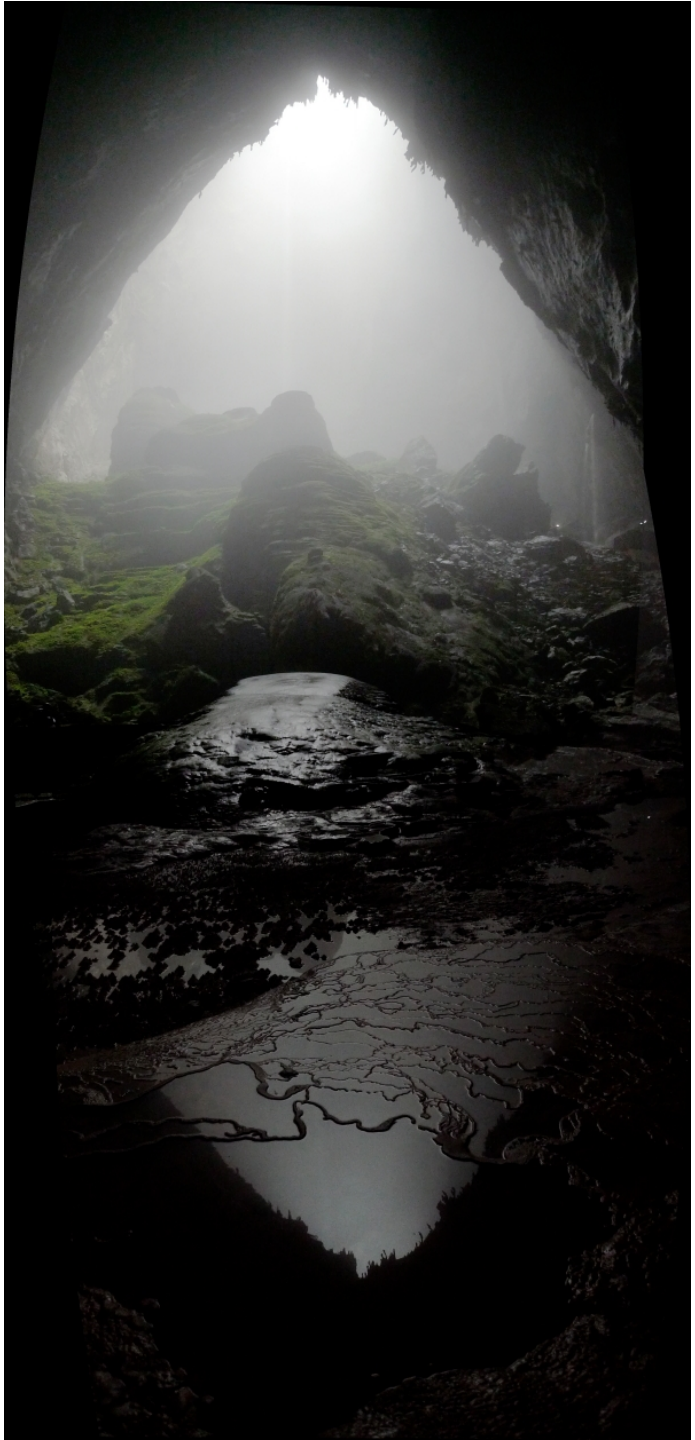
Hang Son Doong, Vietnam

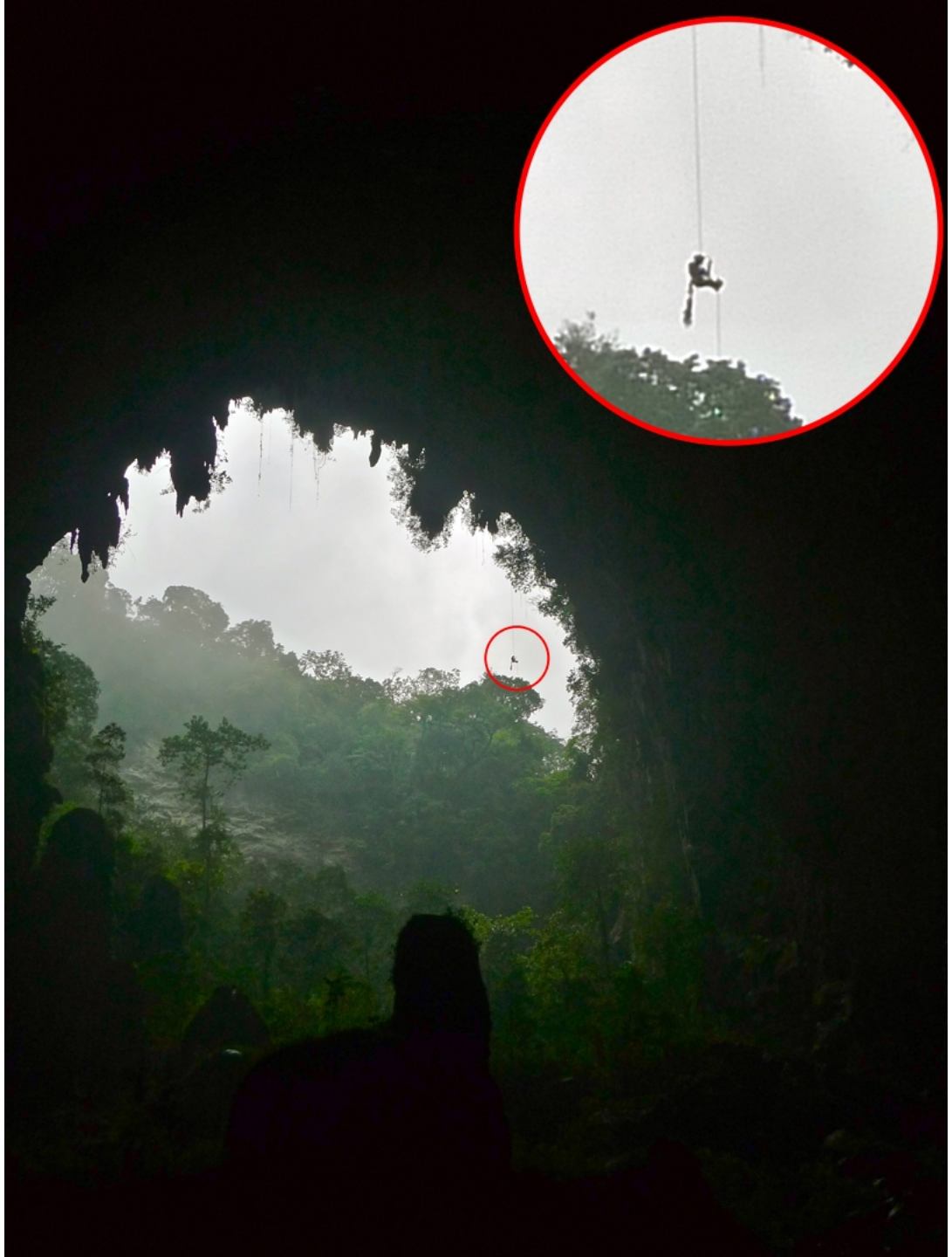


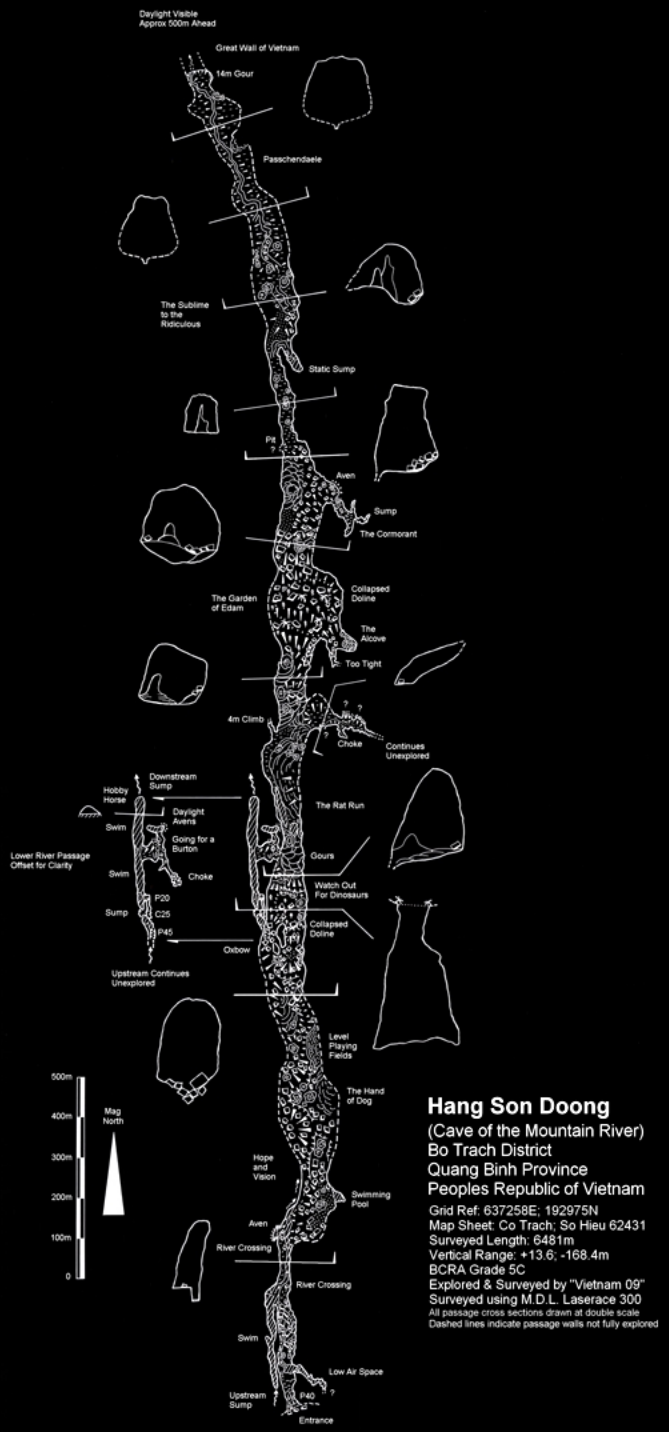
Caves of southern Mulu, Sarawak



Carlsbad Caverns, USA







Hang Son Doong

(Cave of the Mountain River)
Bo Trach District
Quang Binh Province
Peoples Republic of Vietnam

Grid Ref: 637258E; 192975N
Map Sheet: Co Trach; So Hieu 62431
Surveyed Length: 6481m
Vertical Range: +13.6; -168.4m
BCRA Grade 5C
Explored & Surveyed by "Vietnam 09"
Surveyed using M.D.L. Laserace 300
All passage cross sections drawn at double scale
Dashed lines indicate passage walls not fully explored

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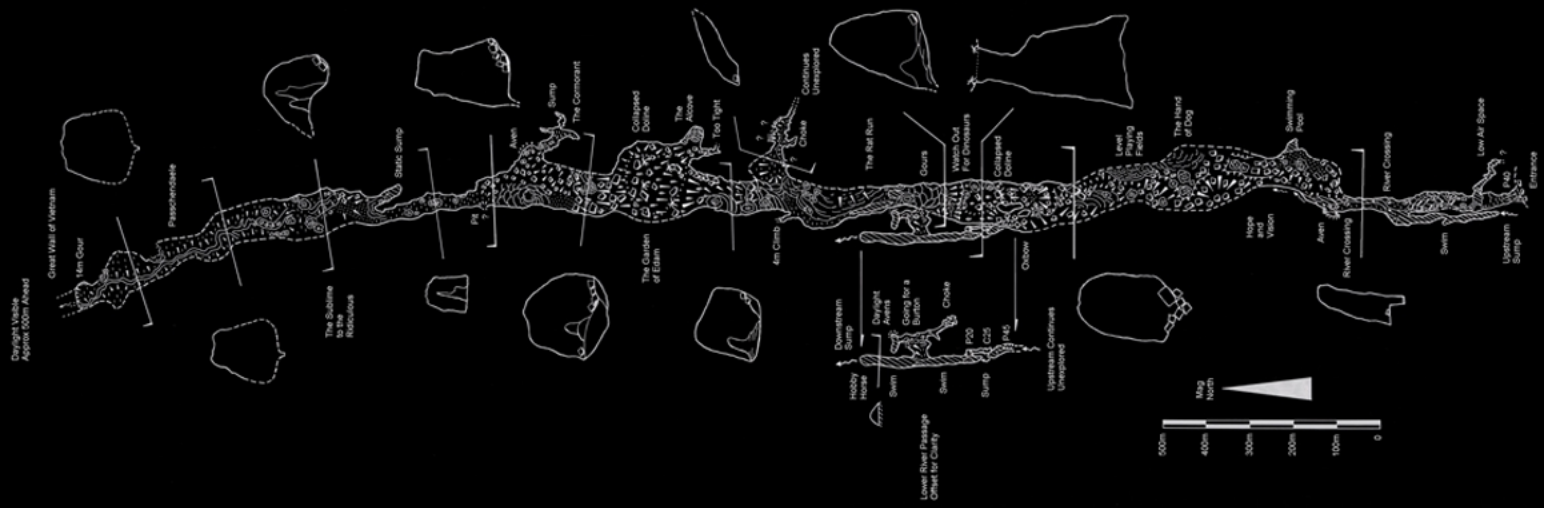
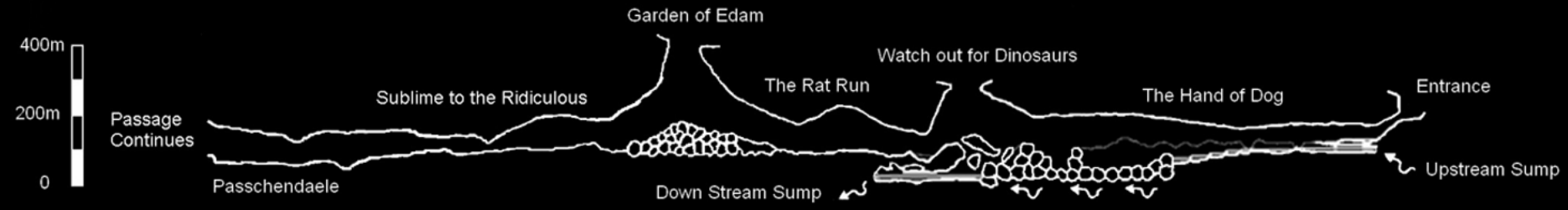
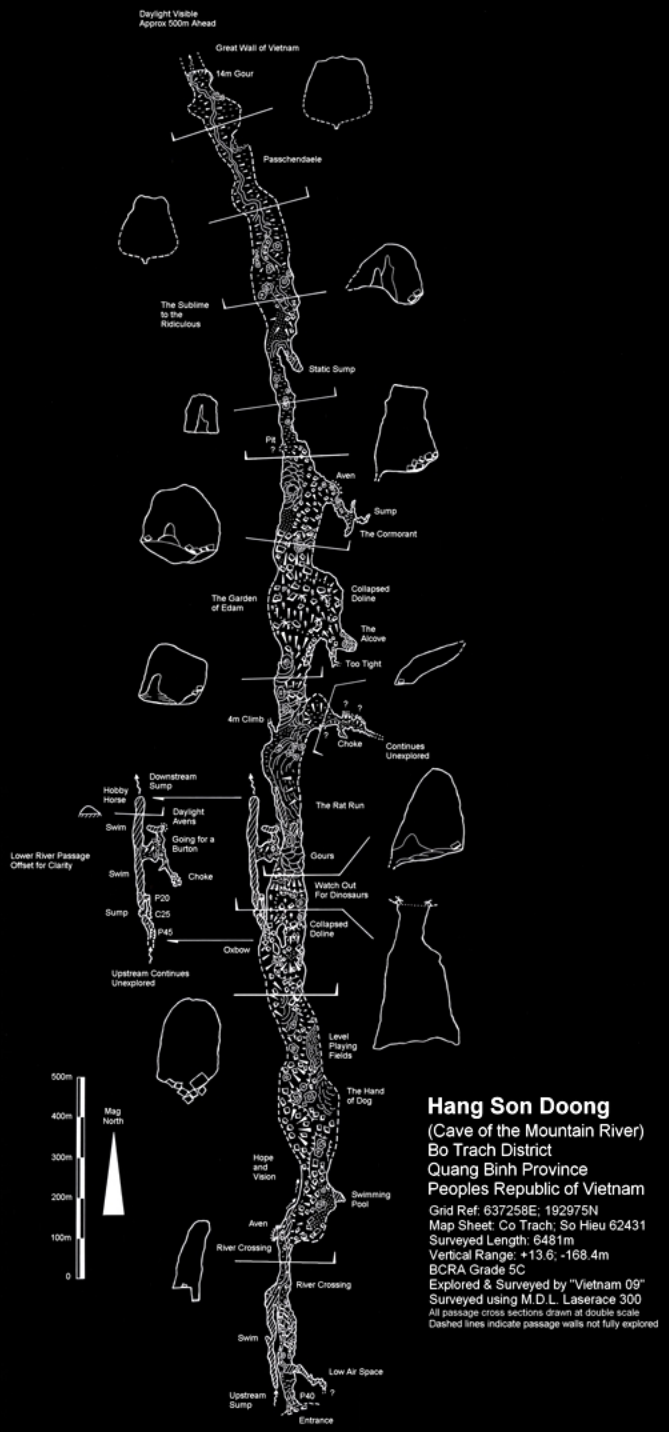




Elevation Looking East
Minor passages ommitted for clarity



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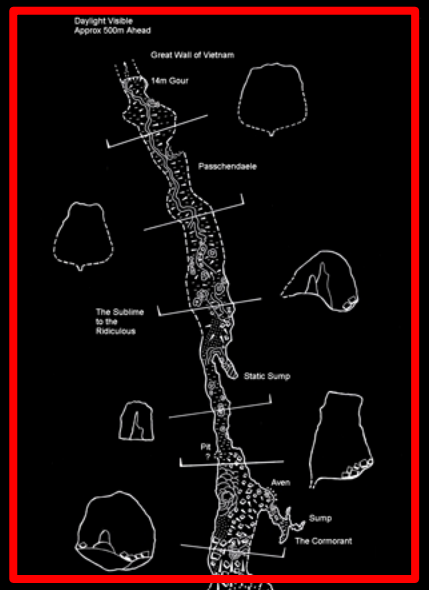

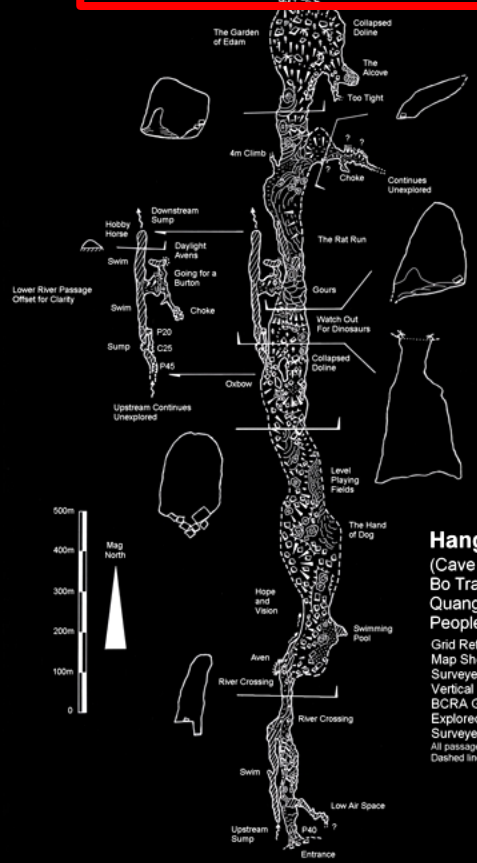

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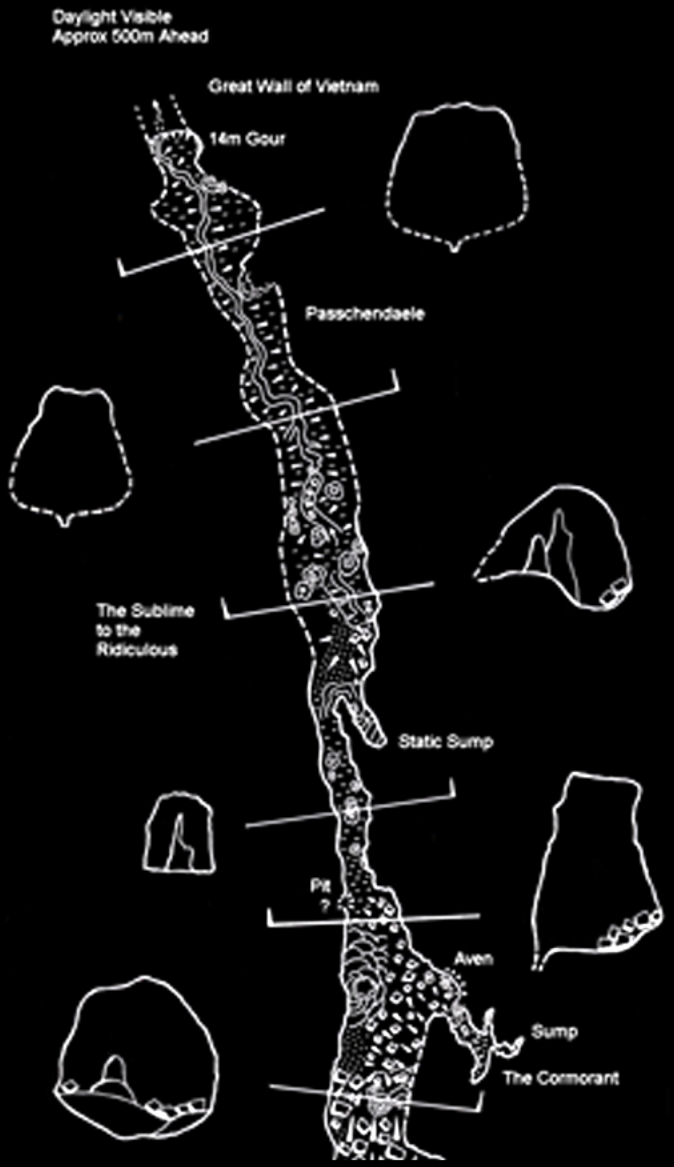

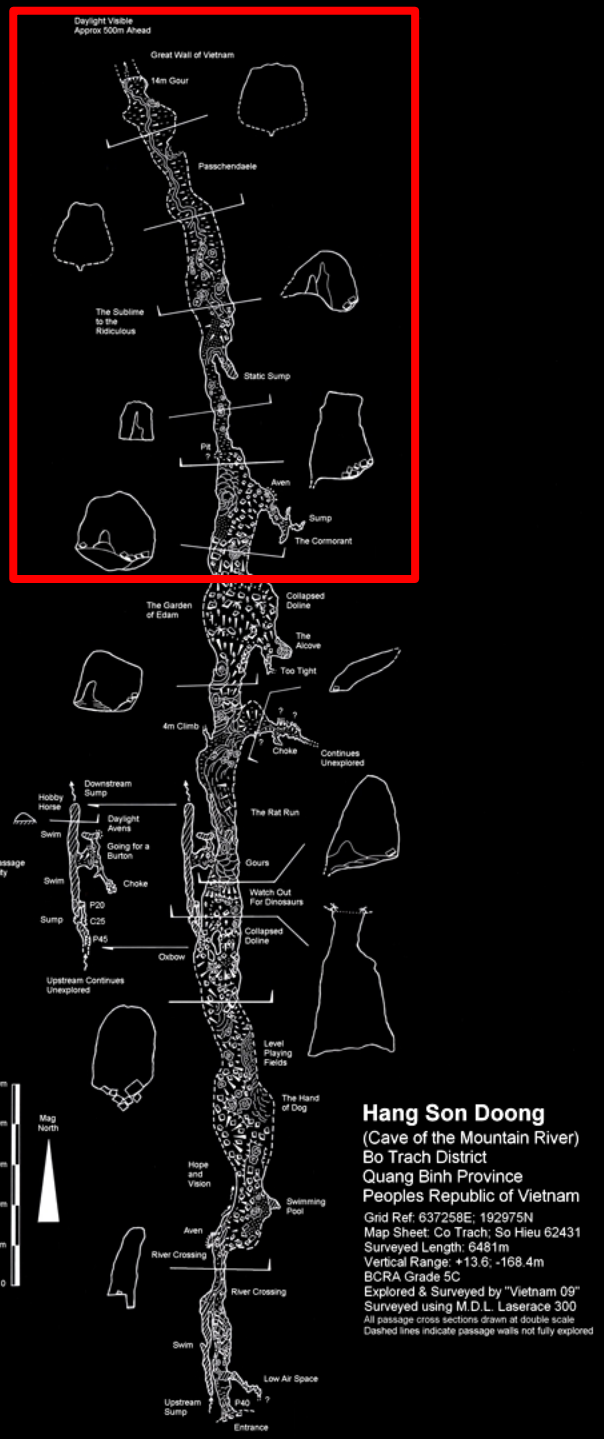

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PATH OF A RIVER CAVE

In April 2009 a British-Vietnamese team began exploring Hang Son Doong, or "mountain river cave" (below). Beneath the rain forest along the Vietnam-Laos border they discovered a cavernous limestone passage more than 2.5 miles long and in places over 600 feet high, carved by a subterranean river two to five million years ago. Expeditions have found more than 150 caves in this area since 1990, mapping nearly 90 miles of passages.

A MEGA-SINKHOLE OPENS

The cave's Garden of Edam sinkhole owes its size to its location: Another passage entered the main cave here. When the ceiling collapsed at this junction, it opened a pit 1,500 feet deep, with a 650-foot-wide opening.

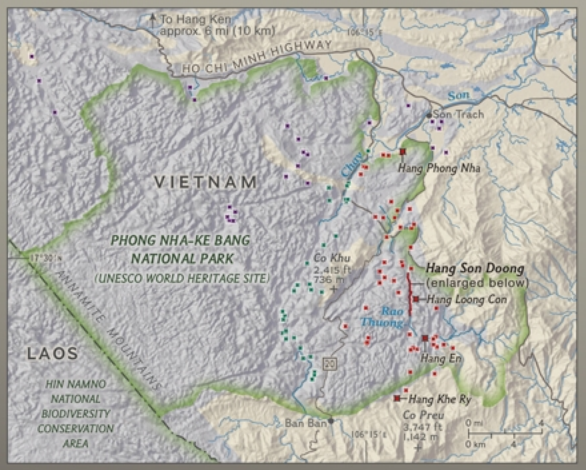
Dissolving
2 million to 5 million years ago
A subterranean chamber (**A**) forms as water flowing along fracture lines (**B**) dissolves the limestone.

Expanding
With continued erosion and collapse (**C**), debris accumulates faster than it can be removed by the flowing water (**D**).

Collapse and colonization
Within the past million years
The chamber's roof collapses, opening the cave to the sky. Ferns and trees colonize the exposed debris cone (**E**).

CANVAS FOR CAVES

Vast formations of limestone, in places thousands of feet thick, were deposited across this region 250 to 350 million years ago. Tectonic action uplifted and fractured the rock. Rivers followed these fractures underground, dissolving networks of cave passages.



Networks of caves
Vom caves · Phong Nha caves · Other caves · Limestone extent

Two drainage systems, the Vom and the Phong Nha, channel subterranean waters that have carved two namesake cave networks.

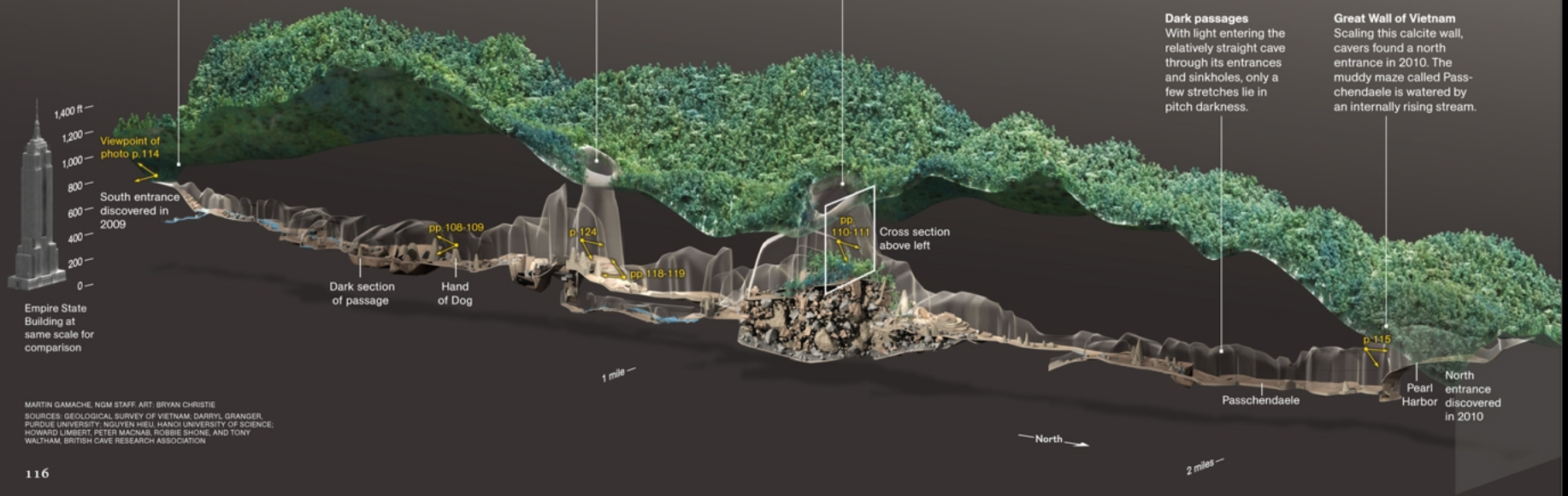
South entrance
Flowing into the cave, the Rao Thuong River soon vanishes into the limestone. High water makes exploration too dangerous in summer's rainy season.

Watch Out for Dinosaurs
The whimsically named sinkhole lets in light and rain, which seeps into the river now carving new passages beneath the cave floor.

Garden of Edam
In the larger and older of the cave's two sinkholes, a forest of 100-foot trees covers an 850-foot-tall debris cone.

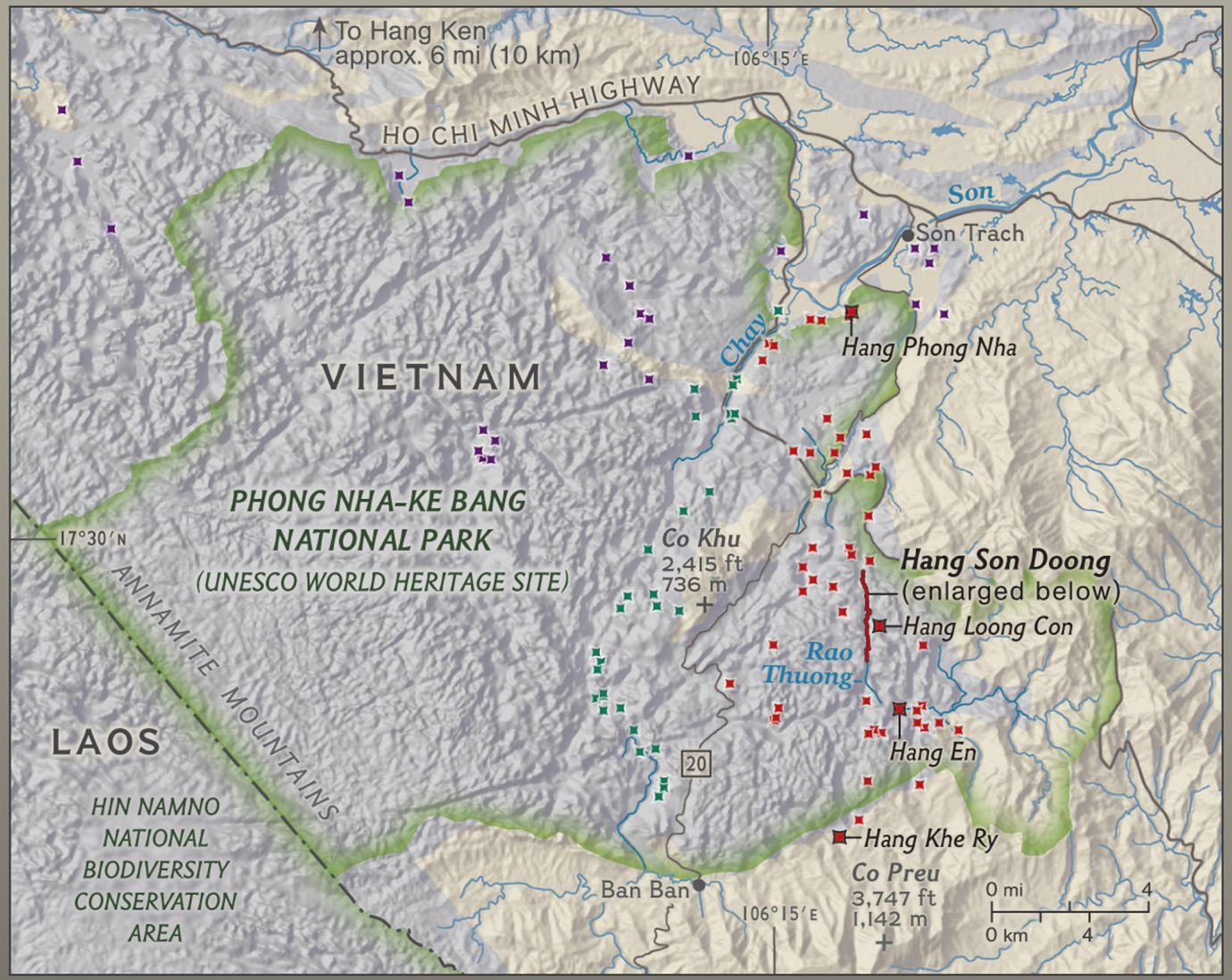
Dark passages
With light entering the relatively straight cave through its entrances and sinkholes, only a few stretches lie in pitch darkness.

Great Wall of Vietnam
Scaling this calcite wall, cavers found a north entrance in 2010. The muddy maze called Passchendaele is watered by an internally rising stream.



MARTIN GAMACHE, NGM STAFF. ART: BRYAN CHRISTIE

SOURCES: GEOLOGICAL SURVEY OF VIETNAM; DARRYL GRANGER, PURDUE UNIVERSITY; NGUYEN HIEU, HANOI UNIVERSITY OF SCIENCE; HOWARD LIMBERT, PETER MACNAB, ROBBIE SHONE, AND TONY WALTHAM, BRITISH CAVE RESEARCH ASSOCIATION



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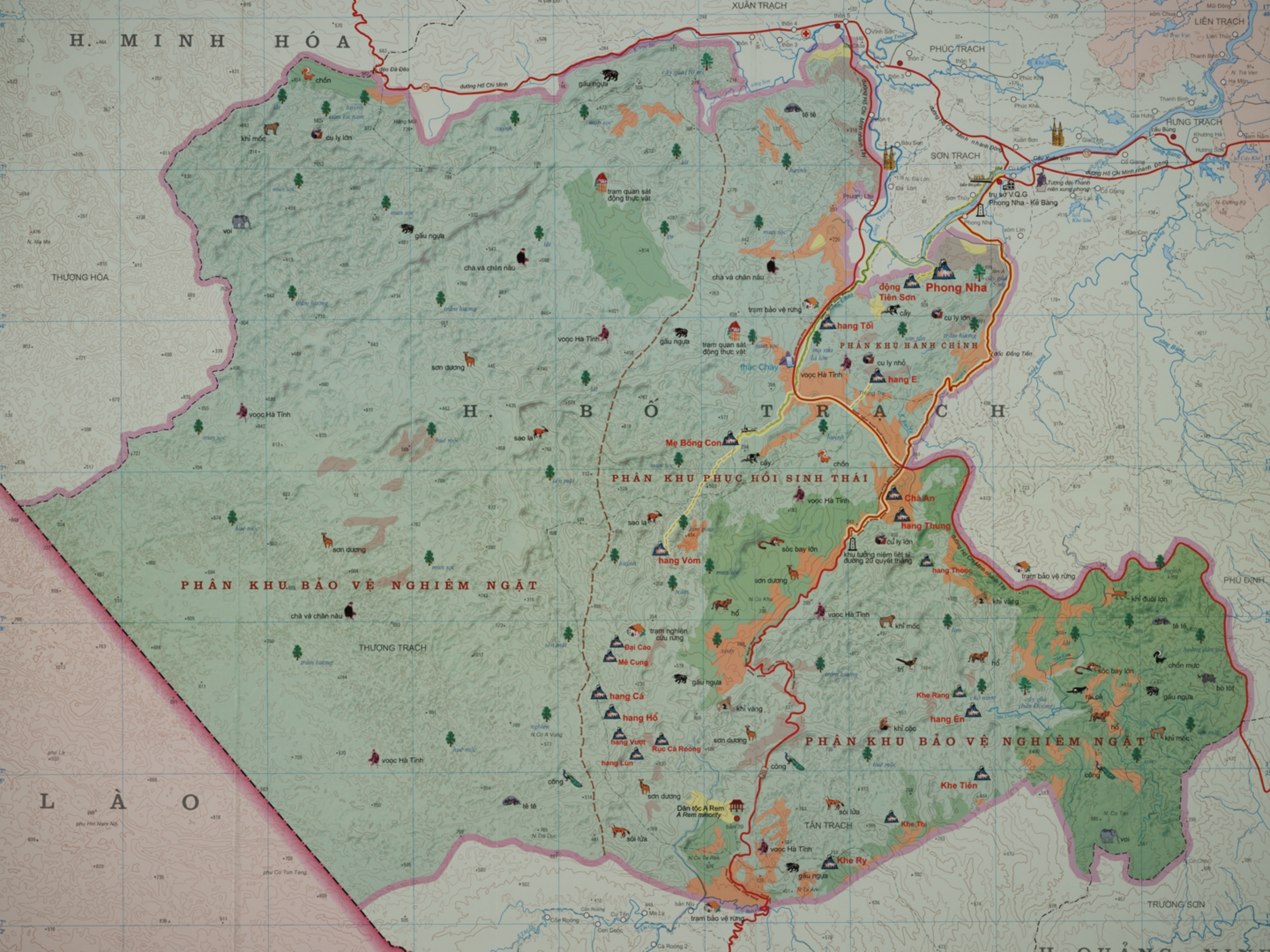
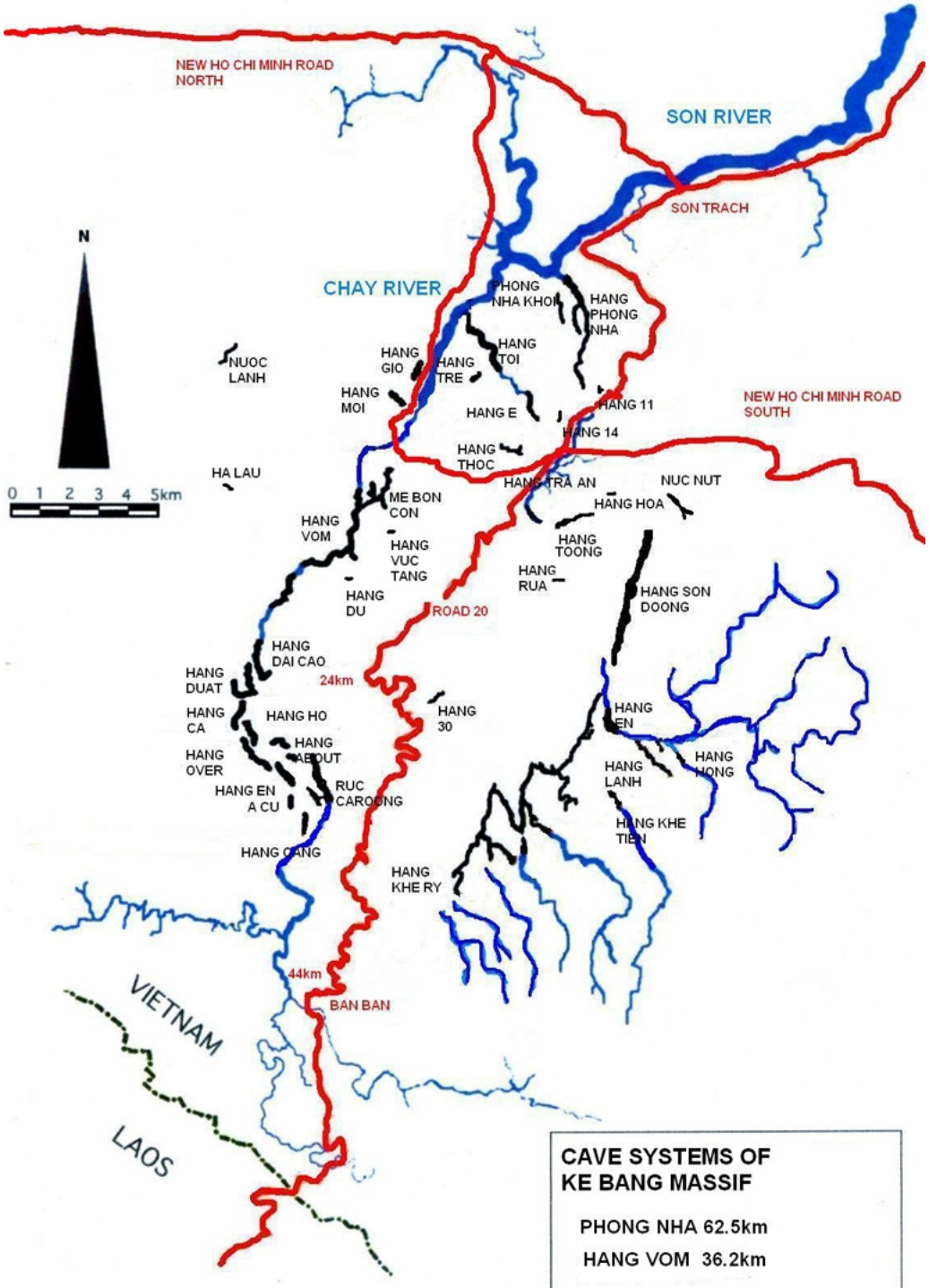
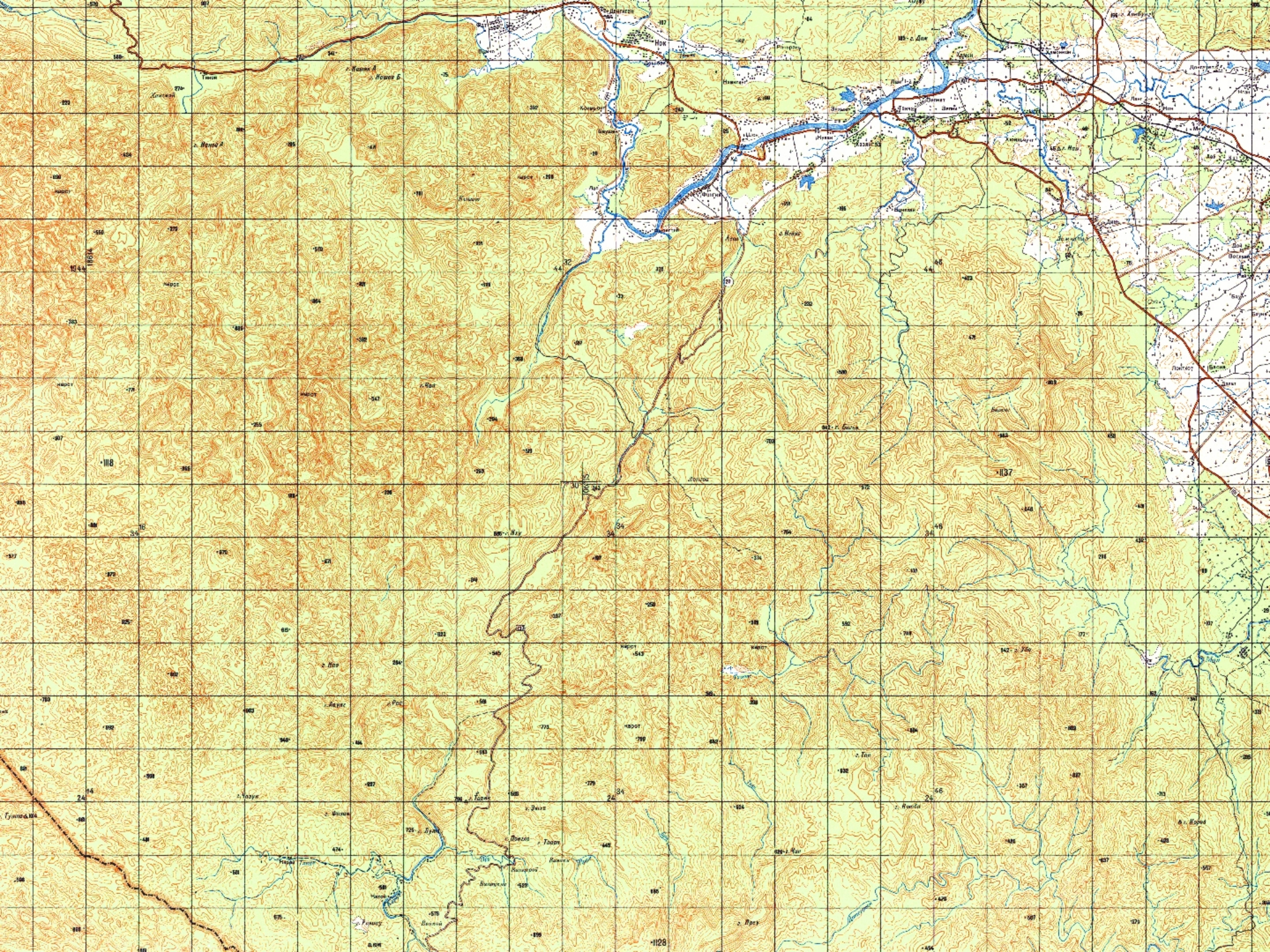
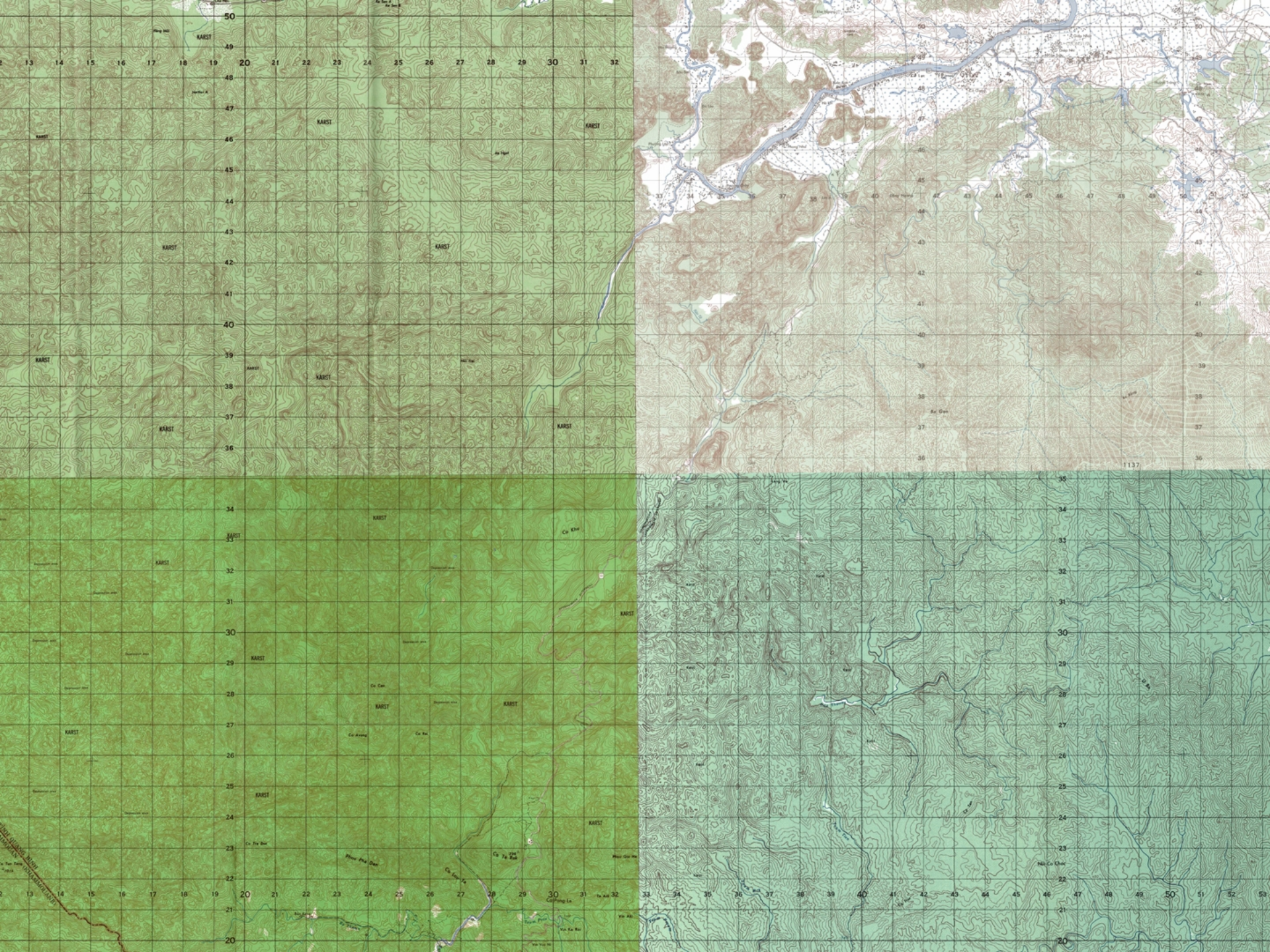


H. MINH HÓA
XUÂN TRẠCH
LIÊN TRẠCH
PHÚC TRẠCH
HƯNG TRẠCH
SƠN TRẠCH
THƯỢNG HÓA
H. BỐ TRẠCH
PHÂN KHU HÀNH CHÍNH
PHÂN KHU PHỤC HỒI SINH THÁI
PHÂN KHU BẢO VỆ NGHIÊM NGẶT
THƯỢNG TRẠCH
TÂN TRẠCH
TRƯỜNG SƠN
PHÚ ĐỊNH
LÀO
đường Hồ Chí Minh
đèo Đá Đẽo
trụ sở V.Q.G Phong Nha - Kẻ Bàng
Phong Nha
động Tiên Sơn
hang Tối
hang E
thác Chày
Mẹ Bồng Con
Chà An
hang Thung
hang Vòm
hang Thoọc
Đại Cáo
Mê Cung
hang Cá
hang Hổ
hang Vượt
Rục Cà Roòng
hang Lùn
Khe Rang
hang Én
Khe Tiên
Khe Tri
Khe Ry
Dân tộc A Rem
A Rem minority
trạm quan sát động thực vật
trạm bảo vệ rừng
trạm nghiên cứu rừng
khu tưởng niệm liệt sĩ đường 20 quyết thắng
chồn
khỉ mốc
cu ly lớn
cu ly nhỏ
voi
gấu ngựa
chà vá chân nâu
voọc Hà Tĩnh
sơn dương
sao la
cầy
tê tê
sóc bay lớn
hổ
khỉ vàng
khỉ đuôi lợn
khỉ cộc
trĩ
công
sói lửa
chồn mực
bò tót


NEW HO CHI MINH ROAD NORTH
SON RIVER
SON TRACH
CHAY RIVER
N
0 1 2 3 4 5km
PHONG NHA KHOI
HANG PHONG NHA
HANG TOI
HANG GIO
HANG TRE
NUOC LANH
HANG MOI
HANG E
HANG 11
HANG 14
NEW HO CHI MINH ROAD SOUTH
HANG THOC
HA LAU
HANG TRA AN
NUC NUT
HANG HOA
ME BON CON
HANG VOM
HANG VUC TANG
HANG TOONG
HANG RUA
HANG DU
HANG SON DOONG
ROAD 20
HANG DAI CAO
24km
HANG DUAT
HANG 30
HANG CA
HANG HO
HANG EN
HANG ABOUT
HANG OVER
HANG LANH
HANG HONG
HANG EN A CU
RUC CAROONG
HANG KHE TIEN
HANG CANG
HANG KHE RY
44km
VIETNAM
BAN BAN
LAOS
CAVE SYSTEMS OF KE BANG MASSIF
PHONG NHA 62.5km
HANG VOM 36.2km




KARST
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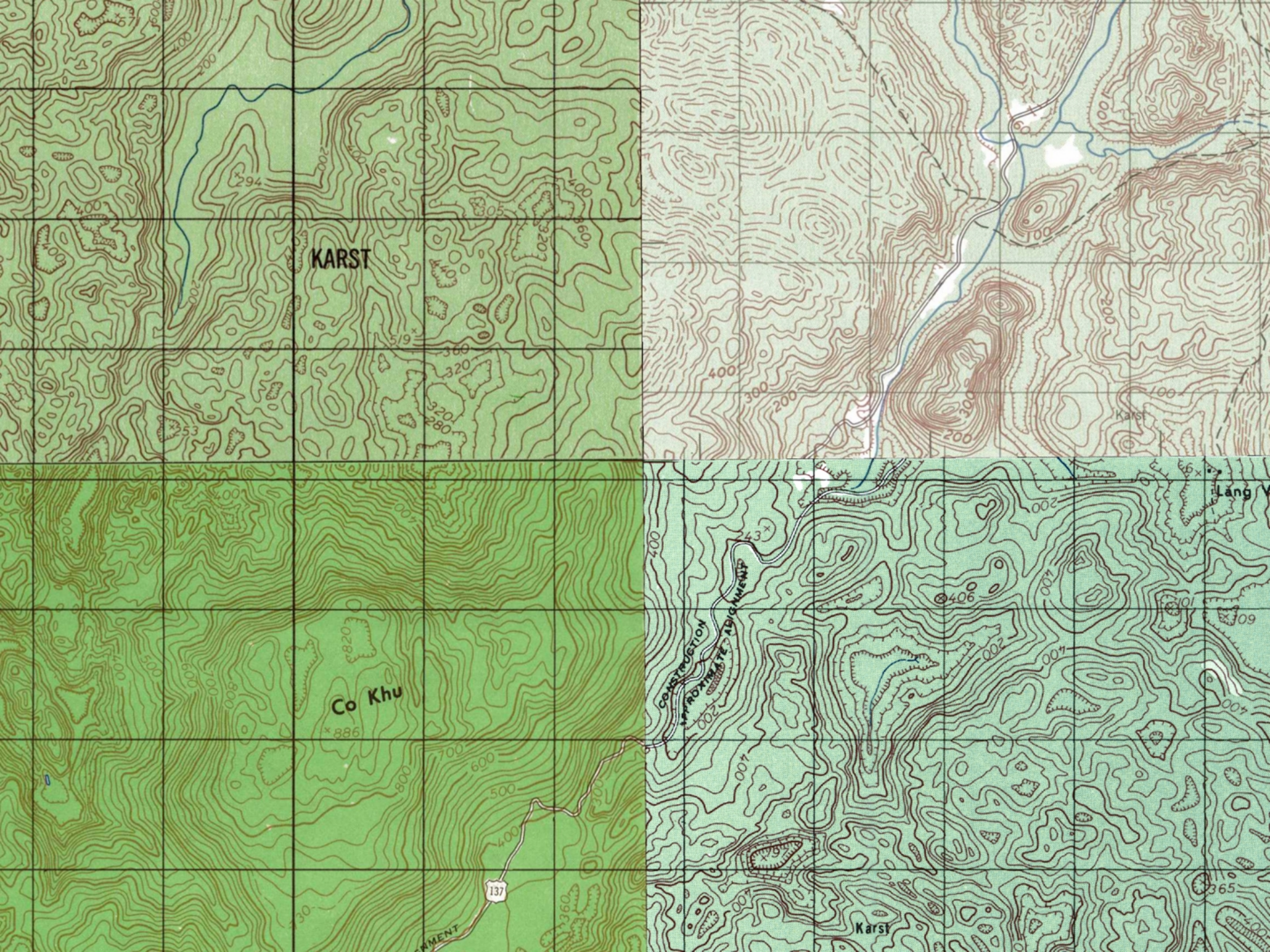
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Co Khu
Karst
Karst
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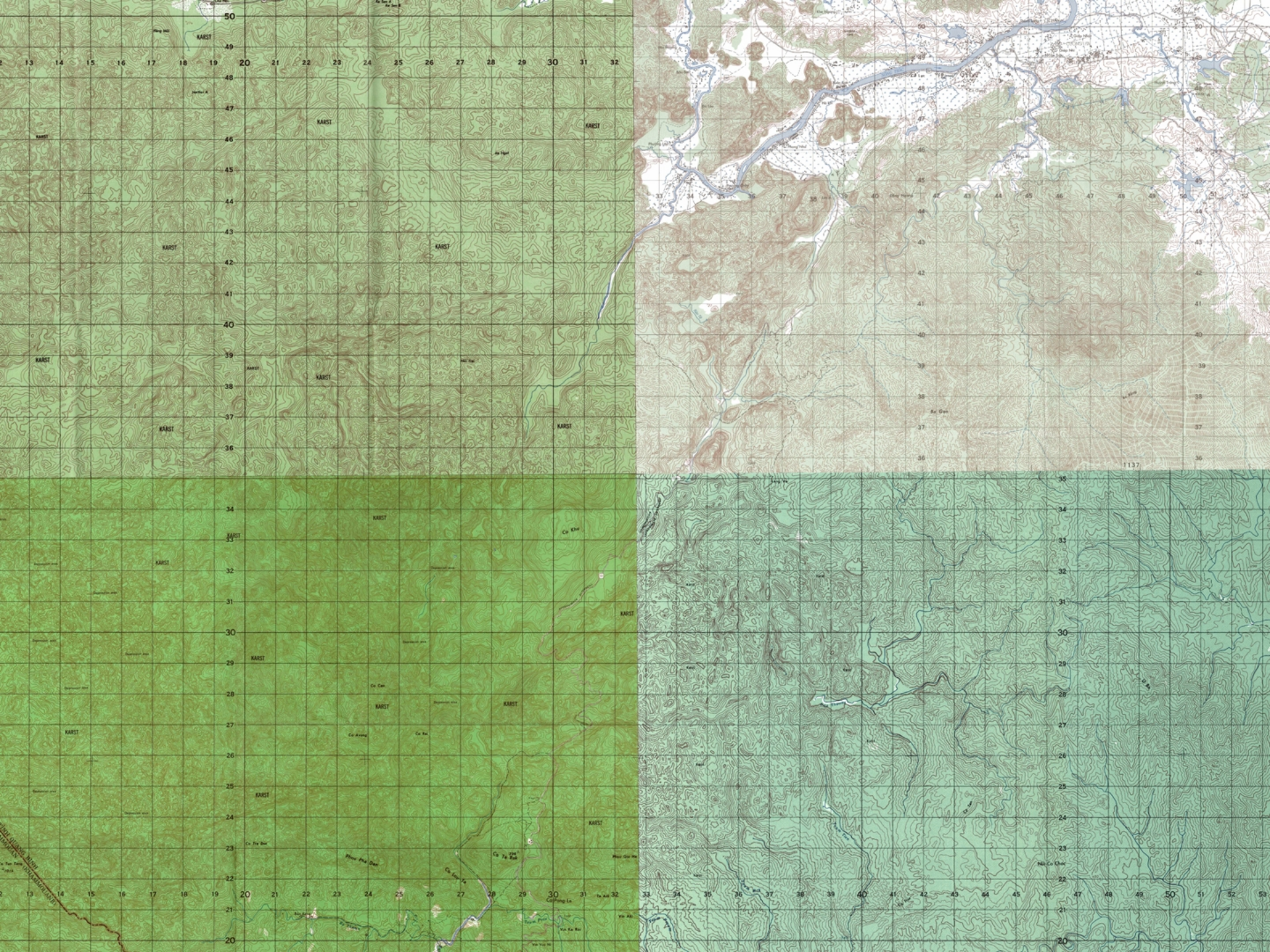
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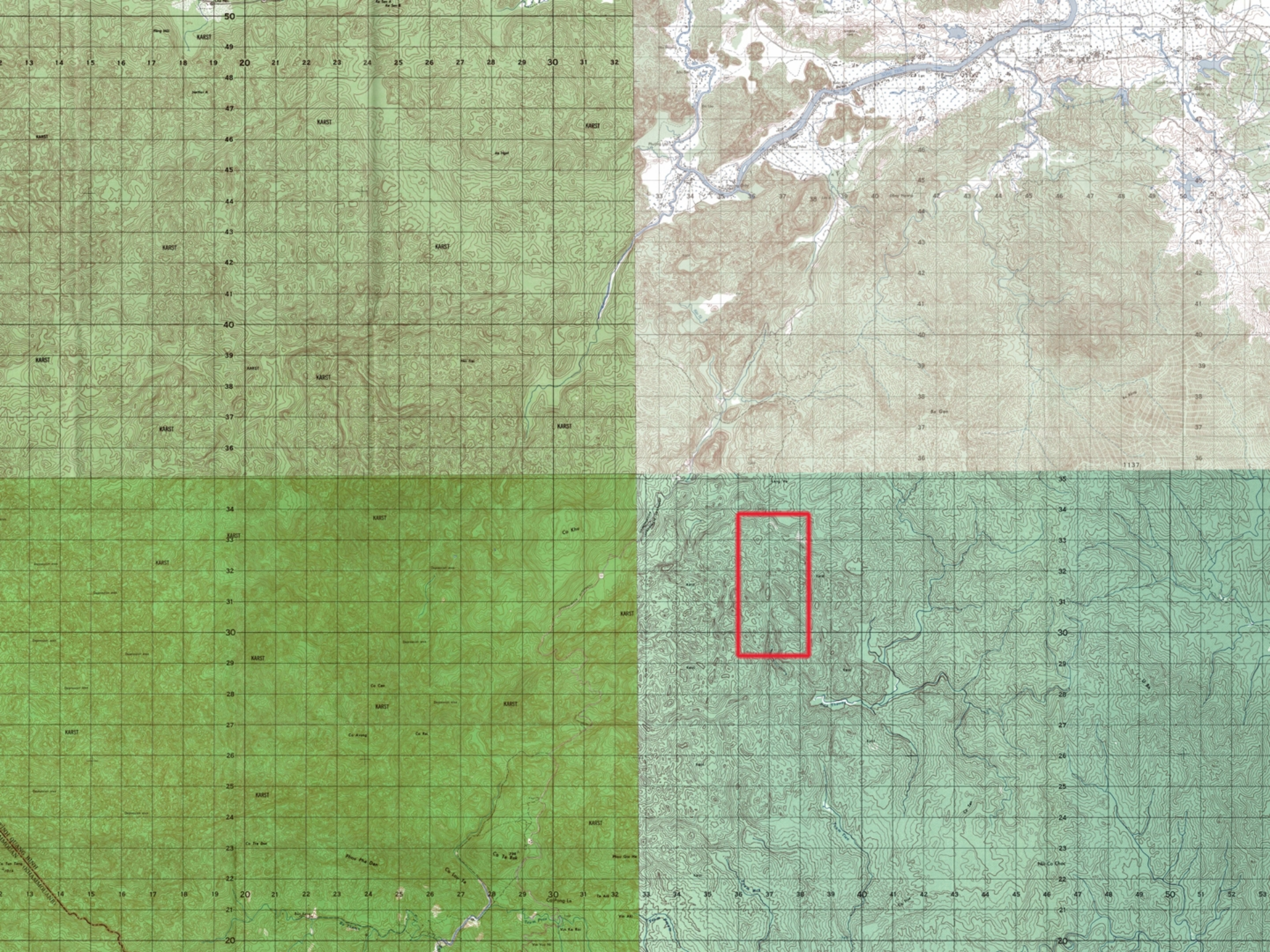
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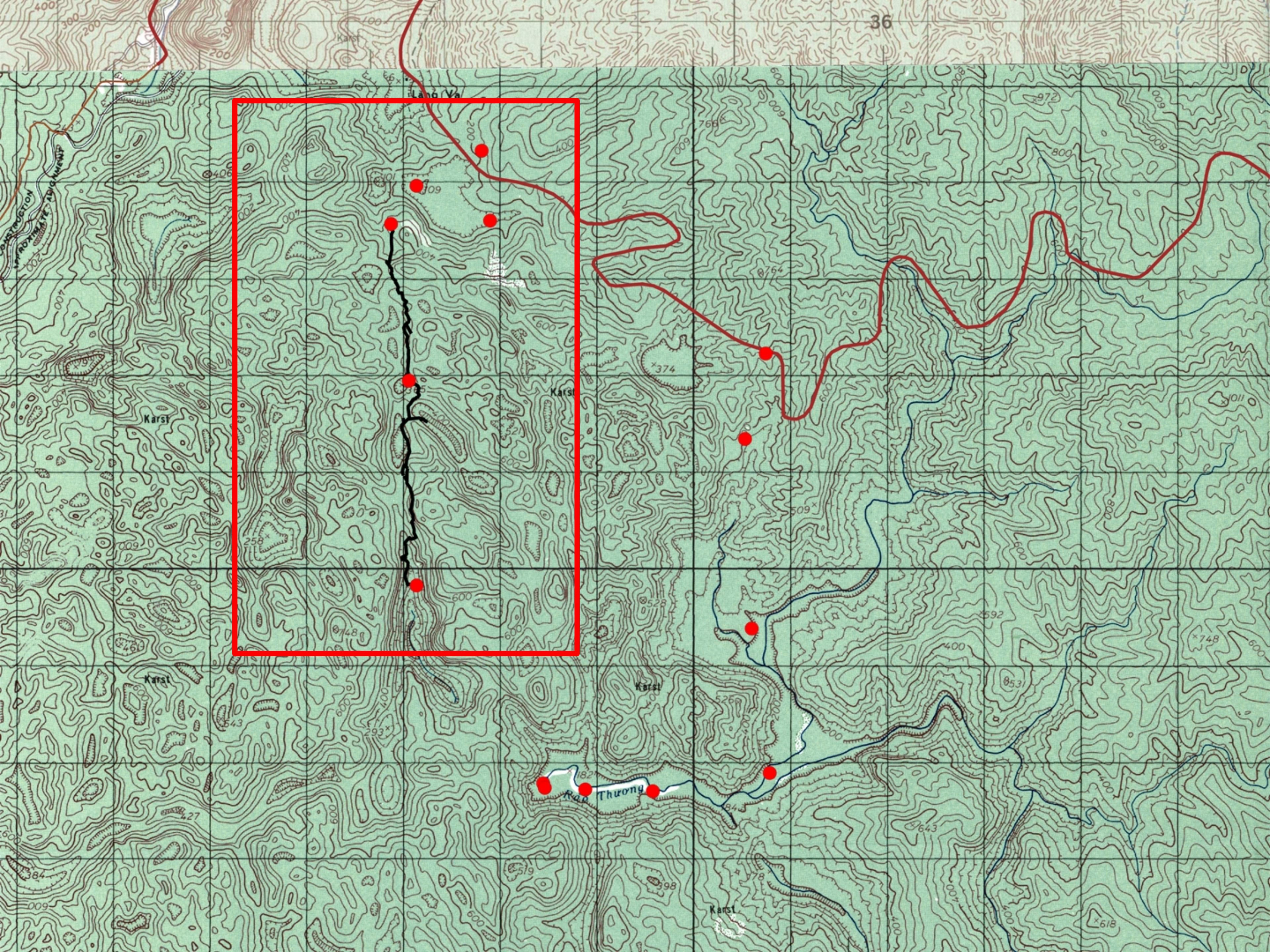
36
Lang Va
Karst
Karst
Karst
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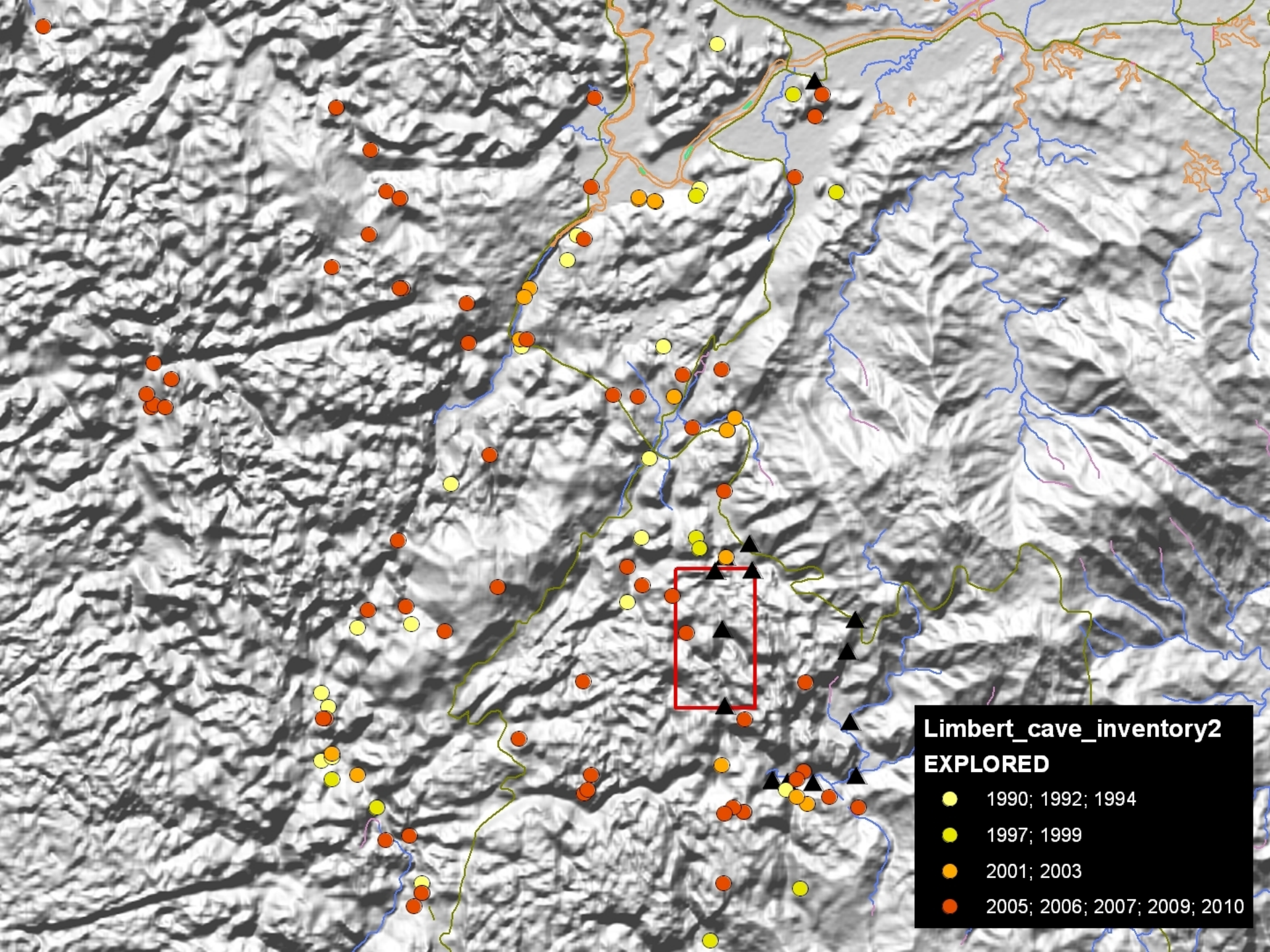
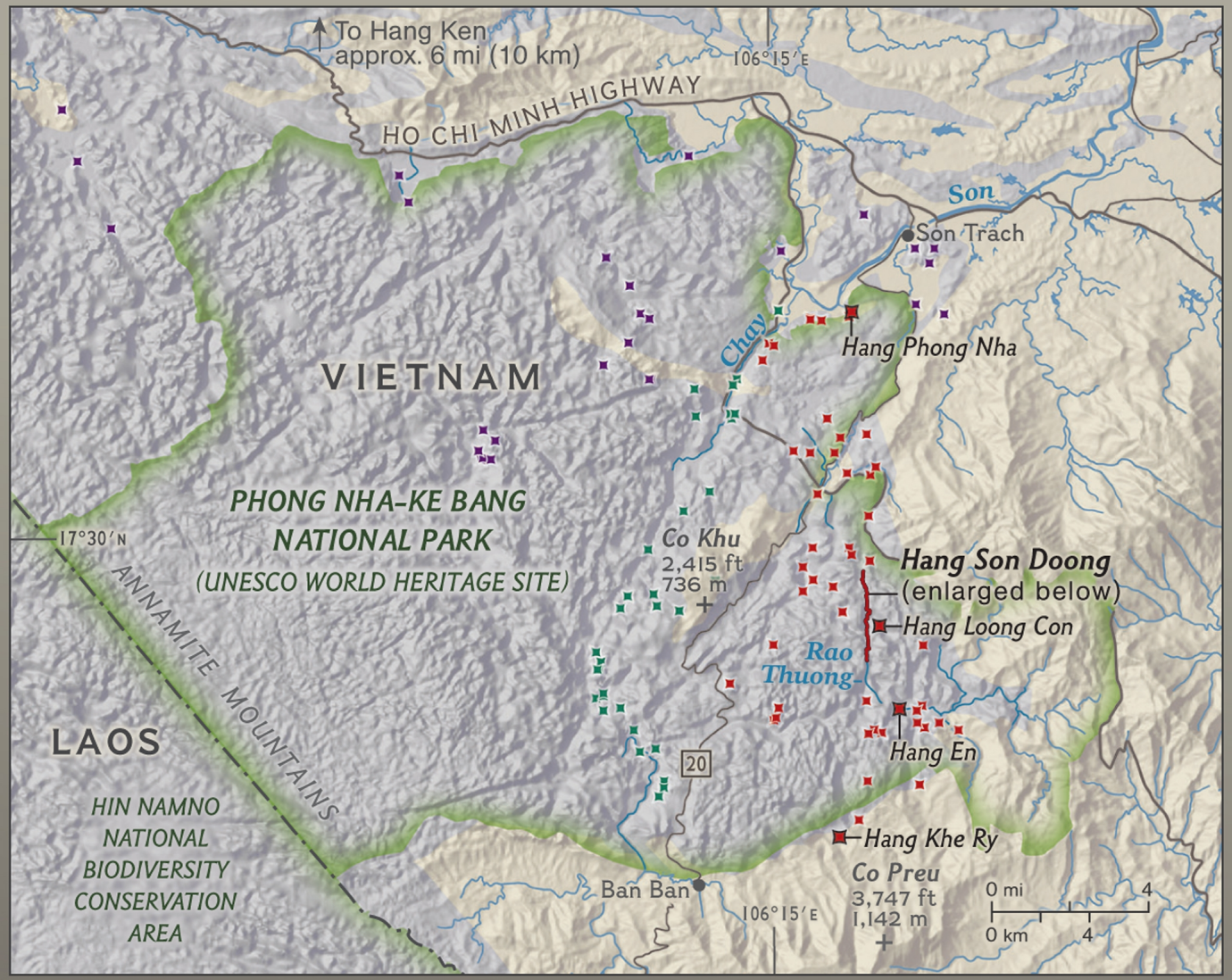
Karst
Thuong

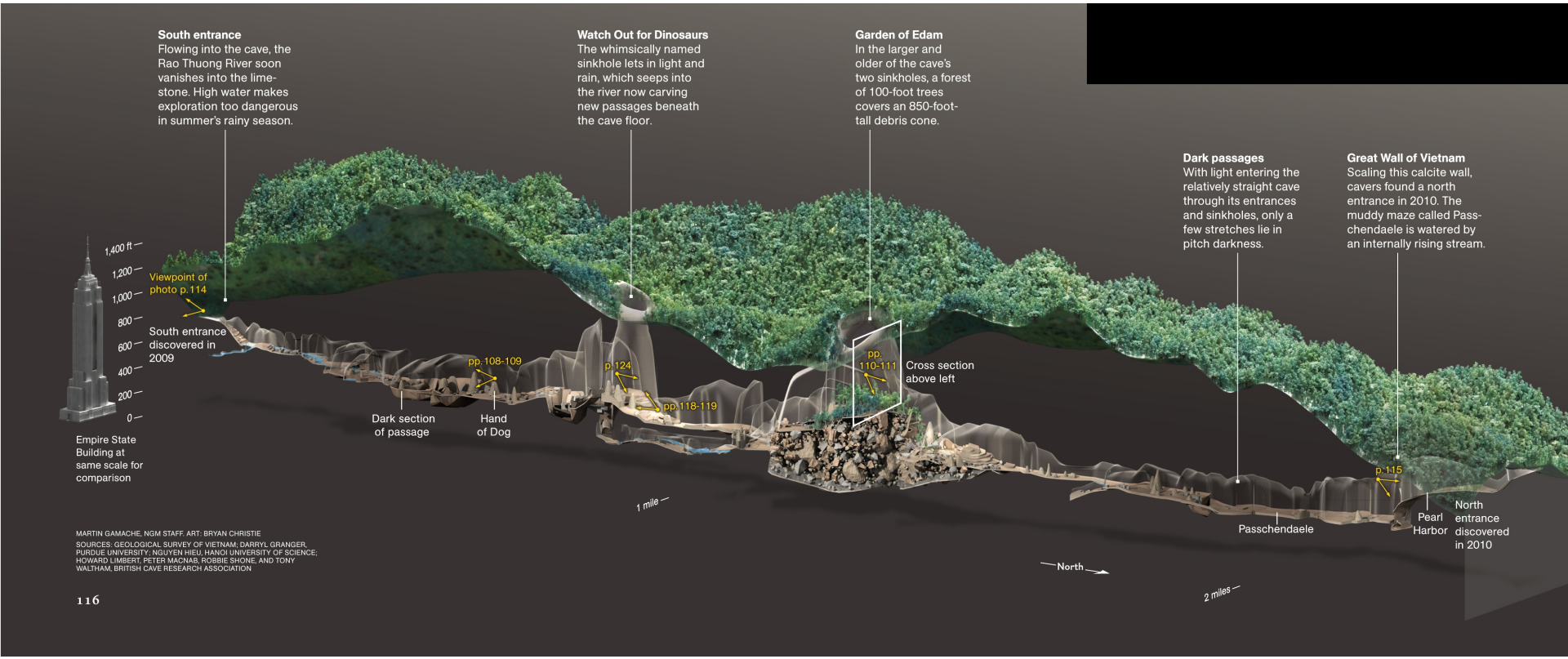

Limbert_cave_inventory2
EXPLORED
1990; 1992; 1994
1997; 1999
2001; 2003
2005; 2006; 2007; 2009; 2010



Networks of caves

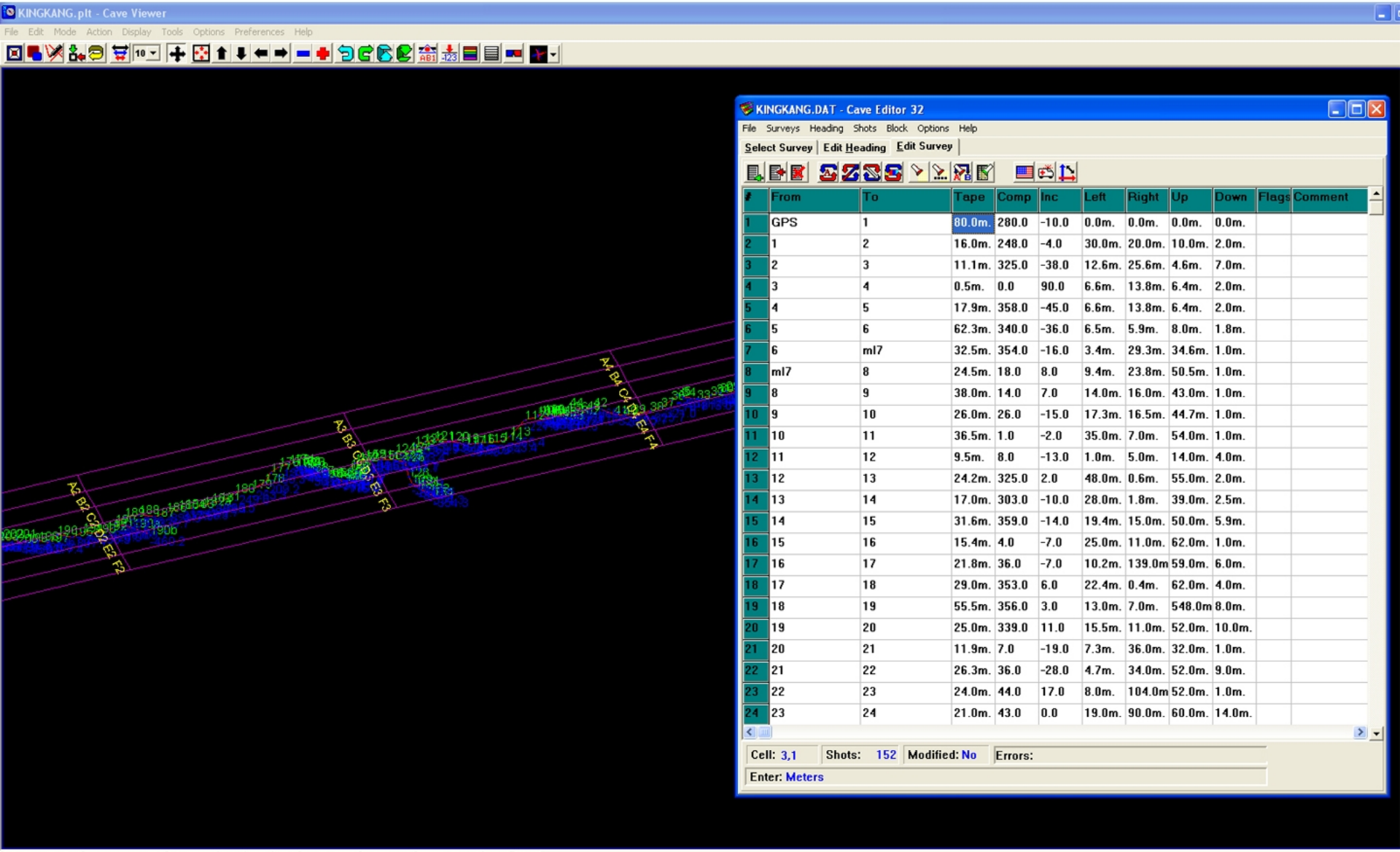
Vom caves | Phong Nha caves | Other caves | Limestone extent

Two drainage systems, the Vom and the Phong Nha, channel subterranean waters that have carved two namesake cave networks.



MARTIN GAMACHE, NGM STAFF. ART: BRYAN CHRISTIE

SOURCES: GEOLOGICAL SURVEY OF VIETNAM; DARRYL GRANGER, PURDUE UNIVERSITY; NGUYEN HIEU, HANOI UNIVERSITY OF SCIENCE; HOWARD LIMBERT, PETER MACNAB, ROBBIE SHONE, AND TONY WALTHAM, BRITISH CAVE RESEARCH ASSOCIATION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File Edit Mode Action Display Tools Options Preferences Help
KINGKANG.DAT - Cave Editor 32
File Surveys Heading Shots Block Options Help
Select Survey | Edit Heading | Edit Survey
From To Tape Comp Inc Left Right Up Down Flags Comment
1 GPS 1 80.0m. 280.0 -10.0 0.0m. 0.0m. 0.0m. 0.0m.
2 1 2 16.0m. 248.0 -4.0 30.0m. 20.0m. 10.0m. 2.0m.
3 2 3 11.1m. 325.0 -38.0 12.6m. 25.6m. 4.6m. 7.0m.
4 3 4 0.5m. 0.0 90.0 6.6m. 13.8m. 6.4m. 2.0m.
5 4 5 17.9m. 358.0 -45.0 6.6m. 13.8m. 6.4m. 2.0m.
6 5 6 62.3m. 340.0 -36.0 6.5m. 5.9m. 8.0m. 1.8m.
7 6 ml7 32.5m. 354.0 -16.0 3.4m. 29.3m. 34.6m. 1.0m.
8 ml7 8 24.5m. 18.0 8.0 9.4m. 23.8m. 50.5m. 1.0m.
9 8 9 38.0m. 14.0 7.0 14.0m. 16.0m. 43.0m. 1.0m.
10 9 10 26.0m. 26.0 -15.0 17.3m. 16.5m. 44.7m. 1.0m.
11 10 11 36.5m. 1.0 -2.0 35.0m. 7.0m. 54.0m. 1.0m.
12 11 12 9.5m. 8.0 -13.0 1.0m. 5.0m. 14.0m. 4.0m.
13 12 13 24.2m. 325.0 2.0 48.0m. 0.6m. 55.0m. 2.0m.
14 13 14 17.0m. 303.0 -10.0 28.0m. 1.8m. 39.0m. 2.5m.
15 14 15 31.6m. 359.0 -14.0 19.4m. 15.0m. 50.0m. 5.9m.
16 15 16 15.4m. 4.0 -7.0 25.0m. 11.0m. 62.0m. 1.0m.
17 16 17 21.8m. 36.0 -7.0 10.2m. 139.0m 59.0m. 6.0m.
18 17 18 29.0m. 353.0 6.0 22.4m. 0.4m. 62.0m. 4.0m.
19 18 19 55.5m. 356.0 3.0 13.0m. 7.0m. 548.0m 8.0m.
20 19 20 25.0m. 339.0 11.0 15.5m. 11.0m. 52.0m. 10.0m.
21 20 21 11.9m. 7.0 -19.0 7.3m. 36.0m. 32.0m. 1.0m.
22 21 22 26.3m. 36.0 -28.0 4.7m. 34.0m. 52.0m. 9.0m.
23 22 23 24.0m. 44.0 17.0 8.0m. 104.0m 52.0m. 1.0m.
24 23 24 21.0m. 43.0 0.0 19.0m. 90.0m. 60.0m. 14.0m.
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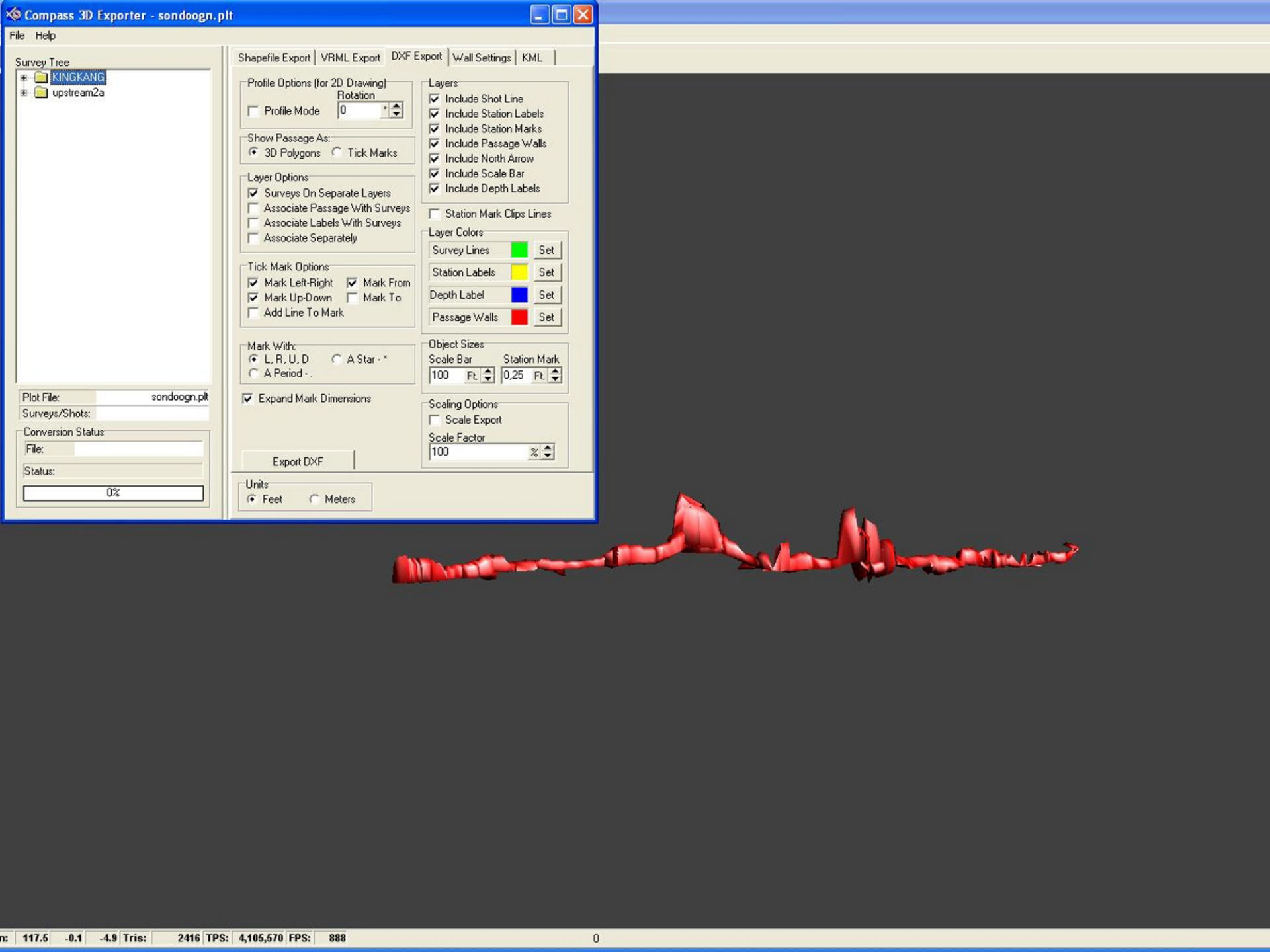
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KINGKANG
upstream2a
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Surveys/Shots:
Conversion Status
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Shapefile Export
VRML Export
DXF Export
Wall Settings
KML
Profile Options (for 2D Drawing)
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3D Polygons
Tick Marks
Layer Options
Surveys On Separate Layers
Associate Passage With Surveys
Associate Labels With Surveys
Associate Separately
Tick Mark Options
Mark Left-Right
Mark From
Mark Up-Down
Mark To
Add Line To Mark
Mark With:
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A Star - *
A Period - .
Expand Mark Dimensions
Export DXF
Units
Feet
Meters
Layers
Include Shot Line
Include Station Labels
Include Station Marks
Include Passage Walls
Include North Arrow
Include Scale Bar
Include Depth Labels
Station Mark Clips Lines
Layer Colors
Survey Lines
Station Labels
Depth Label
Passage Walls
Set
Object Sizes
Scale Bar
Station Mark
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Scaling Options
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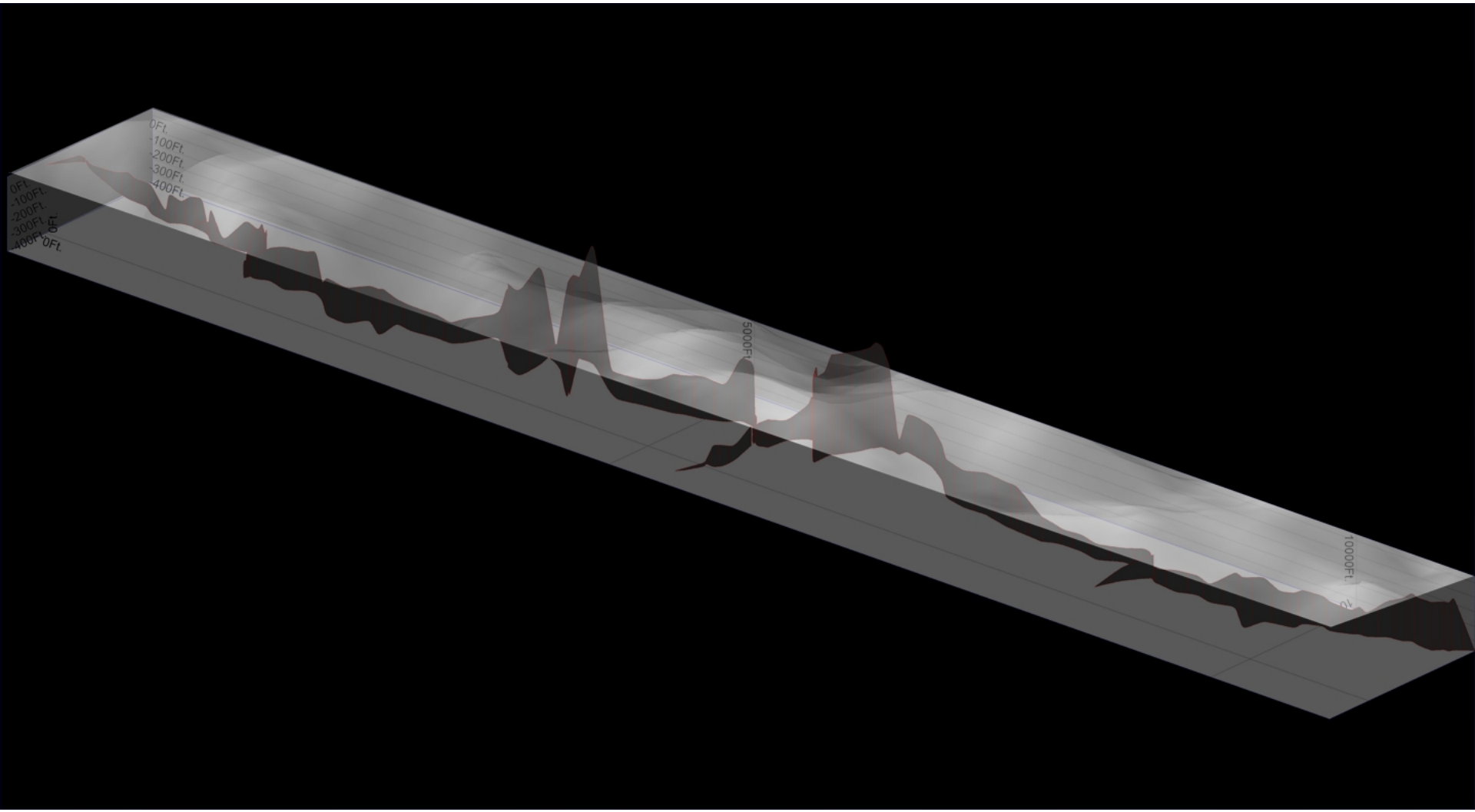
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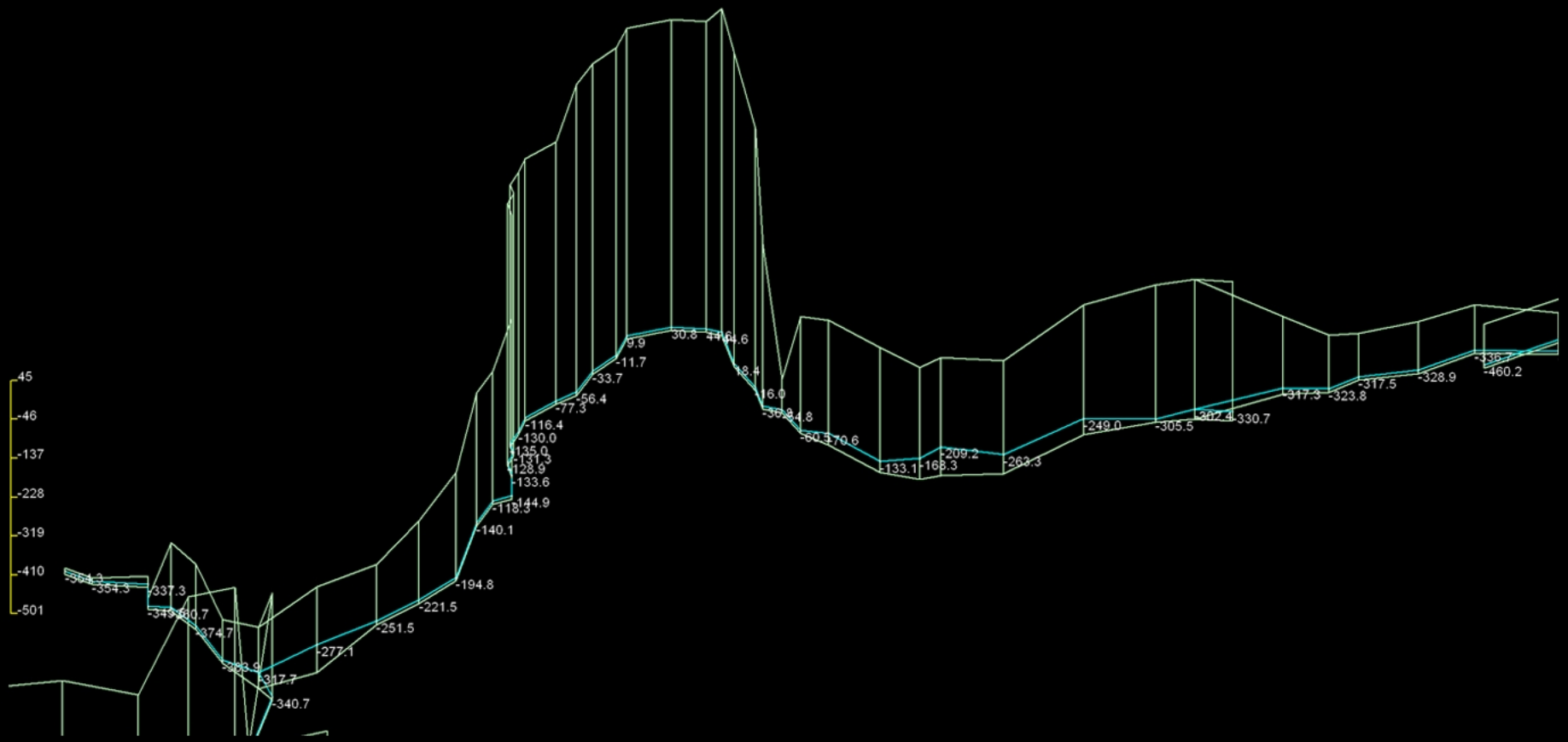
10000Ft.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-33.7
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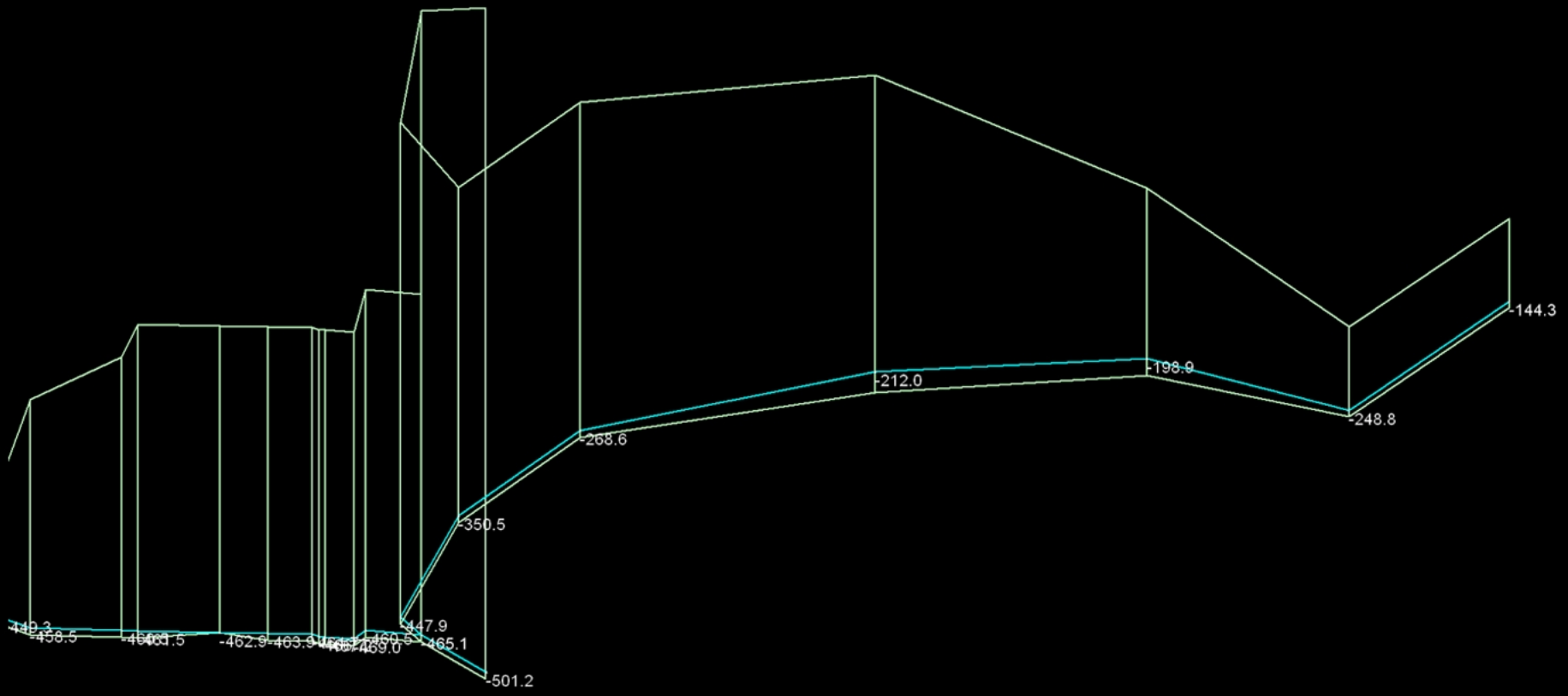
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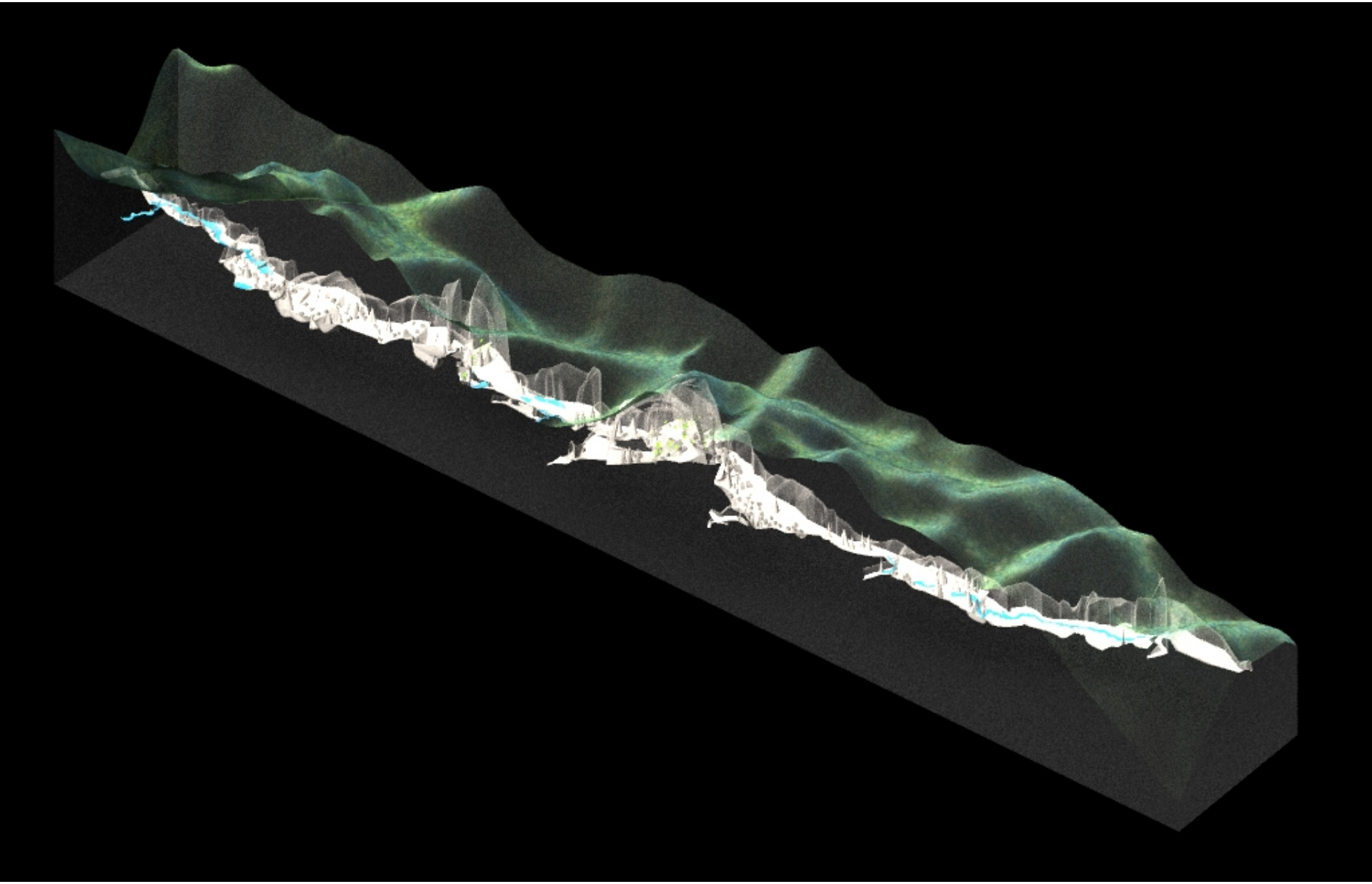

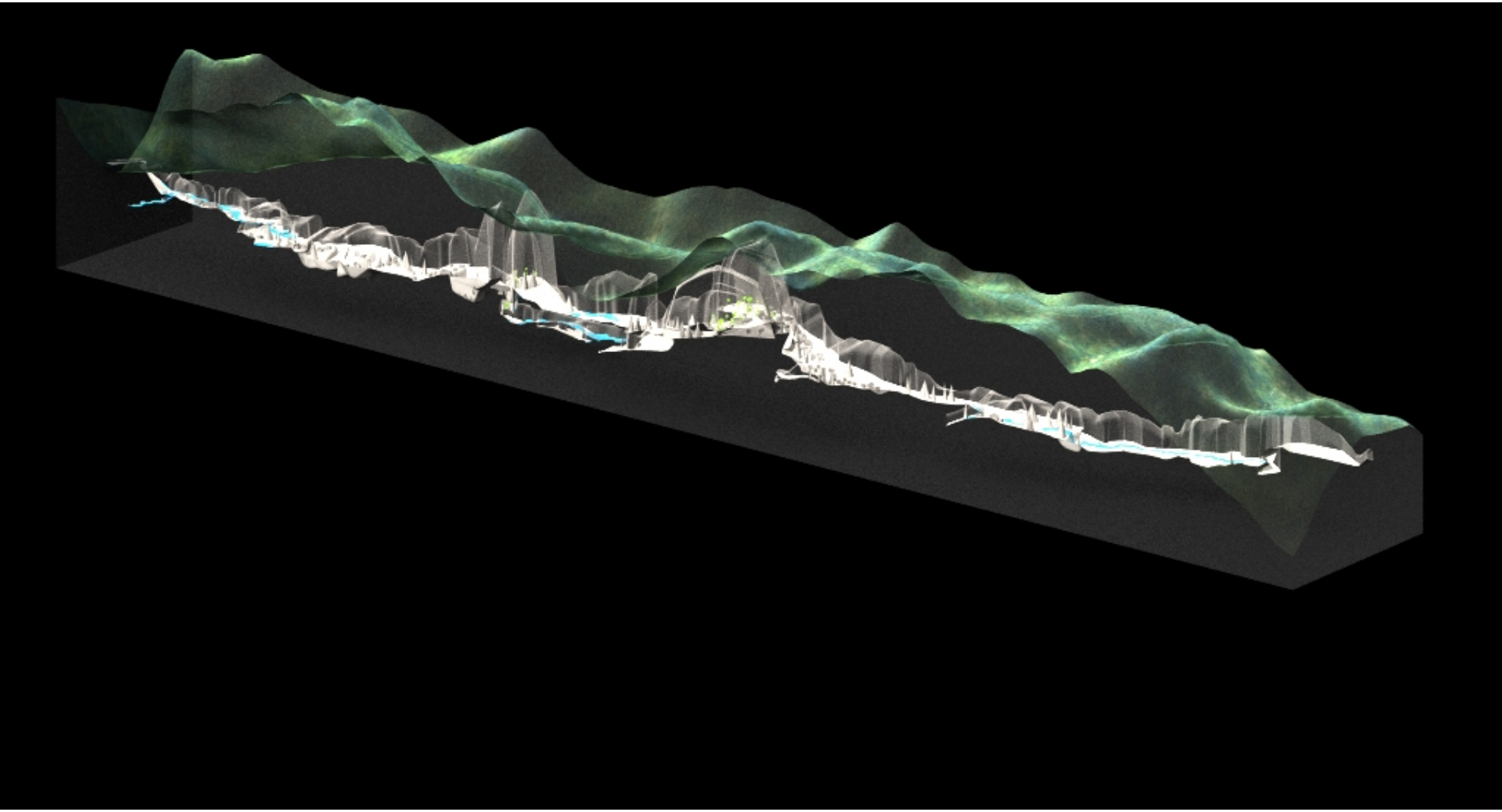

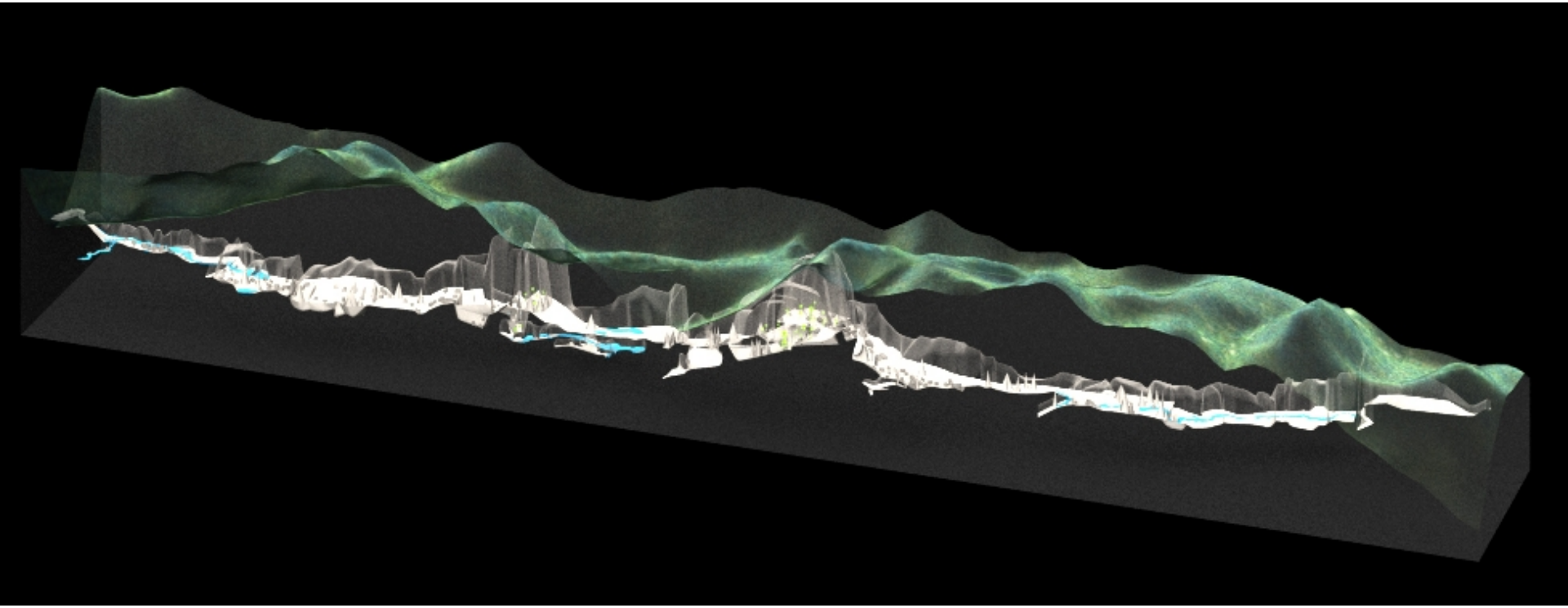

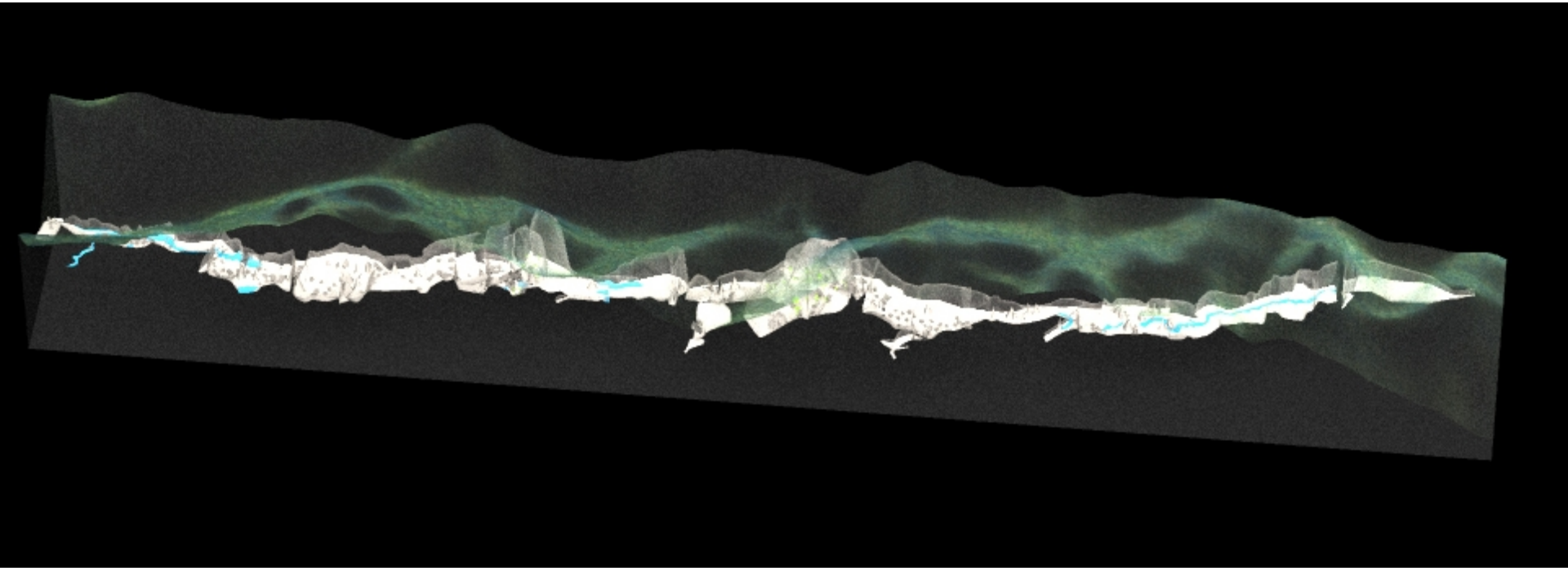

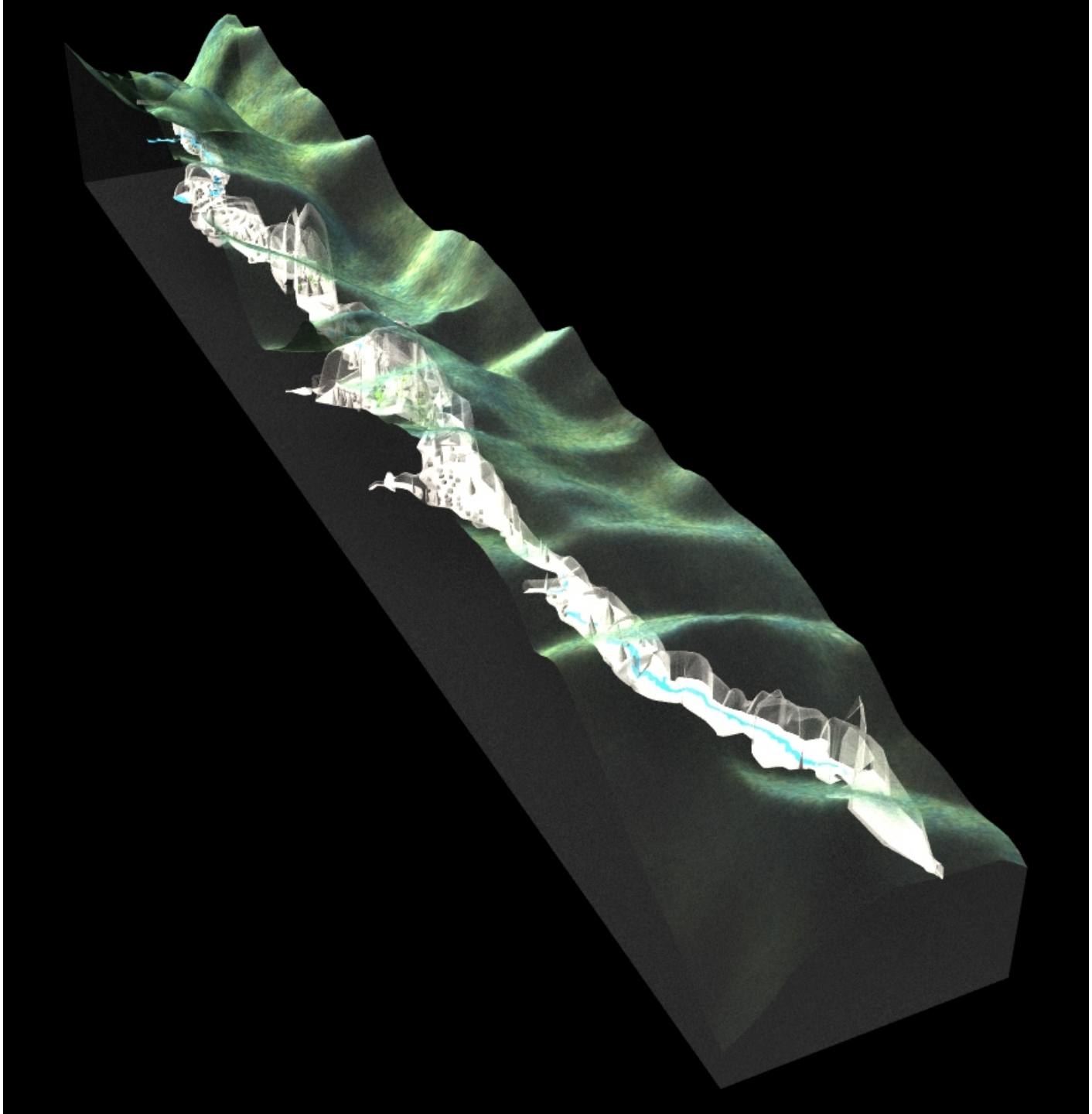

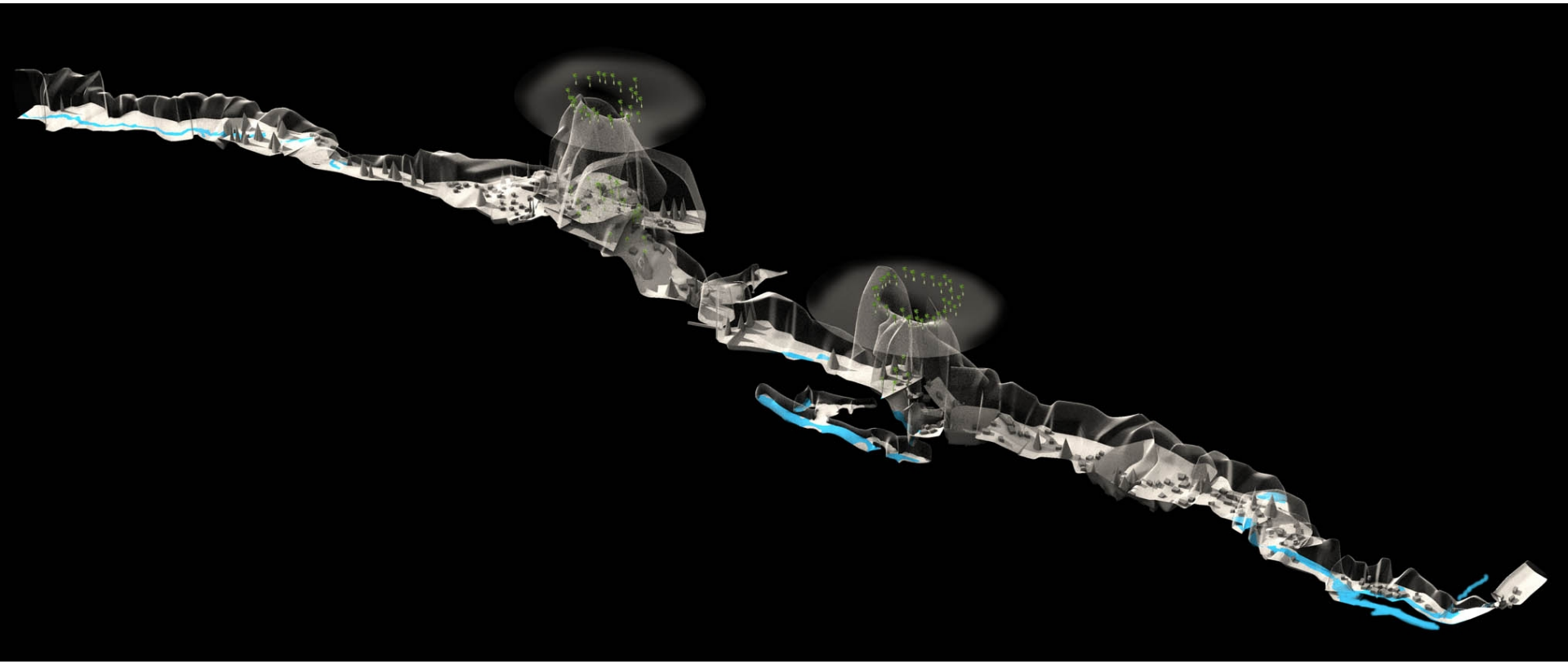

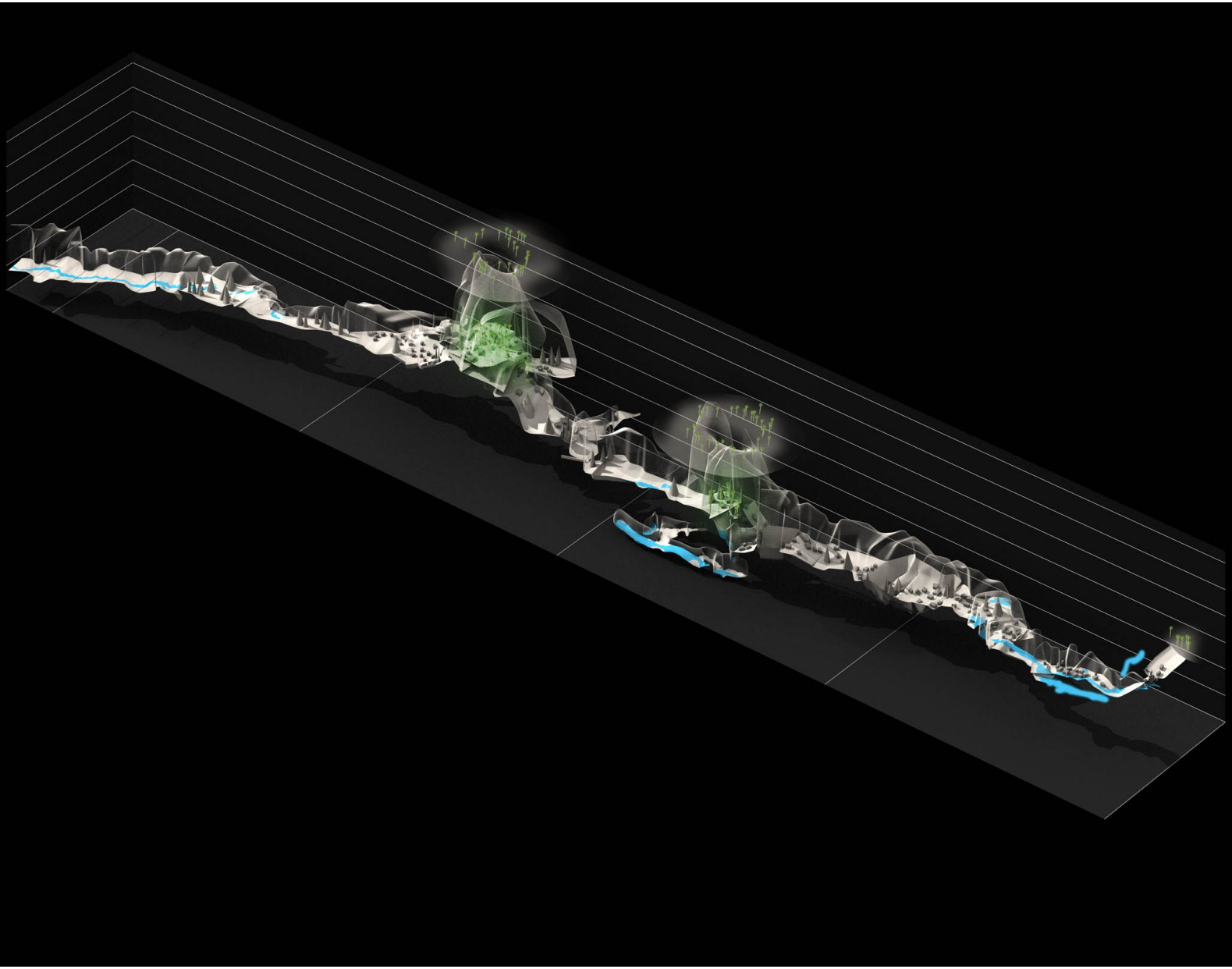

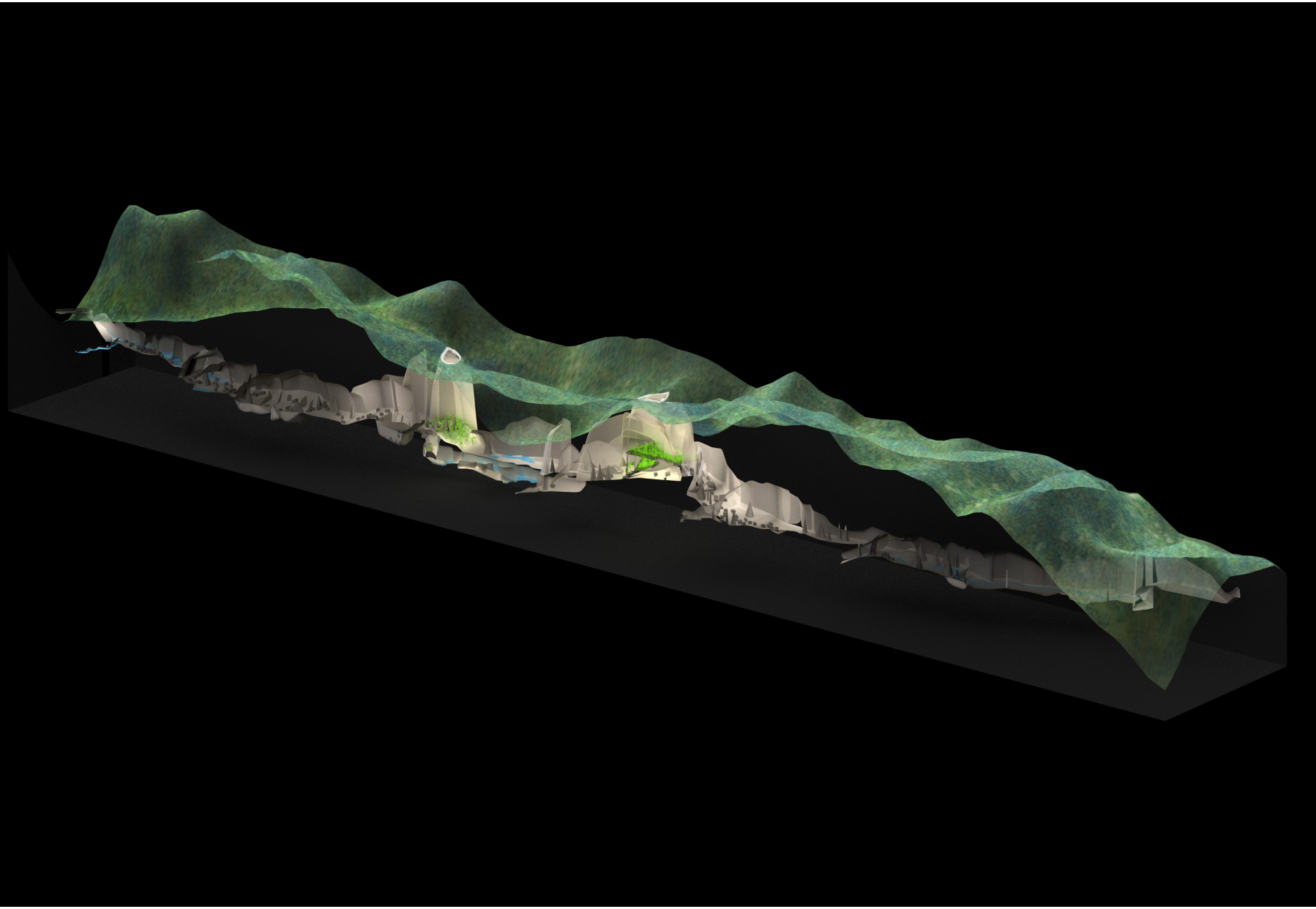

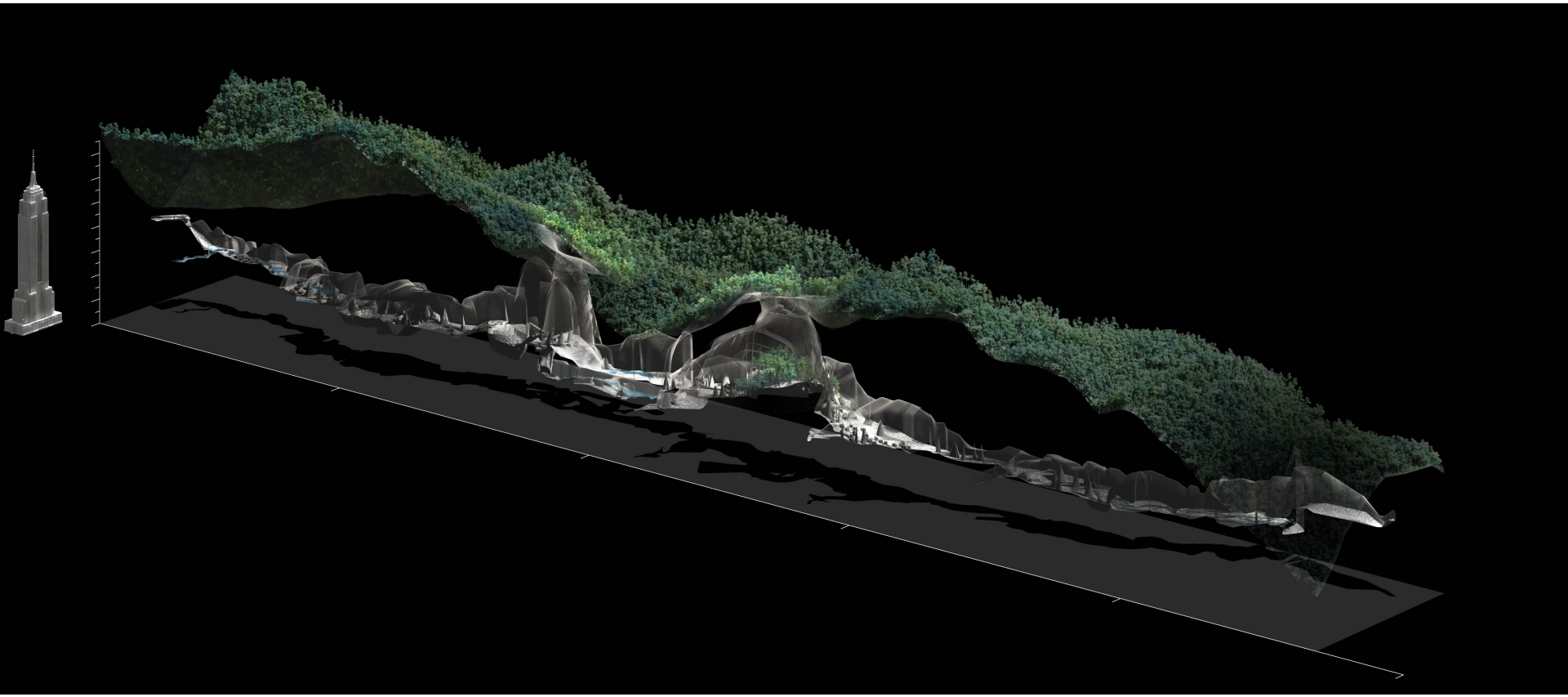

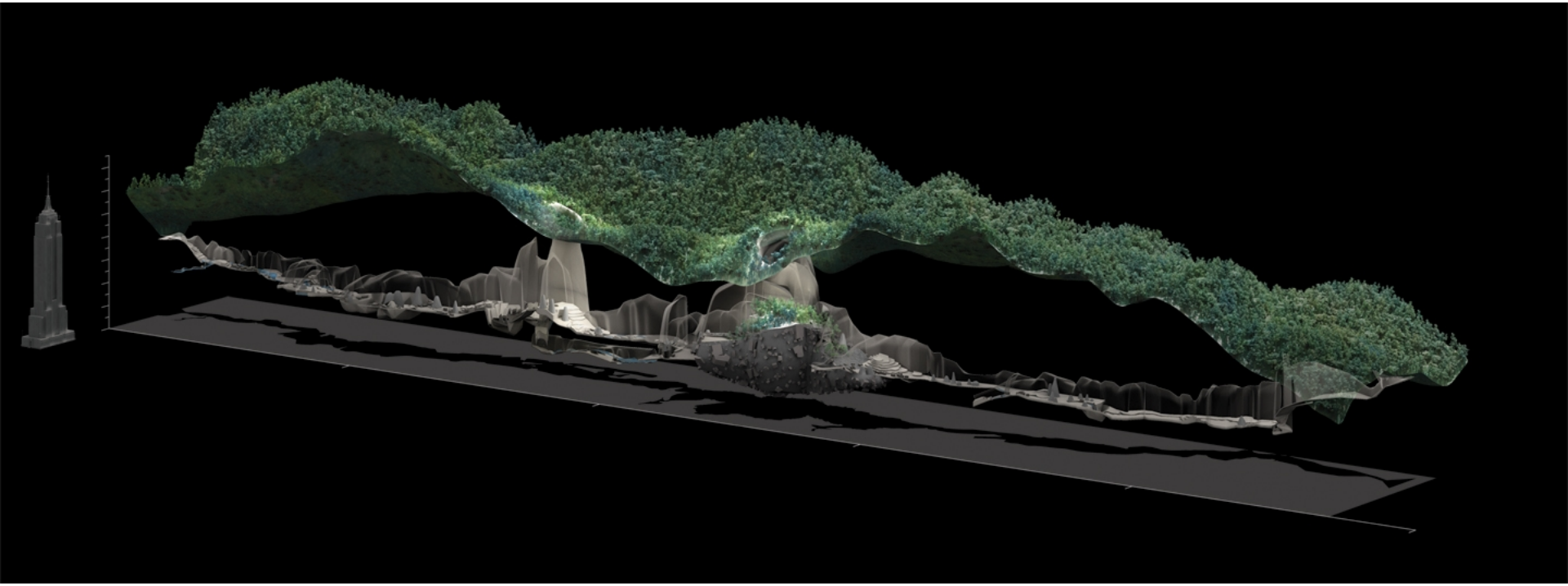

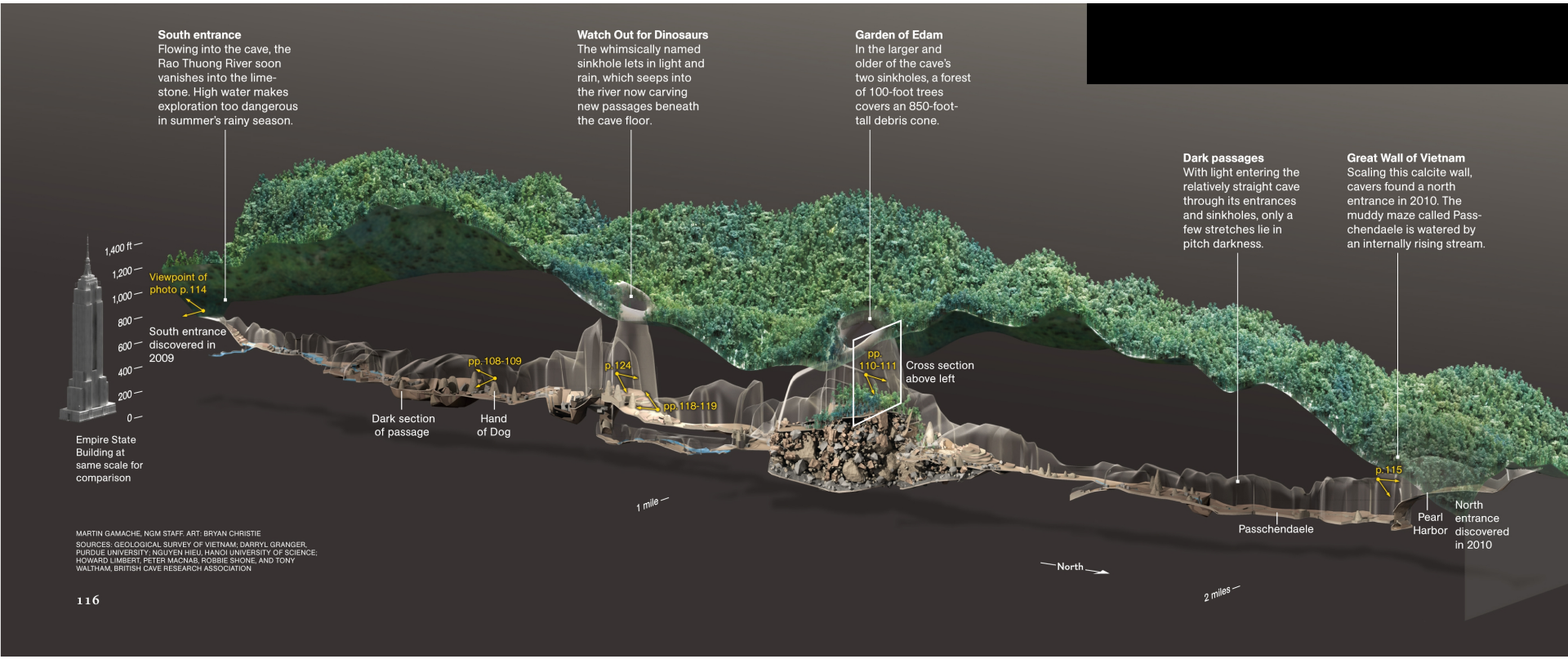

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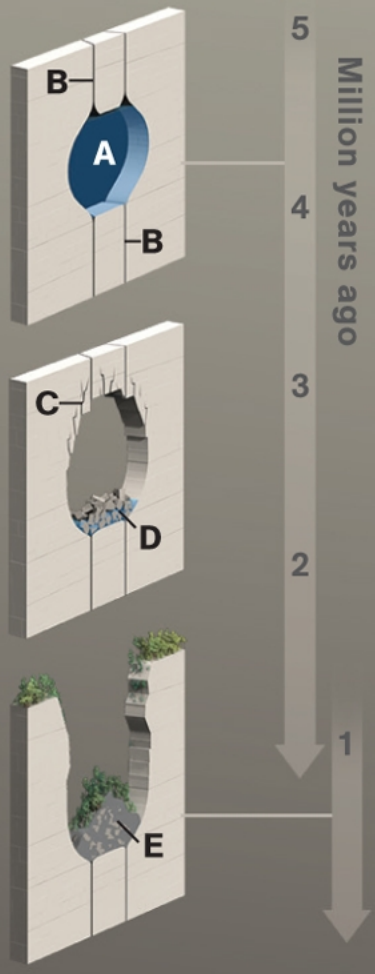
A MEGA-SINKHOLE OPENS

The cave's Garden of Edam sinkhole owes its size to its location: Another passage entered the main cave here. When the ceiling collapsed at this junction, it opened a pit 1,500 feet deep, with a 650-foot-wide opening.



Dissolving

2 million to 5 million years ago

A subterranean chamber (**A**) forms as water flowing along fracture lines (**B**) dissolves the limestone.

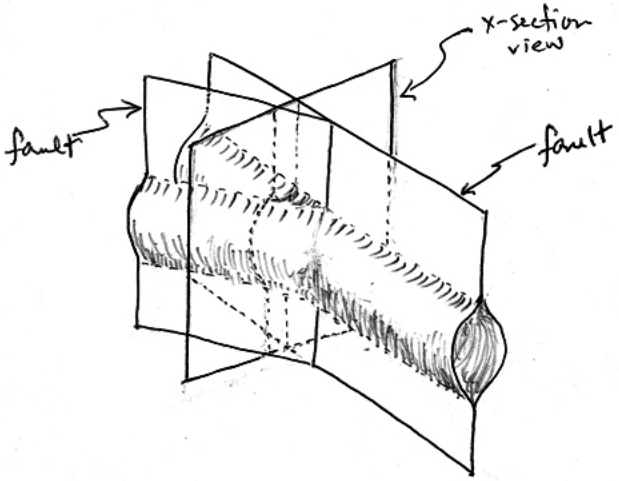
Expanding

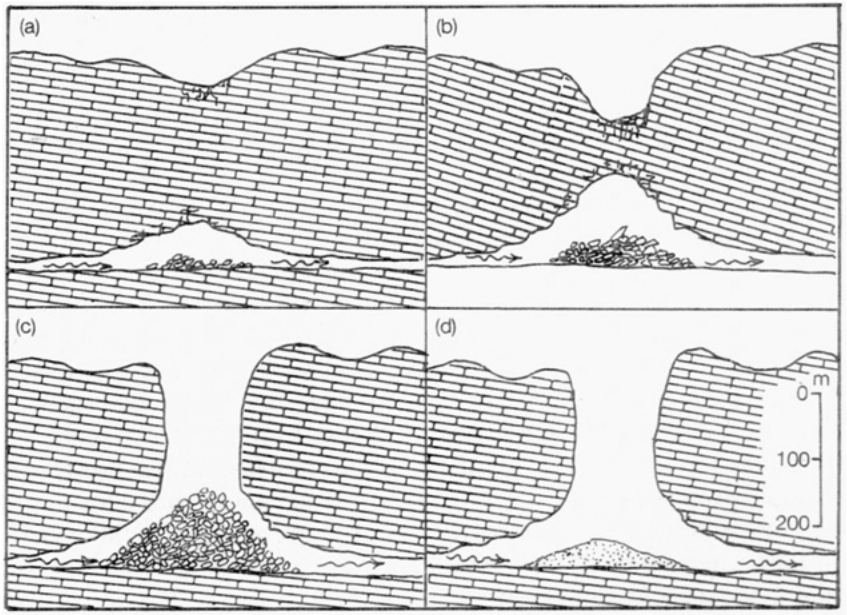
With continued erosion and collapse (**C**), debris accumulates faster than it can be removed by the flowing water (**D**).

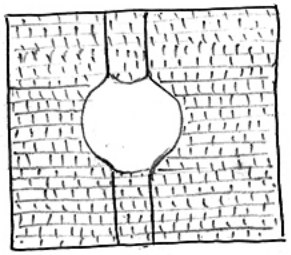
Collapse and colonization

Within the past million years

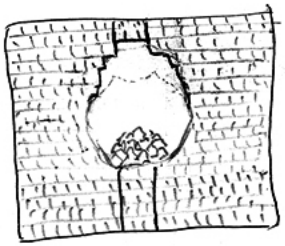
The chamber's roof collapses, opening the cave to the sky. Ferns and trees colonize the exposed debris cone (**E**).



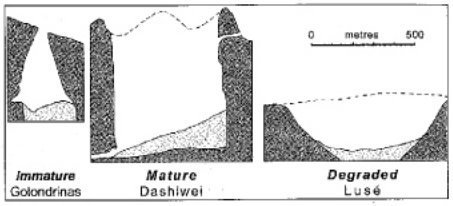


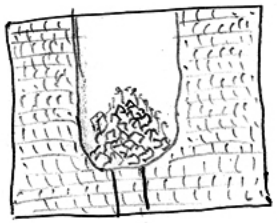


passage is extra-wide, and ceiling is faulted.

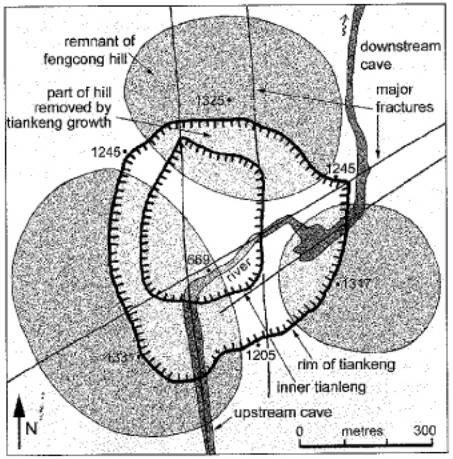


stoping collapse (from below)





tiankeng & forest

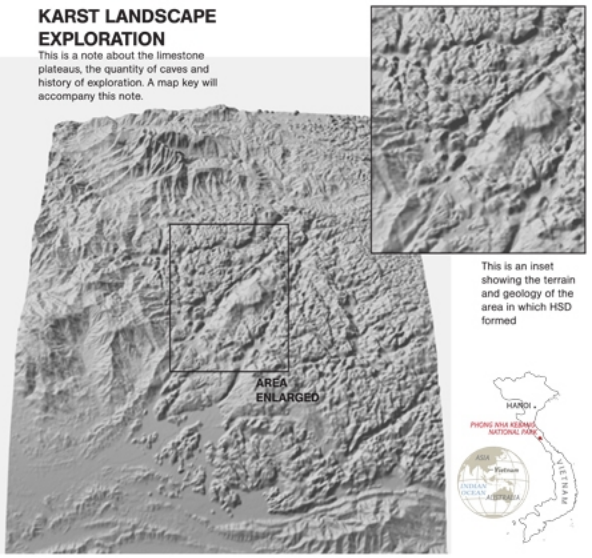


DEEP GREEN:

VIETNAM'S SON DOONG CAVE MAY CONTAIN THE WORLDS LARGEST CAVE PASSAGE

KARST LANDSCAPE EXPLORATION

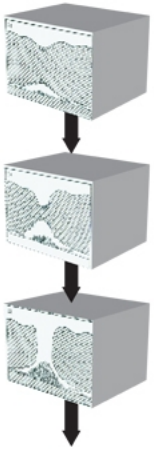
This is a note about the limestone plateaus, the quantity of caves and history of exploration. A map key will accompany this note.



This is an inset showing the terrain and geology of the area in which HSD formed

Evolution of the Garden of Edam Tiankeng/Doline/Sinkhole

This is a note about the size and description of the other wordly dolines found in Han Song Doong and their genesis from cave collapse due to erosion, internal failure and fault weaknesses. These dolines are technically Tian Keng dolines, a type of large collapse previously described in China but in the US usually known as a sinkhole. That term however does not do these vegetation filled, rock cliff lined open pits justice.



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This is a note about stage 1 of the doline formation dolor sit amet, consectetuer adipiscing elit.

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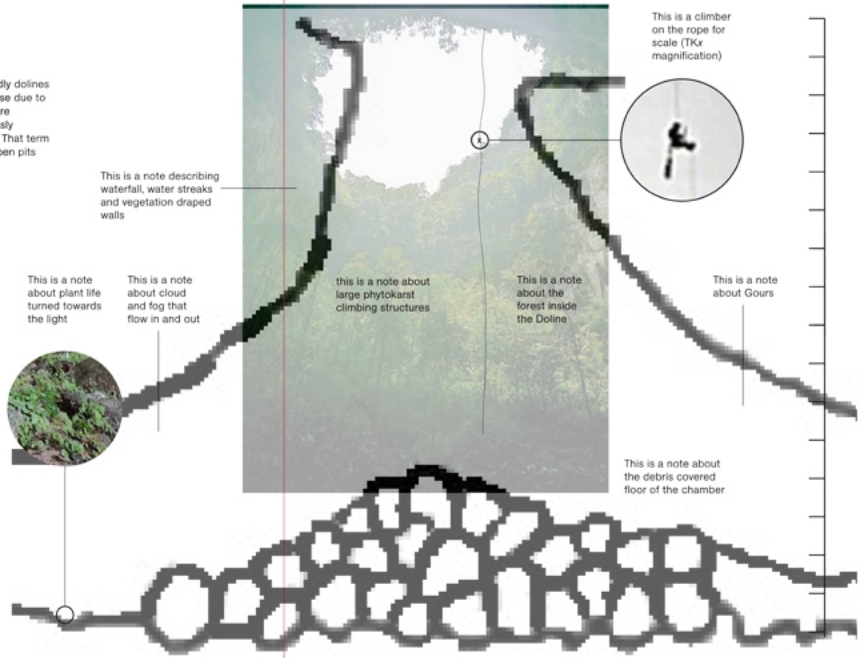
PHASE 3
This is a note about stage 3 of the doline formation dolor sit amet, consectetuer adipiscing elit.

PHASE 4
This is a note about stage 4 of the doline formation process, the final stage.



This is a climber on the rope for scale (TKx magnification)

This is a note describing waterfall, water streaks and vegetation draped walls

This is a note about plant life turned towards the light

This is a note about cloud and fog that flow in and out

this is a note about large phytokarst climbing structures

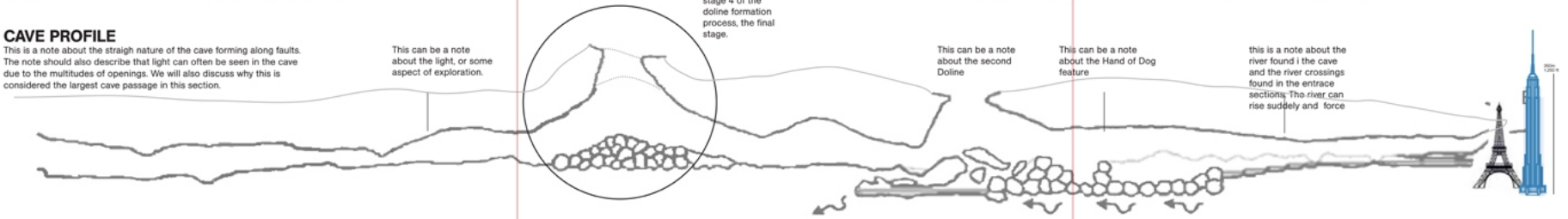
This is a note about the forest inside the Doline

This is a note about Gours

This is a note about the debris covered floor of the chamber

CAVE PROFILE

This is a note about the straigh nature of the cave forming along faults. The note should also describe that light can often be seen in the cave due to the multitudes of openings. We will also discuss why this is considered the largest cave passage in this section.



This can be a note about the light, or some aspect of exploration.

This can be a note about the second Doline

This can be a note about the Hand of Dog feature

this is a note about the river found i the cave and the river crossings found in the entrace sections. The river can rise suddely and force

DEEP GREEN:

VIETNAM'S SON DOONG CAVE MAY CONTAIN THE WORLDS LARGEST CAVE PASSAGE

KARST LANDSCAPE EXPLORATION

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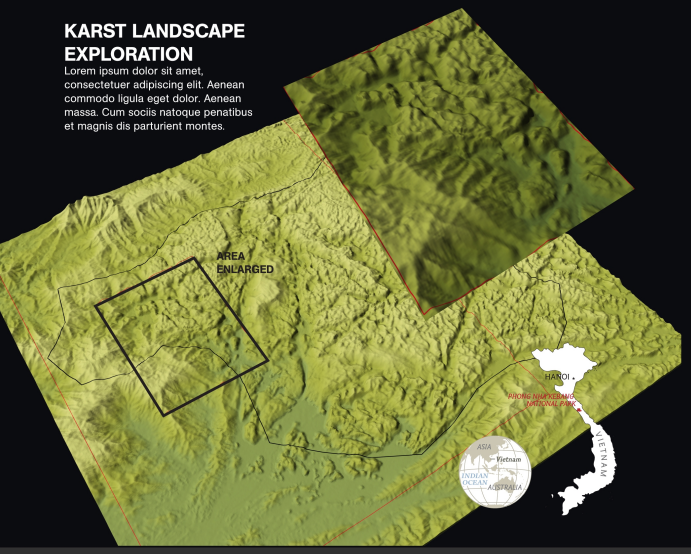

Evolution of the Garden of Edam Tiankeng

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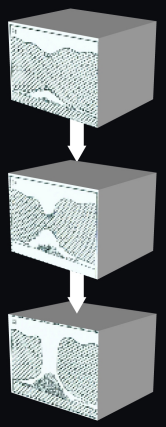

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CAVE PROFILE

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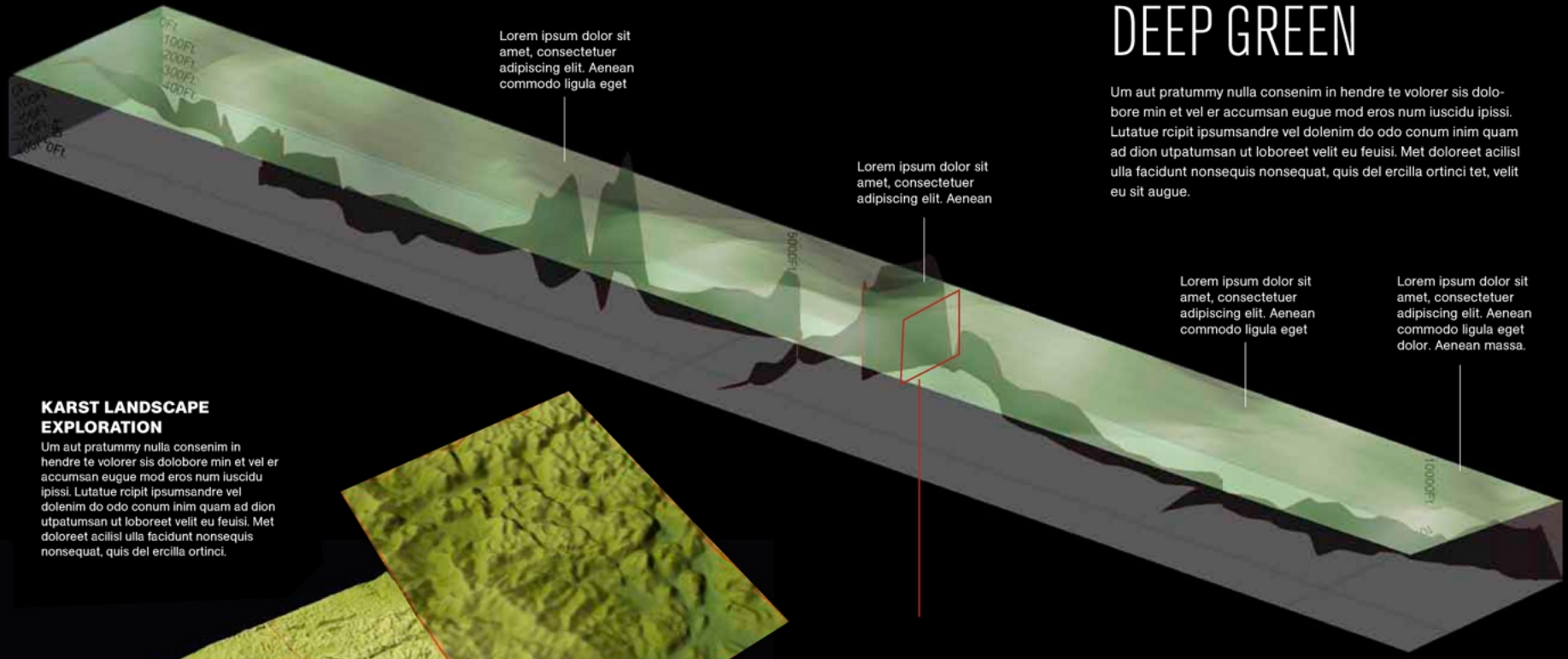

KARST LANDSCAPE EXPLORATION

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EVOLUTION OF THE GARDEN OF EDAM

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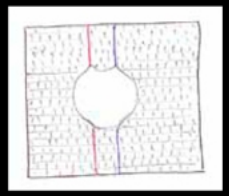

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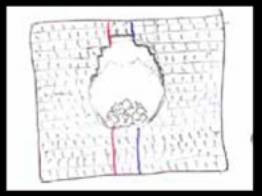

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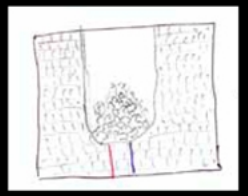

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ARTIST'S NAME, NG STAFF
SOURCE: LOREM IPSUM, UNIVERSITY OF LOREM IPSUM; DIAGRAMS COURTESY NAME HERE, LOREM IPSUM ORGANIZATION

PATH OF A RIVER CAVE

In April 2009 a British-Vietnamese team began exploring Hang Son Doong, or "mountain river cave" (below). Beneath the rain forest along the Vietnam-Laos border they discovered a cavernous limestone passage more than 2.5 miles long and in places over 600 feet high, carved by a subterranean river two to five million years ago. Expeditions have found more than 150 caves in this area since 1990, mapping nearly 90 miles of passages.

A MEGA-SINKHOLE OPENS

The cave's Garden of Edam sinkhole owes its size to its location: Another passage entered the main cave here. When the ceiling collapsed at this junction, it opened a pit 1,500 feet deep, with a 650-foot-wide opening.

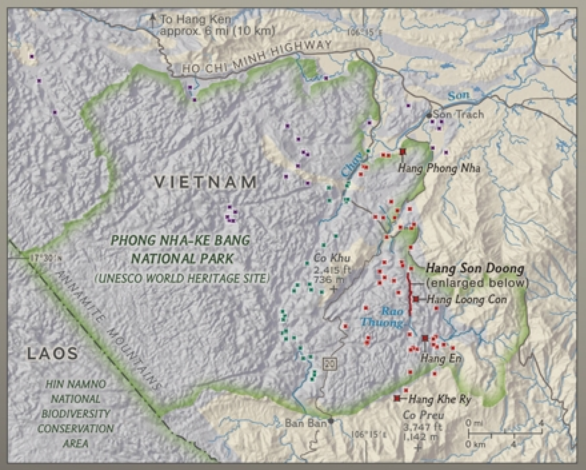
Dissolving
2 million to 5 million years ago
A subterranean chamber (**A**) forms as water flowing along fracture lines (**B**) dissolves the limestone.

Expanding
With continued erosion and collapse (**C**), debris accumulates faster than it can be removed by the flowing water (**D**).

Collapse and colonization
Within the past million years
The chamber's roof collapses, opening the cave to the sky. Ferns and trees colonize the exposed debris cone (**E**).

CANVAS FOR CAVES

Vast formations of limestone, in places thousands of feet thick, were deposited across this region 250 to 350 million years ago. Tectonic action uplifted and fractured the rock. Rivers followed these fractures underground, dissolving networks of cave passages.



Networks of caves
Vom caves · Phong Nha caves · Other caves · Limestone extent

Two drainage systems, the Vom and the Phong Nha, channel subterranean waters that have carved two namesake cave networks.

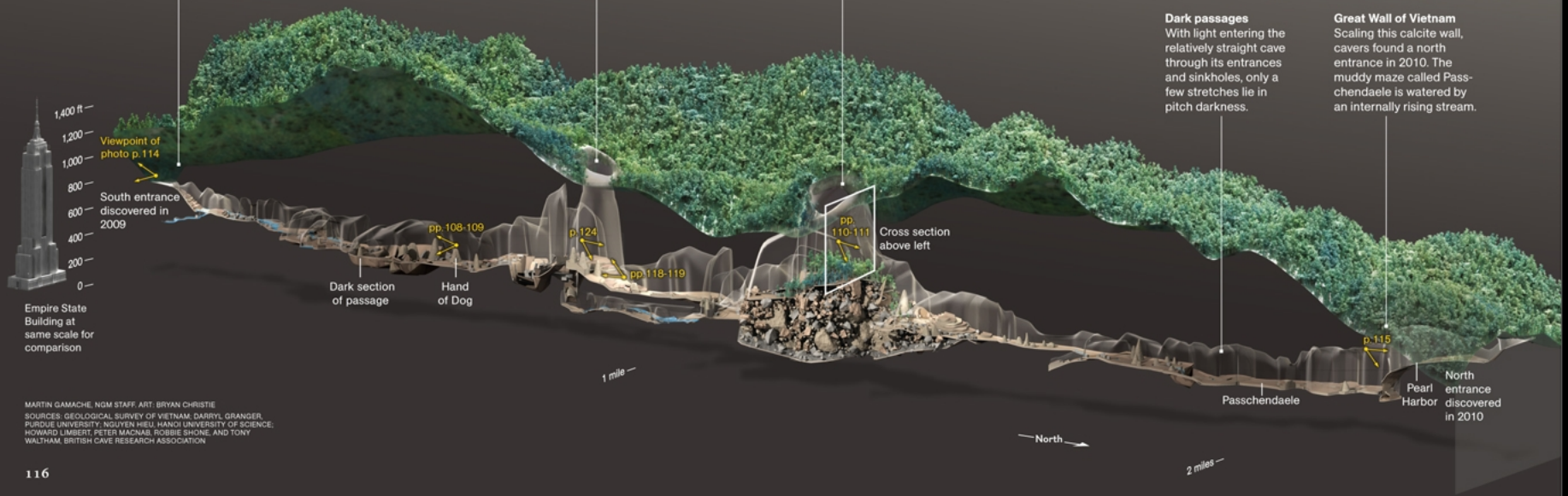
South entrance
Flowing into the cave, the Rao Thuong River soon vanishes into the limestone. High water makes exploration too dangerous in summer's rainy season.

Watch Out for Dinosaurs
The whimsically named sinkhole lets in light and rain, which seeps into the river now carving new passages beneath the cave floor.

Garden of Edam
In the larger and older of the cave's two sinkholes, a forest of 100-foot trees covers an 850-foot-tall debris cone.

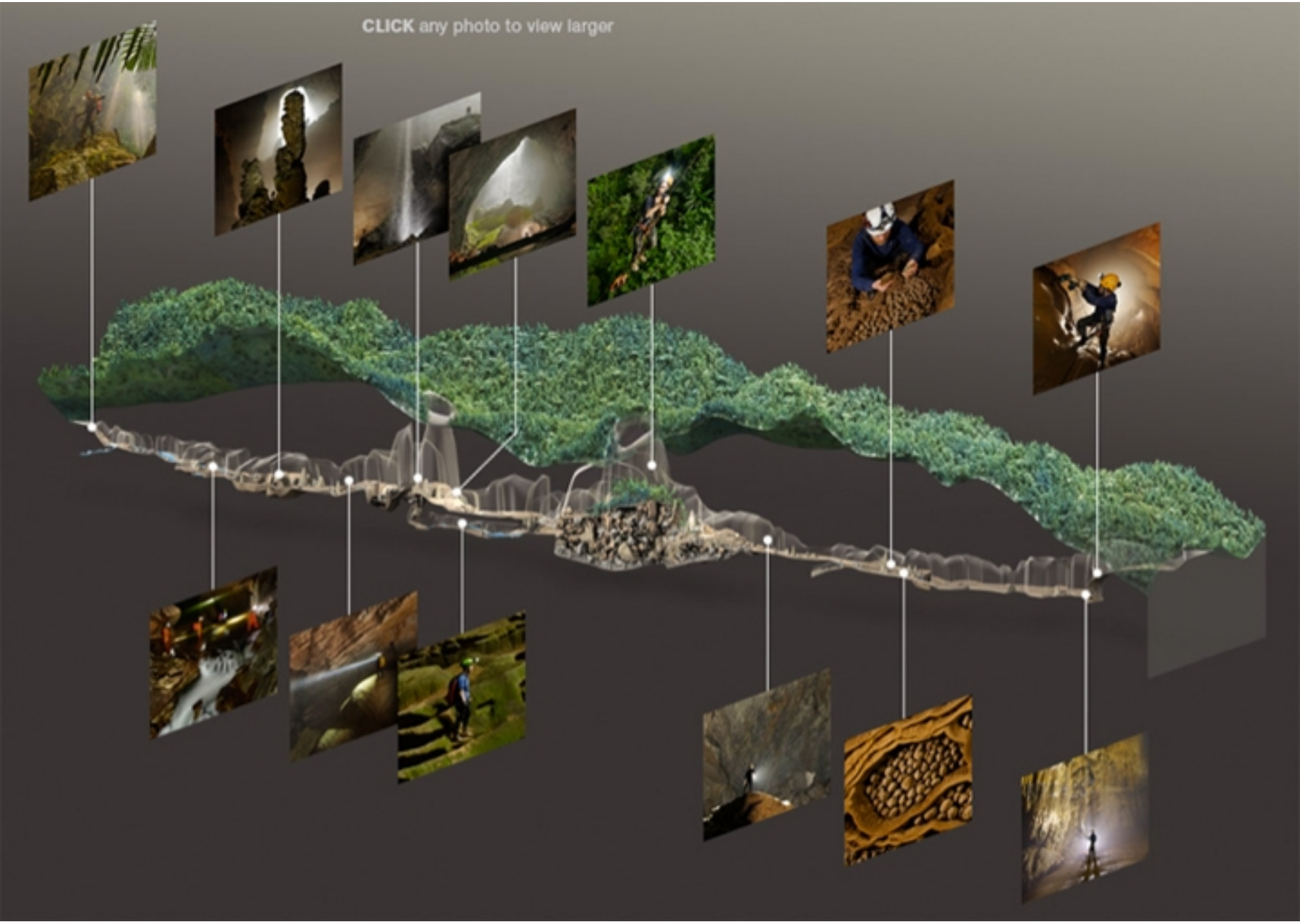
Dark passages
With light entering the relatively straight cave through its entrances and sinkholes, only a few stretches lie in pitch darkness.

Great Wall of Vietnam
Scaling this calcite wall, cavers found a north entrance in 2010. The muddy maze called Passchendaele is watered by an internally rising stream.



MARTIN GAMACHE, NGM STAFF. ART: BRYAN CHRISTIE

SOURCES: GEOLOGICAL SURVEY OF VIETNAM; DARRYL GRANGER, PURDUE UNIVERSITY; NGUYEN HIEU, HANOI UNIVERSITY OF SCIENCE; HOWARD LIMBERT, PETER MACNAB, ROBBIE SHONE, AND TONY WALTHAM, BRITISH CAVE RESEARCH ASSOCIATION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