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.
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

"Paddled 11 pm to 2 am under a magical full moon," Skurka said, in a note on a map of the Copper River (left). He used it to plan his route.

How Skurka's Gear Measured Up

<table>
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<tr>
<th>Gear Weight (Pounds)</th>
<th>Summer</th>
<th>Winter</th>
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<tr>
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<td>Sleeping gear</td>
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<td>Other gear in pack</td>
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<td>Total</td>
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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-prepared the whole way, whether skiing, paddling, or hiking. Occasionally he hitchhiked into towns off his route to stock up on supplies.

- **Skiing**: 2,573 miles
- **Paddling**: 2,090 miles
- **Hiking**: 2,682 miles

Total: 7,345 miles

- **Food or gear resupply**
- **Rescue day**

Average daily temperature (°F) along Skurka's route

<table>
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<tr>
<th>Day of trek</th>
<th>March 14</th>
<th>April 1</th>
<th>May 1</th>
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Longest distance traveled in one day (81 miles)

Fastest 100-mile segment

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<th>Time</th>
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<td>24 hrs</td>
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Longest distance walked in one day (38.5 miles)

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<th>Distance</th>
<th>Time</th>
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<tr>
<td>38.5 miles</td>
<td>17 hrs</td>
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Sources: ADKIR INC. RESEARCH CENTER, MICHAEL ROSS, RON ENNER, ANDREW SKURKA

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

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 Skarka 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: 1,317.5 miles
- Paddling: 1,269.2 mi
- Hiking: 2,013.7 mi
- Total: 4,600.6 mi

- Food or gear resupply
- Rest day

Average daily temperature (°F) along Skarka's route

- Day of trek: 1 to 60
- Month: March 14 to May 1
- Coldest temperature: -20°F (-29°C)
- Hours of daylight
- Longest distance traveled in one day (81 miles)

- Fastest 50-mile segment
- Longest distance walked in one day (25.5 miles)

Sources: Journey and Alaska Climate Research Center. Photograph by Rebecca Haiz

Andrew Skarka
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.

Date: March 14

Day: 1

Bars show each day's estimated mileage.

Skiing: 33.1 miles
Paddling: 0.0 mi
Hiking: 0.0 mi
Total: 33.1 mi

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 ladder made of aluminum scaffolding could fit inside this 6,000-foot-high cavern, which may be the world’s biggest unmapped cave system. In October 2016, a climber ascends a shaft of sunlight.
The largest caves in the world

Hang Son Doong, Vietnam

Garden of Edam

Green Cave

Deer Cave

Garden of Eden
(Sarawak Chamber superimposed)

Caves of southern Mulu, Sarawak

Carlsbad Caverns, USA
Hang Son Doong
(Cave of the Mountain River)
Bo Trach District
Quang Binh Province
People's Republic of Vietnam

OS Ref: 97235/56, 95375N
Map Sheet: Co Trach, So Hieu 62431
Surveyed Length: 1443 m
Vertical Range: +13.6 to -168.4 m
Surveyor: Chandra S.C.

Discovered & Explored by Vietnam 05
Surveyed using N.O.L. LaserAce 300

Note: Tunnels beneath the river are not fully explored.
Hang Son Doong
(Cave of the Mountain River)
Bo Trach District
Quang Binh Province
Peoples Republic of Vietnam

Grid Ref: 10275546 9923652
Map Sheet: Co Trach 50 H6 62431
Surveyed Length: 8441m
Vertical Range: +13.6 - 136.4m
GPR Crude 5G
Exploded & Surveyed by "Vietnam 09"
Surveyed using M.O.L. LaserAce 300
Multiple surveys and data show the cave to be 3km long
Detailed route markers present: not fully explored
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 Edom 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 600-foot-wide opening.

Dissolving
2 million to 5 million years ago
A karst terrane 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. Fungi 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 260 to 350 million years ago. Tectonic action uplifted and fractured the rock. Rivers followed these fractures underground, dissolving networks of cave passages.

Watch Out for Dinosaurs

The whimsically named sinkhole lake is light and rain, which seeps into the river now carving new passages beneath the cave floor.

Garden of Edom

In the larger and older of the cave's two sinkholes, a forest of 100-foot trees covers an 850-foot-deep 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

Sealing this Edwin wall covers bound a north entrance in 2010. The muddy mire called Phong chandassle is watered by an internally running stream.
Two drainage systems, the Vom and the Phong Nha, channel subterranean waters that have carved two namesake cave networks.
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South entrance
Flowing into the cave, the Rao Thong River soon vanishes into the limestone. High water makes exploration too dangerous in summer’s rainy season.

Watch Out for Dinosaurs
The whimsically named anh-khe hole 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
Scalable calcite wall, cavern found a north entrance in 2010. The muddy maze called Passchendaele is watered by an intermittently rising stream.

Pearl Harbor
North entrance discovered in 2010
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)

sinkhead & forest
DEEP GREEN:
VIETNAM’S SON DOONG CAVE MAY CONTAIN THE WORLD’S LARGEST CAVE PASSAGE

KARST LANDSCAPE EXPLORATION

Evolution of the Garden of Edam
Tankeng/Doline/Sinkhole

This is a note about the size and description of the other worldly dolines found in the Son Doong cave and their genesis from cave collapse due to erosion, internal failures and fault weaknesses. These dolines are termed Karst 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.

PHASE 1
This is a note about the doline formation, start at errosion, concentric vertical collapses and flow in and out.

PHASE 2
This is a note about the doline formation, start at erosion, concentric vertical collapses and flow in and out.

PHASE 3
This is a note about the doline formation, start at erosion, concentric vertical collapses and flow in and out.

PHASE 4
This is a note about the doline formation, start at erosion, concentric vertical collapses and flow in and out.

This is 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 in the cave and the river crossings found in the artifice waterfalls. This river can rise suddenly and force
DEEP GREEN: VIETNAM’S SON DOONG CAVE MAY CONTAIN THE WORLD’S LARGEST CAVE PASSAGE

KARST LANDSCAPE EXPLORATION

CAVE PROFILE

Evolution of the Garden of Edam Tankeng


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 1960, mapping nearly 90 miles of passages.

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The cave’s Garden of Eden 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 3 million years ago
tectonic forces uplifted the limestone.

Expanding

With continued erosion and collapse, debris accumulates faster than it can be removed by the flowing water.

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.

Watch Out for Dinosaurs

The whimsically named sinkhole is a light and rain, which seeps into the river now carving new passages beneath the cave floor.

Garden of Eden

In the larger and older of the cave’s two sinkholes, a forest of 100-foot trees covers an 850-foot-deep debris cone.

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 forces uplifted and fractured the rock. Rivers followed these fractures underground, dissolving networks of cave passages.

Networks of caves

Green: Main cave
Blue: Other caves
Lilac: Limestone extent

Two discharge systems, the Voi and the Phong Mau, channel subterranean waters that have carved two remarkable cave networks.

Great Wall of Vietnam

Sealing this cobble wall, cover 900 feet high in pitch darkness.

North entrance discovered in 2010

Pearl Harbor

Covered by 20 feet of sand in 1937.

North entrance discovered in 2010

Covered by 20 feet of sand in 1937.

Pearl Harbor