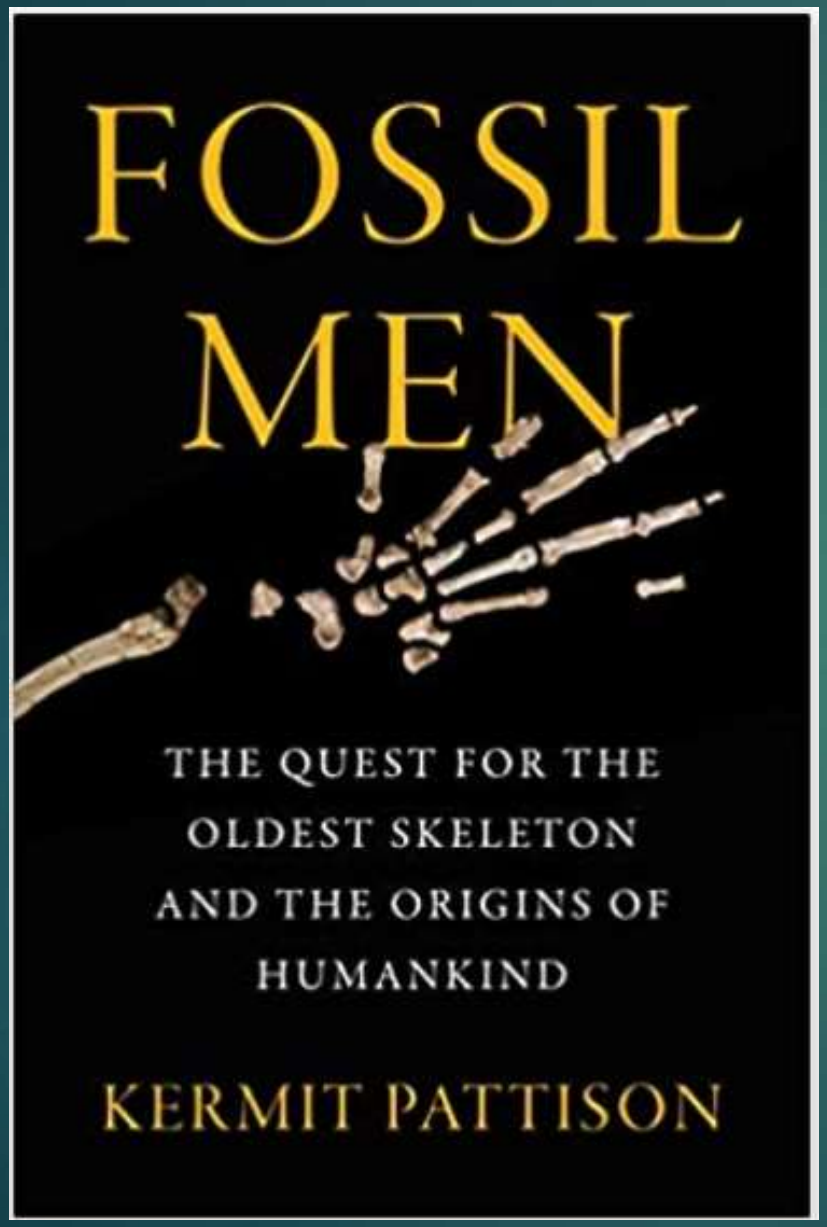
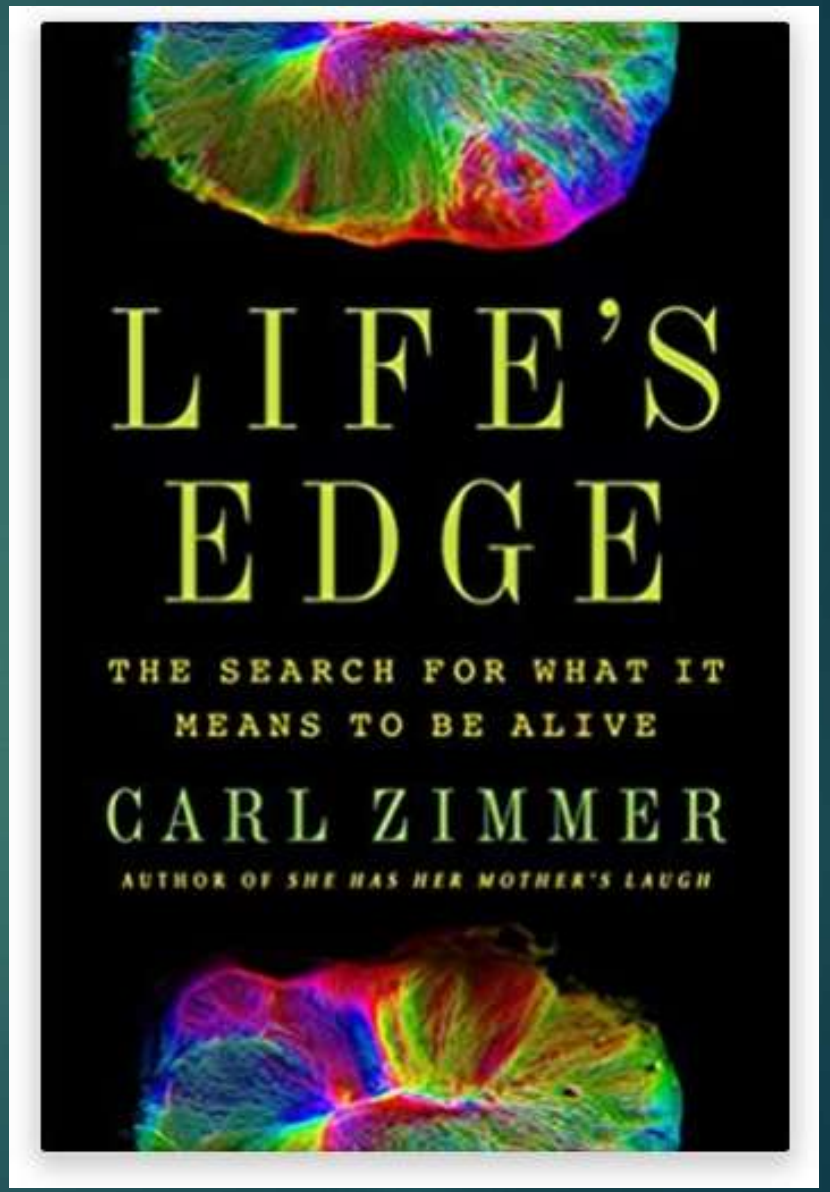
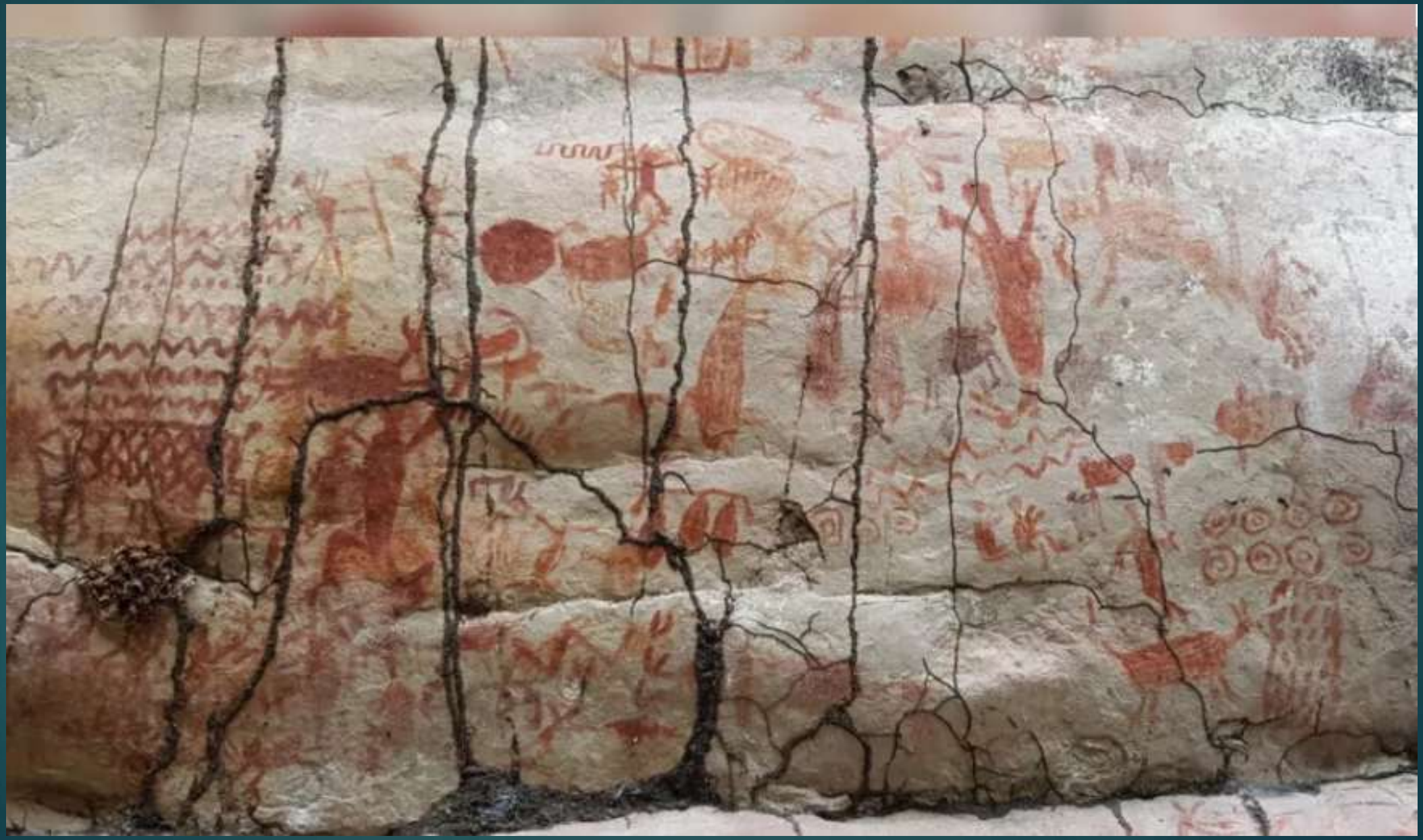
New Books: Ardi

March 2021





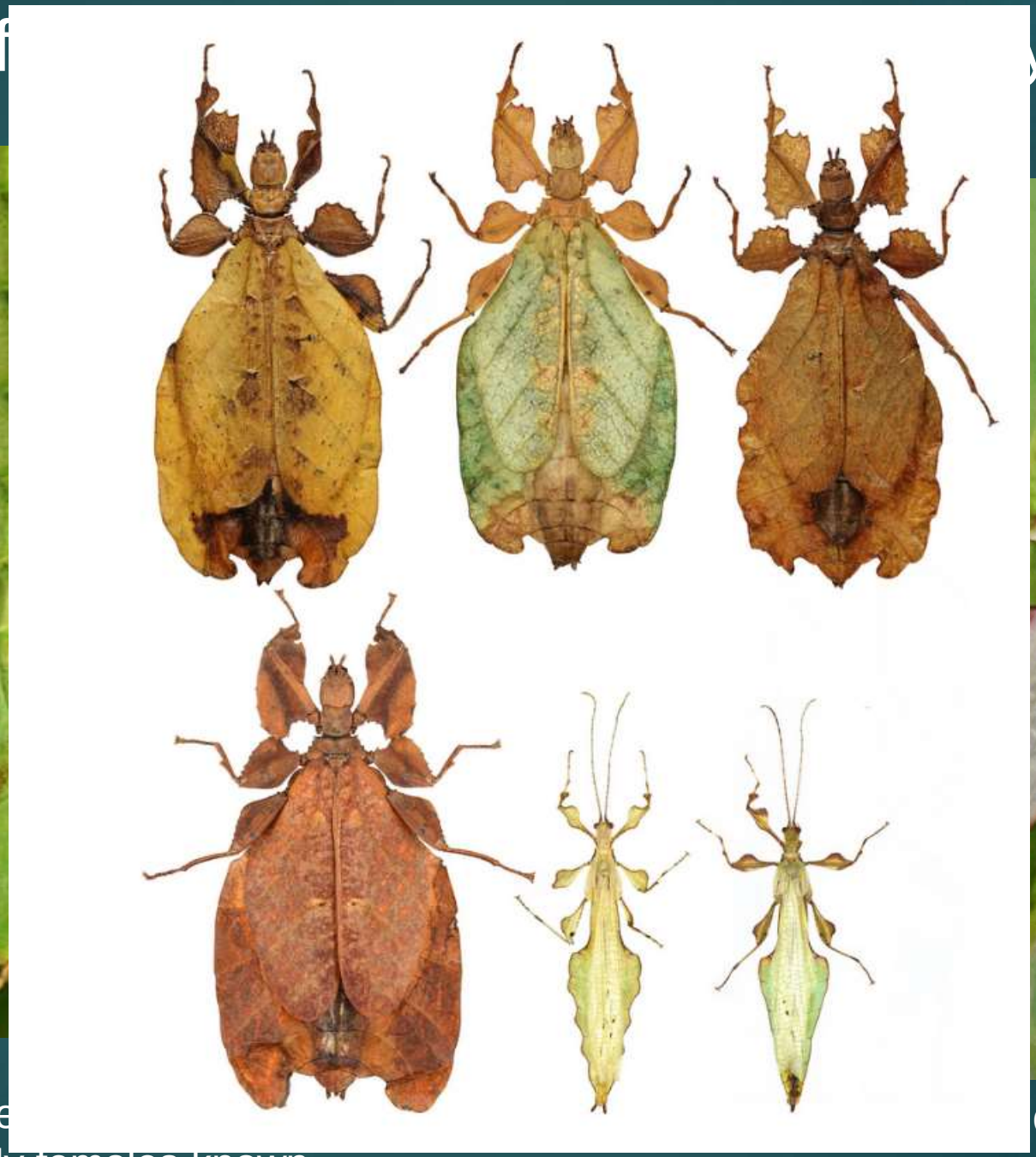
8 miles of art: 12 Ka old rock art in the Colombian Amazon



Leaf Insects

Leaf insects are notoriously hard to spot. For instance, this image shows nine. Hsin-hsiung Chen

She Was a Leaf … y Made History



A female Phyllium asekie… Or sexual dimorphism?
Papua New Guinea. Only females known.

La Ferrassie 8: 2 y o N – definite burial

- A. Balzeau, et al., 2020: re-examination of 1970s excavation of the La Ferrassie 8 Neandertal skeleton
- Results show that a pit was dug in a sterile sediment layer and the corpse of a two-year-old child was laid there.
- ZooMS: N mitochondrial DNA, yielded a direct ^{14}C age of 42–41 Ka
- This age makes the bone one of the most recent directly dated Neandertals. It is consistent with the age range for the Châtelperronian in the site and in this region and represents the third association of Neandertal taxa to Initial Upper Palaeolithic lithic technocomplex in Western Europe

Homo naledi

CHARLES J. VELLA, PHD

DECEMBER 16, 2020

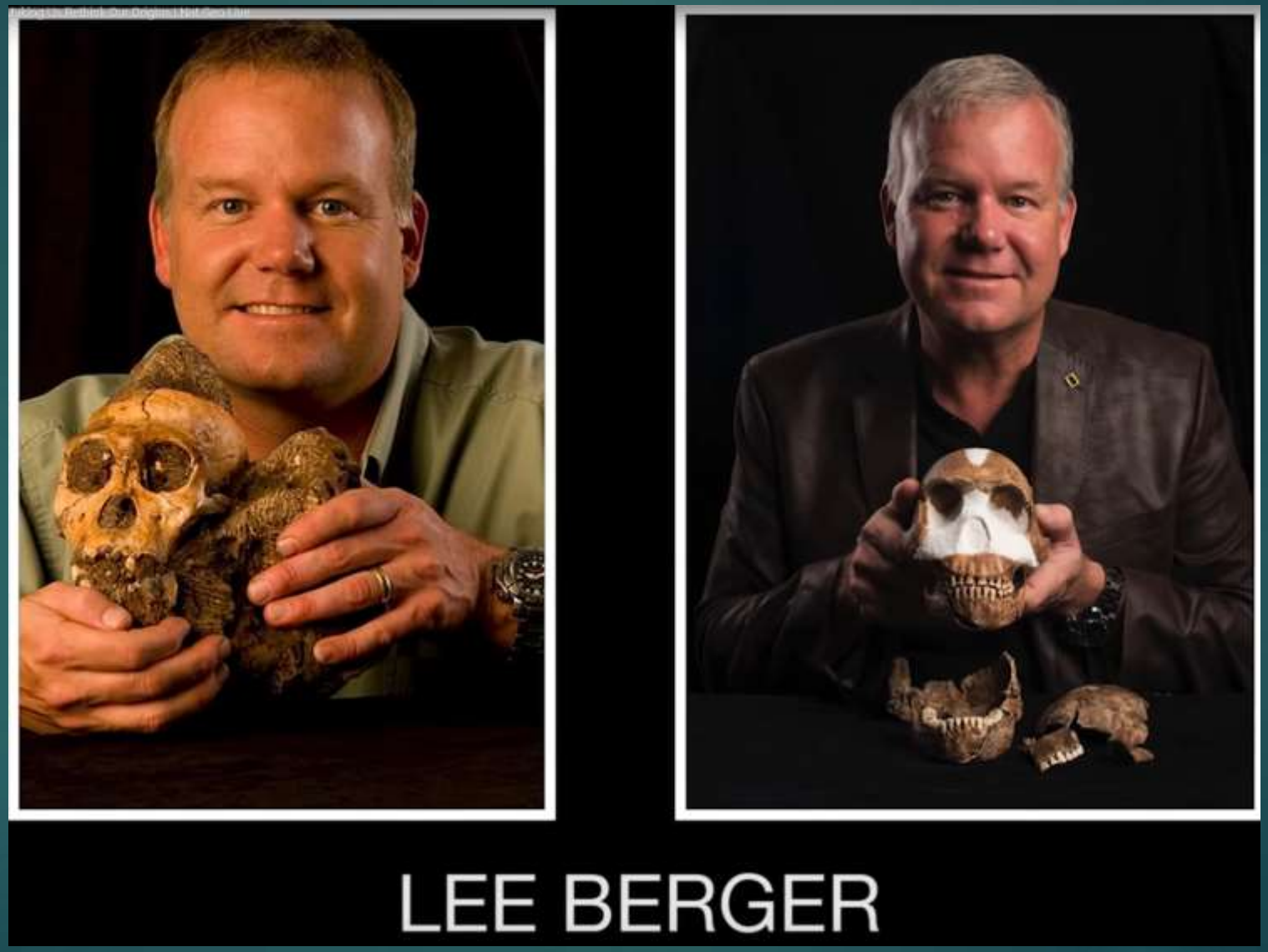
Homo naledi

The Star Man

“This must surely be a glorious moment to be a paleontologist.“

Lightning strikes twice

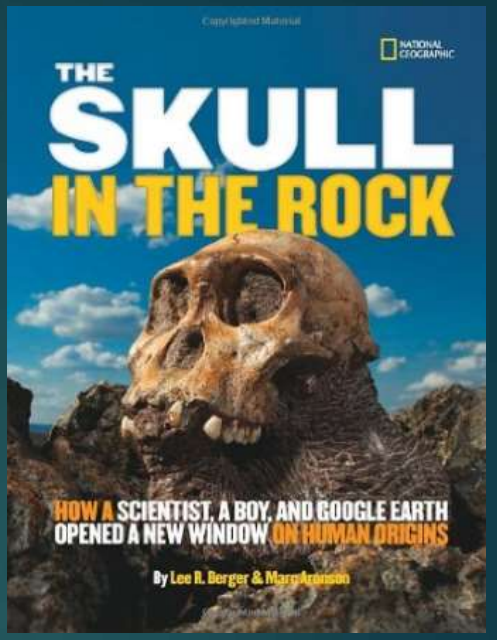
A. sediba



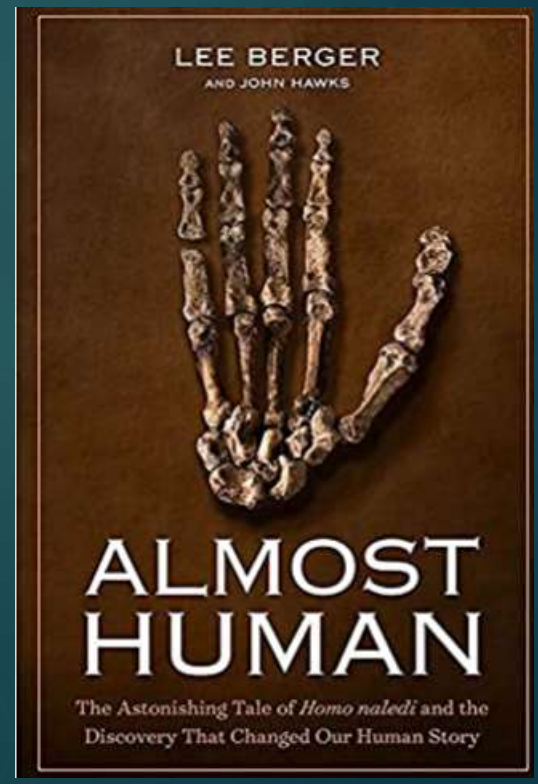
H. naledi

Lee Rogers Berger (1965-):

- Grew up in Georgia; grandfather was oil wildcatter
- Berger moved to Johannesburg to study for his doctorate under Phillip Tobias (Raymond Dart's student); He is a paleoanthropologist, physical anthropologist and archeologist

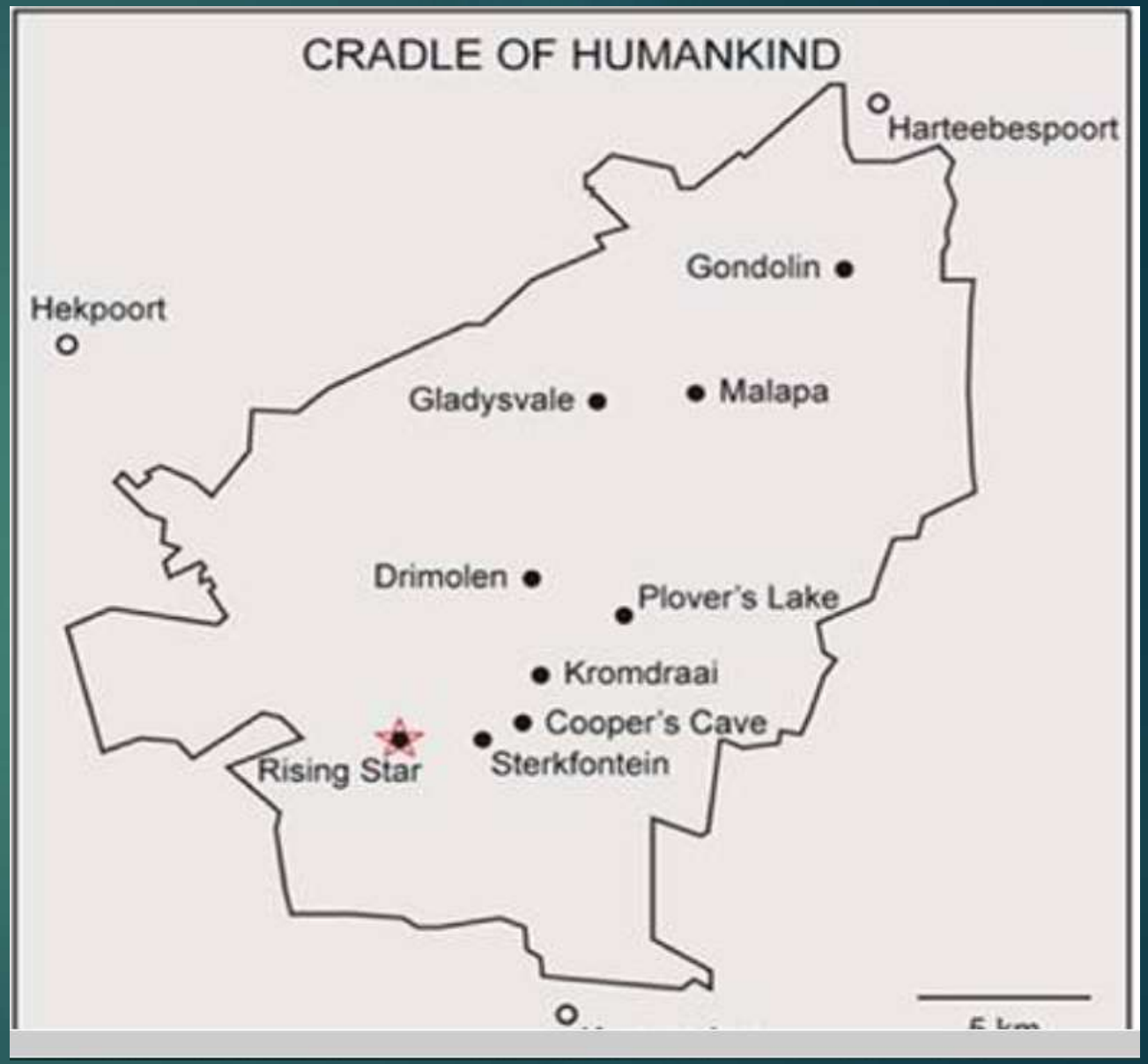


- University of the Witwatersrand
- He hunted for fossils in South Africa for 17 years before making his first major discovery.
- Taung Bird of Prey Hypothesis
- Surveying South Africa's Malapa Cave in 2008: son Matthew discovers *Australopithecus sediba,* 1.98M
- In 2012, Berger published a children's book, *The Skull in the Rock;* in 2017, *Almost Human,* about *H. naledi*



Cradle of Humankind

- The 50,000-hectare (123,550-acre) area of hilly grasslands is recognized as the Cradle of Humankind, featuring a network of caves that has yielded nearly 40 percent of known hominin fossils;
- The caves in the Cradle of Humankind (CoH), South Africa have yielded rich fossil assemblages of late Pliocene to early Pleistocene age, which include a range of hominin species (*A. africanus*, *A. prometheus (Little Foot)*, *A. sediba*, *P. robustus*, *H. ergaster, H. naledi* and early *Homo*) and associated mammals, reptiles, and birds



1991: Lee Berger: Gladysvale, S. Africa: *A. africanus??*

AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY 92:107–111

Brief Communication: Gladysvale: First Early Hominid Site Discovered in South Africa Since 1948

LEE R. BERGER, ANDRÉ W. KEYSER, AND PHILLIP V. TOBIAS
Palaeo-anthropology Research Unit, Department of Anatomy and Human Biology, University of the Witwatersrand, Johannesburg 2193 (L.R.B., P.V.T.) and Department of Geological Survey, Pretoria 0001 (A.W.K.), South Africa

Lee Berger: GPS for trees

- 1991 – Berger at Gladysvale cave for 17 years: found 200,000 animal bones and two teeth of *Australopithecus africanus* (found by 2 students). Average African hominin find: 1 hominin fragment for every 250 K antelope bone

- He got P. Tobias academic position at the Wits Univ. and then fired his rival Ronald Clarke. Clarke then announced Little Foot. The South Africa *Sunday Times* named Berger the Idiot of the Week. Wits U kept Clark.

- In 2002, Berger wrote two books which received scathing reviews.
  - George Washington University professor Bernard Wood wrote a review of Berger's first book, *In the Foot Steps of Eve*, for the *South African Journal of Science* . He said the book "exceeds by literally an order of magnitude the mistakes and errors I have ever encountered in a book."
  - In the same publication, paleoanthropologist Tim White from the University of California wrote an even less charitable review, using phrases such as "grandstanding," "self-promotional hype," and "pattern of fabrication." White said Berger's book "signals a new era: one of smoke and mirrors, in which style triumphs over substance."

Palau, Micronesia

- Berger has cited both White and Clarke as examples of scientists who withhold data and take too long to publish findings. White considers Berger to be engaged in “selfie science”.

- Palau bones Controversy, 2008: 1200 hominin bones; many outlandish claims about human ancestry; island dwarf claim; in fact, they were recent small people

- 2007: Berger got bored and started to hunt for other caves using Google Earth.

Google Earth

Google Earth: Grove of trees at sites – fractured dolomite = cave with wild olive and white stinkwood trees

Berger asked where trees they got their water. Seeds found their way to water in caves and trees sprouted from cave openings.

Often clustered in linear patterns following fault lines that allowed caves to form

South Africa, 2 Ba Dolomite (CA-MG/lime) domes, fractured, caves, breccia

800 new caves/250 fossil sites

Then 1 km from Gladysvale: Malapa Cave in 2008

Berger: Archeology's disputed genius

- Lee Berger: Indiana Jones of South African paleoanthropology,
- Over the course of 21 days in November 2013, Berger's team unearthed 1,550 individual hominin bone fragments, more than had previously been discovered in 90 years of exploration in Southern Africa.
- Berger: "We are going to tell the world that this nonhuman animal deliberately disposed of its dead in that chamber."
- Those are wildly speculative hypotheses, the sort which Berger's peers have criticized him for propagating in the past.

Bobby Bascomb, Nova, 2015

Lee Berger

- W. Jungers: Many of Berger's colleagues thought he was trying too hard to create a *Homo* connection for A. sediba that didn't exist. At 2 million years old, his critics argued, *sediba* is too recent to be a direct ancestor of *Homo* . "That's where Lee got the most grief—that *sediba* had implications for our genus *Homo.*"

- P. Kramer: Some of Berger's other extraordinary claims have drawn fire from his peers who say they lack the meticulous research necessary to back them up. "Detailed analysis doesn't appear to be his strength"

- He formed relationship with spelunking community who were exploring those newly discovered caves.

Berger

- According to some, he has the wrong academic pedigree; Wits was not best graduate school
- Paleoanthropologists often take years, sometimes decades, to publish their work. Ron Clarke has famously spent the last 18 years excavating and describing a fossil known as Little Foot, which was found in the same area of South Africa as *A. sediba* and *H. naledi.*
- In contrast, it took Berger just three years to excavate the *A. sediba* bones and publish 13 papers in the journal *Science* .
- Carol Ward: His breakneck pace resulted in sloppy work. “I’m working on a fossil from Kenya, and I wanted to compare it to *sediba* ,” she says. “In one set of papers, they have one set of measurements, and in another set of papers it might be different.” “There were inconsistencies.”

Lee Berger

- Berger believes the best way to advance the field is to make new information available to the community as quickly as possible and allow his colleagues to form their own hypothesis.

- To describe the *H. naledi* fossils in quick succession, Berger recruited nearly 60 scientists from across the discipline. “It’s been said many hands make light work. Many minds make better science,” he says.

- Media blitz: *H. naledi* has been the subject of blogs, a Twitter feed, a video series, a two-hour NOVA film, and a *National Geographic* feature.

Berger

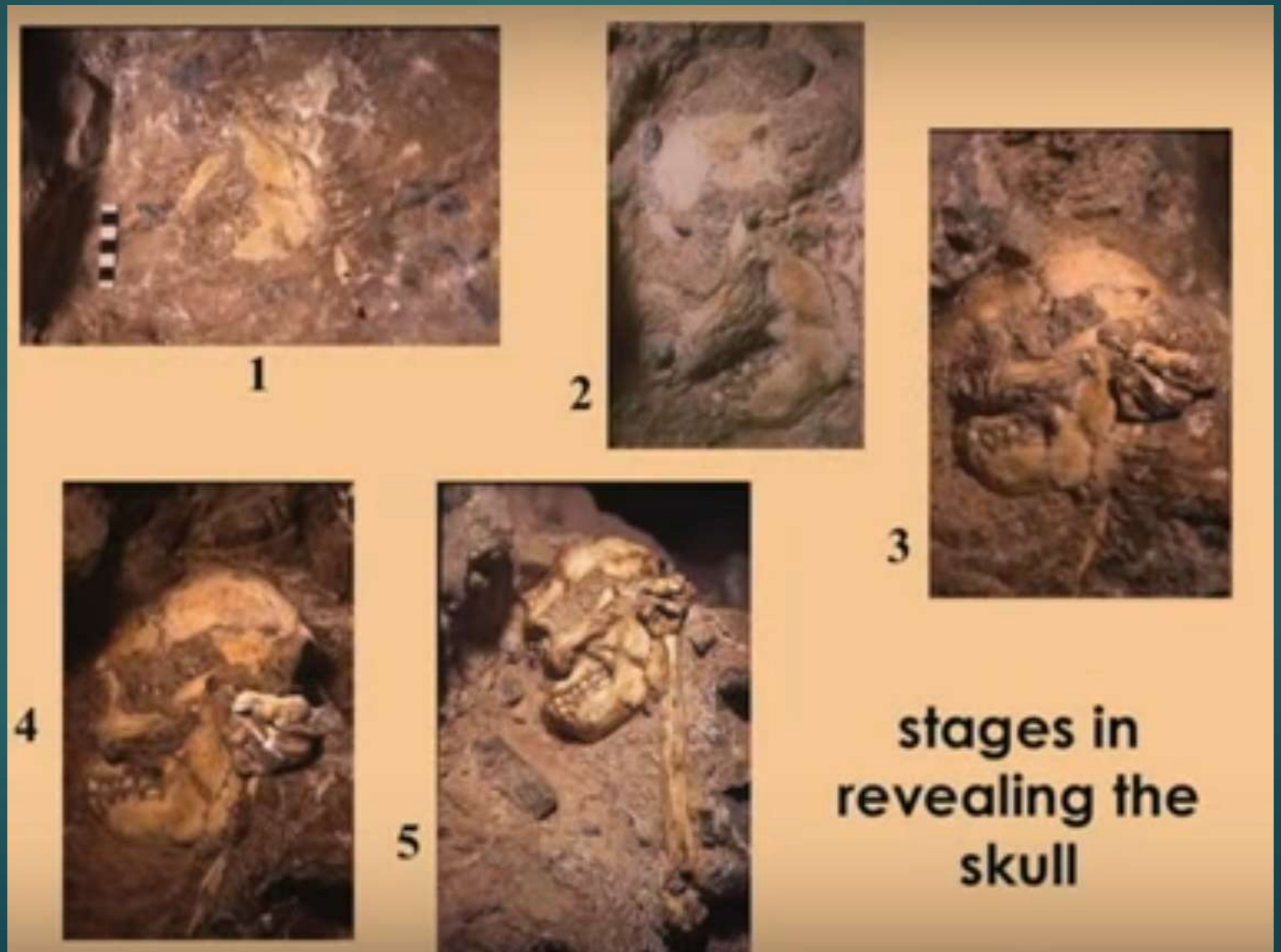
- Jungers: “Lee was considered something of a media darling without much substance. Well, listen, he’s got all the substance in the world now”
- “I’m willing to write off stuff in the past as an eager young paleontologist that wanted to make a name for himself. He’s far down the road to rehabilitating his image with the fossils he’s found and his way of dealing with them. I think he’s going to be a spokesman for our field in the future.”
- “Some people like him and some people don’t, but he’s got the fossils.”

Lee Berger

- And there's likely more to come. Berger's team has literally just scratched the surface of the Rising Star cave.
- In just three weeks, they excavated an area less than three feet square and a foot deep. In that time, they found more fossils than the century's worth of work that preceded them.
- Berger estimates there are tens of thousands of bones yet to be removed and described. He could spend the rest of his life excavating this find and leave behind a colossal body of work, but that's not his plan.
- Discovery of 800 fossil sites

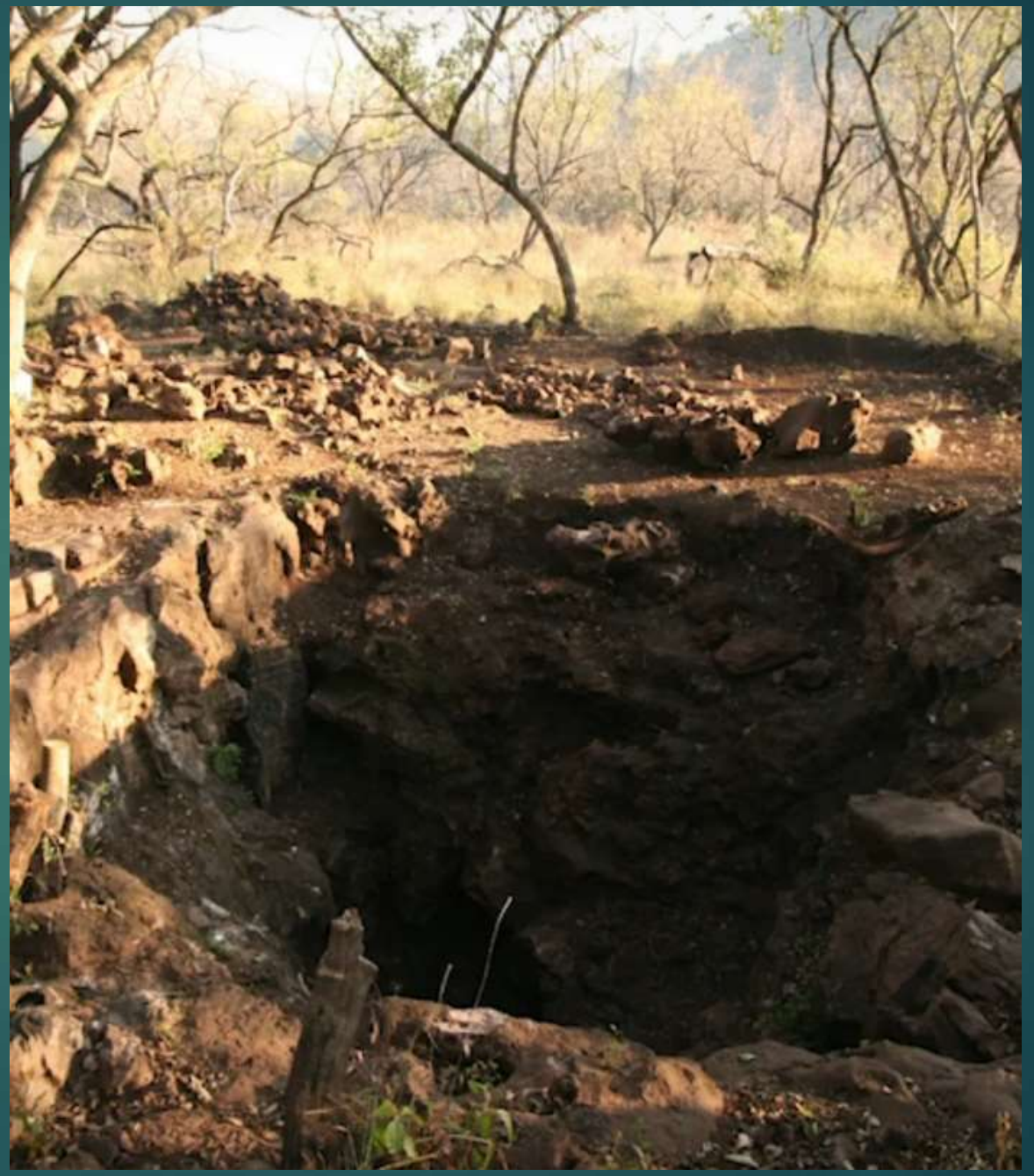
Classic South African cave breccia (bones in calcite concrete-like rock); need pneumatic hammer

Example: Little Foot: 20 years to excavate from breccia using miniature air hammer



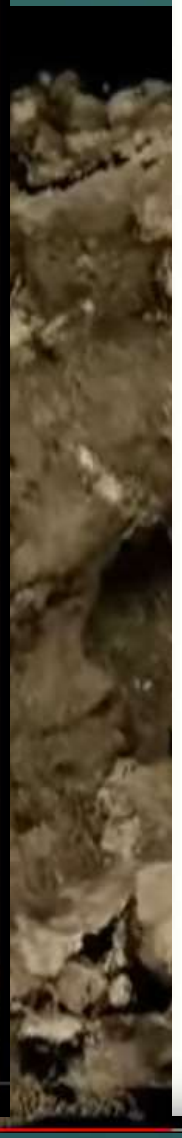
Malapa Cave in 2008: son finds a hominin clavicle

Malapa Cave:
A hole excavated by lime miners (3 dynamite blasts & then abandoned); also 46 new caves nearby, which miners had destroyed



Matt Berger today: 6’4”, helped explore Dinaledi; Univ. of AL

Malapa Cave hole

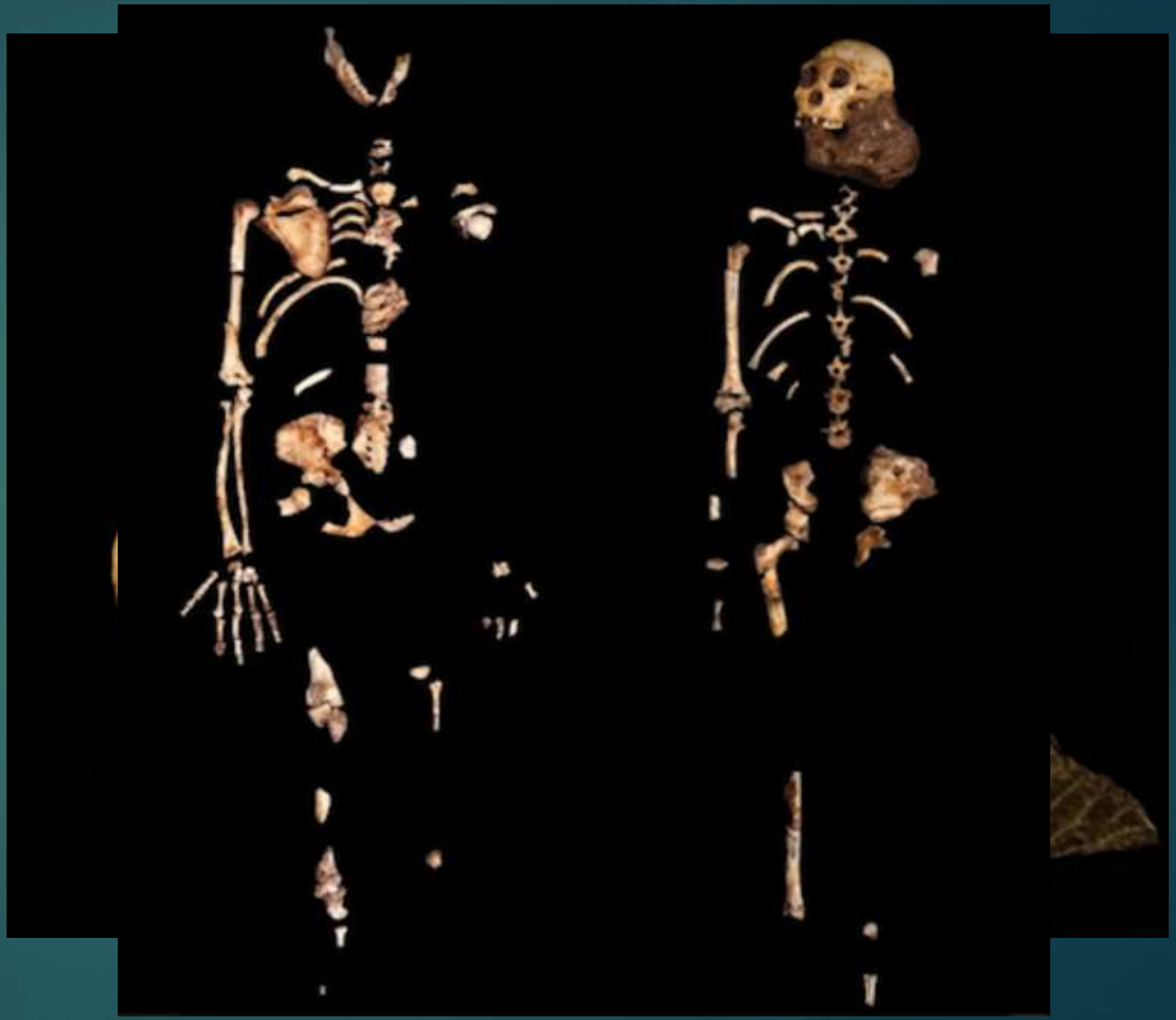


Bone in breccia

Lee’s wife is radiologist:

CT scan

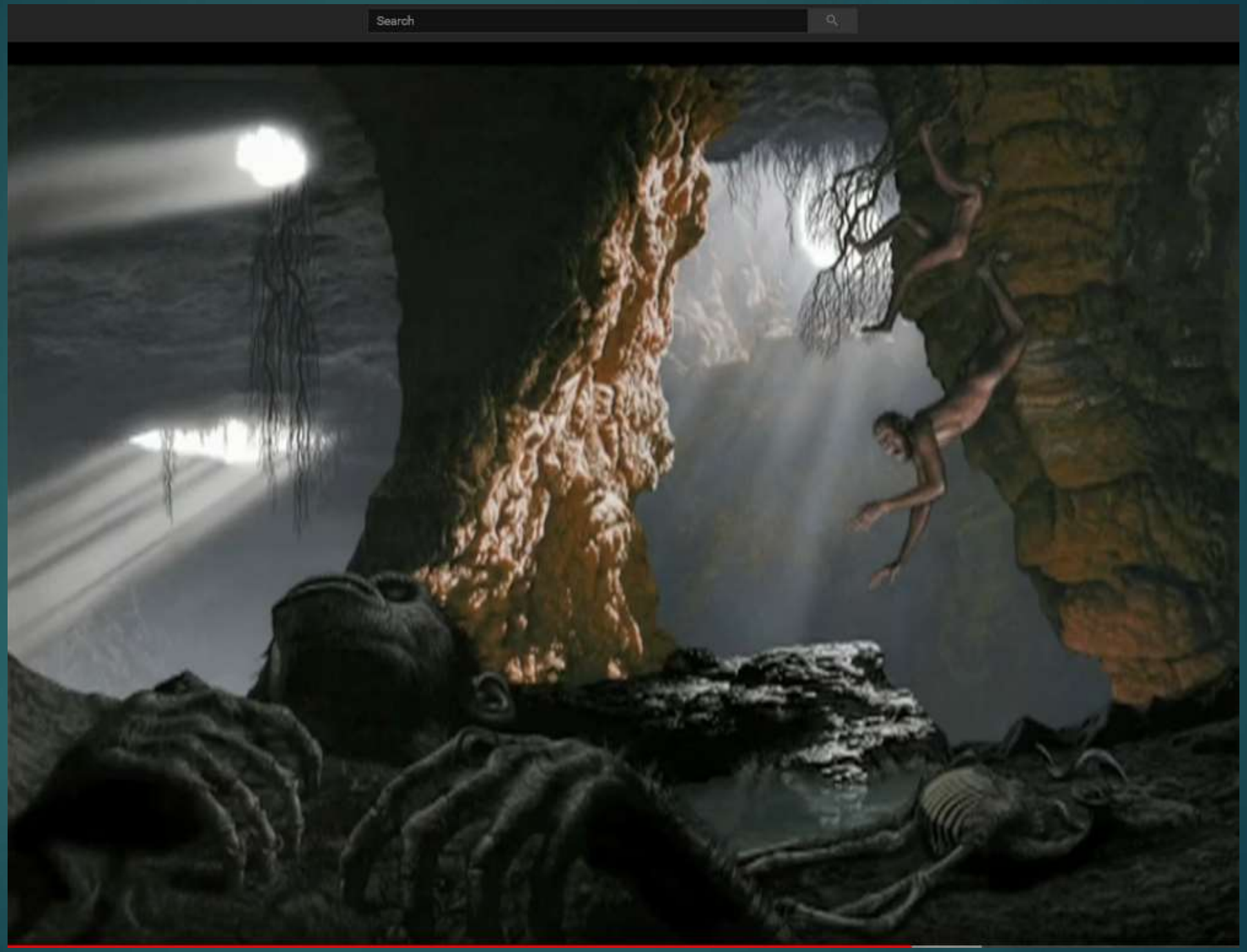
Berger, et al., 2010



Malapa:

Death trap

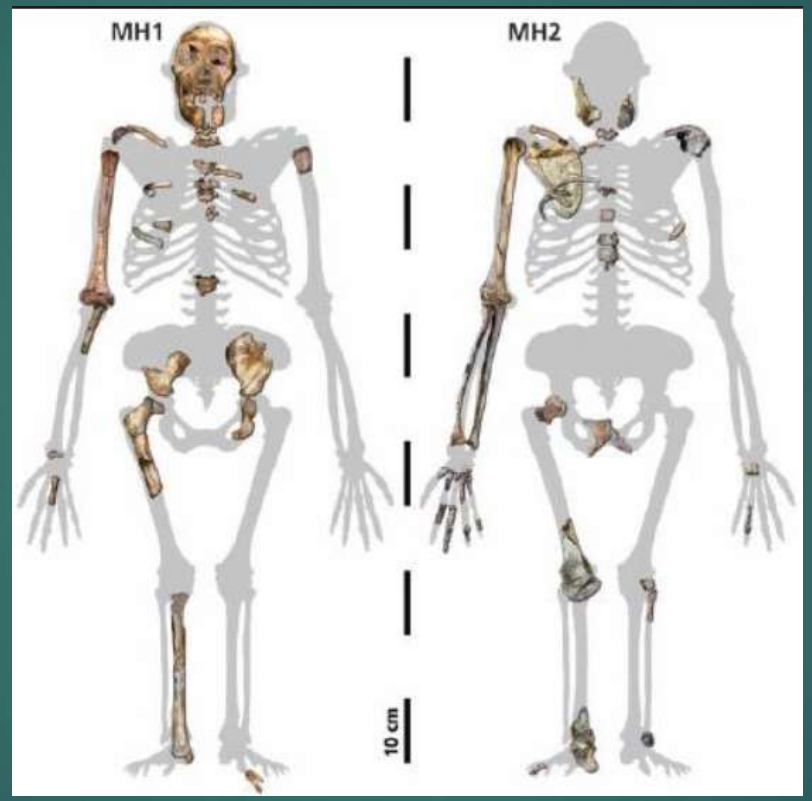
At least 4 other hominins



A. sediba: Mother and child, fatal fall; then buried in mud

2008: *Australopithecus sediba*, 1.98 Ma

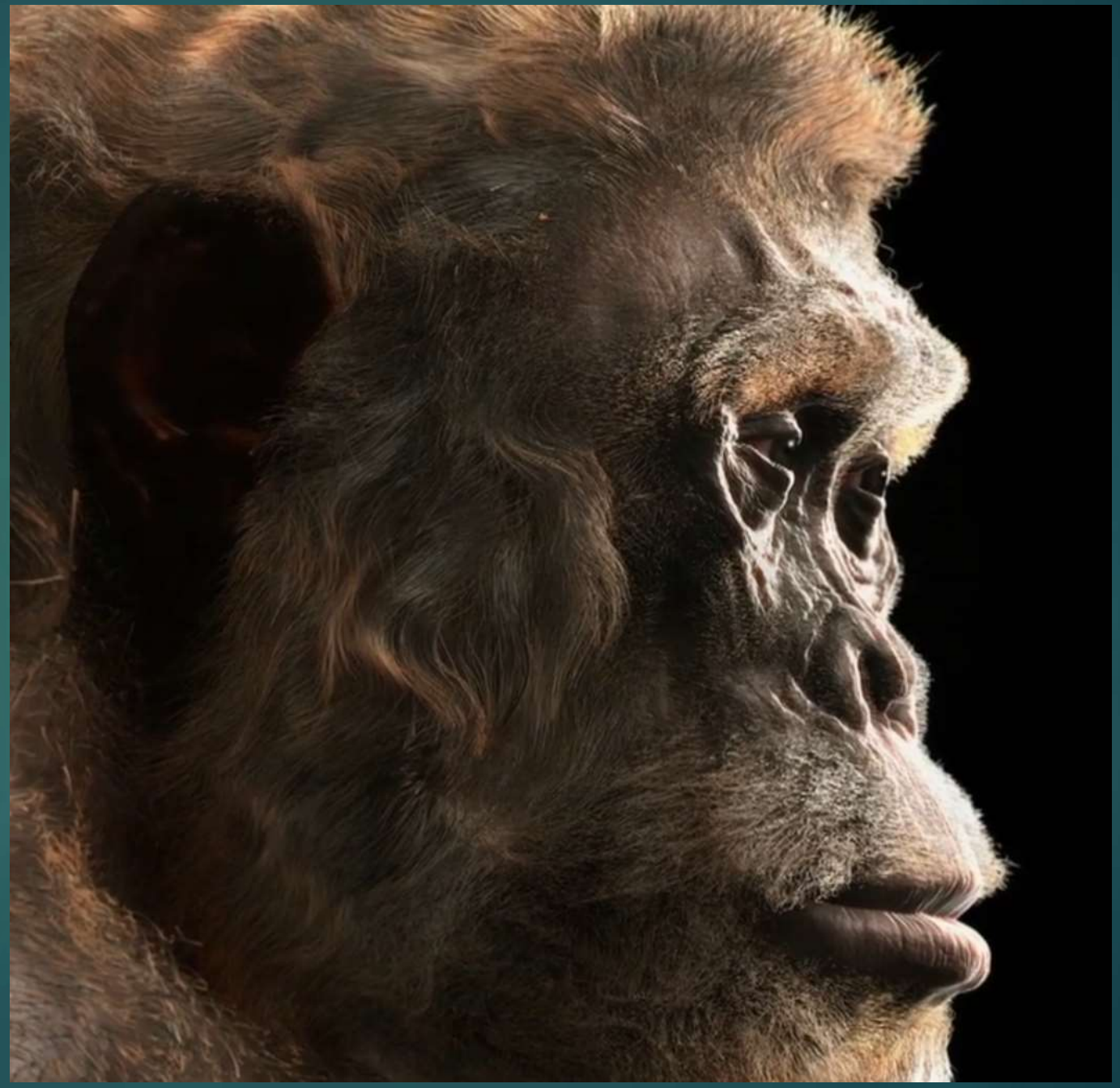

Brett Eloff, via Lee Berger and the University of the Witwatersrand



Australopithecus sediba
(LH1, type, cranium)
Discoverer: Matthew Berger
Locality: Malapa Cave, South Africa
Date: 2008


NewScientist
THE SKULL IN THE ROCK
Physics
New Perspective on QUANTUM GRAVITY
Neuroscience
How Stress Cripples YOUR BRAIN
Space Exploration
Next Missions to THE MOON
SCIENTIFIC AMERICAN
Humanity's Beginning
Two-million-year-old fossils offer a tantalizing connection to our
Science
Science
TIME
100 New Scientific Discoveries
Science

A. sediba reconstruction



2015 Discovery:

Homo naledi

New species of the genus *Homo*

from the Dinaledi Chamber, South Africa

“This fossil will be probably one of the best known hominin species discovered in the history of this science,” says Lee Berger, research professor

at the University of Witwatersrand in South Africa

In the middle of the most explored fossil sites of South Africa…

Rising Star Cave system (30 miles north of Johannesburg; had been explored for 50 years)

- Location: 26°10130 0 S; 27°420430 0 E
- Well known cave among sport cavers who used it as a training area
- 800 meters SW from well explored Swartkrans cave; 1.5 miles from Sterkfontein

Above Rising Star Cave System

Under the hillside: a kilometer of caves in Rising Star system

2 Spelunkers in 2013:
Steve Tucker, an accountant
Rick Hunter, a Mensa member, who was kicked out of high school for blowing up chemistry lab; construction worker

Rising Star Cave: community of spelunkers

Pedro Boshoff; bone hunter hired by Lee Berger to hunt for fossils in S. African caves

Steve Tucker:
1st spelunker into the Dinaledi Chamber

Rick Hunter

The Discovery:

- Berger had asked Pedro Boshoff to help investigate about 800 sites he had identified using Google Earth.

- On September 13, 2013 while exploring the Rising Star cave system, looking for an extension, recreational cavers Rick Hunter and Steven Tucker of the Speleological Exploration Club (SEC) of South Africa found a narrow, vertically oriented "chimney" or "chute" measuring 12 m (39 ft) long with an average width of 20 cm (7.9 in).

- This chute led to a room 30 m (98 ft) underground (Site U.W. 101, the Dinaledi Chamber), the surface of which was littered with fossil bones. Their camera failed. Had to return to photo chamber.

Discovery

- On October 1, 2013, Hunter & Tucker reported the find to Boshoff. They went to Berger's home at 9 PM. "You 're going to want to let us in."

- Oct 5, sent 14 yo, 6-foot, son Matthew down with professional camera to verify.

- Got South African excavation permit and landowner's permission.

Rising Star Cave

Rising Star Cave

Homo naledi

- The Dinaledi collection is the richest assemblage of associated fossil hominins ever discovered in Africa, and aside from the Sima de los Huesos collection and later Neanderthal and modern human samples, it has the most comprehensive representation of skeletal elements across the lifespan, and from multiple individuals, in the entire hominin fossil record.

- For comparison, 50 years of excavations at Olduvai = 100 hominin fossils

- H. naledi has doubled the total African fossil record.

The “King Tut’s Tomb” of Hominin Fossil Discovery: 2015

Rising Star Cave, Dinaledi Chamber

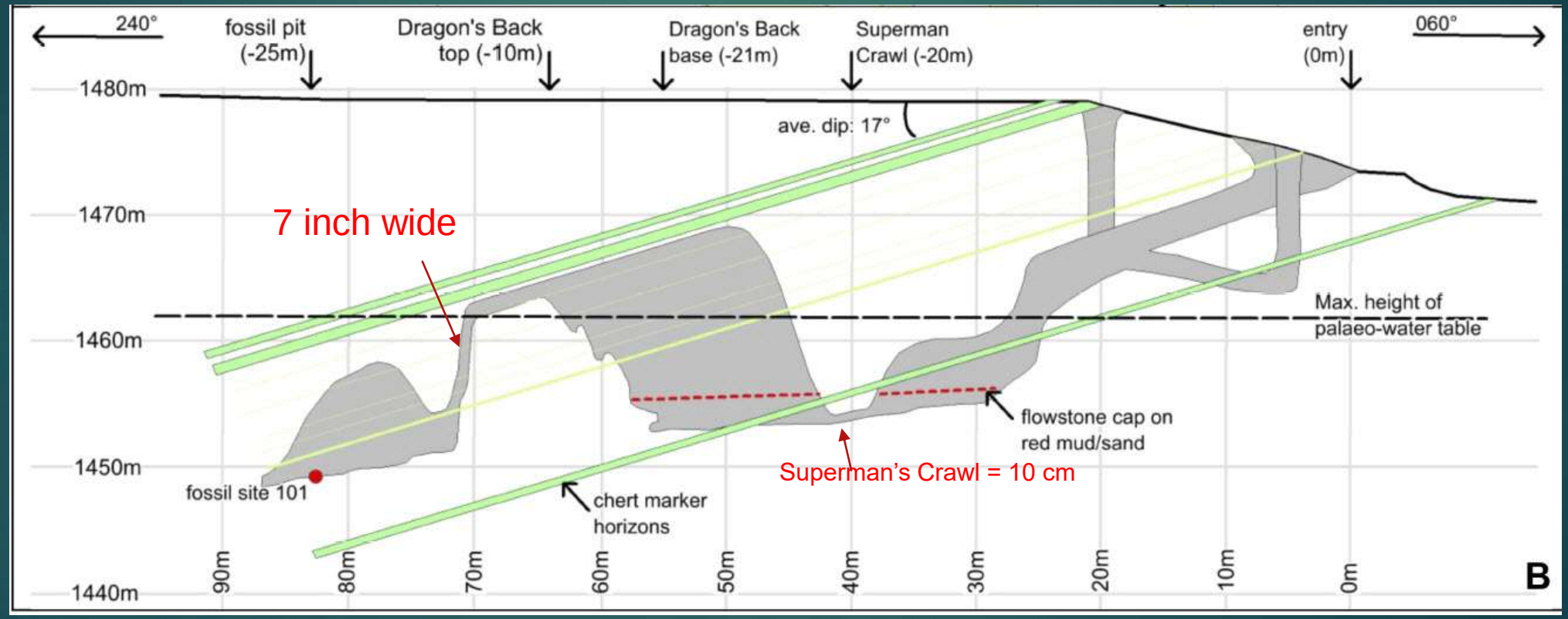
Homo naledi

2015: *Homo naledi*

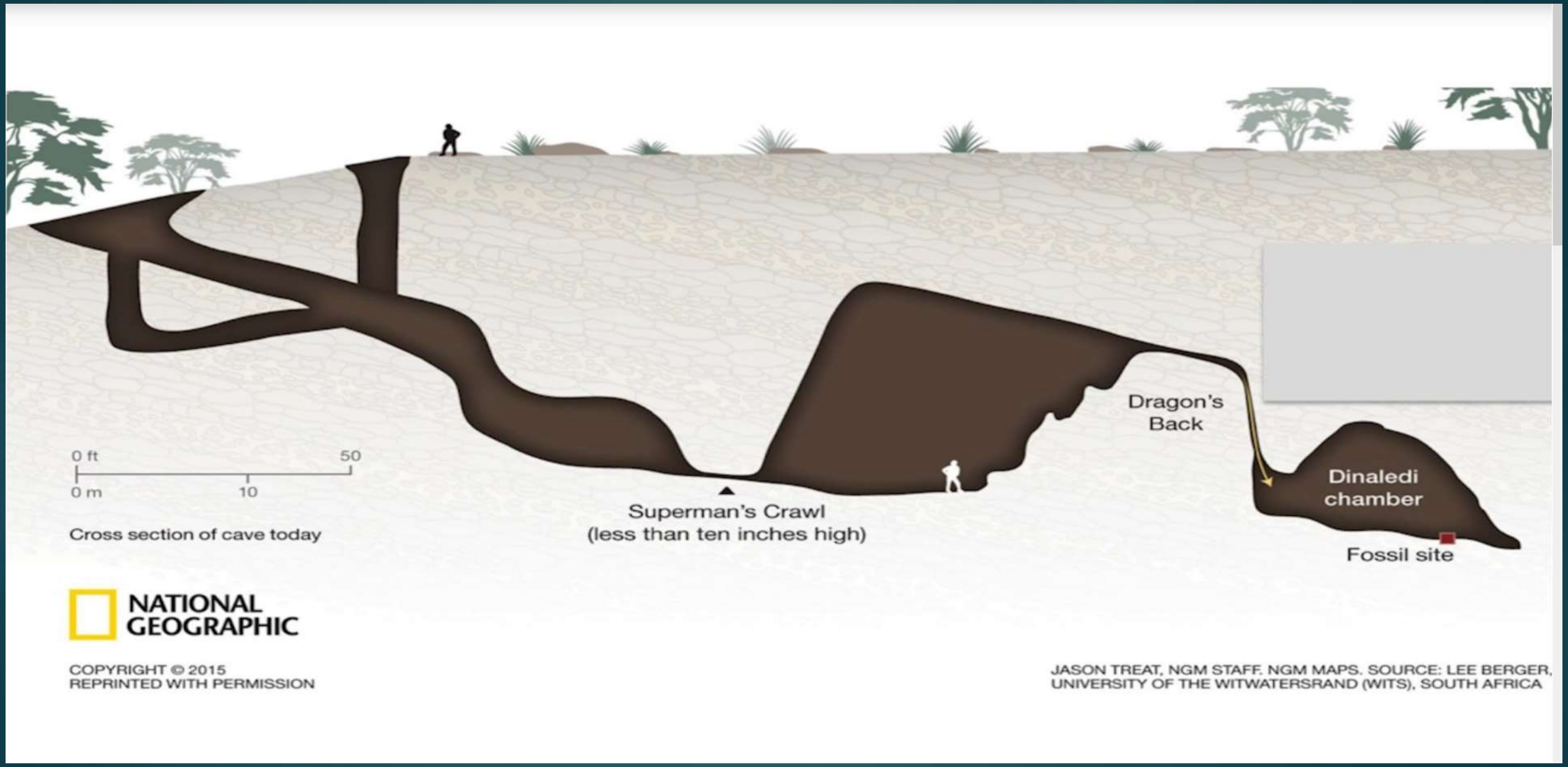
- *Homo naledi*: A new species of the genus *Homo* from the Dinaledi Chamber, South Africa
- One of the largest finds in the history of paleoanthropology
- Supervised by Lee Berger of University of the Witwatersrand

2015: *Homo naledi* ("star" in South African language Sotho; from chamber of stars "Dinaledi")

Rising Star dolomite cave system in South Africa (caved for 50 y): 90 meters long, pitch black; ~30 m below surface and ~80 m, in a straight line, away from the present, nearest entrance to the cave



Through a 39-foot crack just seven inches wide at times, finally the Dinaledi Chamber, 30 feet long and only a few feet wide, with bones everywhere



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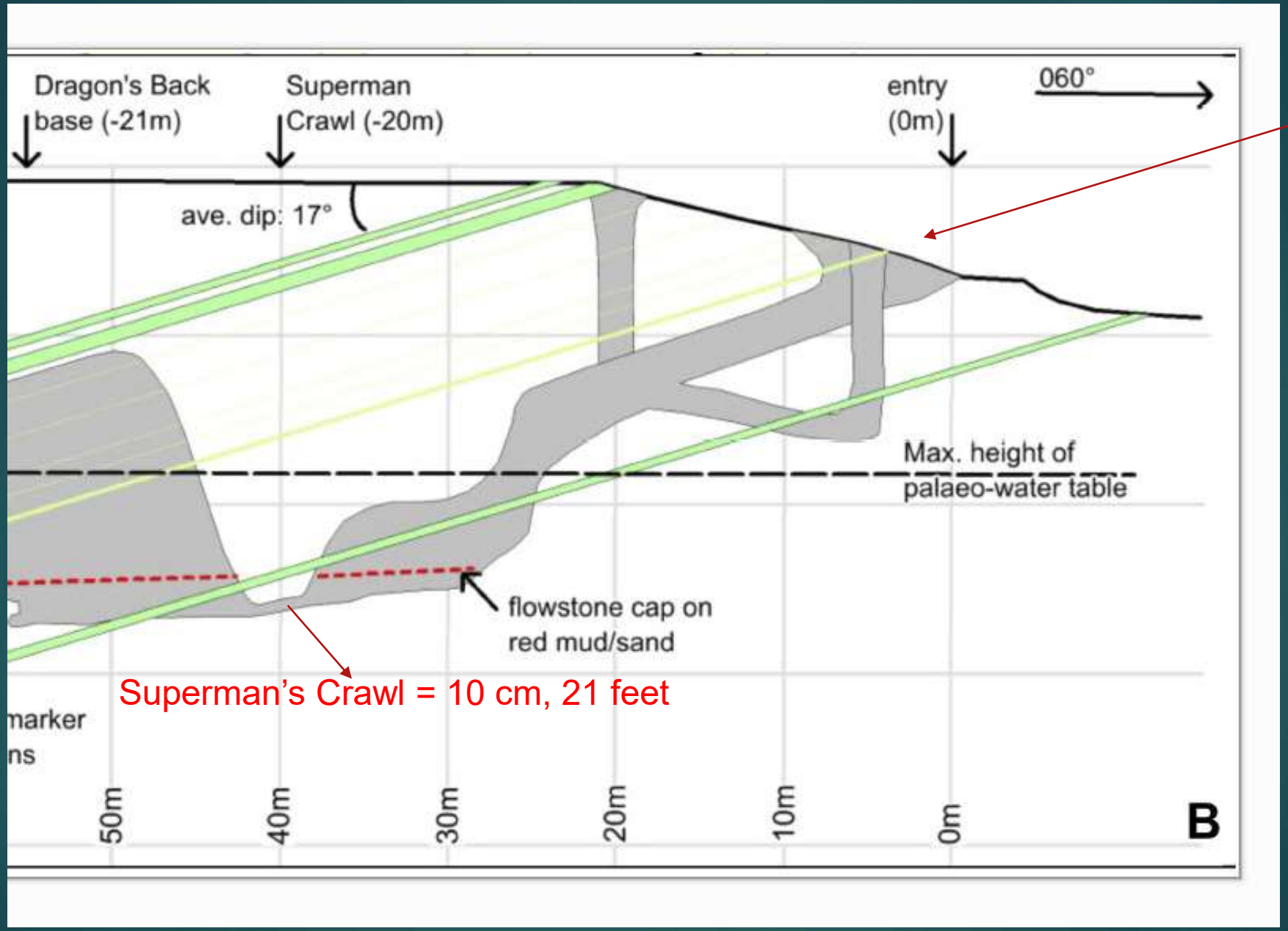
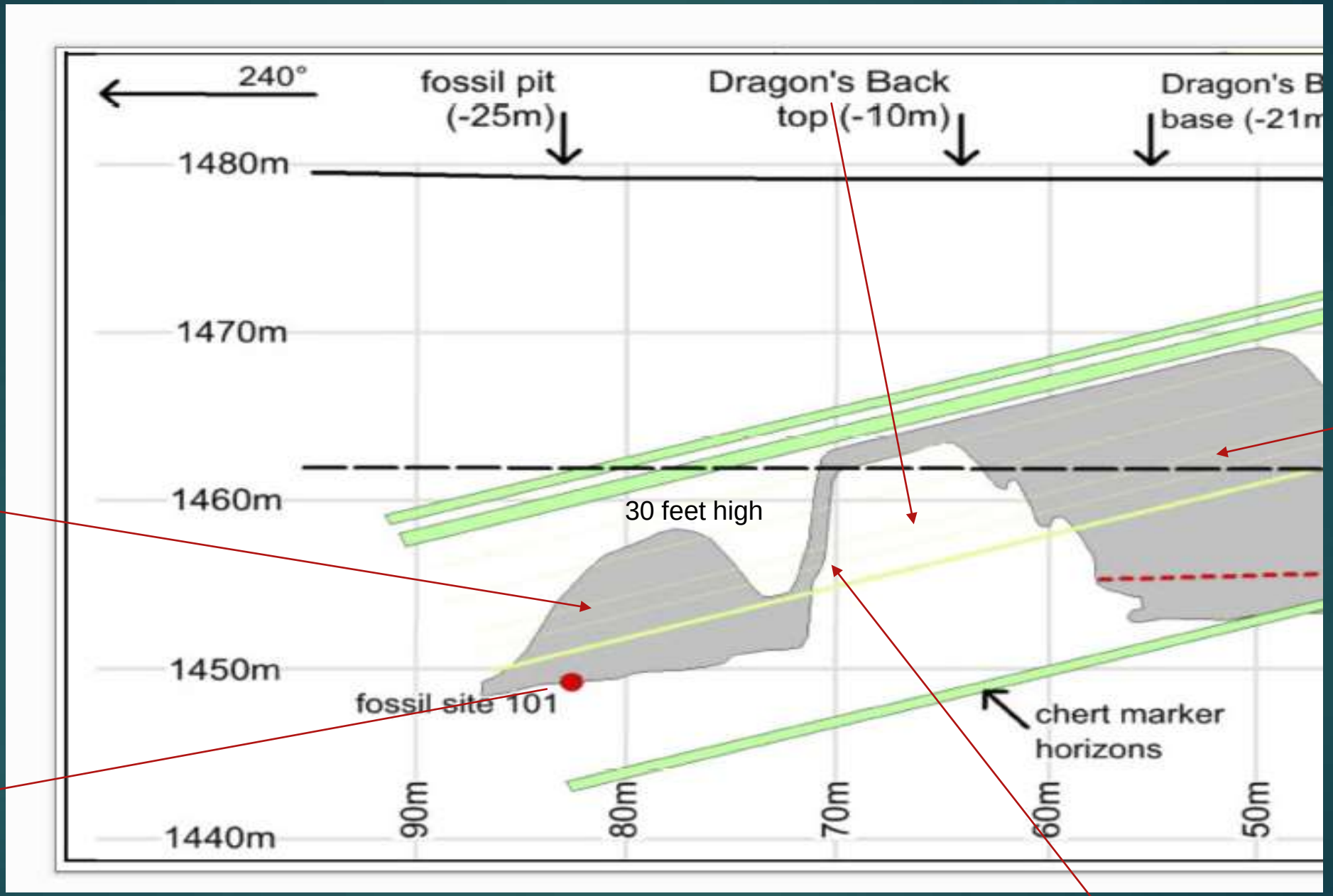
JASON TREAT, NGM STAFF. NGM MAPS. SOURCE: LEE BERGER, UNIVERSITY OF THE WITWATERSRAND (WITS), SOUTH AFRICA

PBS

DINALEDI CHAMBER


Dragon's Back
base (-21m)
Superman
Crawl (-20m)
entry
(0m)
060°
ave. dip: 17°
Max. height of
palaeo-water table
flowstone cap on
red mud/sand
Superman's Crawl = 10 cm, 21 feet
marker
ns
50m
40m
30m
20m
10m
0m
B

Entry

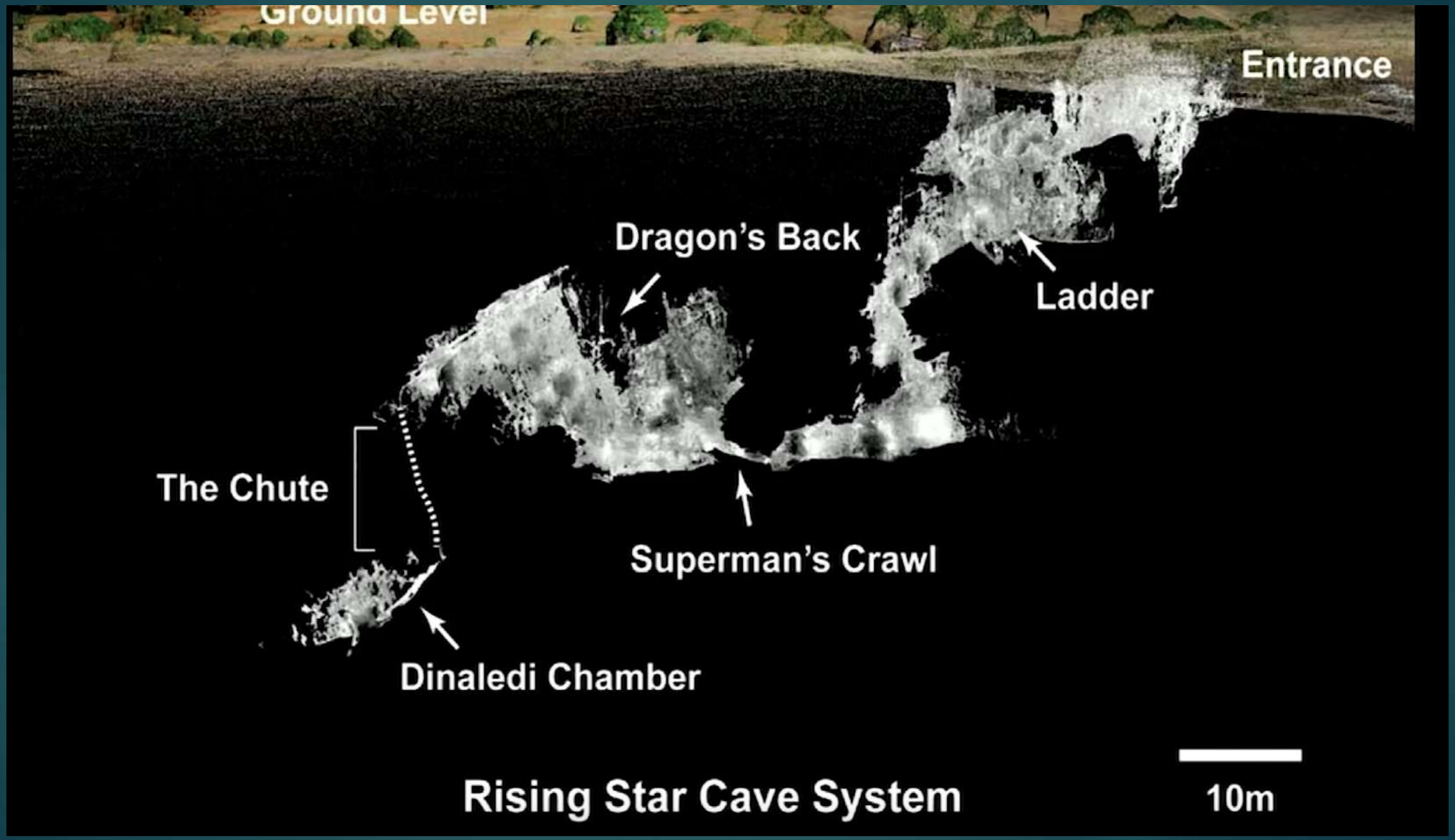


Dinaledi Chamber: UW 101

Most Fossils

Many fossil baboon teeth in walls: Not mentioned in reports

The Chute: 12 m, punctuated by shark-teeth protrusions


Ground Level
Entrance
Dragon's Back
Ladder
The Chute
Superman's Crawl
Dinaledi Chamber
Rising Star Cave System
10m

Sep. 13, 2013: An evening stroll of Rising Star Cave

Rising Star Cave on one evening; after 4 hours of exploring; Steve rests on and then descends the Chute

Steve Tucker: First Descent

At end of the Chute descent: first time, no rope

Not the first ones in the cave

- Among all of the fossils, they found old survey pegs left behind in this chamber, and evidence that some of the fossils on the floor surface had been moved and broken (white ends). Steve and Rick were not the first ones to have stumbled upon it.

- Yet until quite recently, no one knew this cave existed; whoever left those survey pegs did not recognize the importance of this find and didn't bother to note it on a map.

- Instead of dispatching a lithe paleoanthropologist with caving experience, Berger sent Matthew, his son, who was 14, down with Tucker and Hunter.


Play (k)

Then Rick: down the the 7-inch, 30-foot stone Chute

Bottom hole of the Chute

First footage of Dinaledi Chamber

Rick thru Superman's Crawl and down the Chute

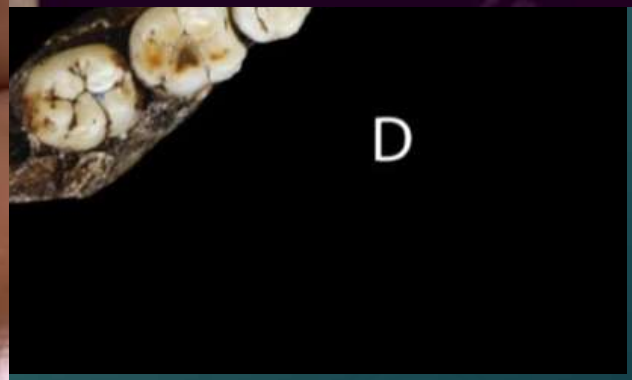
First sight: bones on surface

Recent dead human?

Berger sent this photo to John Hawks & Steve Churchill & noted progression of molar size with largest molar at back end = Archaic hominin

Bottom of 39 foot Chute

Molar progression was clue



Facebook: American Association of Physical Anthropologists
October 6, 2013

- Dear Colleagues,
- **I need the help of the whole community to reach out to as many related professional groups as possible. We need...individuals with excellent archaeological/palaeontological and excavation skills for a short-term project...The catch is this -** the person must be **skinny and preferably small.** They must **not be claustrophobic,** they must be **fit,** they should **have some caving experience, climbing experience would be a bonus.** They must be **willing to work in cramped quarters, have a good attitude** and be **a team player....we will cover flight…field accommodations, food…**
- Anyone interested please contact me directly...
- Many thanks
- Lee Berger

2013 Facebook, Twitter, LinkedIn Ads for “underground astronauts”

- Successful candidates had to come to Johannesburg immediately and accept a blind mission, for no pay.
- 60 applicants, not all women; final list of 10 contained 1 man; 6 picked by Berger; 1 got cold feet; the man admitted he could not fit tight space.
- Berger’s secretary: “What are you doing?” “I have a bunch of messages from women giving me their body dimensions!”
- On site on Nov. 7th. 20 canvas tents. For 21-day dig. National Geographic and PBS Nova crew.
- Used 3D Artec Scanner with 0.1 mm resolution to map entire Chamber, as well as every time they removed a fossil from soil. Absolute location. 3 ½ km of military grade video and audio cabling.

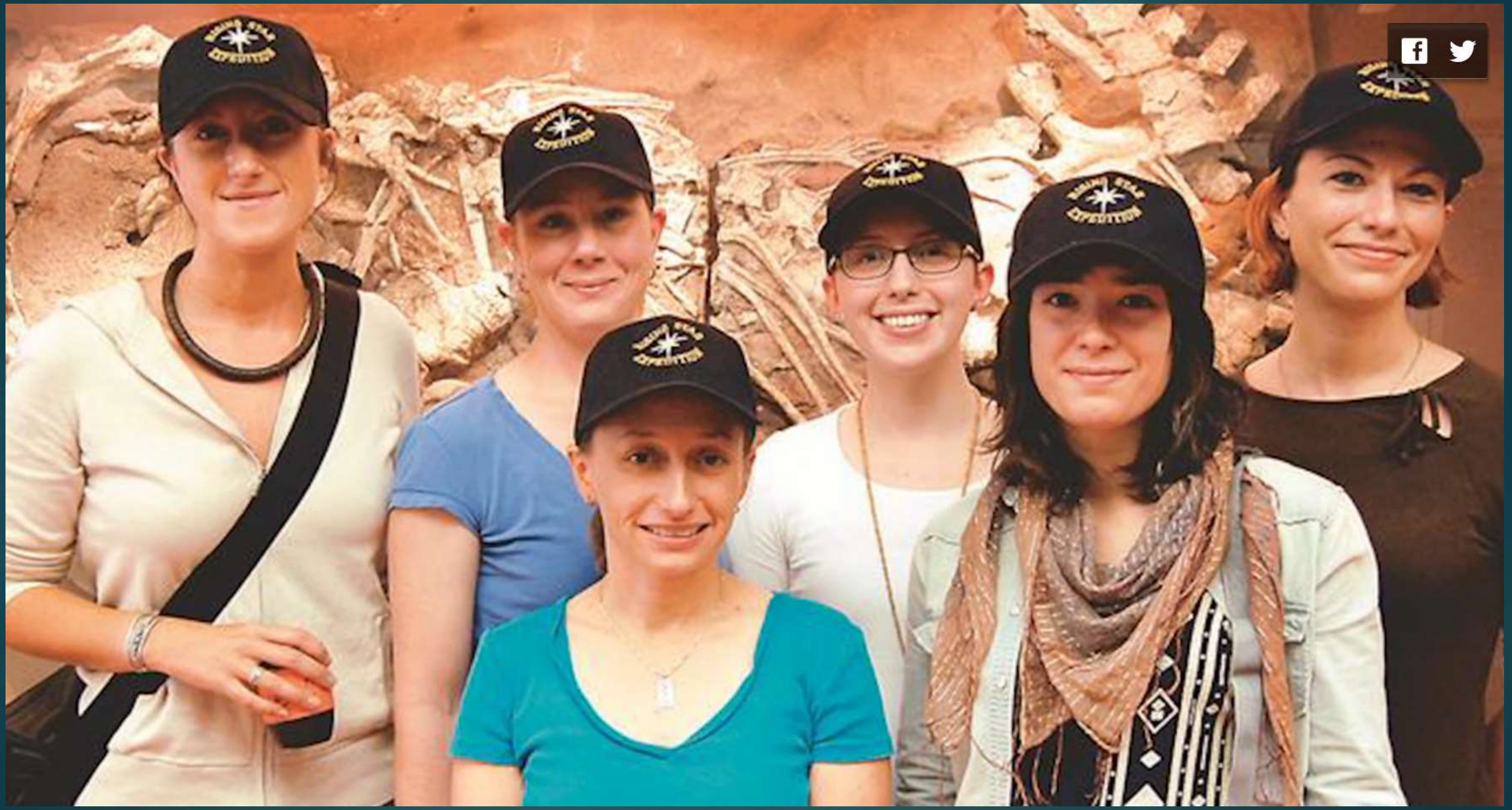
Rising Star Tent City

Underground astronauts of the Dinaledi Chamber

All 6 were larger than largest *H naledi* males.

All-female early career team – Hannah Morris, Marina Elliott (1st down the chute), Becca Peixotto, Alia Gurtov, Lindsay Eaves and Elen Feuerriegel – were drawn from Australia, Canada and the US. All worked for free.

They brought out the largest assemblage of fossil human relatives ever discovered in the history of the continent of Africa.



Within a month, a 60 member expedition

John D. Hawks: 2nd in command at Rising Star

- Best **Paleoanthropology** blog on internet: https://johnhawks.net/weblog/
- Ph.D. in Anthropology from the University of Michigan where he studied under Milford Wolpoff.
- Professor, University of Wisconsin–Madison
- In 2014, Hawks launched an online course on Coursera on "Human Evolution: Past and Future"; 30 K students, incl. me

Lee Burger (& Hawks) were too big to fit in cavern; so supervised it all on HD TV monitor; they have never been in the cavern

Berger gets thru Superman’s crawl once (45 minutes)

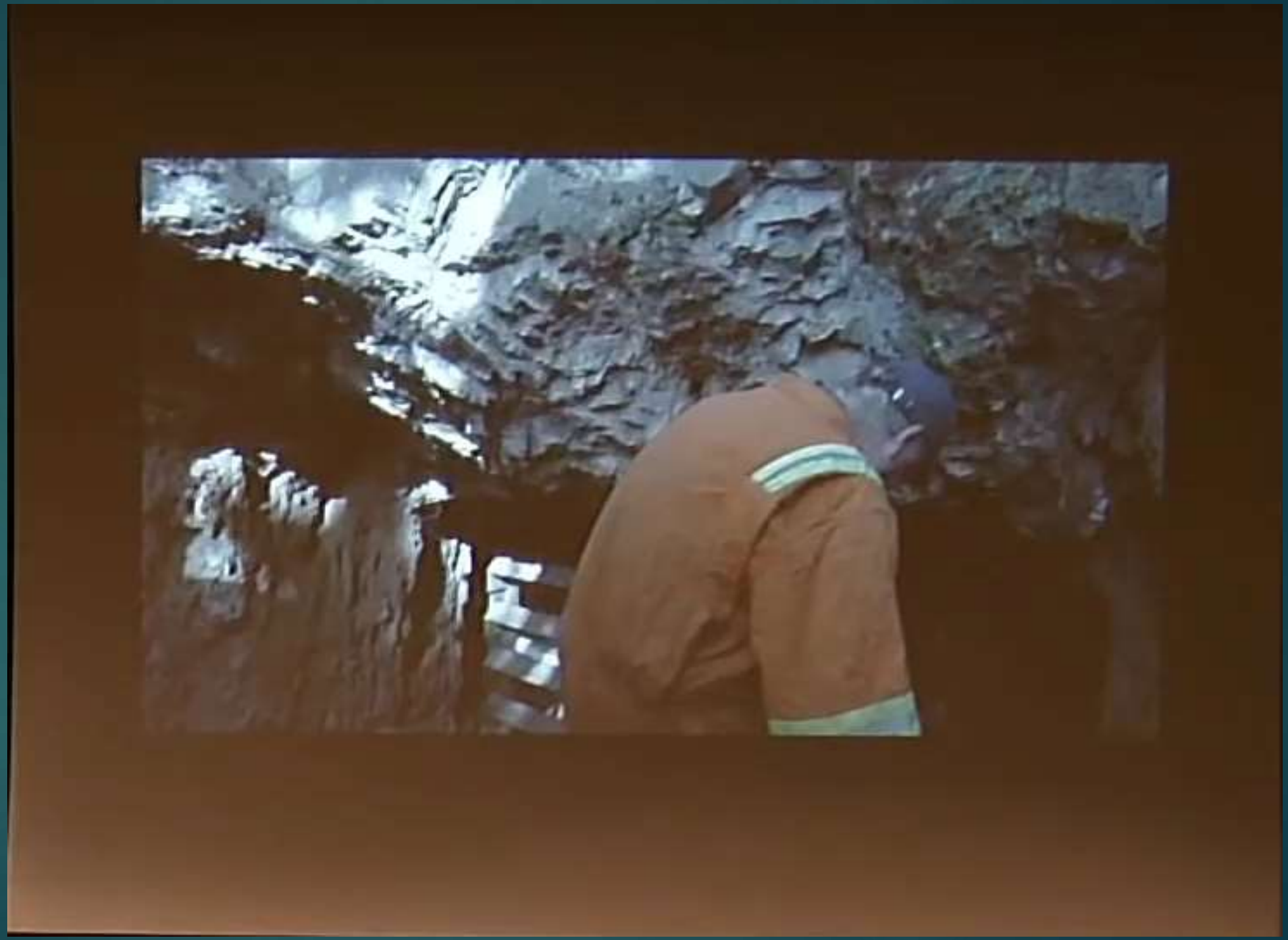
Getting ready: internet cabling, safety gear

Wooden ladder at bottom of Chute “Landing Zone”

Gated entrance now

Entrance and Superman Crawl

Cave Temp: 66 F



Base of Chute: barefoot requirement

Only 2 or 3 persons fit in chamber, work on hands/knees/bellies

Silt, not breccia: Toothpicks, not pneumatic hammers

Climbing in and out twice a day resulted in…

Walking The Dark Cave

- The chamber is a football field's length from the cave's entrance, past two nauseatingly tight passages, the second one a 39-foot vertical drop only 7 inches wide in places.

- From the cave entrance, it's about 80 meters into the dark zone before you get to a chute leading to the bones.

- You go down the walk-in entrance, which is a slope with a drop-off to the left-hand side. Then you duck into a small chamber.

Walking in the dark

- On the right-hand side there's an open chamber that has an installed light; and there are a lot of porcupine nests and porcupine fleas. Avoided at first.

- The team put in a rope line that you could follow. You sort of slope down, and there are some ladders, and some sideways squeezes and things, and when you get to the Superman Crawl — where you have to have one arm in front and one arm in back as you squeeze through.

- After the crawl, you come out into the Dragon's Back Chamber, a collapsed section of cave which requires a 20-meter rope ascent. It resembles the back of a dragon where you climb up its spines up toward its head.

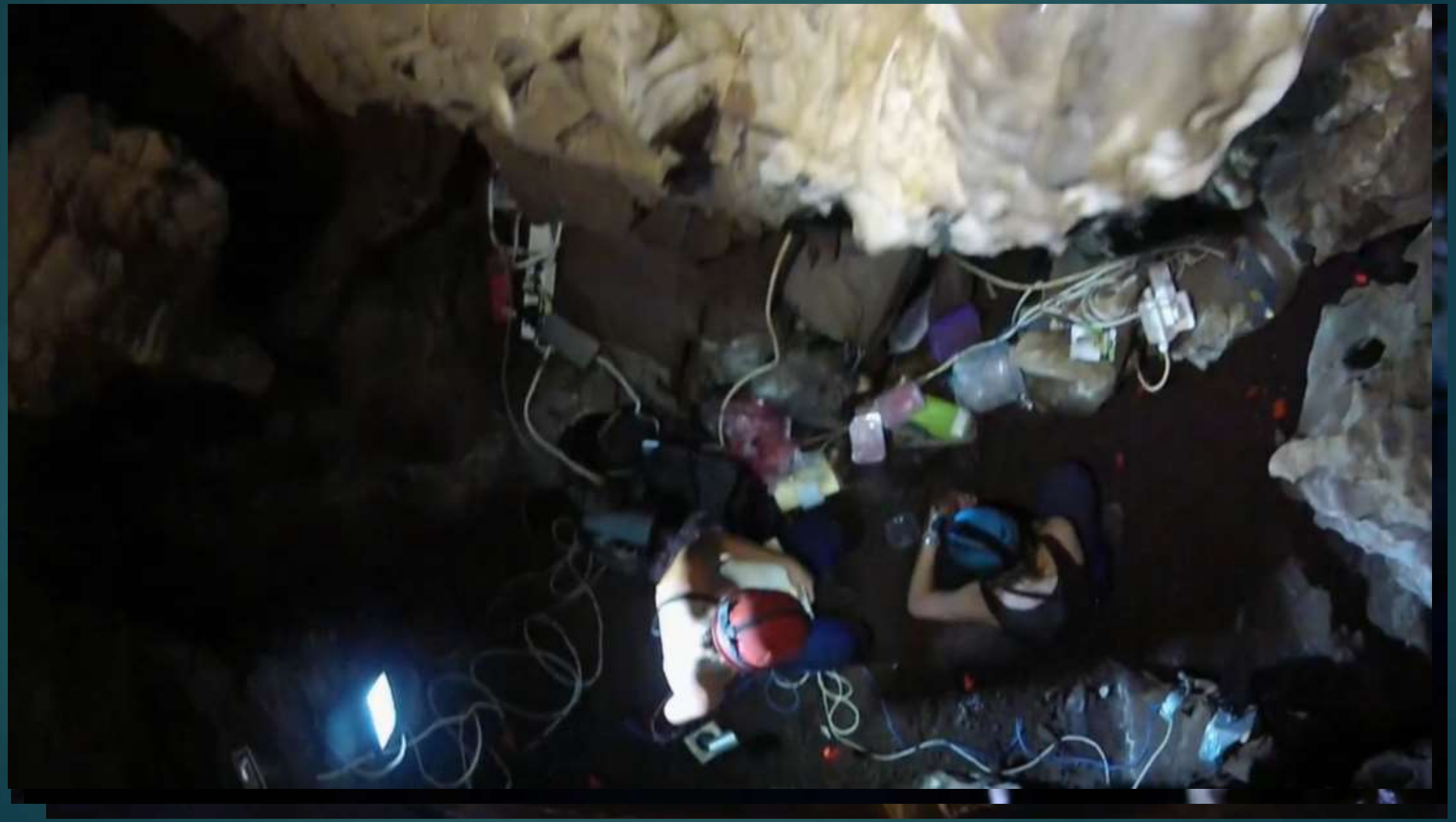
The cave

- So, as we were going along its spine, we would take a harness and rope in and climb along the little ledge next to it. Then you get to the top and you have to climb onto the Dragon's Back, and there's a gap with a little precipice on the other side.

- But there's nothing to hold on to, so you need to just jump over the [about 1-meter-wide] gap — and that was the one part where we were all like, "You'd fall about 12 to 20 meters if you didn't clear the gap.

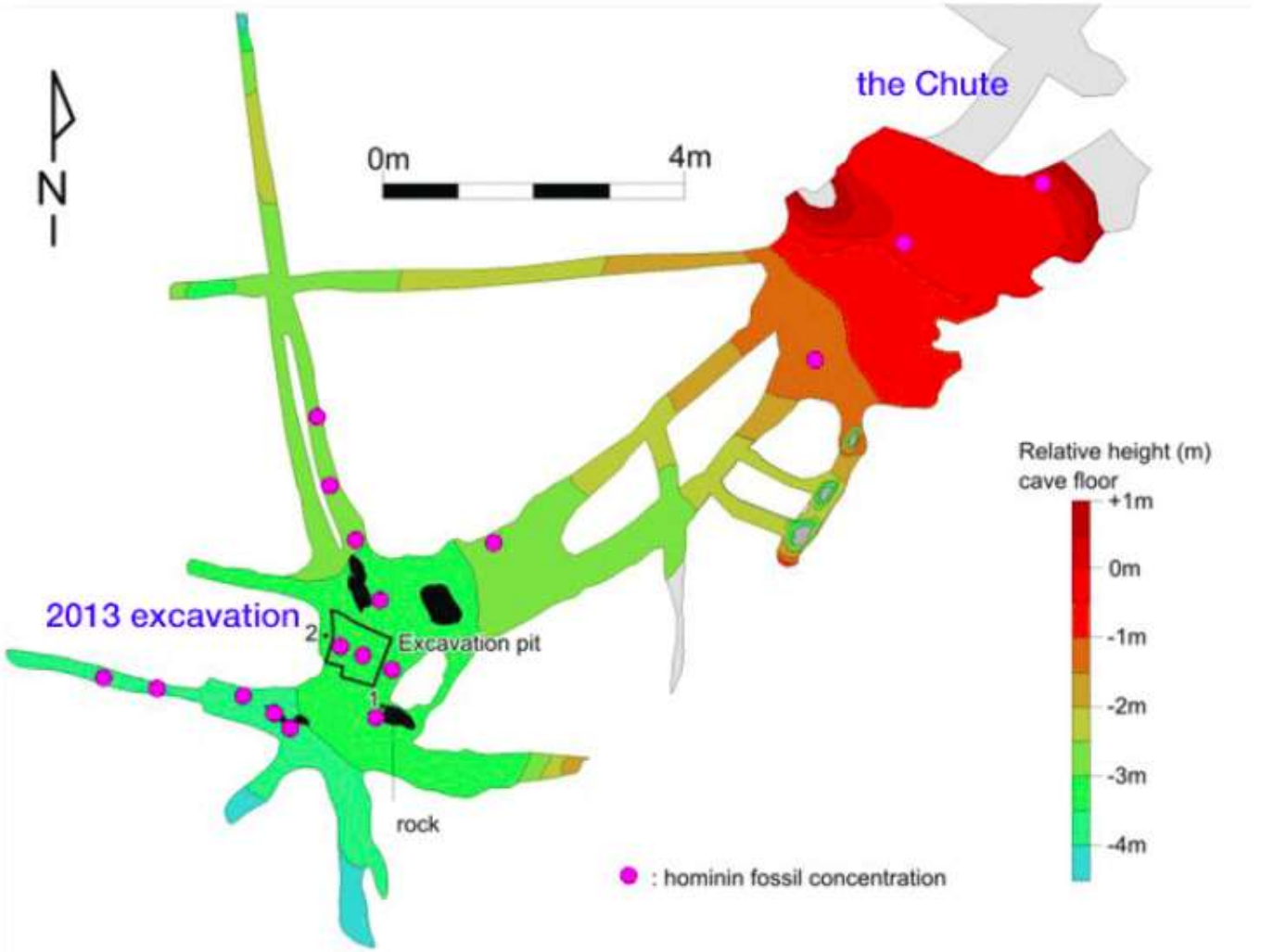
- Then there's a small little labyrinth of formations that you go into, and there's another little gap, and then a crevasse that has the Chute [that leads into Dinaledi Chamber] down at the bottom.

Roof of Dinaledi Chamber




Discovering Homo Naledi: Journey to Find a Human Ancestor, Part 3


NATIONAL
GEOGRAPHIC



Floor plan of the Dinaledi Chamber. Most of the hominin remains come from the very small 2013 excavation area (at left). The team is digging now near the Chute to determine whether remains may be concentrated there also. Hominin remains were located on the surface in the areas with pink dots.

“”Puzzle Box”: jumbled bones in variety of layers in excavation area, labeled by team as “Puzzle Box”

Excavation: The Puzzle Box

- The majority of the material came from a meter by meter square pit excavated to a depth of ~25 cm (10 “).
- Three weeks work in such a space with loose clay is not a speedy endeavor.
- They used two shifts of 2-3 excavators, in six-hour shifts (= 8 weeks in person-time)
- Three surveillance cameras, which were monitored at all times by senior scientists above ground.
- Meticulous protocols set in place before entering the cave and then modified as conditions warranted.

Puzzle Box

- The 3D surface scans (white light laser scanning) and high-resolution forensic camera photos of the process used in lieu of traditional hand-mapping not only have yielded greater detail, but also allow us to “re-dig” the site virtually from any angle.

- In sum, any inference of impropriety or sloppiness in field methods is very easily refuted using solid evidence.

Temperature

- Marina Elliott: "It's pitch dark except for your head lamp and it is very warm. It's an 18 degrees Centigrade (64 degrees F) constant temperature there, but it's actually 99 per cent humidity. So it's very, very damp and sort of smells like warm, moist earth."
- Bones are very wet and need to be dried out.

Excavation limited to 3’ x 3’ of 30-foot chamber

- Berger chose to take only a tiny percentage of what is in the chamber to preserve the context and other aspects of the assemblage for future work at the site, either by current researchers or by teams of scientists years or decades from now.

- Await new technologies, new methods and new techniques that can be applied to the Dinaledi assemblage in-situ as appropriate.

Fly through of Rising Star Cave: https://www.youtube.com/watch?v=vI-JF28T44U

Rising Star Workshop May, 2014

A move to open access and education

- Rising Star excavation has been the most open paleoanthropological project that has ever been attempted.
- Cameras put in the cave, and research streamed live from day one.
- The dig, in November 2013, lasted three weeks; a smaller dig followed in March 2014 for 2 weeks (300 specimens; part of skull and maxilla; full hand and foot). National Geographic live-blogged and tweeted the latest developments.
- May 2014: Facebook invitation for young career scientists with data sets for five weeks

Open Access

- Lee Berger pulled together 40 senior researchers and invited 30 early career PhD researchers to put together the original papers.
- Divided up by anatomic part (Hand Land; Tooth Booth, etc.): each compared to entire fossil record for that part.
- Discovery to publication: under 2 years. First paper involved 47 authors. Second paper included all 3 original spelunkers.
- Both papers are freely available & downloadable from eLife (already 170,000 downloads; whereas 50% of 1.8 M scientific papers published annually are never cited).

Open Access 3

- Berger has been an advocate of paleodemocracy and open access: the idea the fossils should not be held by researchers for 10-25 years (White: Ardi = 1994-2009); that they should be immediately available to other researchers.

- Information on Twitter, Facebook and Hawks Rising Star Expedition blog were immediately available.

- Many of the fossils are now represented by research-quality 3D scans on MorphoSource (1700 downloads in just 1st few weeks).

September, 2015 – The Big Announcement

The New York Times

Thursday, September 10, 2015 | Today's Paper | Video | 75°F | CAC 40 -0.71%

World U.S. Politics N.Y. Business Opinion Tech Science Health Sports Arts Style Food Travel Magazine T Magazine Real

Afghans See U.S. General as Crucial to Their Defense

By ROD NORDLAND and MUJIB MASHAL 5:00 AM ET

Although Afghanistan's forces and officials are supposed to be running the war, Gen. John F. Campbell's prominent role is being widely taken as a sign that the fight against the Taliban is not going well.

Justice Dept. to Put Focus on White-Collar Criminals

By MATT APUZZO and BEN PROTESS

New policies prioritize the prosecution of individual employees and put pressure on corporations to turn over evidence against their

A reconstruction of the skull and hand of Homo naledi, a human ancestor discovered in South Africa.

A New Species of Human Ancestor Is Found

By JOHN NOBLE WILFORD 5:02 AM ET

A cave in South Africa yielded the discovery of a previously unidentified member of the early human lineage — Homo naledi, a new hominin species who seem to have buried their dead.

Your Thursday Briefing

By ARIEL HASSAN 59 minutes ago

The Opinion Pages

A Senseless Delay on the Iran Deal

By THE EDITORIAL BOARD

Republicans seem determined to drag out the fight, even it means neglecting other business.

- **Blow: Hillary Is Hobbling, for Now**
- **Obama's Syrian Nightmare**
- **Collins: A Presidential Primary Cheat Sheet**

ROOM FOR DI
Aiding a Su… End Is Not N…
Should the r… age, incurabl… deep depress… justify helpin…

- **Kristof: Com… Refugees len…**

MORE IN OPIN…
- **Op-Ed: A Sm… Raise Psych…**
- **Join us on F…**

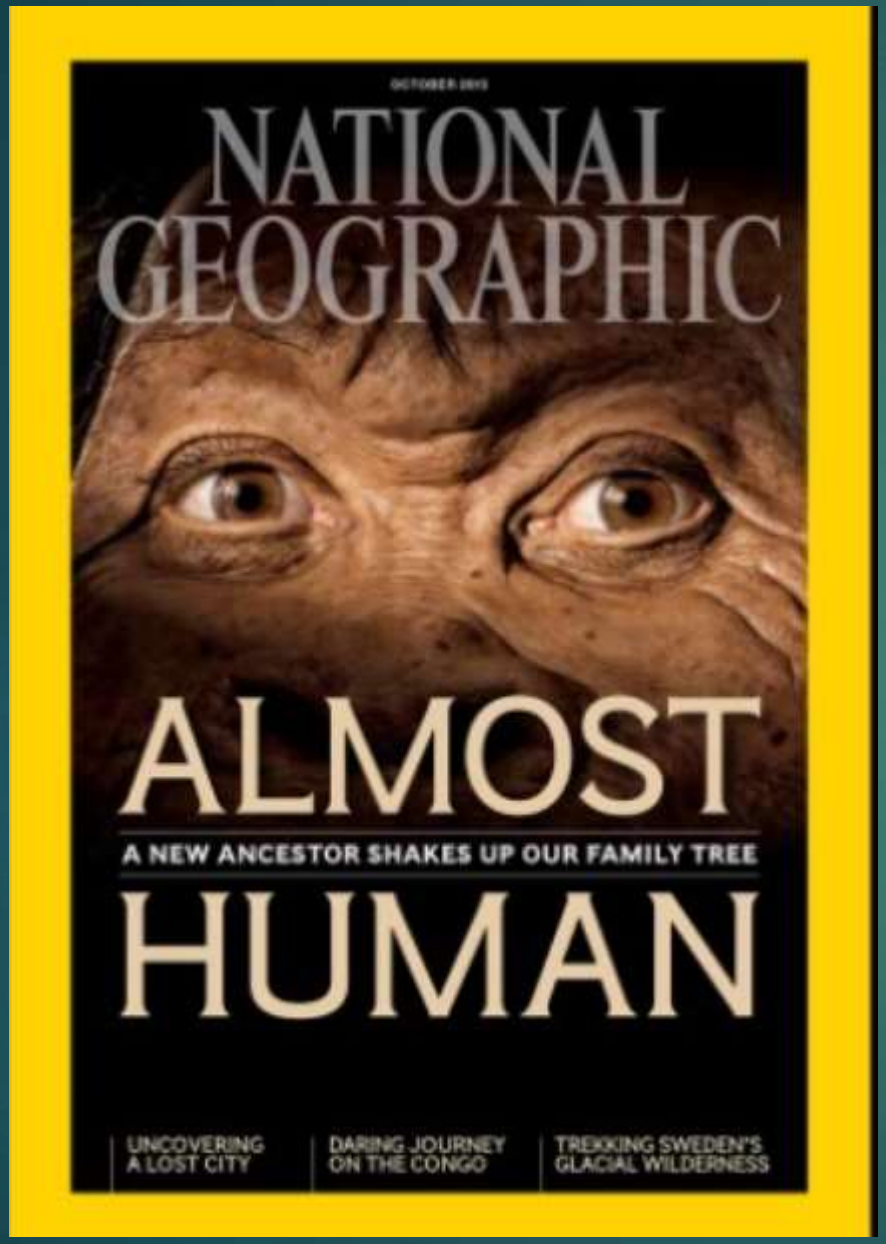
Watching

7h BMI, the music licensing agency, plans to ar… exceeded **$1 billion** in annual revenue for th… The New York Times

8h A 21-year-old New Jersey man pleaded guilty… court to planning to travel abroad with other… York and New Jersey to **join the Islamic Stat…** The New York Times

2015: 4 papers on *Homo naledi* published

- 1 *Homo naledi*, a new species of the genus Homo from the Dinaledi Chamber, South Africa - Lee R Berger, John Hawks, et al. (45 other authors), 2015, *eLife*
- *2* Geological and taphonomic context for the new hominin species *Homo naledi* from the Dinaledi Chamber, South Africa - Paul HGM Dirks, Lee R Berger, et al. (22 other authors), 2015, *eLife*
- 3 The foot of *Homo naledi* - W. E. H. Harcourt-Smith et al., 2015, *Nature Communication*
- *4* The hand of *Homo naledi* - Tracy L. Kivell, et al., 2015, *Nature Communication*



October 2015

Lee Burger and friend

"All the News That's Fit to Print"

The New York Times

VOL. CLXIV . . . No. 56,986 FRIDAY, SEPTEMBER 11, 2015

A Homo naledi skeleton in a bone vault. The fossils were among those found in a nearly inaccessible cave near Johannesburg.

DEMOCRATS HAND VICTORY TO OBAMA ON PACT WITH IRAN

Senate Vote Ensures Nuclear Deal Will Take Effect Without Veto Battle

By JENNIFER STEINHAUER

WASHINGTON — Senate Democrats delivered a major victory to President Obama when they blocked a Republican resolution to reject a six-nation nuclear accord with Iran on Thursday, ensuring the landmark deal will take effect without a veto showdown between Congress and the White House.

A procedural vote fell two short of the 60 needed to break a Democratic filibuster. It culminated hours of debate in the Senate and capped weeks of discord since the United States, Britain, France, Germany, Russia and China announced the agreement with Iran in July.

The debate divided Democrats between their loyalties to the president and to their constituents, animated the antiwar movement on the left and exposed the diminishing power of the Israeli lobbying force that spent tens of millions of dollars to prevent the accord.

"Regardless of how one feels about the agreement," Senator Chuck Schumer, one of four Democrats to vote against Mr. Obama, said on the Senate floor, "fair-minded Americans should acknowledge the president's strong achievements in combating and containing Iran."

Acknowledging the tortured road he and other skeptical Democrats traveled, Mr. Schumer said, "I also have a great deal of respect for the careful thought and deliberation my colleagues went through," adding, "I recognize for them that this is a vote of conscience just as it is for me."

Mr. Obama's triumph in securing the deal — without the support of a single member of the party now in control of Congress — is refashioning the definition of victory for a waning presidency in the era of divided government.

While bipartisan victories tend to be those most celebrated outside of Washington, success by the president is now often measured more by the scope of the policy achieved than by any claim of sweeping consensus. And losing has its own evolving meaning as well. Republicans will use Mr. Obama's triumph — as they did

Continued on Page A10

Cave Yields Addition to the Human Family Tree

A Rich Trove of Fossils From a New Species of Hominin

By JOHN NOBLE WILFORD

Acting on a tip from spelunkers two years ago, scientists in South Africa discovered what the cavers had only dimly glimpsed through a crack in a limestone wall deep in the Rising Star Cave: lots and lots of old bones.

The remains covered the earthen floor beyond the narrow opening. This was the scientific

Further, the scientists said, that sample is probably a small fraction of the fossils yet to be recovered from the chamber. So far the

The finding, like so many others in science, was the result of pure luck followed by considerable effort.

Two local cavers, Rick Hunter and Steven Tucker, found the narrow entrance to the chamber, measuring no more than seven and a half inches wide. They were skinny enough to squeeze through, and in the light of their headlamps they saw the bones all

Swift Apologies In Harsh Arrest Of a Tennis Star

This article is by **Benjamin Mueller, Al Baker and Liz Robbins.**

A New York Police Department officer was stripped of his gun and badge on Mayor Bill de

Pro-Israel Group Went 'All In,' But Suffered a Stinging Defeat

By JULIE HIRSCHFELD DAVIS

WASHINGTON — Officials at the American Israel Public Affairs Committee knew the odds

kill the accord anyway.

On Thursday, the committee, known as Aipac, was handed a

Tearful Anthropologists Discover Dead Ancestor Of Humans 100,000 Years Too Late

'Sadly, There Was Nothing We Could Do,' Scientists Say

NEWS IN BRIEF
September 10, 2015
VOL 51 ISSUE 36
Science & Technology · Science

VP of South Africa: “This reveals our common humanity.”

Open access: research papers and 3-D shape files

eLIFE

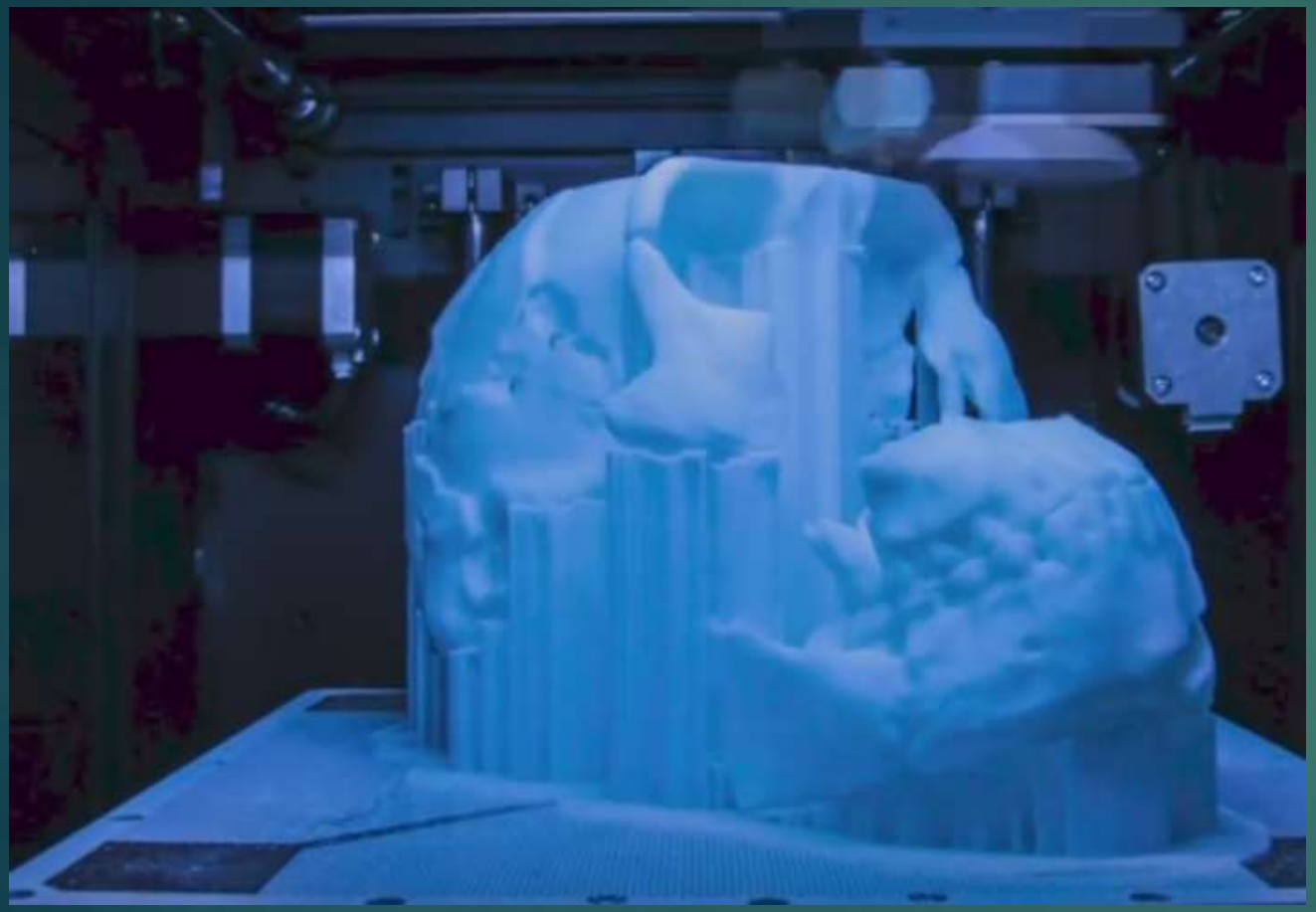
MORPHO SOURCE

100 of best bones from H. naledi downloadable as 3-D shape files

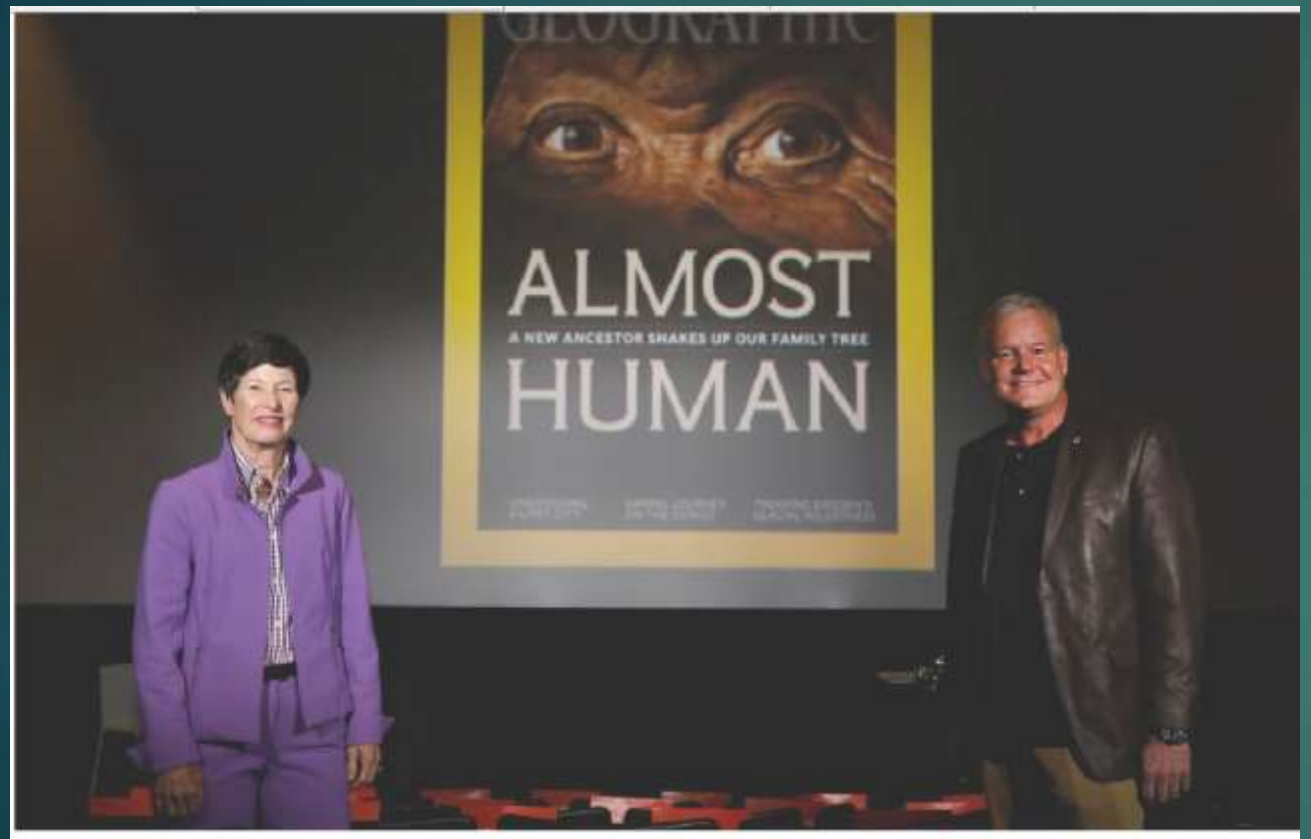
You can 3D Print your own 96 bones from *H. naledi*

- http://morphosource.org/index.php
- Anyone can sign up for a free login and download the shape files, and print them out
- To 3D print other hominin fossils, files at: http://africanfossils.org/

3-D Printing of *Homo naledi* skull



Lyda Hill, Texas oil billionaire, has been in the cave



Lyda Hill and Lee Berger celebrate October issue of National Geographic.

Lee Berger received funding ($2 M) from the National Geographic Society to excavate the site

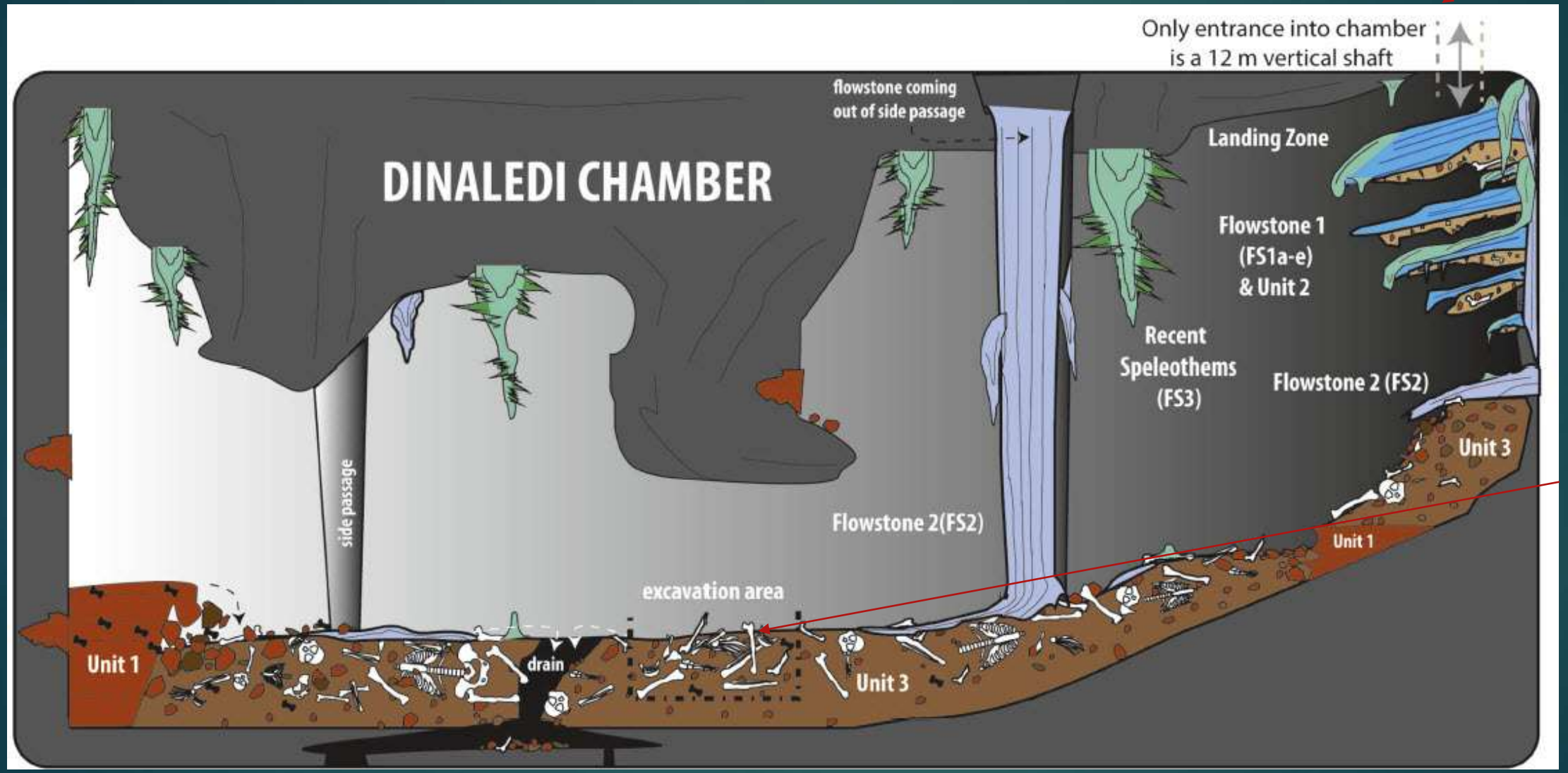
His groundbreaking expedition and research was later financed by nearly $3 million from Lyda Hill, the 73-year-old Dallas billionaire and philanthropist who's the granddaughter of legendary oil tycoon H.L. Hunt. Hill became Big Rich with the sale of her family's Hunt Petroleum Corp. for $4.2 billion in 2008 to Fort Worth-based XTO. Hill was among the first billionaires to sign Warren Buffett's Giving Pledge.

Naledi team (minus Berger): 10,000 hours of research

Worldwide: 100 ongoing collaborators

2015: Dinaledi Chamber (“chamber of many stars”)

Only Entrance



Red unit 1 is Oldest; no bones

1 square meter excavation area

Dinaledi Chamber

- This cave chamber lies some 80 meters from entrance of the Rising Star system,

- Always in constant darkness.

- A periodically wet or water-saturated, dark depositional environment (but with no water movement of bone).

- *H. naledi* fossils entered the chamber over an extended period of time; that is, not all remains were deposited at once

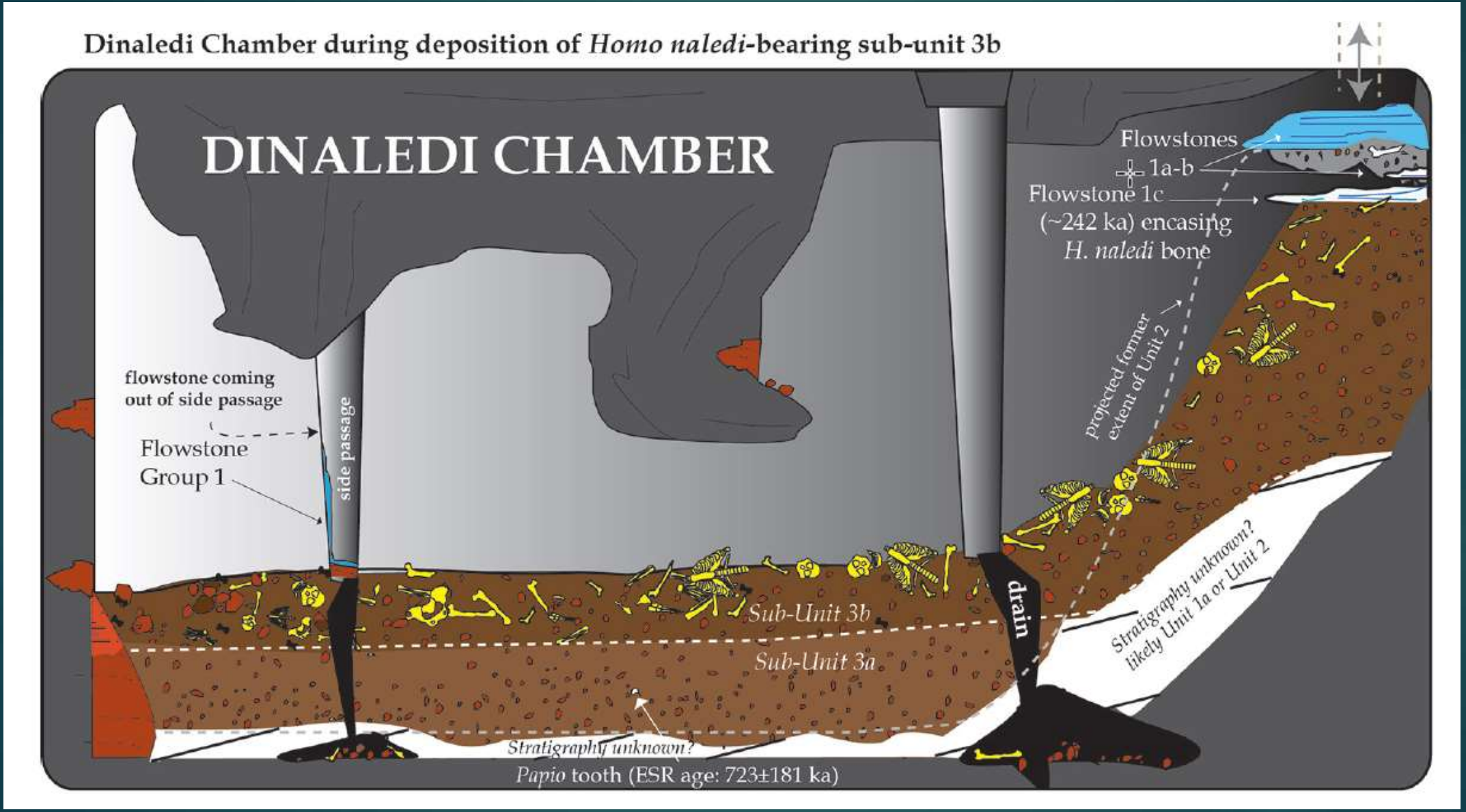
Geology of Chamber

- Orange clay filled Dinaledi chamber first
- Orange clay was removed by water in past. Chamber never saw a rush of water, only rise in water table. There are small drains in floor.
- Hominins came into chamber
- Slowly covered by fine, brown sediment
- Brown sediment extended farther up the walls at some point; surface of sediment with the bones was once higher.

Geology of Chamber

- Sediment has been seeping out of the drains in floor
- Very different sediment particles in Dragon's Back chamber: evidence of extensive entry of outside material; Superman's crawl may not have been there when H. naledi entered.
- Cannot absolutely rule out another entrance to Dinaledi chamber

2017 publication: Dinaledi Chamber during deposition

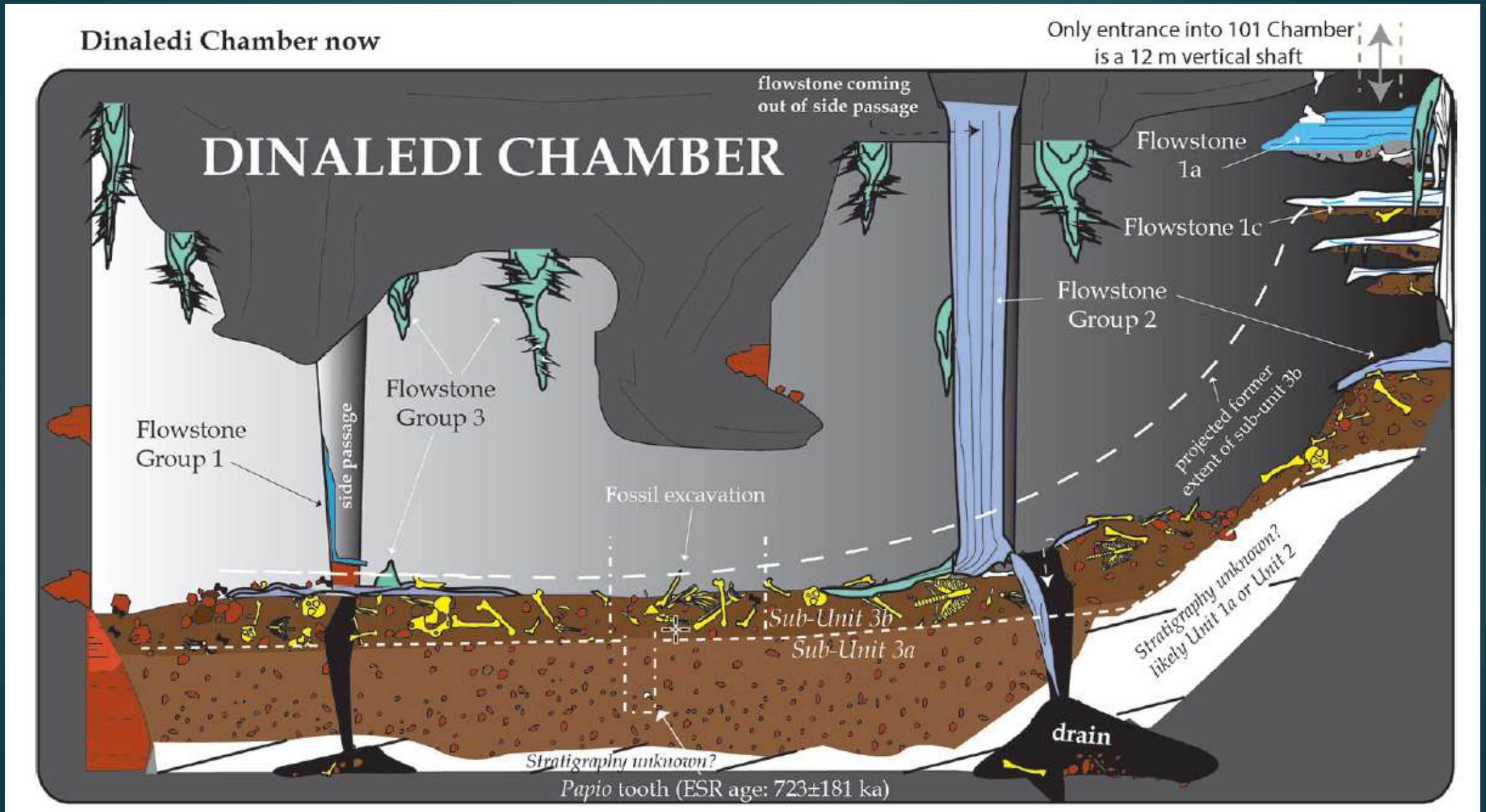


Originally higher debris area

Single baboon bone 800 Ka

Radar Indicates bottom is 2 meters down

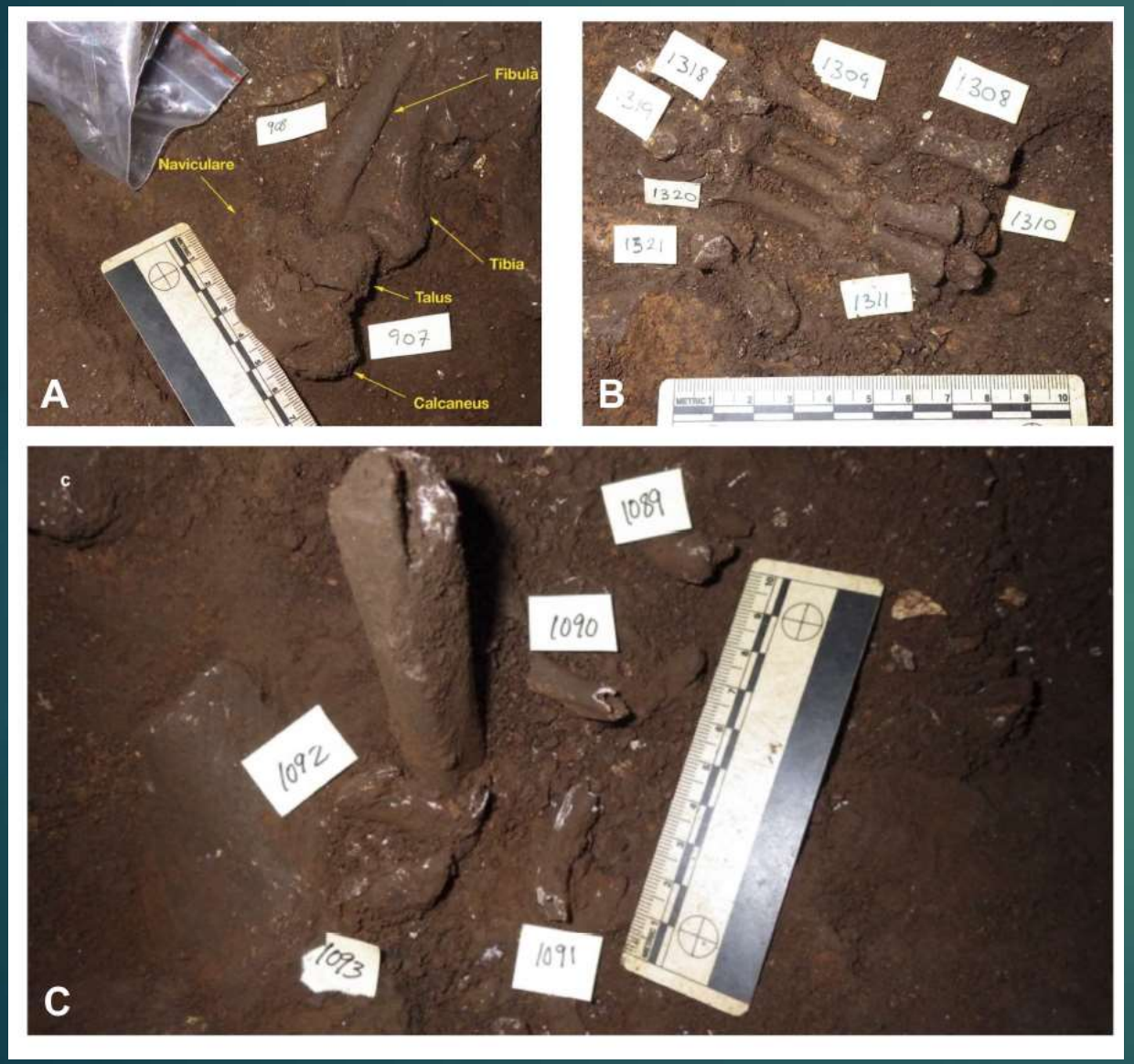
Chamber now


Dinaledi Chamber now
Only entrance into 101 Chamber is a 12 m vertical shaft
flowstone coming out of side passage
DINALEDI CHAMBER
Flowstone 1a
Flowstone 1c
Flowstone Group 2
Flowstone Group 3
Flowstone Group 1
side passage
projected former extent of sub-unit 3b
Fossil excavation
Sub-Unit 3b
Sub-Unit 3a
Stratigraphy unknown? likely Unit 1a or Unit 2
drain
Stratigraphy unknown?
Papio tooth (ESR age: 723±181 ka)

“A sea of bone” just lying on the ground: 400 bones on surface;
“Rick kicked the dirt and hominins fell out”

3D lasered the entire chamber; 30,000 photos of location of bones

Taphonomic spatial patterning



A. Ankle
B. Hand
C. Disarticulated elements in a non-horizontal/vertical resting state.

Continual reworking of Units 2 and 3 due to the gradual erosion of the cave floor as it slumps toward floor drains in the chamber

Erosion in Dinaledi chamber

- Green fracture = when a bone bends and cracks, instead of breaking completely into separate pieces

- The lack of “green fractures” on any of the bone elements in the assemblage suggests that the bodies did not enter the chamber due to catastrophic accident such as falling into the chamber or due to flooding or suffered trauma in any other way shortly before or after death.

- Continual geological reworking of Units 2 and 3 due to the gradual erosion of the cave floor as it slumps toward central floor drains in the chamber

No animal remains

- Except for 6 bones of 1 avian leg & some rodent incisors; avian specimens were part of a group of bones that had been ‘arranged’ on rocks by an unknown caver prior to discovery by our caving team
- Evidence of snail and beetle mandible damage on bones
- Nothing else in the chamber except partially mineralized hominin bones.
- “The lack of other contemporaneous fauna in the assemblage, and complete lack of surface modifications by vertebrates (carnivores, scavengers or rodents) further suggests that the Dinaledi Chamber remained undisturbed by other animals, which could not reach the chamber.”

Initial impressions

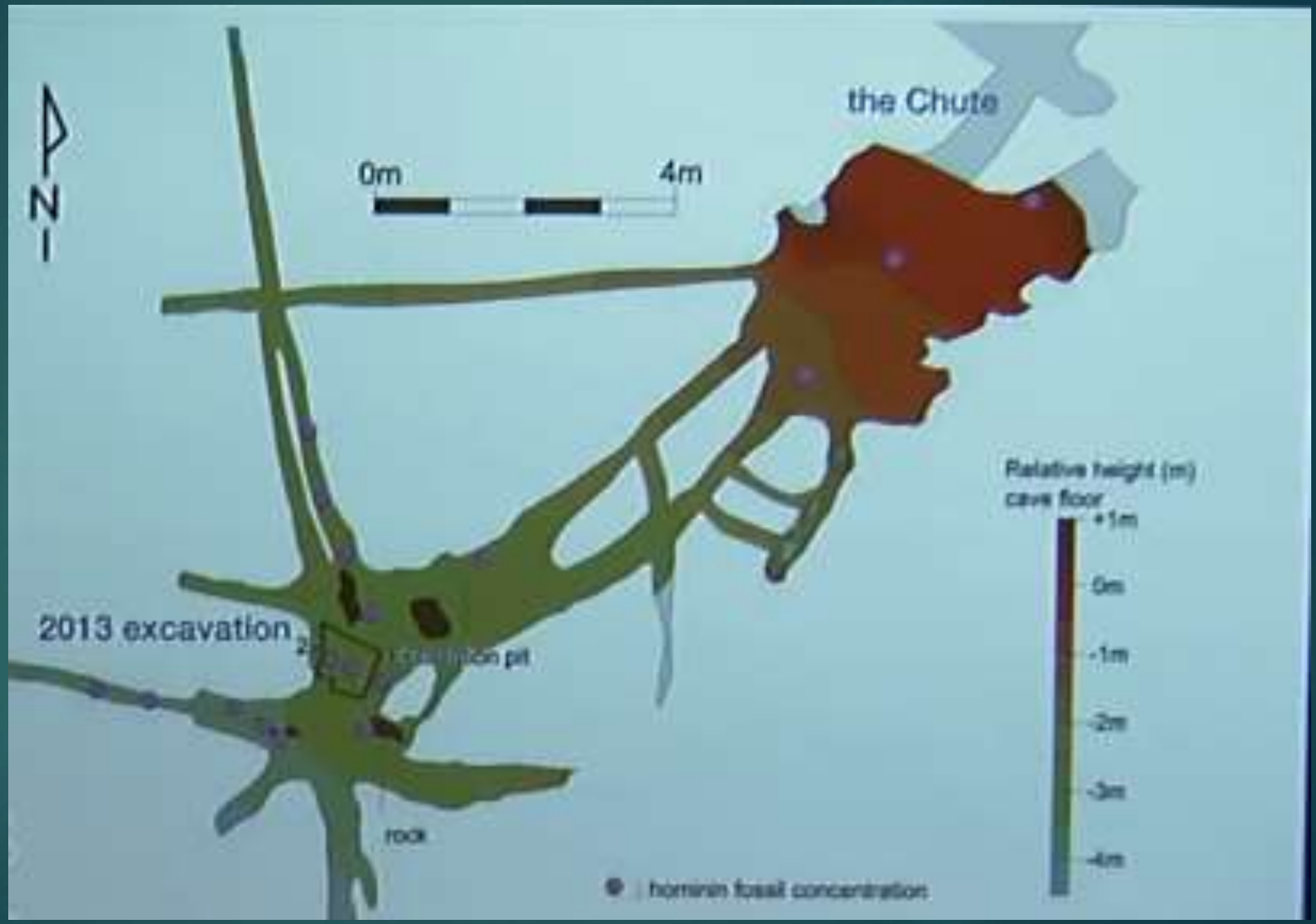
- Initially team believed there was one skeleton.
- On first day brought out the mandible that was on the surface
- Second day they brought out 3 proximal femurs: clearly more than one skeleton
- There is no occupation debris or evidence of occupation within the Dinaledi Chamber, or anywhere else in the Rising Star cave
- No other South African cave has only hominin bones without other fauna. Unlike Sima de los Huesos, Gran Dolina, or Krapina caves.

3-D layer scanning of every bone removal; then labeling and packaging of every bone

Location of fossils

Believe fossils came down the chute;
But main grouping of fossils are 15 meters further down; past 2 thin channels

Bones not eaten, nor flowed in water (no wash of gravel)



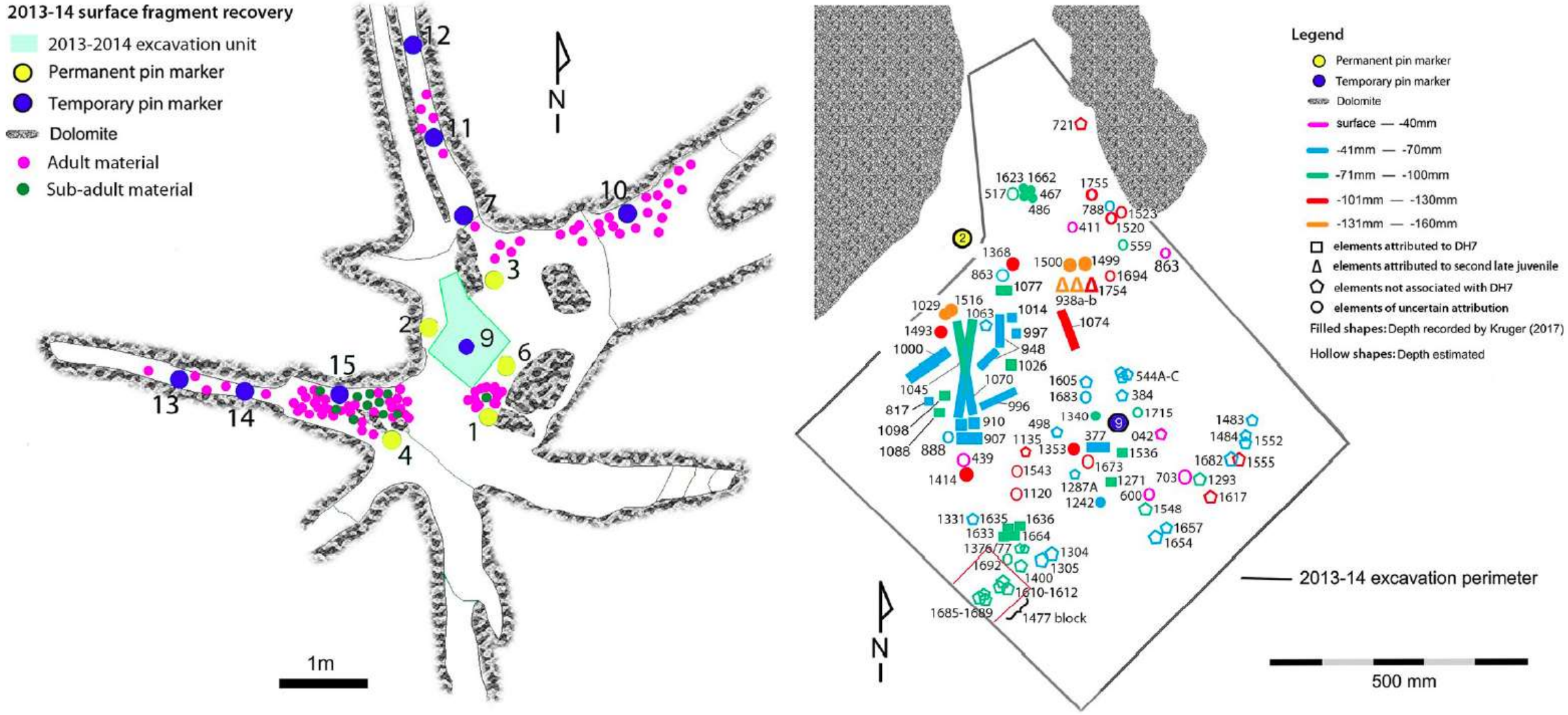


Fig 1. Fossil distribution. A) Schematic of the Dinaledi Chamber floor area, showing the distribution of adult and immature material recovered from the surface during the 2013–2014 expedition; B) All immature postcranial specimens recovered from the excavation pit by accession number and depth level.

Latest look at bottom of Dinaledi Chute

- Rectangular section at base of Chute: crushed skull with few maxillary teeth, then 20 cms lower down, an articulated hand, articulated rib cage, shoulder; all in wet sediment

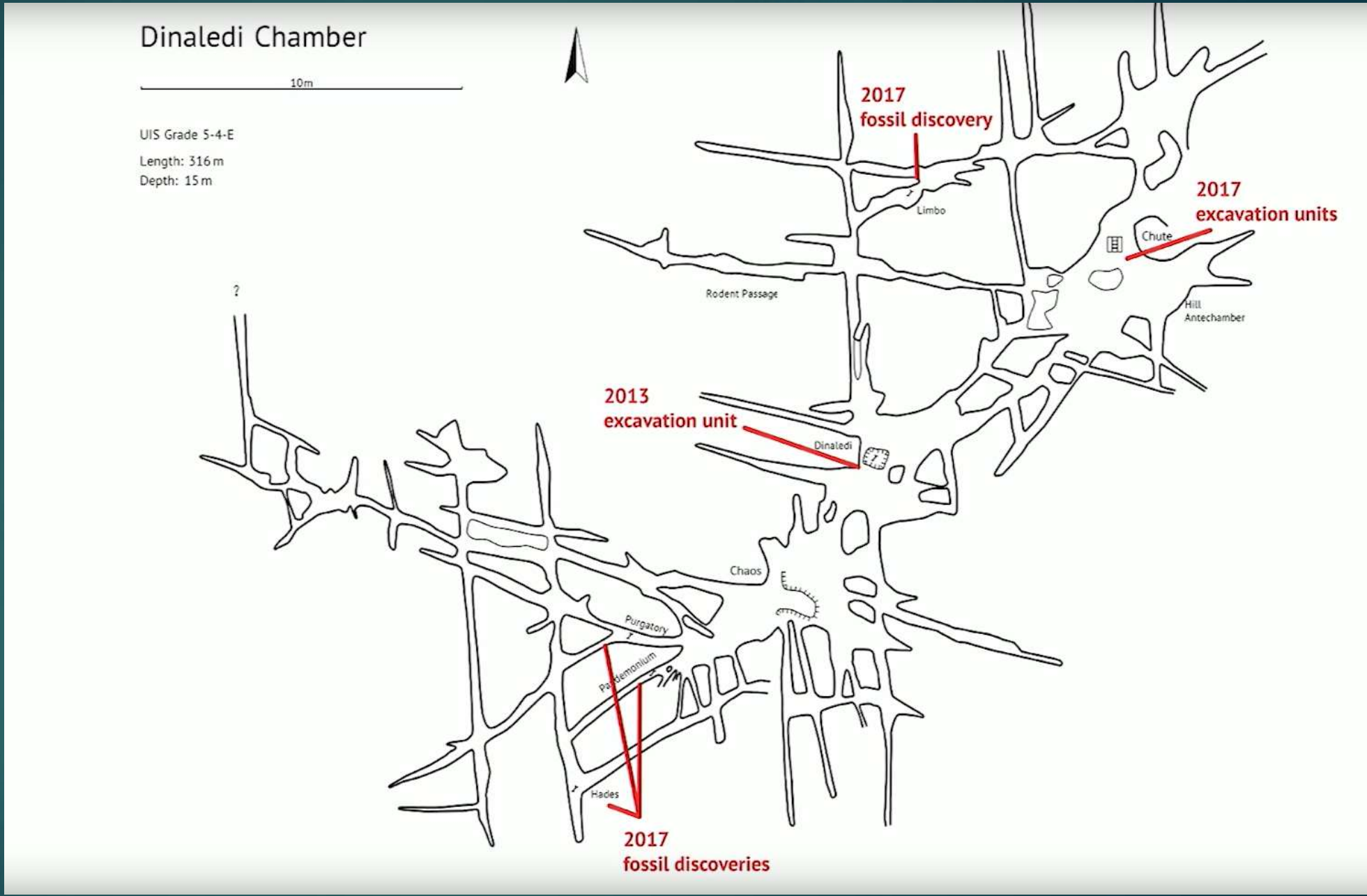
- Believe there is a partial hominin skeleton there that needs to be fixed and removed as a whole

- Dead end side channels like Hades have bones at 30 meters from Chute

Latest study areas of Dinaledi: Hades, Limbo, Purgatory, Pandemonium dead end shafts.

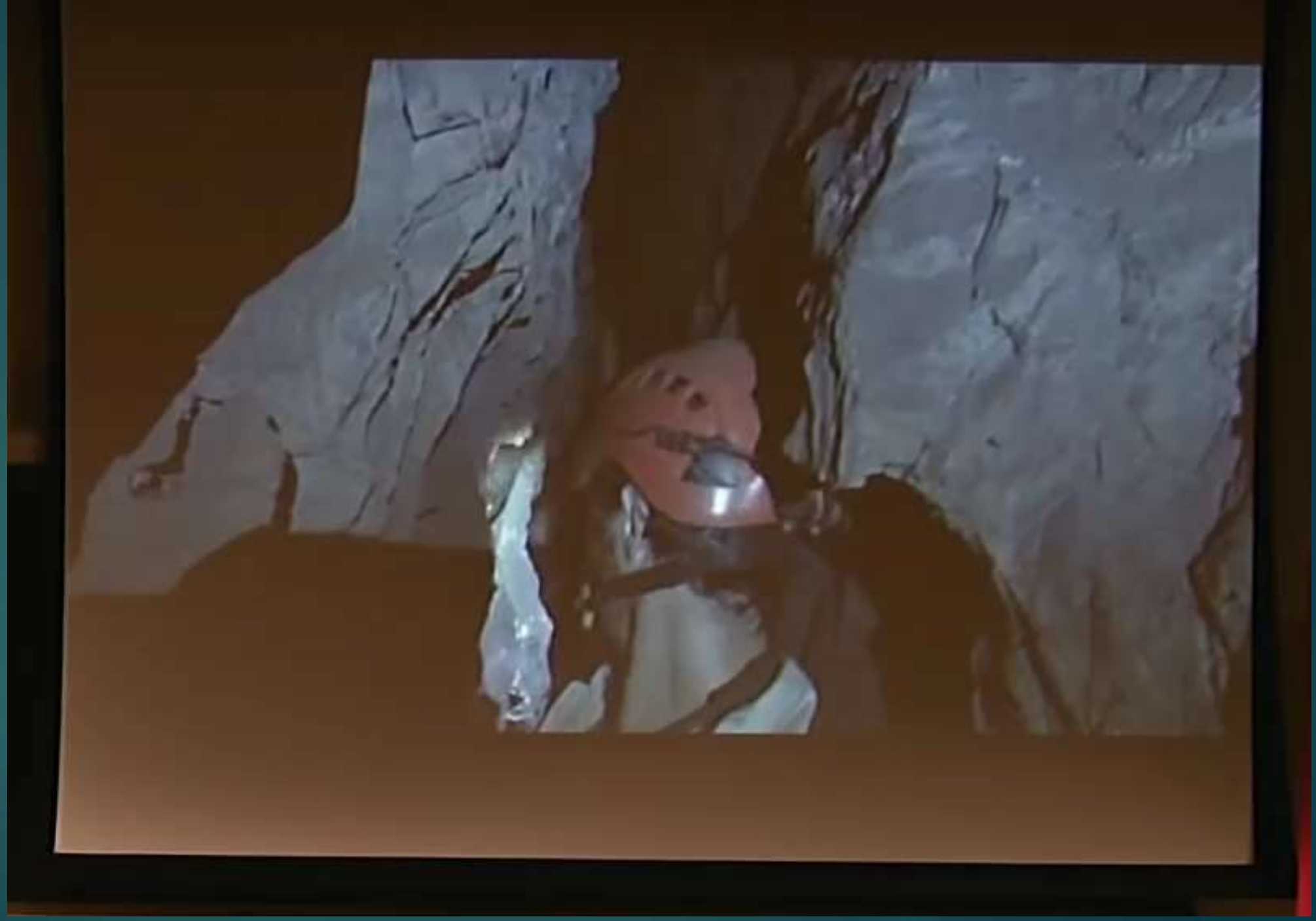
Very tight squeezes; Difficult to get into; only best, smallest cavers; hominin remains there

Why there?



Hades

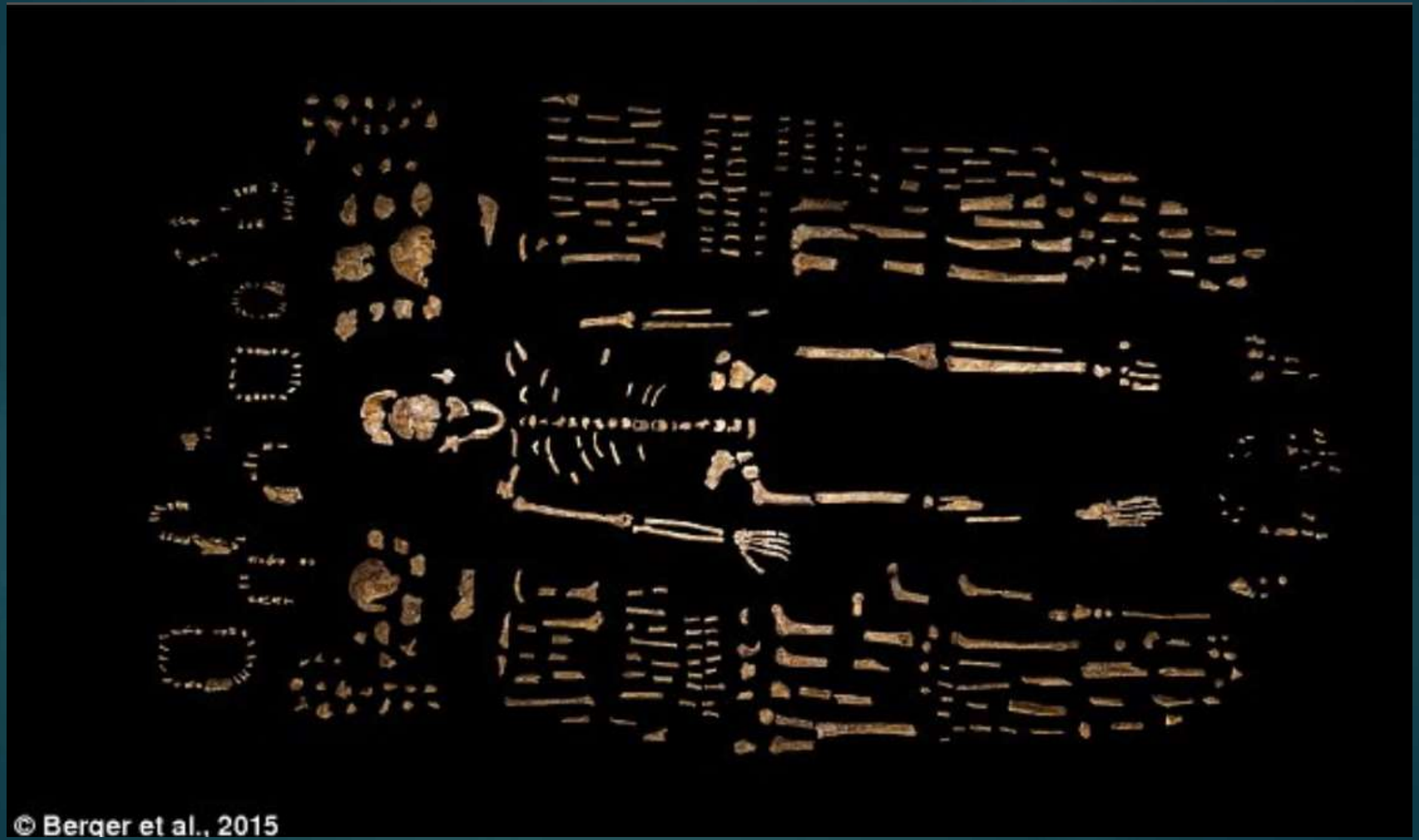
Hades & Purgatory



2014: *Homo naledi:* 15 separate individuals in1550 bones collected in first sweep of surface (400 bones) and an excavation of 1 square meter x half a foot (1150 bones)

Dinaledi skeletal specimens:

- 737 partial or complete anatomical elements
- Now 25 individuals; 2000 bones
- Sterkfontein: 700 bones in
- 70 years


© Berger et al., 2015

Homo naledi: Multiple samples of same bone

Parts of 5 Skulls. Jaws.

150 hand bones
48 rib bones
40 pelvic bones

190 teeth = 15 (now 25) individuals.

100 foot bones: A nearly complete foot.

3 bones of the inner ear.

The room where it happened…

- In Johannesburg,
  - the Center for Human Origin
  - New addition: Evolutionary Studies Institute (ESI),
  - This is a brand new and among the largest of its kind paleoanthropological research institute.
- The room in which *H. sediba* and *H. naledi* are kept is an air, temperature, and humidity regulated vault where all fossils are kept and locked up.
- Also a new industrial-sized high resolution CT scanner that allows the researcher to determine what is inside rocks.

Evolutionary Studies Institute (ESI)

Humanlike: Skull, hands, feet

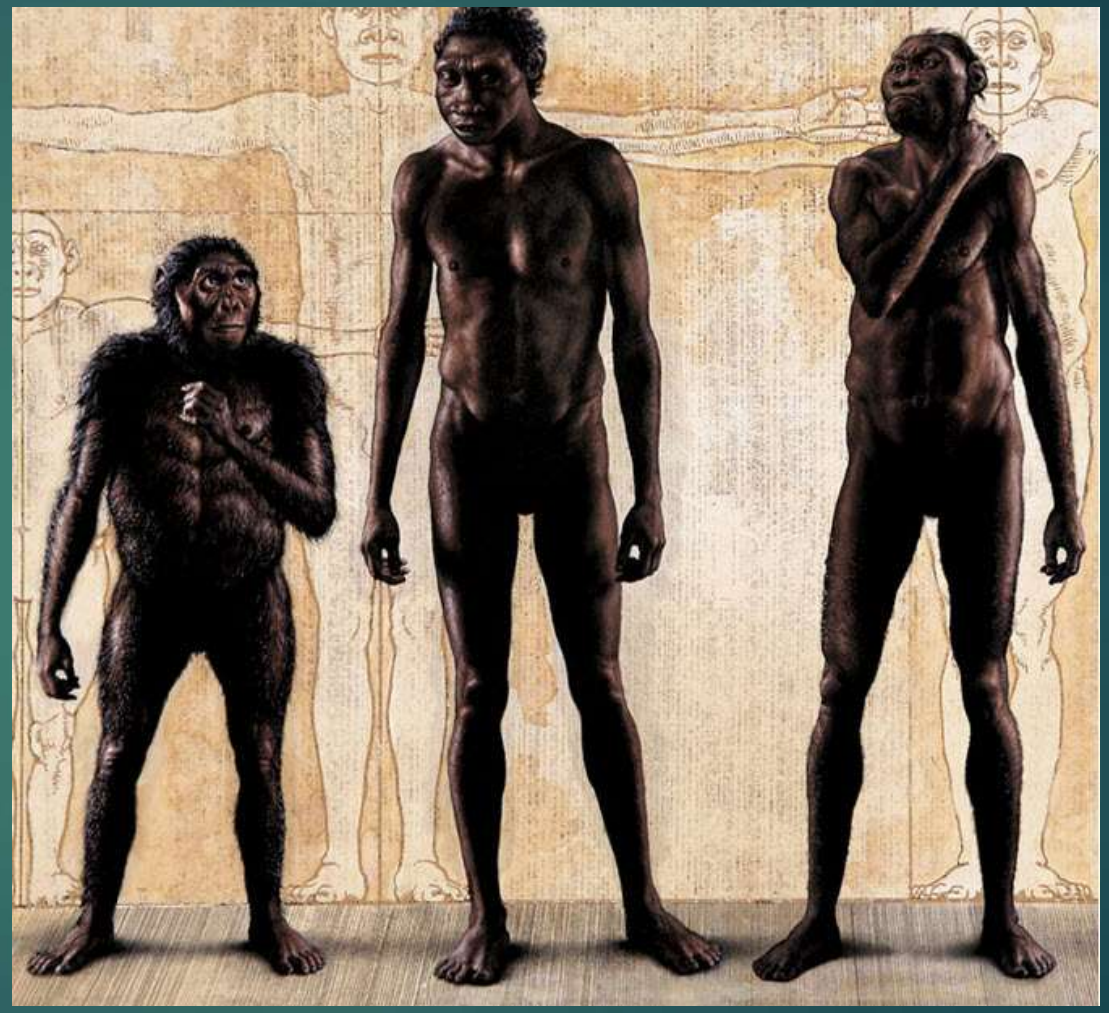
Homo naledi: an anatomical mosaic – both australopithecine and human like

All African fossil partial skeletons

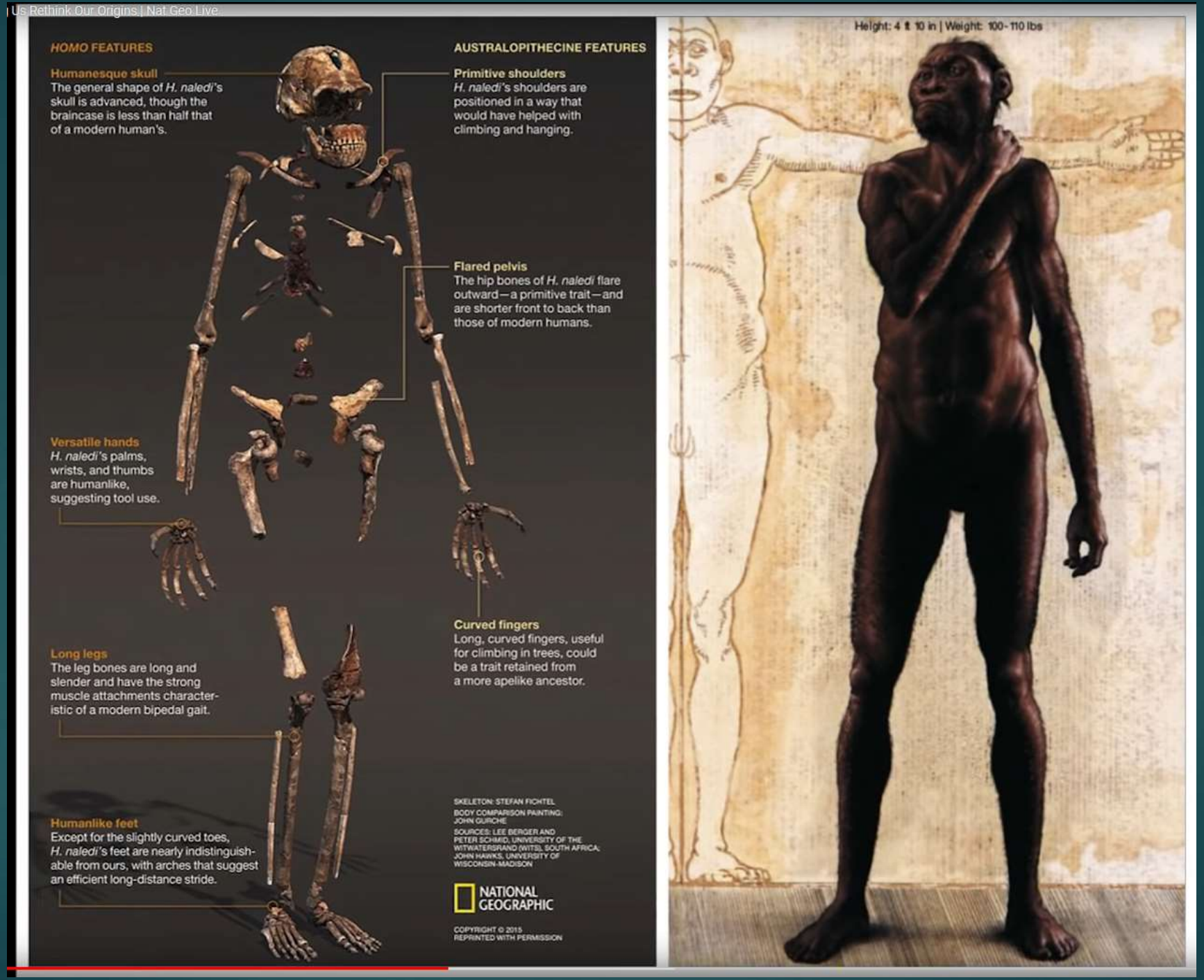
Turkana Boy Lucy Male *A. afarensis* *A. africanus* *A. sediba*

Homo naledi: 1.5 Meters (5 feet) tall, 100 lbs

Skinny, humanlike arms, apelike thorax, ancestral pelvis, long legs, humanlike feet



"Lucy"	"Turkana Boy"	"Rising Star Hominin"
Australopithecus afarensis	*Homo erectus*	*Homo naledi*
3.2 million years ago	1.6 million years ago	Date Unknown
Adult Female	Adolescent Male	Adult Male
3 ft 8 in	5 ft	4 ft 10 in
60-65 lbs	110-115 lbs	100-110 lbs


HOMO FEATURES
Humanesque skull
The general shape of H. naledi's skull is advanced, though the braincase is less than half that of a modern human's.
Versatile hands
H. naledi's palms, wrists, and thumbs are humanlike, suggesting tool use.
Long legs
The leg bones are long and slender and have the strong muscle attachments characteristic of a modern bipedal gait.
Humanlike feet
Except for the slightly curved toes, H. naledi's feet are nearly indistinguishable from ours, with arches that suggest an efficient long-distance stride.
AUSTRALOPITHECINE FEATURES
Primitive shoulders
H. naledi's shoulders are positioned in a way that would have helped with climbing and hanging.
Flared pelvis
The hip bones of H. naledi flare outward—a primitive trait—and are shorter front to back than those of modern humans.
Curved fingers
Long, curved fingers, useful for climbing in trees, could be a trait retained from a more apelike ancestor.
SKELETON: STEFAN FICHTEL
BODY COMPARISON PAINTING: JOHN GURCHE
SOURCES: LEE BERGER AND PETER SCHMID, UNIVERSITY OF THE WITWATERSRAND (WITS), SOUTH AFRICA; JOHN HAWKS, UNIVERSITY OF WISCONSIN-MADISON
NATIONAL GEOGRAPHIC
COPYRIGHT © 2015
REPRINTED WITH PERMISSION
Height: 4 ft 10 in | Weight: 100-110 lbs

Age distribution:

- Originally 13 (now 25) individuals of practically every developmental age, from neonate to elderly:
  - 3 infants (1 fetus; Infants were identified by their thimble-size vertebrae),
  - 3 young juveniles,
  - 1 old juvenile,
  - 1 sub-adult,
  - 4 young adults and
  - 1 old female adult
- 8 of 13 were not adult (implication: not repeated cave exploration by socially isolated adult males)

A side note on terminology: “Primitive” vs “advanced” features

- Describing an organism or trait in “primitive” vs “advanced” terms, promotes the misconception that evolution proceeds along a direct path, with organisms getting increasingly "advanced" or "complex" over time.
- This sort of ladder-of-life thinking does not accurately reflect how evolution works.
- Every species that has lived had traits shaped by its environment over time in a way that enhanced its chances of passing on its genes to the next generation.
- No one species or trait is inherently superior to another.

UC Berkeley: Understanding Evolution

“Ancestral to” or “more derived”: plesiomorphic vs apomorphic

- A better way to describe a species or a trait is as either “ancestral to”, or “more derived” than another species or trait.
- Ancestral = older trait; Derived = newer trait
- Derived trait (apomorphic)/newer: a trait that has changed since the time of a common ancestor.
- The term *syn*apomorphy refers to an apomorphy shared by a group; i.e. for hominins, for example, greatly reduced canine teeth.
- Male chimpanzees and other close non-hominin relatives have huge canine teeth, probably used in threat displays. Hominins do not have this character, suggesting that the trait changed sometime after the hominin lineage and chimpanzee lineage split.

Plesiomorphic vs apomorphic

- Ancestral trait (plesiomorphic): a character that has been inherited from a common ancestor and has remained unchanged, i.e. for the genus *Homo* is an opposable thumb. All members of *Homo* have one, as do all other hominins and primates, suggesting that the groups inherited this trait from a common ancestor.

- When discussing apomorphies and plesiomorphies, it is important to keep context in mind. Whether a trait is ancestral or derived changes depending on the groups you are comparing. A small canine tooth is a synapomorphy/derived for hominins, but it'd be considered a plesiomorphy/ancestral for the genus *Homo* when compared to other hominin groups.

Ancestral (not “primitive”) vs “derived”

- In the case of *Homo naledi*, apomorphies (derived traits) that suggest its placement within the genus *Homo* include certain characteristics of its cranial structure and dentition, which appear derived from earlier hominin species.

- The hands suggest finely tuned motor skills, and the small teeth suggest a diet of high-quality foods, such as meat and tubers.

- The feet are also apomorphic/derived with other *Homo* species and suggest *Homo naledi* was capable of walking efficiently for long periods

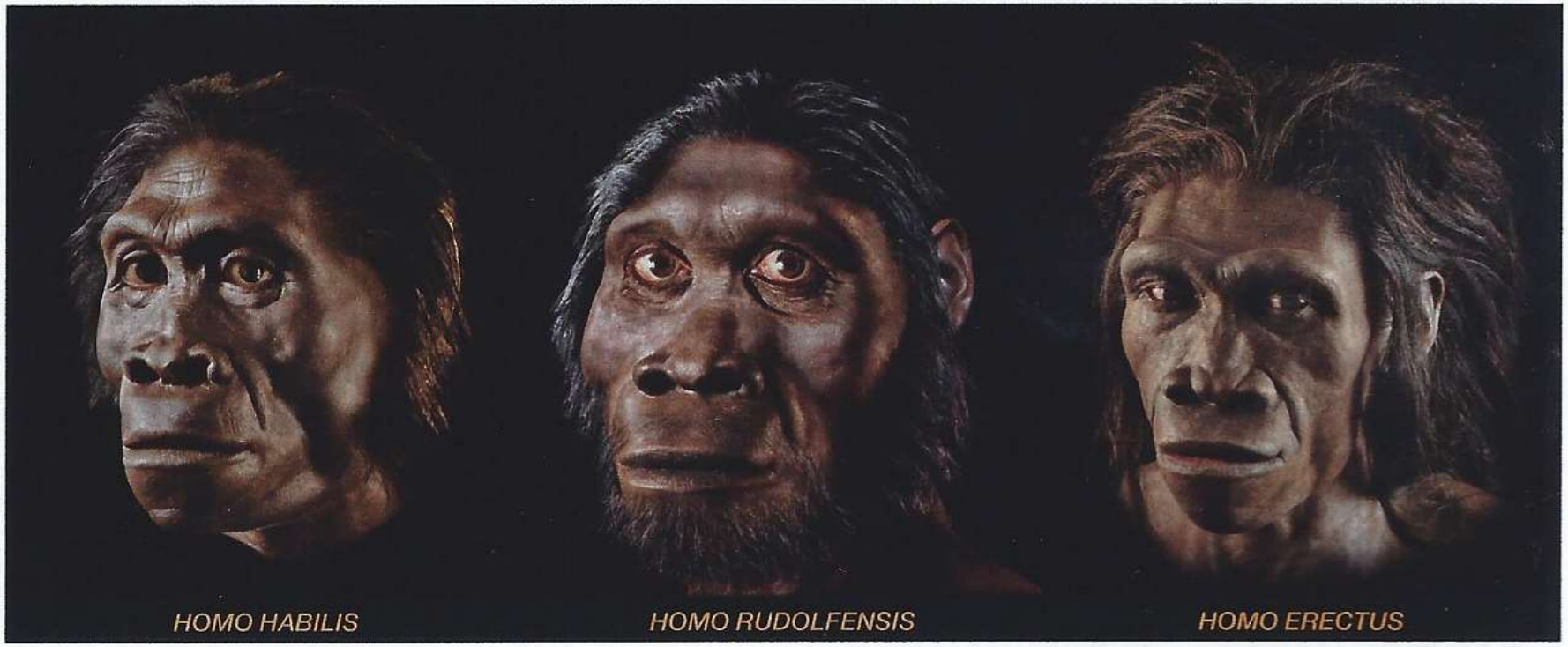
H. naledi: ancestral (not “primitive”) traits

- Ancestral characteristics: its small cranial capacity, short shoulder blades that sit high and wide on the trunk, and its flared upper pelvis, compared to later hominin species. These traits are plesiomorphies (ancestral), and would suggest its placement outside of the *Homo* genus.

- Every species is a mix of ancestral and derived traits.

- The important point is not that it had a mix of traits, but that its particular mix of traits is different from all other known hominins.

A bush of 3 different *Homo* species appear circa 2 Ma: no “linear” progression toward modern humanness



A trio of other *Homo* species, all first appearing in the fossil record around two million years ago, argues against a linear progression toward humanness—a message underscored by *H. naledi*’s unique blend of primitive and advanced traits.

IMAGES NOT TO SCALE

No march of progress in human evolution

- The existence of such anatomical mosaics is not a problem; they are an expected result of evolution.

- Anthropologists once assumed that the species of *Homo* could be placed in a rough order of increasing brain size. But this ‘march of progress’ assumption is false.

- Species with small brains lived both early and late in the evolution of *Homo: H. habilis, H. naledi,* and *H. floresie*nsis,

No march of progress in human evolution

- Smaller teeth in our genus: higher-quality foods and tool use became more important.

- Traditional view: tooth size had a similar trend as brain size in human evolution.
  - *Australopithecus africanus*, had small brains and large premolar/molar teeth.
  - Succession of *Homo* species followed an opposite trend toward smaller tooth size and larger brain size, from *H. habilis* to *H. erectus* to archaic and modern humans.

No march of progress in human evolution

- Theory that larger-brained hominins were able to find and eat more high-quality foods, prompting the evolution of smaller teeth.
- Processing foods using tools or cooking led to evolution of smaller teeth.
- Cooking caused the human lineage to evolve smaller teeth. The underlying idea is that smarter hominins found ways to sustain themselves that substituted cleverness and food processing for tooth wear, so that larger brains and smaller teeth came to be related to each other.

No march of progress in human evolution

- *H. naledi* violates this theory. It had small teeth, but also a small brain. It was similar to MHs in its tooth sizes and had substantially smaller molar teeth than ancestral species like *H. habilis.*

- In other words, the anatomy of H. *naledi* and what we know about its behavior suggest that it shared a similar ecological niche as archaic and modern humans.

- The traditional view would predict that *H. naledi* should have been wiped out by larger-brained humans.

H. naledi: a mosaic

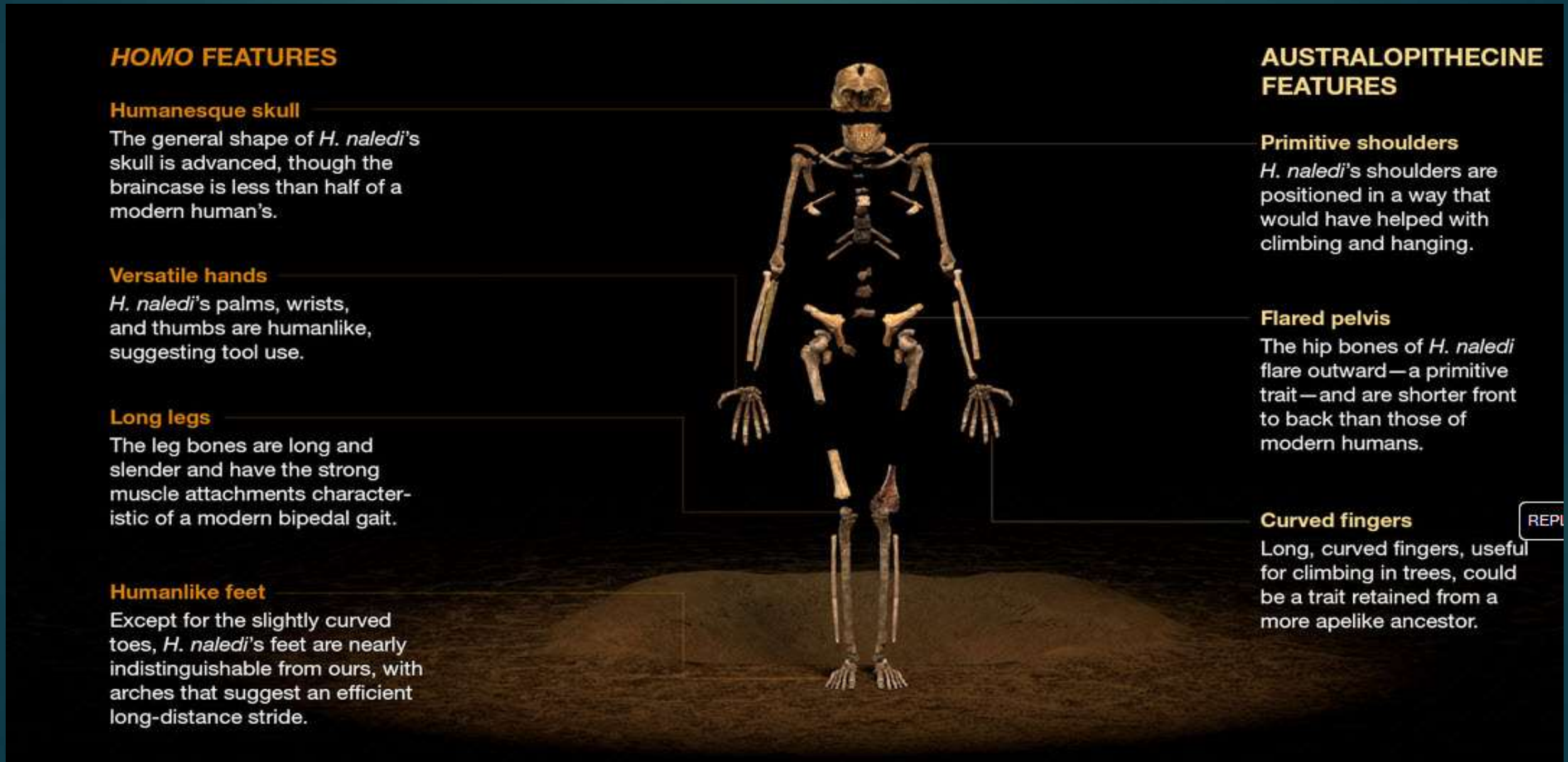
- *H. naledi* exhibits mosaic traits:
  - Ancestral anatomical features shared with Australopithecus,
  - Derived features shared with *Homo*,
  - with several features not otherwise known in any hominin species.

- This anatomical mosaic is reflected in different regions of the skeleton.

- The overall morphology of *H. naledi* places it within the genus Homo rather than Australopithecus or other early hominin genera.

H. naledi is humanlike: Feet, hands, teeth: anything that interacts with environment is *Homo,* derived

Homo naledi: an anatomical mosaic

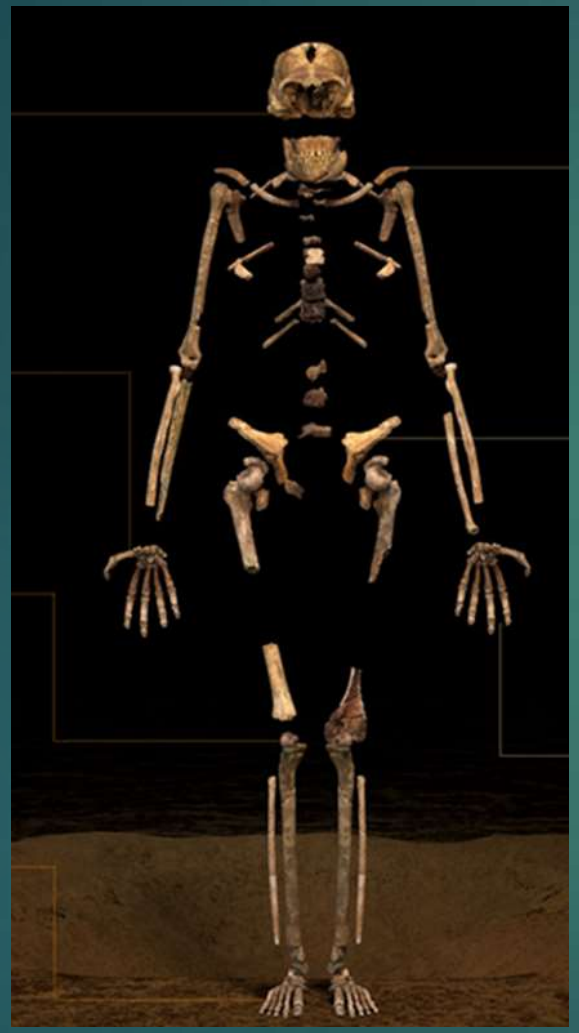


Skeleton: *H. naledi* vs. *A. sediba*: mirror reversal mosaics

H. naledi:

Derived:
skull,
teeth
legs
feet,
hands

Ancestral;
shoulders
thorax,
pelvis
curved
fingers
small brain



A. sediba:

Derived:
skull,
pelvis

Ancestral:
Feet
hands

A. sediba vs *H. naledi*: Another challenge to traditional concepts

- *A. sediba* was found a few kilometers away:
- *Naledi* is almost the mirror of *sediba*.
  - Where you see ancestral features in *sediba*, in *naledi* you see derived;
  - Everywhere that *sediba* is derived, *naledi* is ancestral.

- Researchers have been operating under the assumption that the signature features of Homo— such as a toolmaking hand, big brain and small teeth— evolved in concert.

- *A. sediba and H. naledi* show that things we thought evolved together did not.

An animal right on the cusp of the transition from Australopithecus to *Homo*

- Age was originally unknown; Berger believed *H. naledi* was old: Its trait mix hinted at a species close to the origin of the genus *Homo*, between 2 to 3 million years ago.

- The shoulders were apish & the widely flaring upper blades of the pelvis were similar to Lucy's—but the bottom of the same pelvis looked like a modern human.

- The leg bones started out shaped like an australopithecine's but gathered modernity as they descended toward the ground.

- The feet were virtually indistinguishable from *H. sapiens*.

Mosaic

- Its shoulders, hips, and torso hark back to earlier ancestors, while its lower body shows more humanlike adaptations.
- You could almost draw a line through the hips—ancestral above, modern below.
- The skull and teeth show a mix of traits.

Movement: bipedal and arboreal

- *H. naledi* anatomy indicates that, though they were capable of
  - long distance travel with a humanlike stride and gait,
  - they were more arboreal than other *Homo*,
  - better adapted to climbing and suspensory behavior in trees than endurance running.

A schizoid creature: a mix of ancestral & modern features

- Australopithecine like: the small brain size (550 cc), curved fingers and canted up shoulder, trunk and hip joint (widely flaring blades of the pelvis), top of legs, resemble the australopithecines and *Homo habilis*.

- Homo like: thumb, wrist, and palm bones, bottom of the pelvis, lower legs and feet look most like those of Neanderthals and modern humans; cranium has frontal bossing & a marked degree of parietal bossing. No indication of a sagittal crest or temporal/nuchal cresting

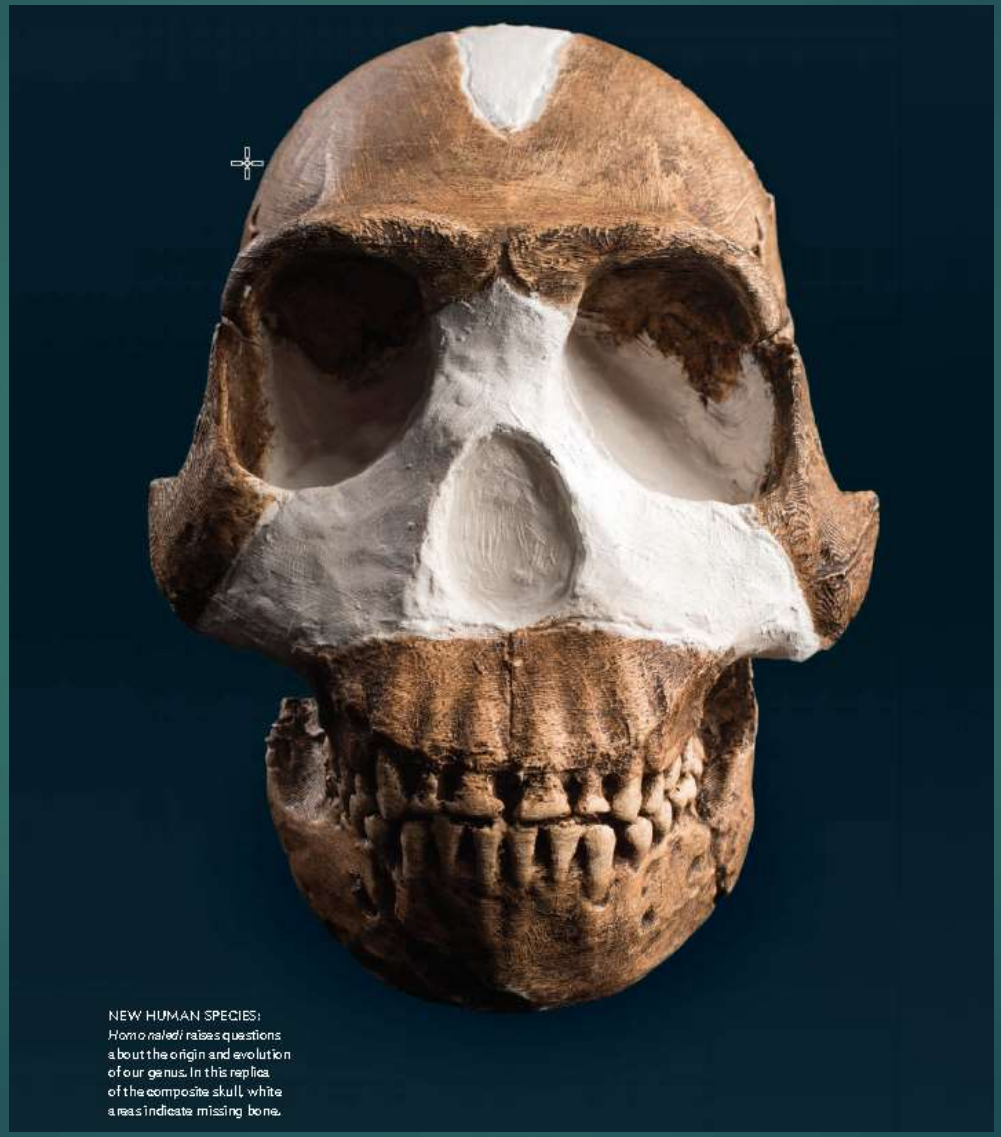
- Vertebrae are most similar to genus *Homo,* whereas the ribcage is wide distally like *Au. afarensis*

Was *Homo* polyphyletic?

- Polyphyletic = derived from more than one common evolutionary ancestor
- Chris Stringer: “The mosaic nature of the *H. naledi* skeletons provides yet another indication that the genus *Homo* had complex origins. The individual mix of earlier and derived characteristics in different fossils perhaps even indicates that the genus *Homo* might be ‘polyphyletic’: in other words, some members of the genus might have originated independently in different regions of Africa.

- If this is the case, it would mean that the species currently placed within the genus *Homo* would need to be reassessed.”

Homo naledi cranium

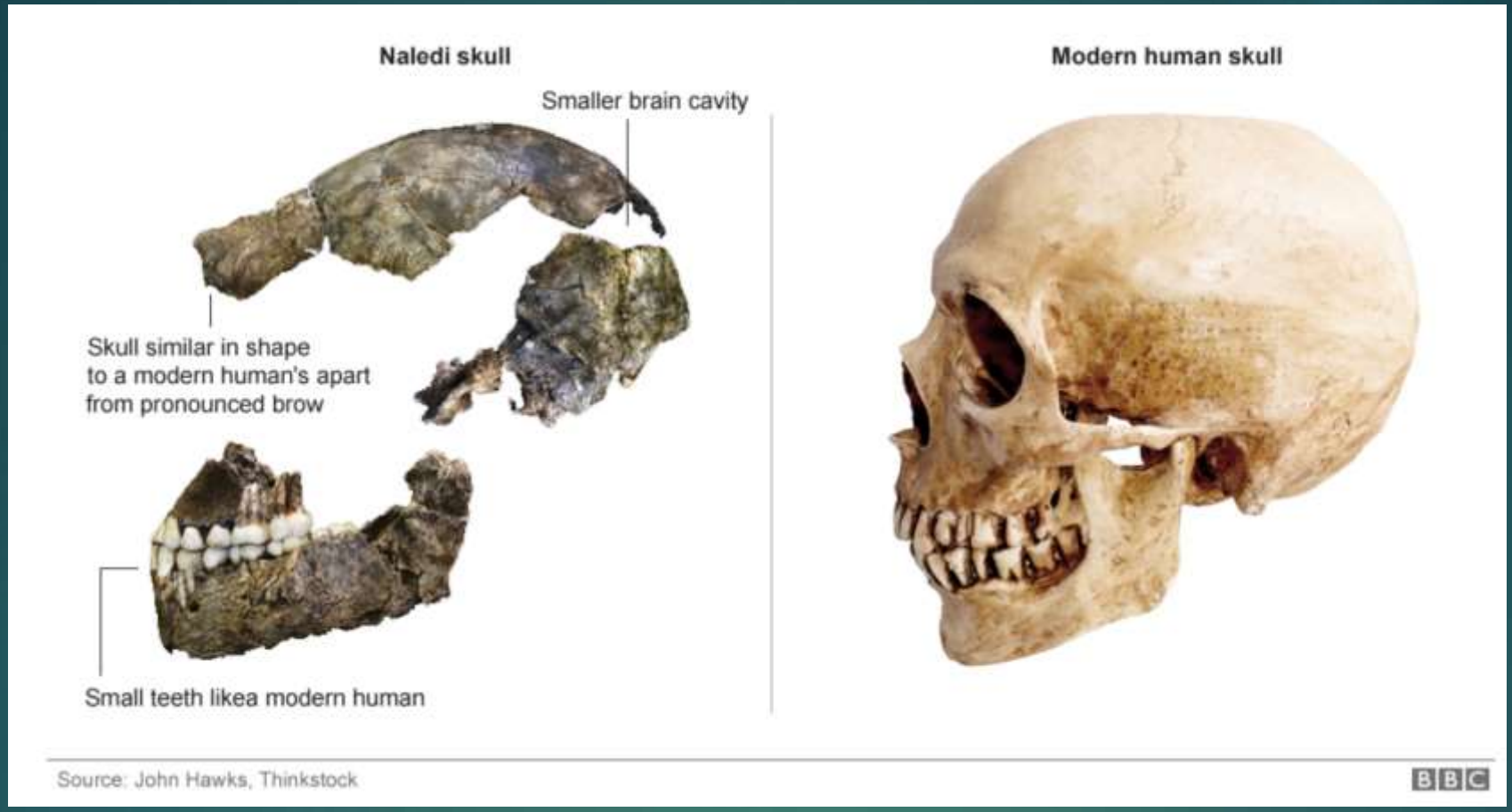


NEW HUMAN SPECIES: *Homo naledi* raises questions about the origin and evolution of our genus. In this replica of the composite skull, white areas indicate missing bone.

DH1: Holotype of *Homo naledi*

Holotype: original specimen used to describe a new species for the first time.

Skull and Mandible



Jamie Shreeve, in his piece for *National Geographic*, described it this way:
"These were pinheads, with some humanlike body parts."

It seems we might have to give up on "big brains" being the hallmark of our genus

Skull

- Features that appear in *Homo*, and in very early *Homo*:
- Angular torus (occipital)
- Nuchal torus (occipital)
- Brow ridge with sulcus
- Low forehead
- No chin; vertical mandible front
- Flat face
- Like 1.5- 2 Ma *Homo*: *erectus, habilis*
- But brain size is way smaller than these early *Homo*

Homo-like skull with Australopithecus sized brain

Differs from *H. sapiens:*
Small cranial capacity, megadont jaw, well-defined supraorbital torus & sulcus (like *H. erectus*), less well-defined chin, increasing molar size gradient, & ancestral aspects of the postcrania

Differs from H. erectus:
Lacks long & low cranial vault, not metopic keeling, flat & square nasoalveolar clius (subnasal area is square & flat)

Differs from *Australopithecus*:
Lacks large jaws & dentition and associated musculature, lack of postorbital constriction (depression behind eye sockets)

H. naledi skull is like basal, ancestral *Homo* (browridge & sulcus, vertical face, thickened nuchals); but smallest *Homo* brain, except for *H. floresiensis*

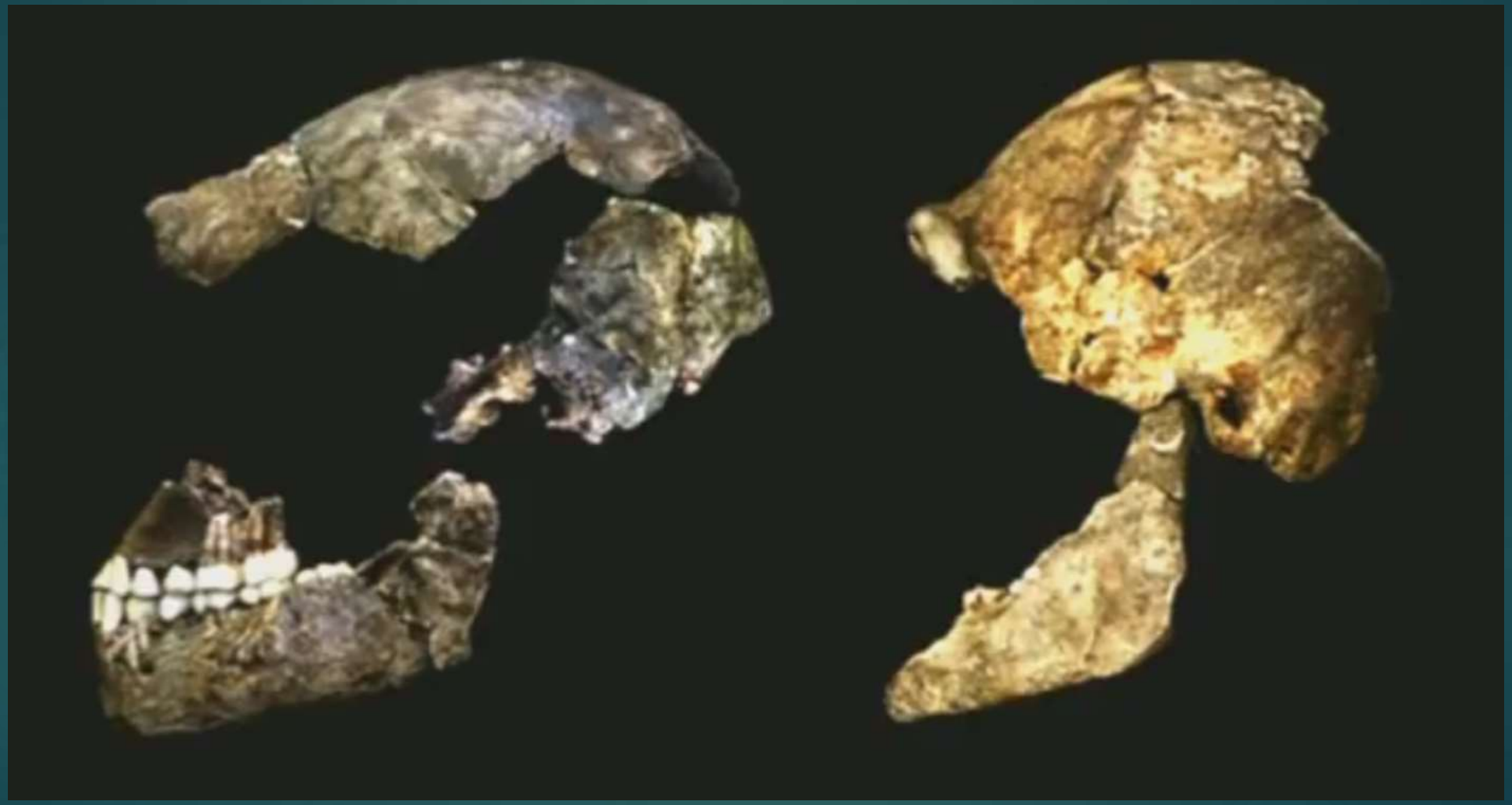
Homo naledi: Cranium 465-610 cc compared to *H. sapiens*

- Five partial skulls had been found—two male, two female.
- Cranial morphology is advanced enough to be called *Homo*.
- But the braincases were tiny—a mere 610 cc for the males and 465 for the females.
- Only the smallest specimens of *H. habilis*, one single *H. erectus* specimen, and *H. floresiensis* overlap with these values.

H. sapiens *H. naledi* *H. erectus*

Note curved hand

Cranium: DH1 (probably male) & DH3 (female)



Holotype

Homo naledi: Reconstructed Skull

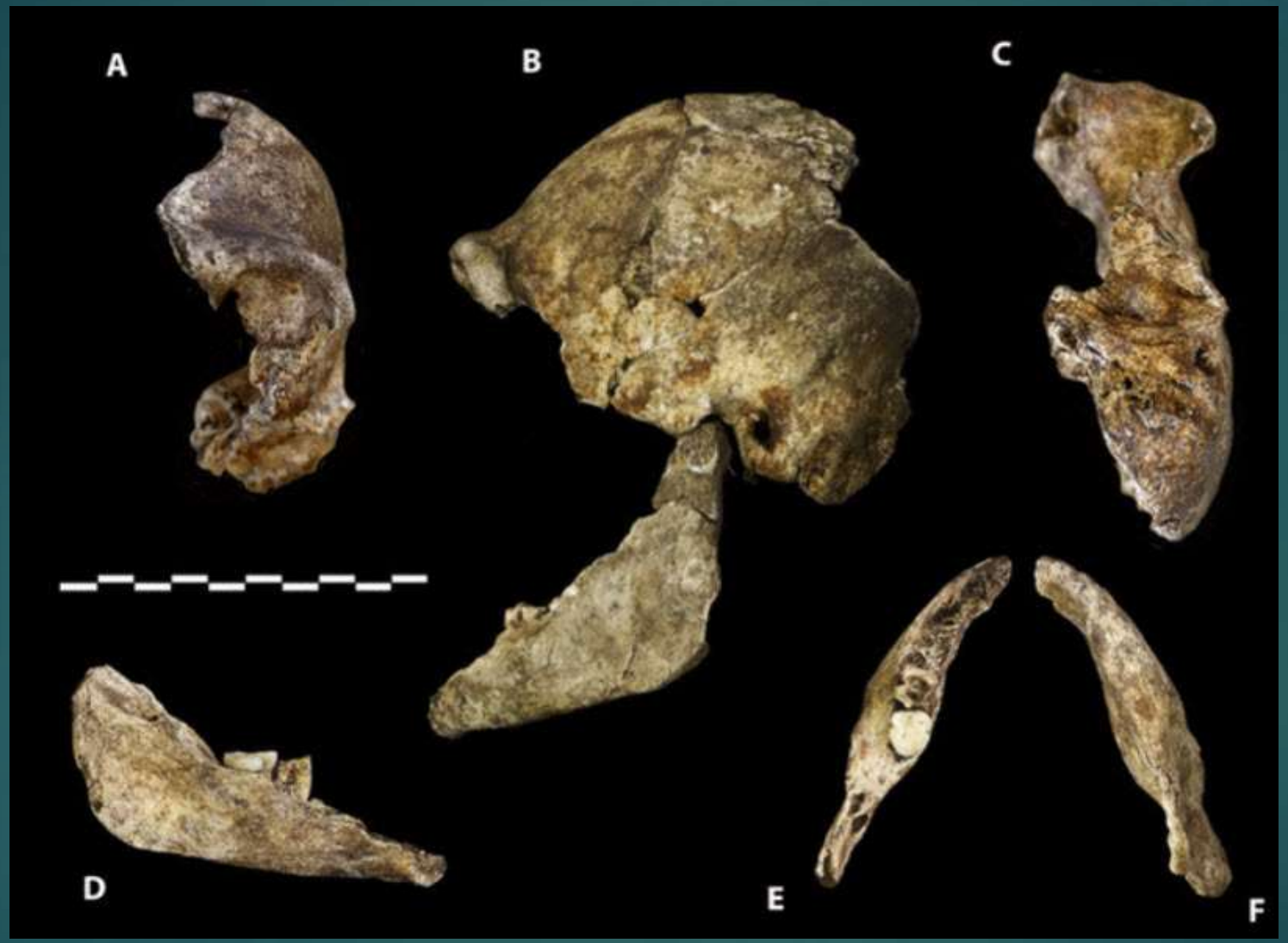
Reconstructed skull from 3-D Printing files

Homo naledi: Globular Braincase & Mandible

Holotype specimen of Homo naledi, Dinaledi Hominin 1 (DH1)

(A) DH2, right lateral view. (**B**) DH5, left lateral view. (**C**) DH4, right lateral view. (**D**) DH4, posterior view.
(B) Scale bar = 10 cm.

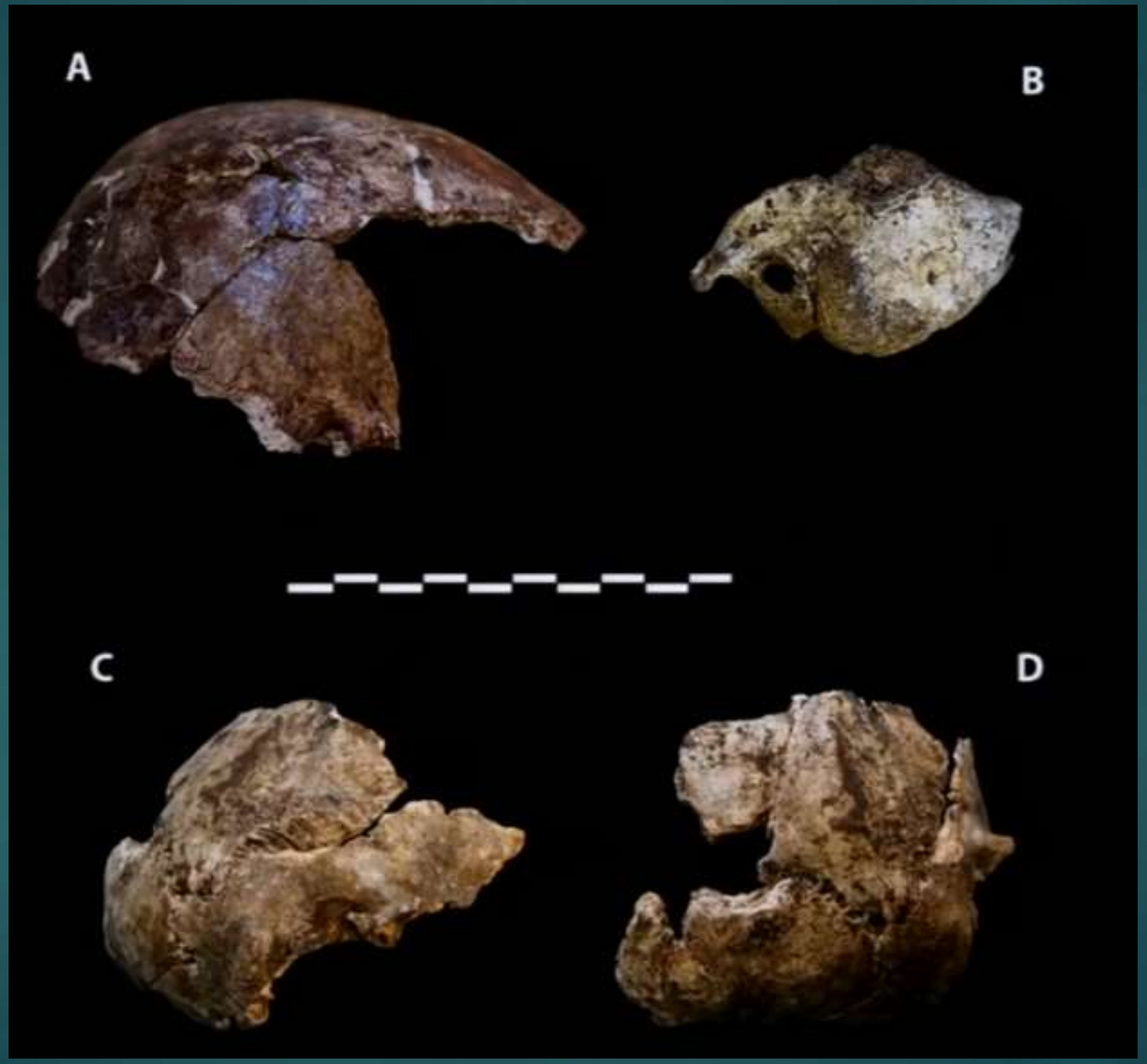
Homo naledi: DH3, an elder woman with worn teeth



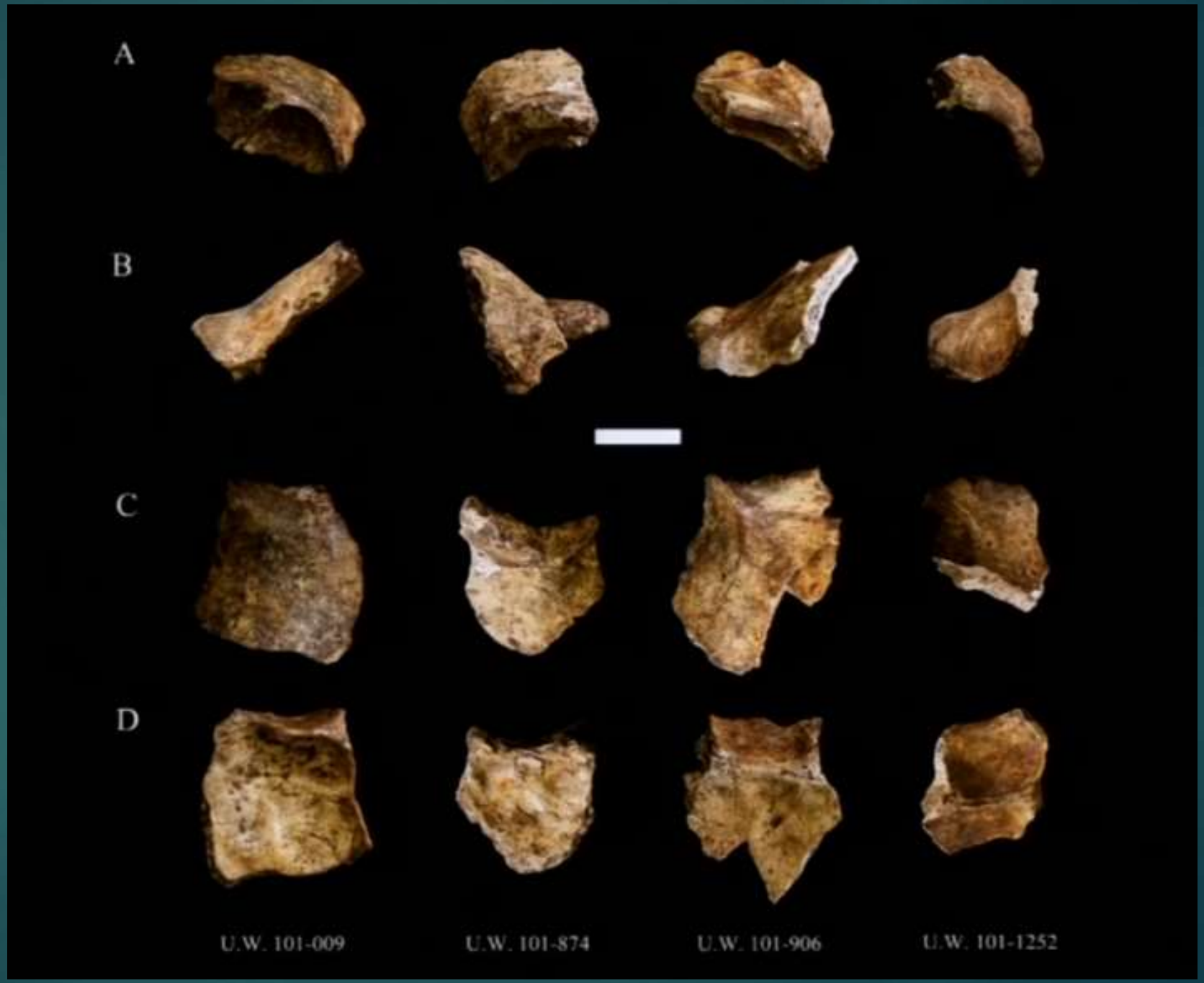
DH3 was a relatively old individual at time of death, with extreme tooth wear

Paratype DH3.(**A**) Frontal view. (**B**) Left lateral view, with calvaria in articulation with the mandible (U.W. 101-361). (**C**) Basal view. Mandible in (**D**) medial view; (**E**) occlusal view; (**F**) basal view.. Scale bar = 10 cm.

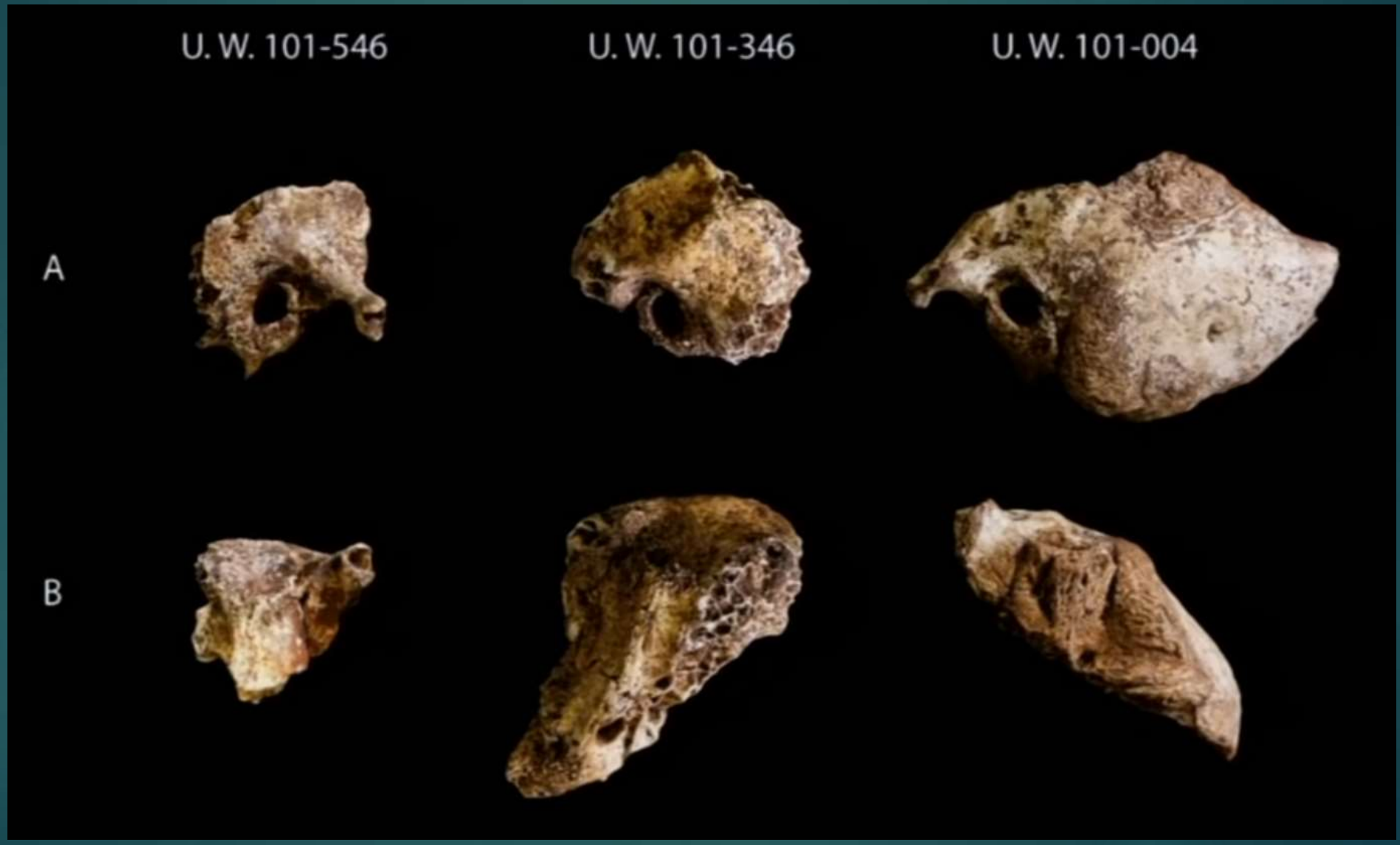
Other skull fragments

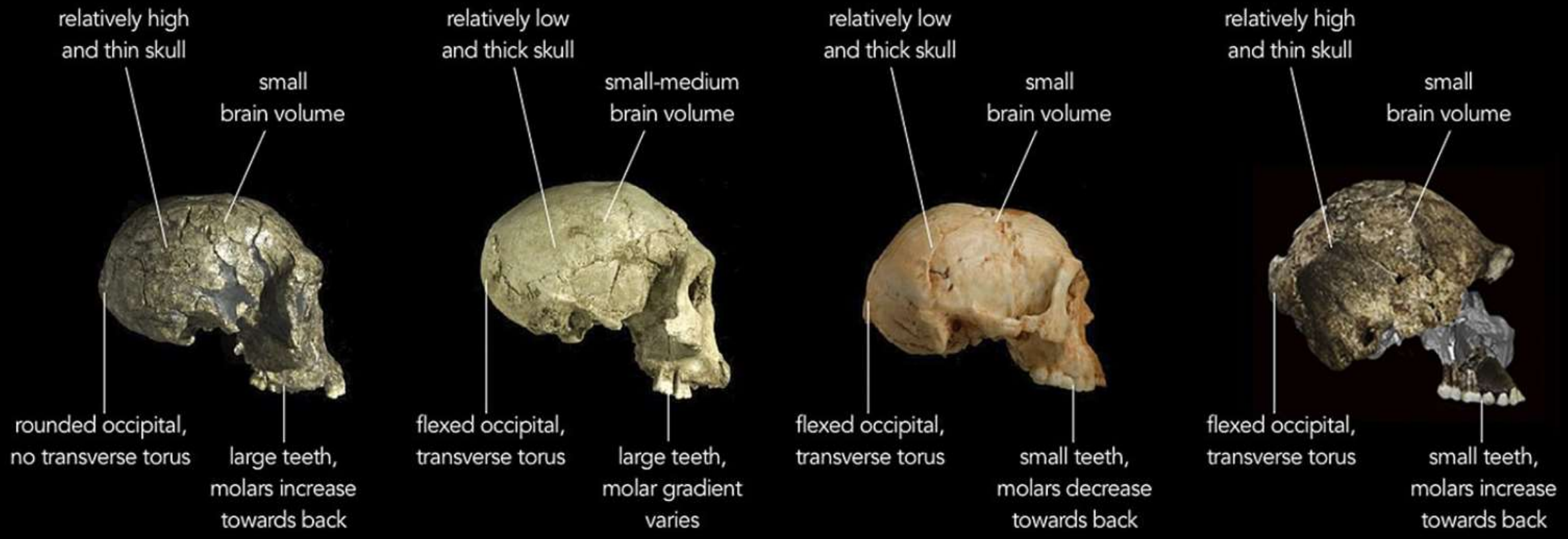


Browridge pieces



Temporal bones: in front of the ear





Homo habilis ***Homo erectus*** ***Homo floresiensis*** ***Homo naledi***

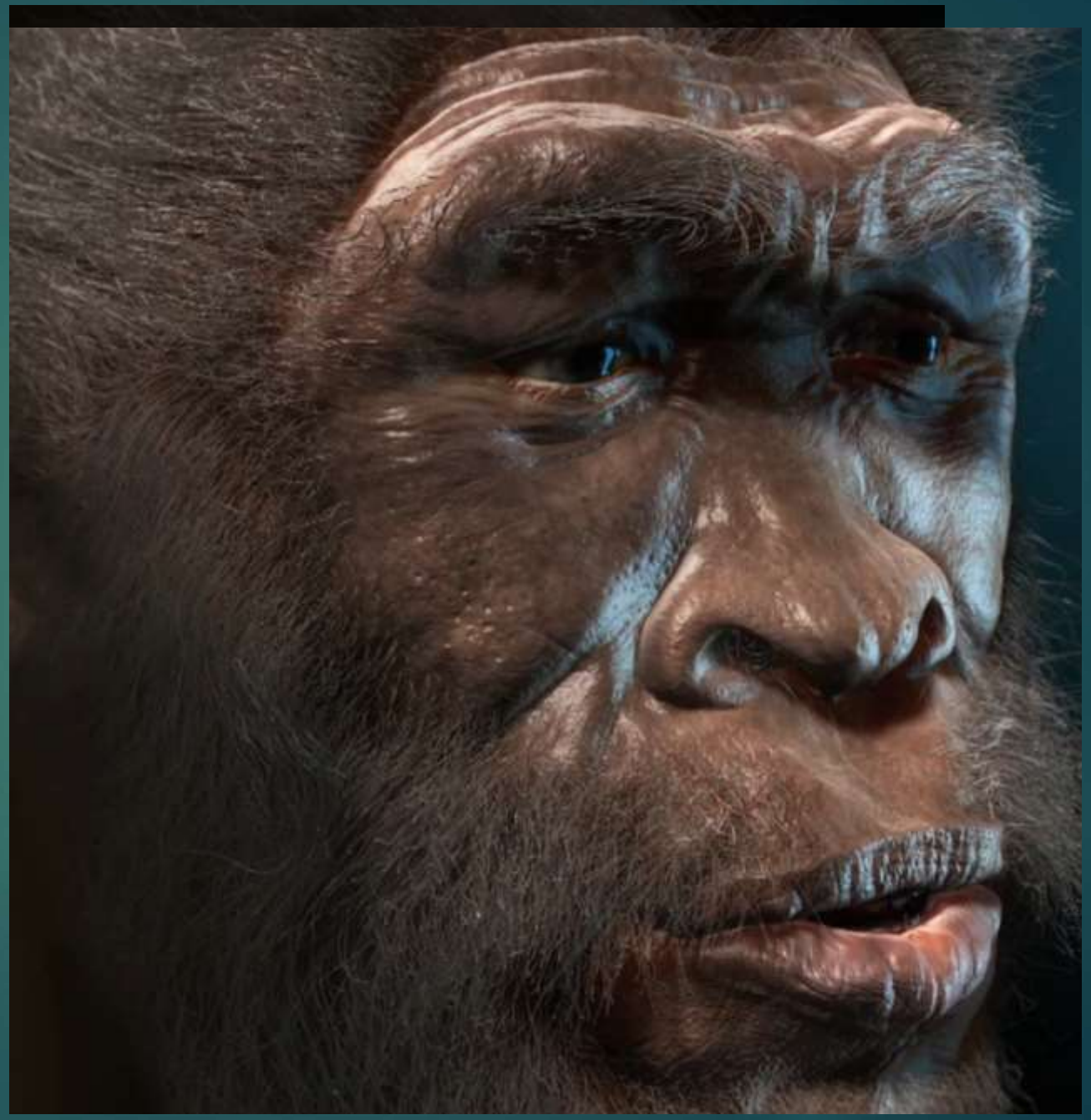
Homo habilis
KNM-ER 1813, Koobi Fora, Kenya ~1.8 Ma,

Homo erectus
D2700, Dmanisi, Georgia, ~1.8Ma

Homo floresiensis
LB1, ~20K

Homo naledi

DH1 Skull reconstruction



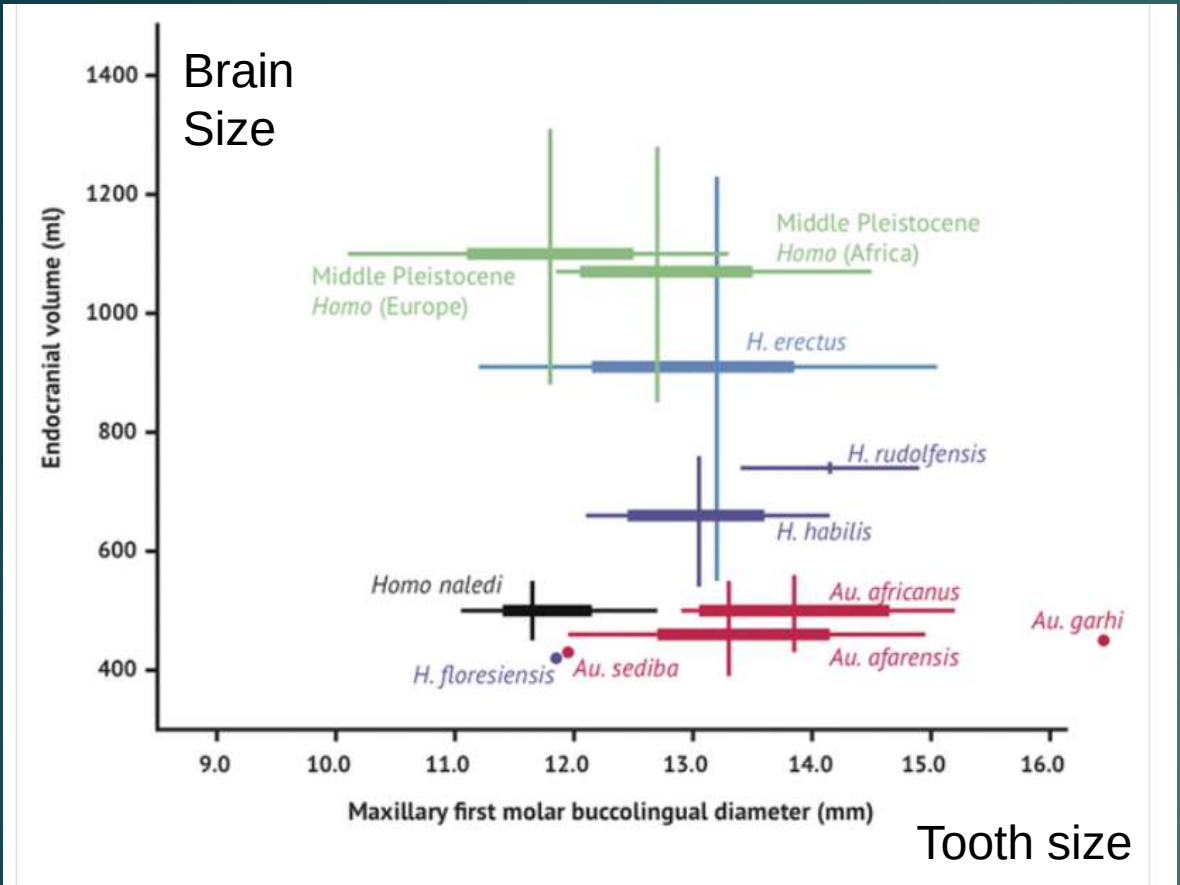
Homo naledi by John Gurche

A reconstruction of Homo naledi's head by paleoartist John Gurche, who spent some 700 hours recreating the head from bone scans

Image is from the 10/2015 issue of National Geographic


1 day ago

Low variation: Small Brain size & 1st Molar Size Comparison



Classic dental size progression from bottom right to upper left:

Green: *Homo*: smaller teeth, bigger brain

Blue: *Homo: H. erectus, rudolfensis, habilis*

Red: *Australopithecus*: large teeth, small brain

Black: Atypical *H. naledi*: small teeth, small brain

H. naledi occupies a position with relatively small molar size (comparable to later *Homo*) & relatively small brain volume (comparable to australopiths).
The range of variation within the Dinaledi sample is also fairly small, in particular in comparison to the extensive range of variation within the *H. erectus sensu lato*.
Vertical lines represent the range of endocranial volume estimates known for each taxon.

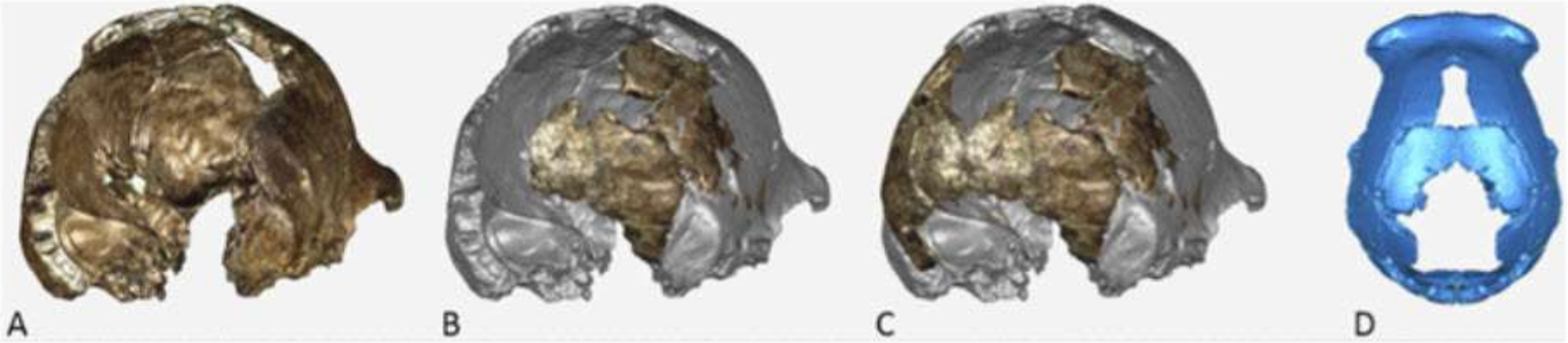
Middle ear bones and face

- Discovered 3 miniscule middle ear bones when sediments sieved and examined for bone.

- The anvil (a middle ear bone) more resembles those of chimps, gorillas, and *Paranthropus* than *Homo*.

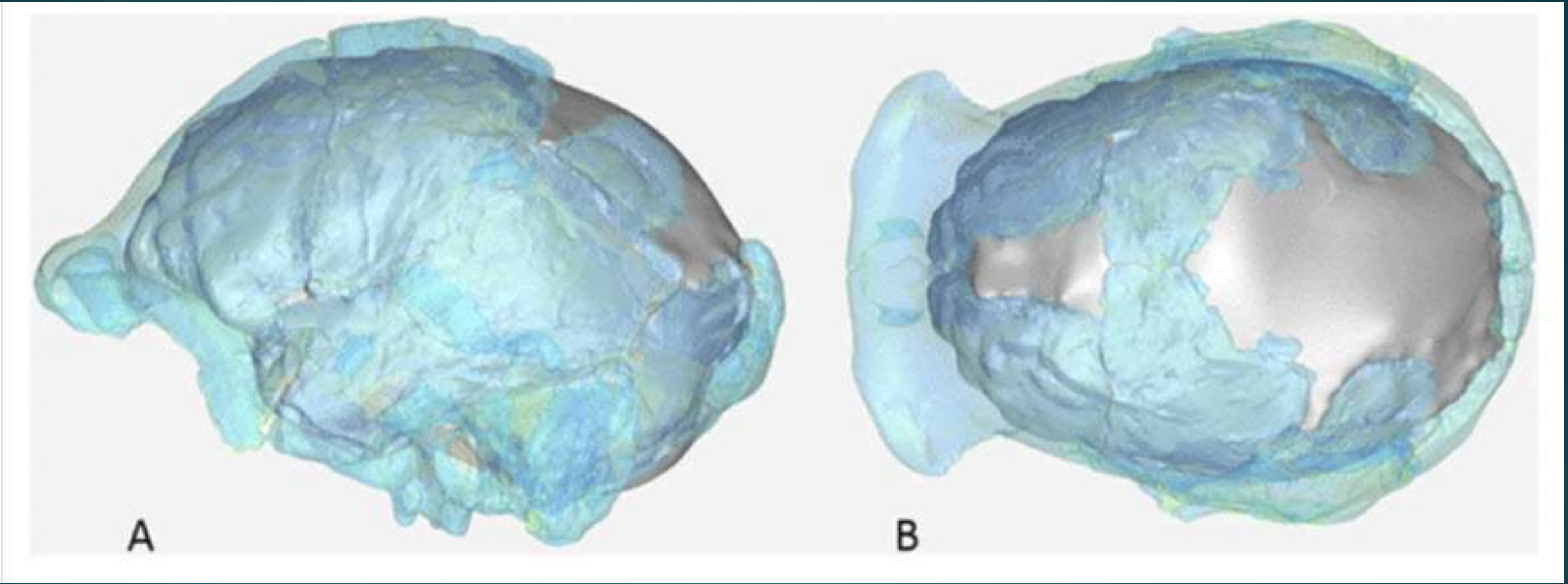
- Well-developed brow-ridge with a fissure stretching across just above the ridge, like *H. habilis* and *H. erectus*
- Pronounced occipital torus, like *H. erectus*
- *H. naledi* has some facial similarities with *H. rudolfensis*.

Homo naledi: DH3 & DH4



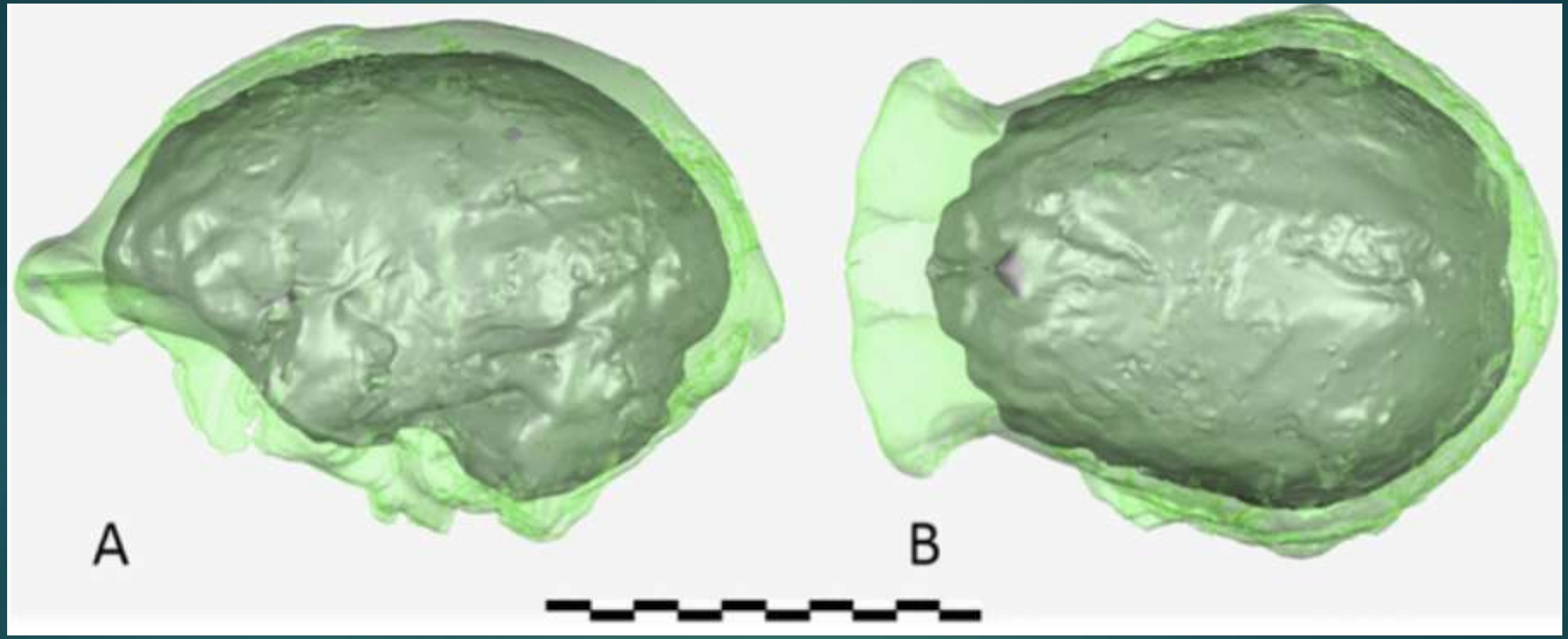
Postero-lateral view of the virtual reconstruction of a composite cranium from DH3 and DH4.

Homo naledi: DH3 (female) & DH4 endocasts



Reconstruction of DH3 & DH 4 endocasts

Homo naledi: DH1 & DH2 endocranium: 560 cc



Virtual reconstruction of the endocranium of the larger composite cranium from DH1 and DH2 overlaid with the ectocranial surfaces. (**A**) Lateral view. (**B**) Superior view. The resulting estimate of endocranial volume is 560 cc. Scale bar = 10 cm.

Cranial volumes

- Two male *H. naledi* skulls from the Dinaledi chamber had cranial volumes of about 560 cc, and two female skulls 465 cc.
- The Dinaledi specimens are more similar to the cranial capacity of australopithecines;
- A male *H. naledi* skull from the Lesedi chamber had a cranial volume of 610 cc.
- However, the Lesedi specimen is within the range of *H. habilis* and *H. erectus georgicus*.
- The encephalization quotient of *H. naledi* was estimated at 4.5, which is the same as the pygmy *H. floresiensis*, but notably smaller than all other *Homo* (contemporary *Homo* were all above 6).

Brain features

- Nonetheless, the skull shape is more similar to *Homo*, with a slenderer shape, the presence of temporal and occipital lobes of the brain and reduced post-orbital constriction (the skull does not become narrower behind the eye-sockets).

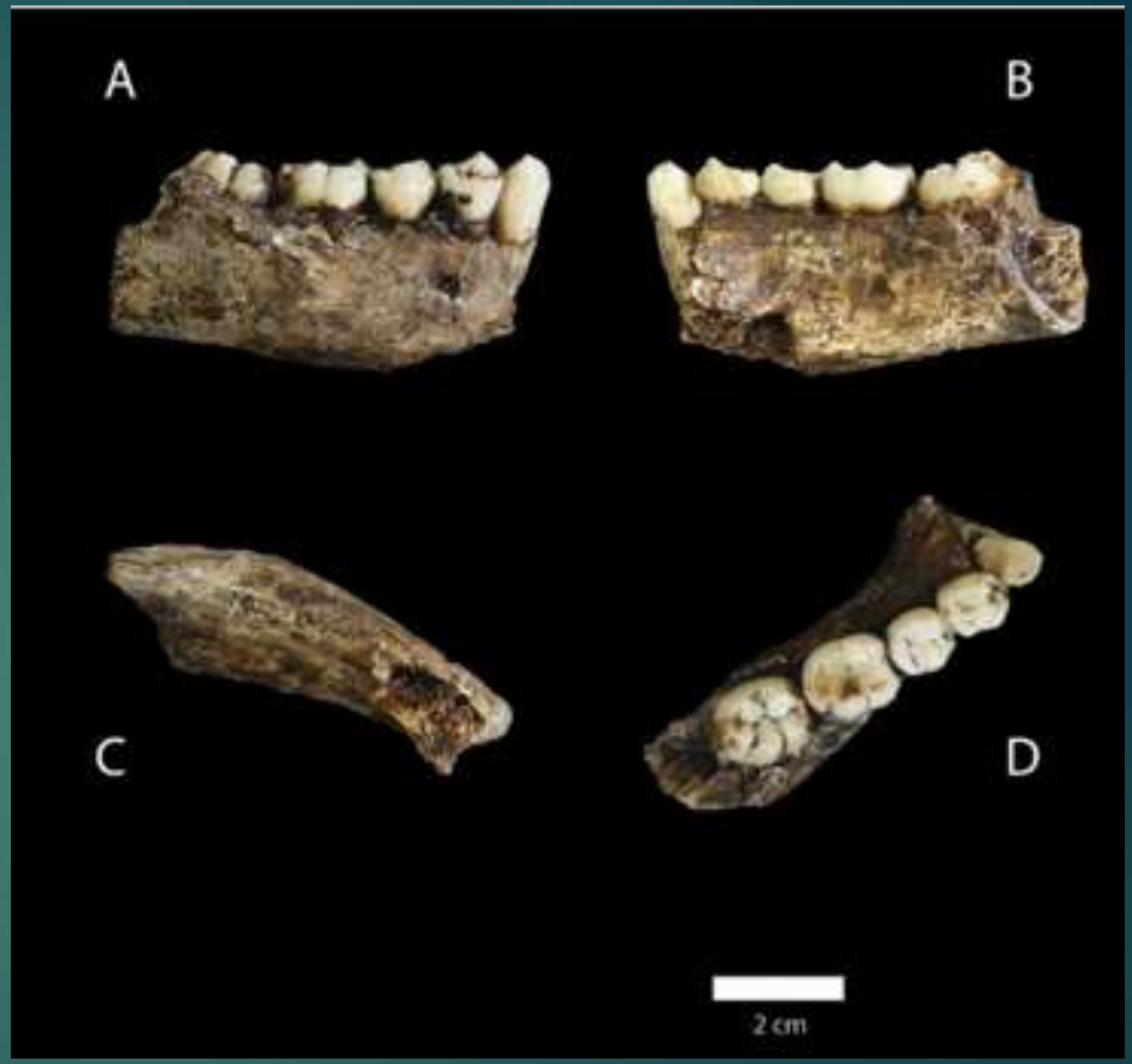
- The frontal lobe morphology is more or less the same in all *Homo* brains despite size, which differs from *Australopithecus*, and has been implicated in the production of tools, the development of language, and sociality.

- It is unclear if *H. naledi* inherited small brain size from the last common *Homo* ancestor, or, if it was evolved secondarily more recently.

Homo naledi: Mandible

Homo naledi: Mandible

Mandible:
Too small to be an australopith;
More curved than H. habilis



U.W. 101-377 mandible.(**A**) Lateral view; (**B**) medial view; (**C**) basal view; (**D**) occlusal view. (**D**) The distinctive mandibular premolar morphology with elongated talonids in unworn state. Scale bar = 2 cm.

Mosaic Teeth of *H. naledi*

- The teeth have some
  - ancestral features (such as molar size increasing towards the back of the tooth row, larger molars & premolar roots) and
  - derived features: small front teeth, molar crowns were small with five lower cusps, and set in lightly built, more curved jawbone

- The teeth were relatively small, which is a modern trait. However, Homo naledi's back molars were the largest, which is an ancestral trait.

Mosaic Teeth of *H. naledi*

- The new species goes against the previously held belief that a small brain and large teeth go together; belief that as brains got larger, teeth could get smaller because of improved use of technology like fire to cook food.

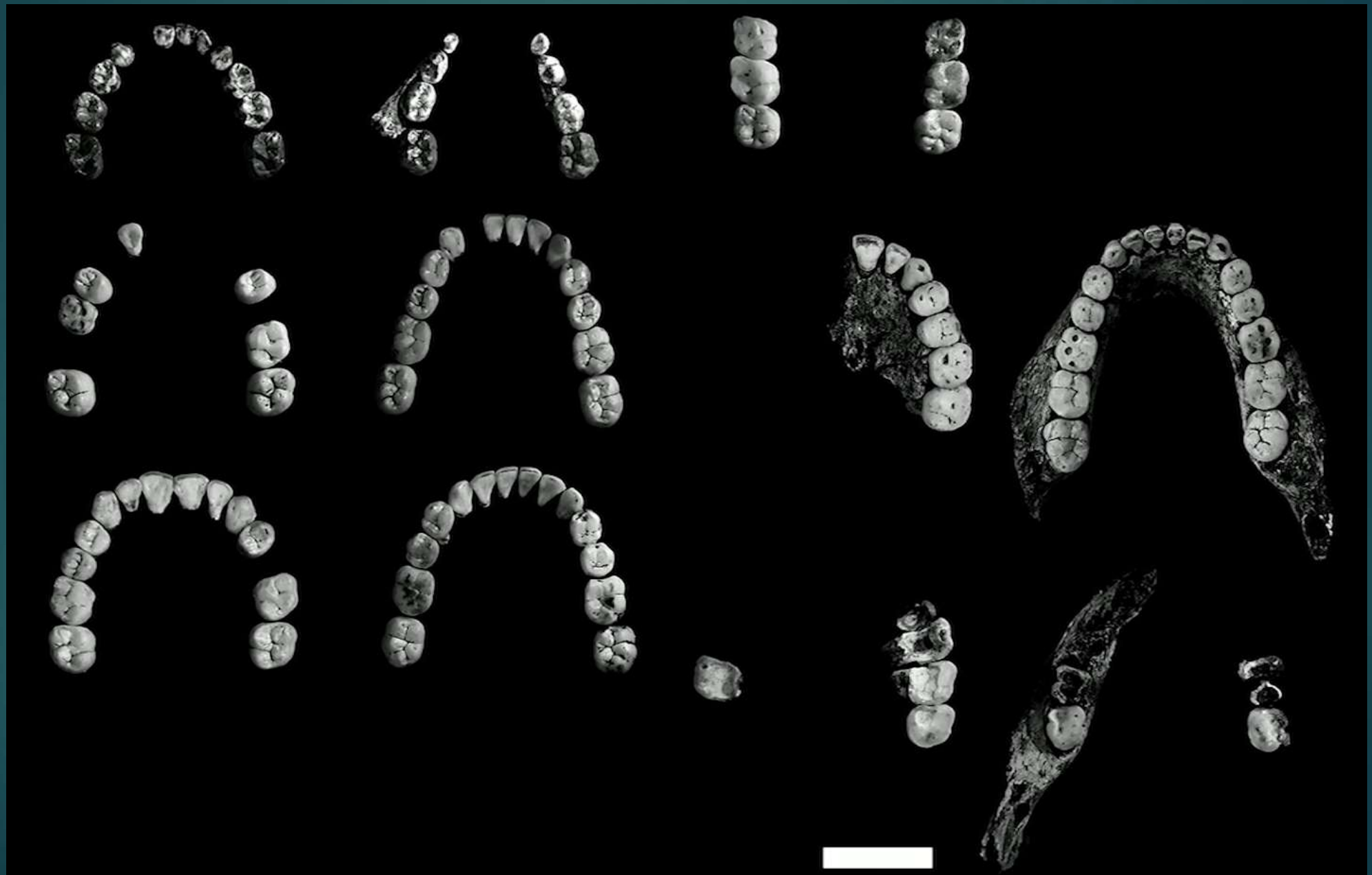
- However, Homo naledi, with its small brain and small teeth, contradicts this theory

How to reunite separately found teeth: teeth leave traces on their neighbors; lower teeth of 10-year-old

190 Teeth: multiple complete sets

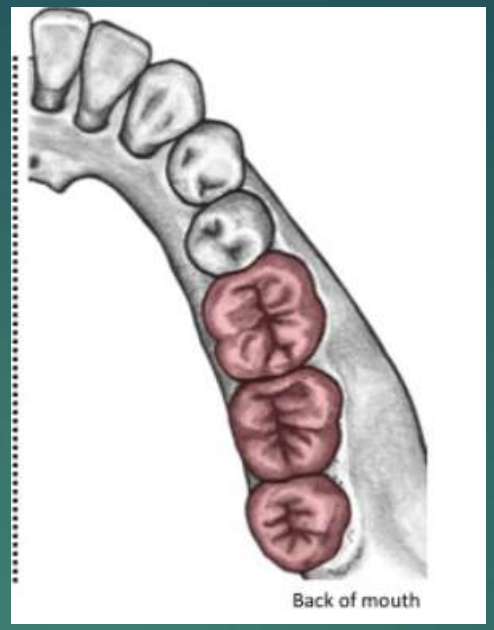
Infants (top left) to very old (30s) (bottom right)

Teeth: Human like in size, but ancestral in anatomy



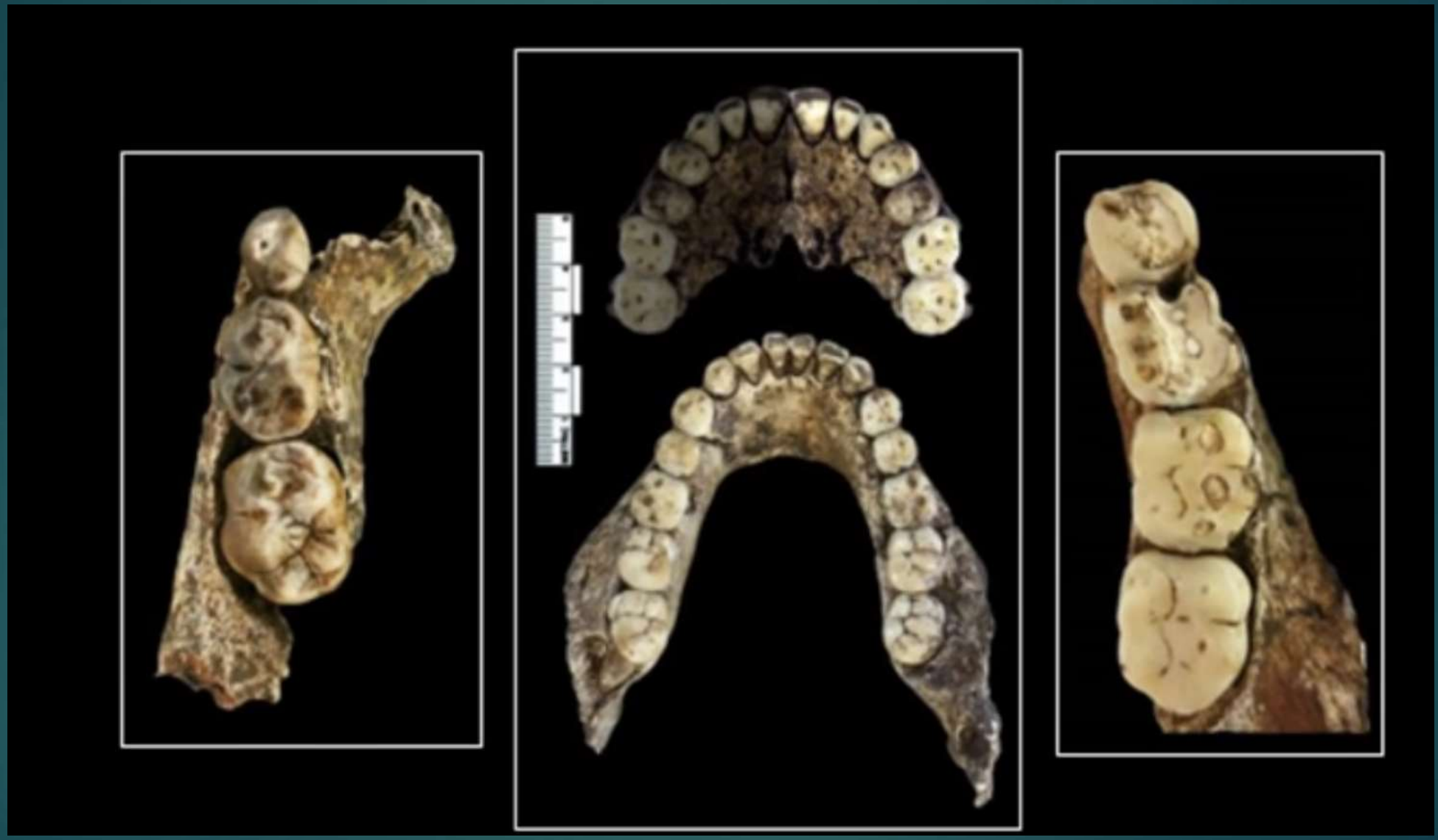
Teeth

- In MHs: 3rd molar is smallest and 1st molar is biggest
- *Homo naledi* has ancestral condition, 3rd molar is largest and 1st molar is smallest
- Anterior teeth are small for genus *Homo*



Deciduous (Baby) Teeth =

Very narrow



Mature – Premolars unique among Hominins: elongated & symmetrical

Teeth development

- A prolonged period of growth and development is a defining feature of humans, but we don't know when this trait evolved

- Dental development has been used as a proxy to reconstruct life history evolution in the hominin clade and indicates a recent emergence of the human developmental pattern.

- Deciduous dental development in *H. naledi* is more similar to humans than to chimpanzees. It may reflect a shared, ancestral hominin trait rather than bearing life history significance.

Teeth development

- The later stages of permanent tooth development present a mix of human- and chimpanzee-like patterns. Surprisingly, the M2 of *H. naledi* emerges late in the eruption sequence, a pattern previously unknown in fossil hominins and common in modern humans.

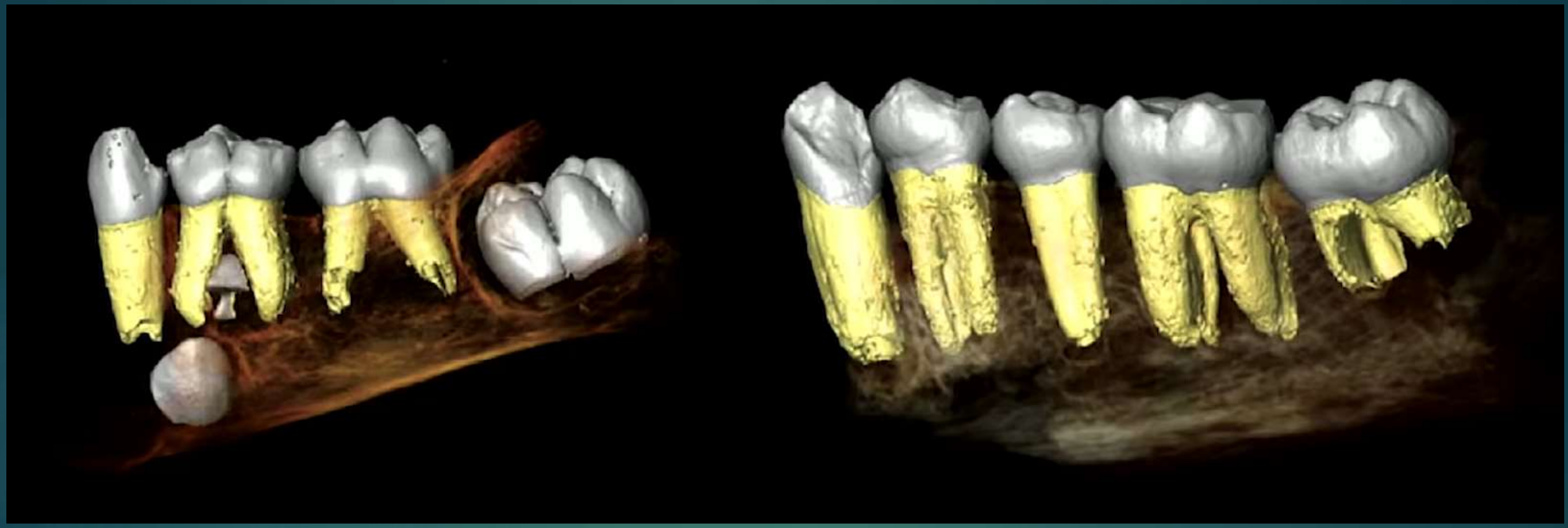
- This pattern has been argued to reflect a slow life history and is unexpected in a small brained hominin.

- Even Neanderthals have a more ancestral dental eruption sequence.

Child tooth development: Human like

- The permanent 2nd molar erupted comparatively late in life, emerging alongside the premolars instead of before, which indicates a slower maturation, as in modern humans.
- The tooth formation rate of the front teeth is also most similar to modern humans.

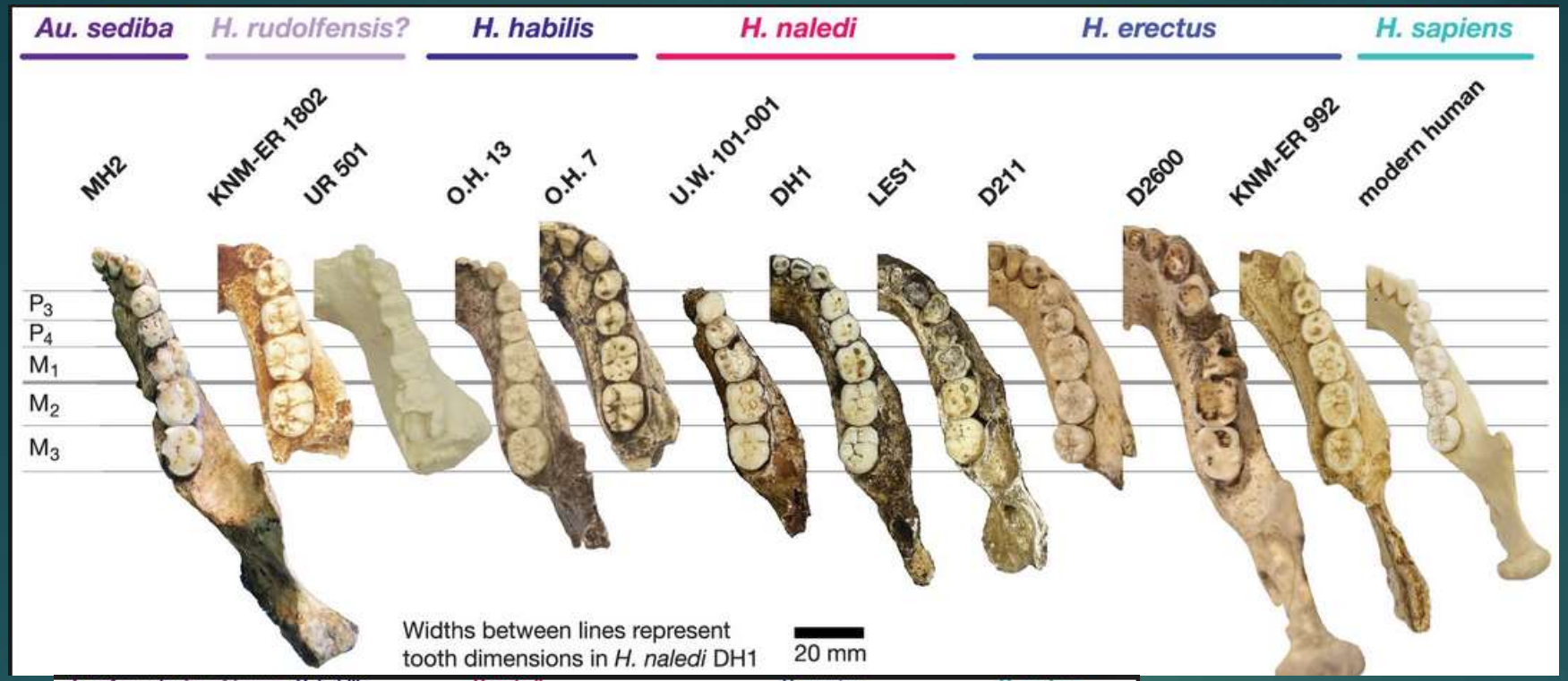
Dental development

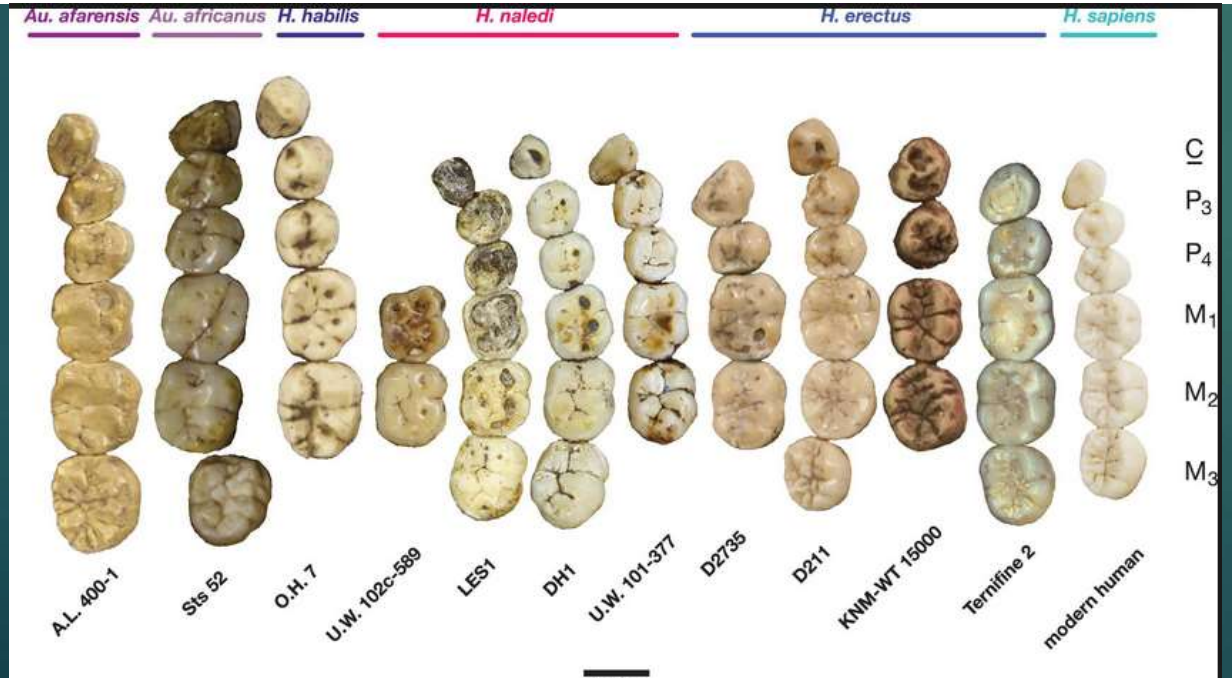


Permanent canine teeth present; But 2nd molar not yet erupted, like us

Opposite of apes and earlier hominins: Molar 1st, canines later
Larger canines are for social dominance: ready for fight

Teeth





Smaller teeth than earlier groups

Naledi molar pattern (progressively larger toward back) is like Australopithecus; unlike MH

Their premolars are unique

Chipped teeth

CHIPPED OFF Tooth damage sustained by *Homo naledi,* resulted from a diet heavy on hard or gritty objects. One likely chip culprit: dirt-covered, nutritious underground plants such as tubers.

Chipped teeth

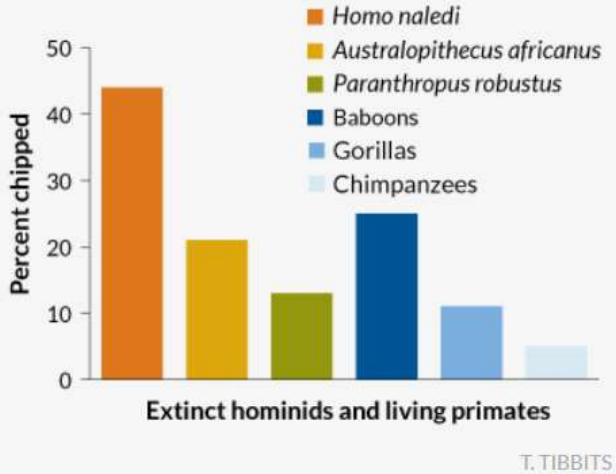
- More dental fractures than in all other closely related species studied; due to acute trauma

- In *H. naledi*, 44% of teeth are affected – which is very high. This chipping is not distributed evenly over the teeth. The back teeth are the most fractured (>50% with 1 or more chips)
- The front teeth are still affected much more than in other species – more than 30% have one or more chips. Baboons – 25% of their teeth have fractures.

- *H. naledi* regularly chewed on small, hard objects. A diet containing hard and resistant foods like nuts and seeds, or contaminants such as grit, including tubers and roots.

Where the chips fall

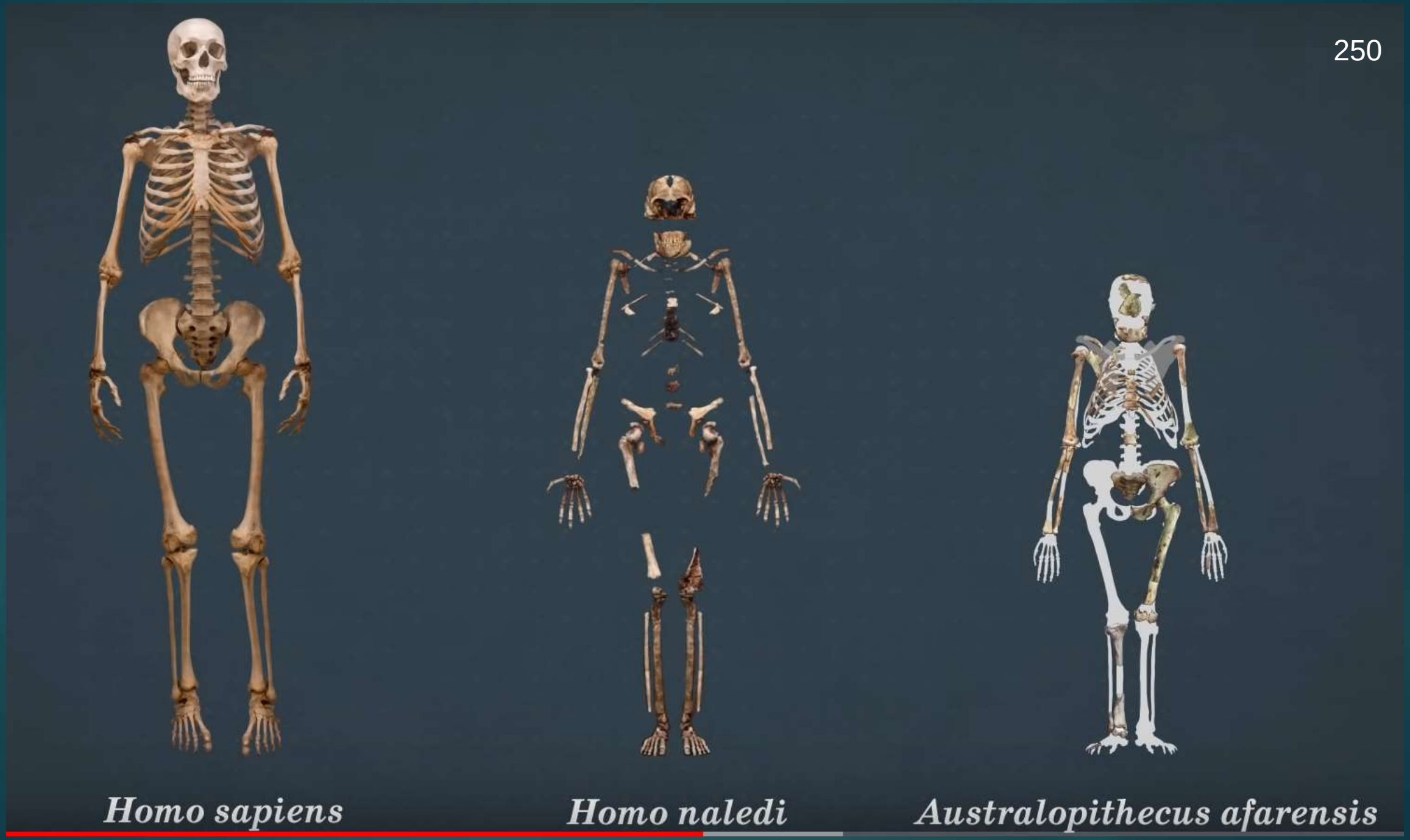
This bar graph shows reported chipping rates for teeth from some living primates and fossil hominids. Homo naledi displays particularly high rates of chipping.

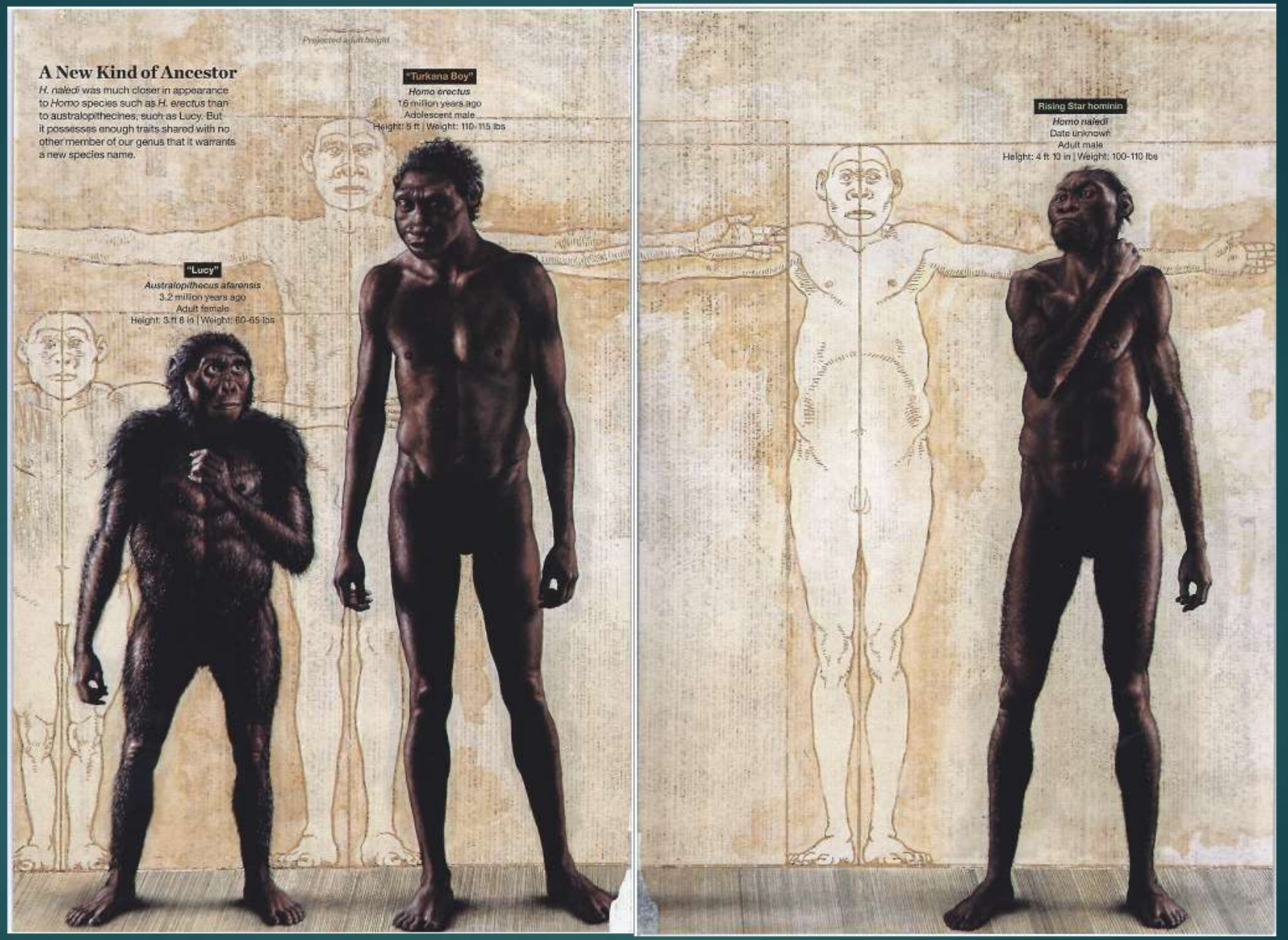


Source: I. Towle et al/Amer. J. of Phys. Anthro. *2017*

Dental microwear and diet of *Homo naledi.* Peter S. Ungar & Lee R. Berger, 2018

- Examine the dental microwear textures of *H. naledi.*
- 10 individuals preserve antemortem wear.
- Our results indicate that *H. naledi* had complex microwear textures dominated by large, deep pits.
- Only *Paranthropus robustus* had higher average texture complexity; today only found in: hard-object feeder, sooty mangabey monkey, and the eurytopic generalist, baboon.
- *H. naledi* likely consumed hard and abrasive foods, such as nuts or tubers, at least on occasion, and that these might well be responsible for the pattern of chipping observed on their teeth.


Homo sapiens
Homo naledi
Australopithecus afarensis

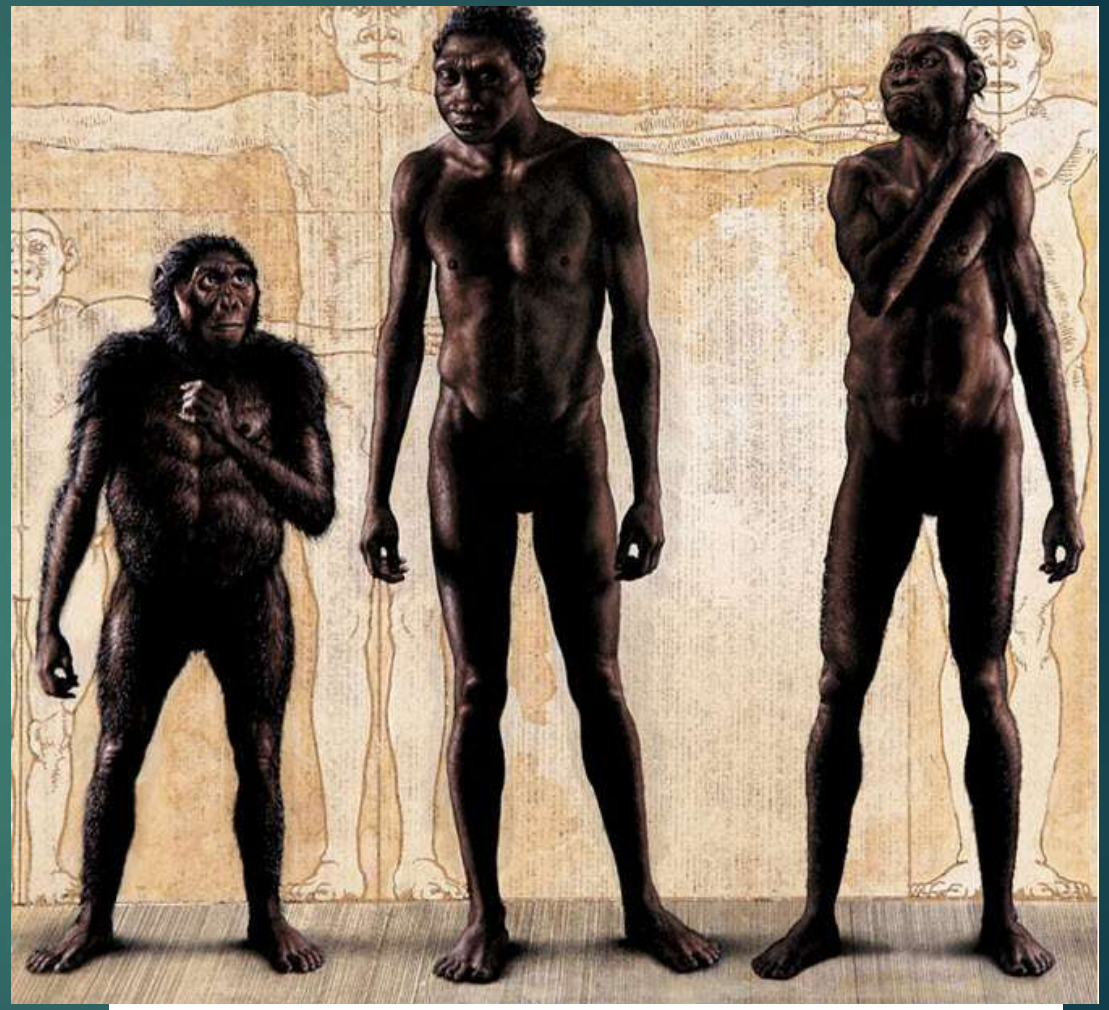


Homo naledi:
4 ft 9 in
100-110 lbs

National Geographic comparison

Homo naledi: 1.4 Meters (4’6” feet) tall, 88 lbs

Skinny, humanlike arms,
apelike thorax, more ancient pelvis,
long legs, humanlike feet



"Lucy"	"Turkana Boy"	"Rising Star Hominin"
Australopithecus afarensis	*Homo erectus*	*Homo naledi*
3.2 million years ago	1.6 million years ago	Date Unknown
Adult Female	Adolescent Male	Adult Male
3 ft 8 in	5 ft	4 ft 10 in
60-65 lbs	110-115 lbs	100-110 lbs

H. Naledi Postcranials:

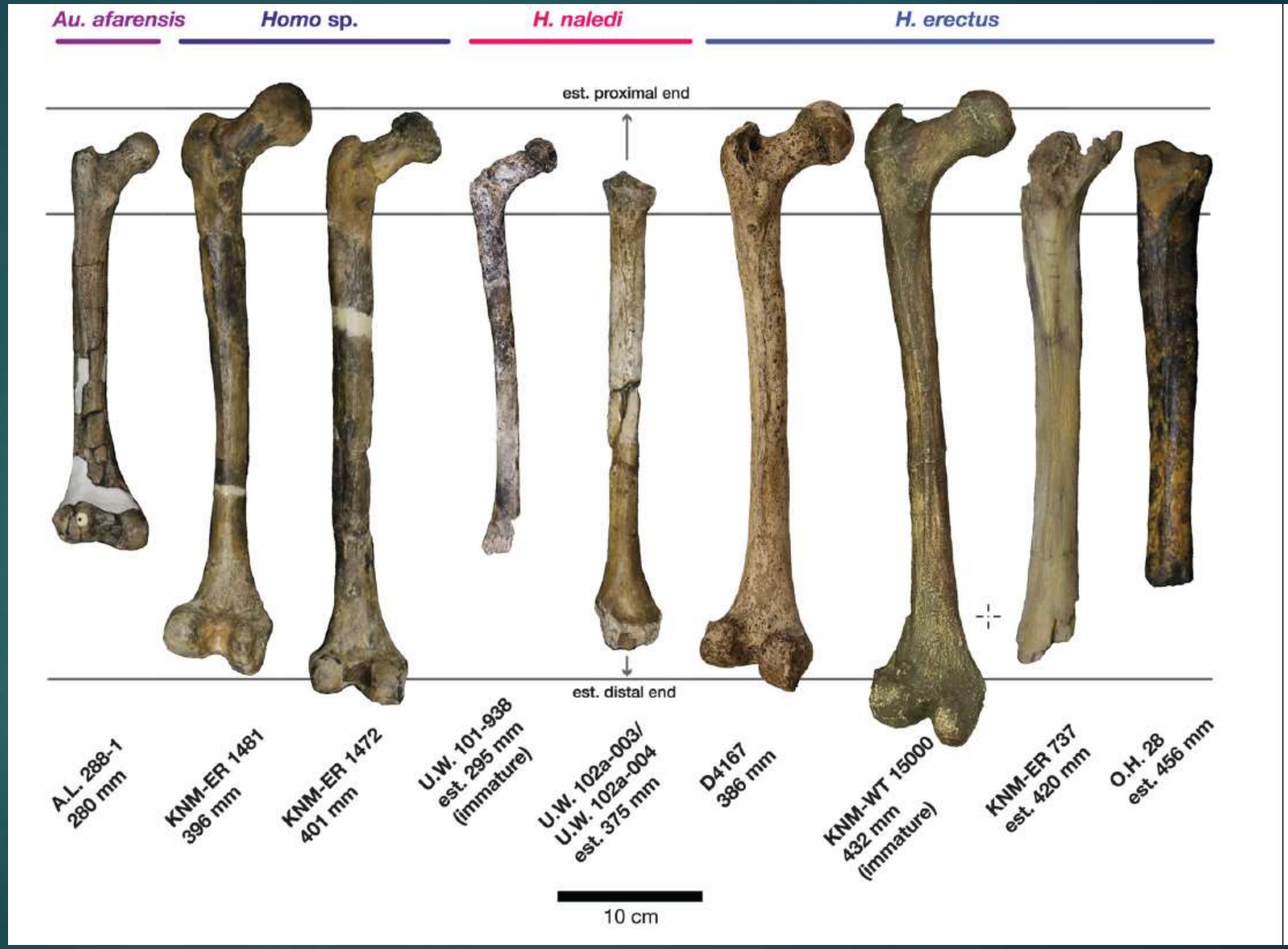
- Shoulders were flared, for climbing/suspension
- Flared pelvis and curved fingers are ancestral
- Flared pelvis goes with long femur head
- Derived: wrist; long, slender legs, modern feet
- Femur: predicts body mass – 40-55 kg (85-110 lbs)
- Similar to *H. erectus* skull and teeth
- Looks like it should be 2 Ma years old

- No hyoid bone yet.

Skeleton

- Stood around 143.6 cm (4 ft 9 in) and weighed 39.7 kg (88 lb).
- Male and female *H. naledi* were likely about the same size, males on average about 20% larger than females.
- A juvenile specimen, DH7, is skeletally consistent with a growth rate similar to the faster ape-like trajectories of MH1 (*A. sediba*) and Turkana boy (*H. ergaster*): shorter childhood.
- DH7 = 8–11 years old (if use faster growth rate), or 11–15 years old (if slower rate).
- Only the 10th and 11th thoracic vertebrae (in the chest region) are preserved, similar to those of MHs, but are the smallest recorded of any hominin.

Comparison of femora



Clavicle

Humerus

Ulna

Metacarpals

10th thoracic vertebrae

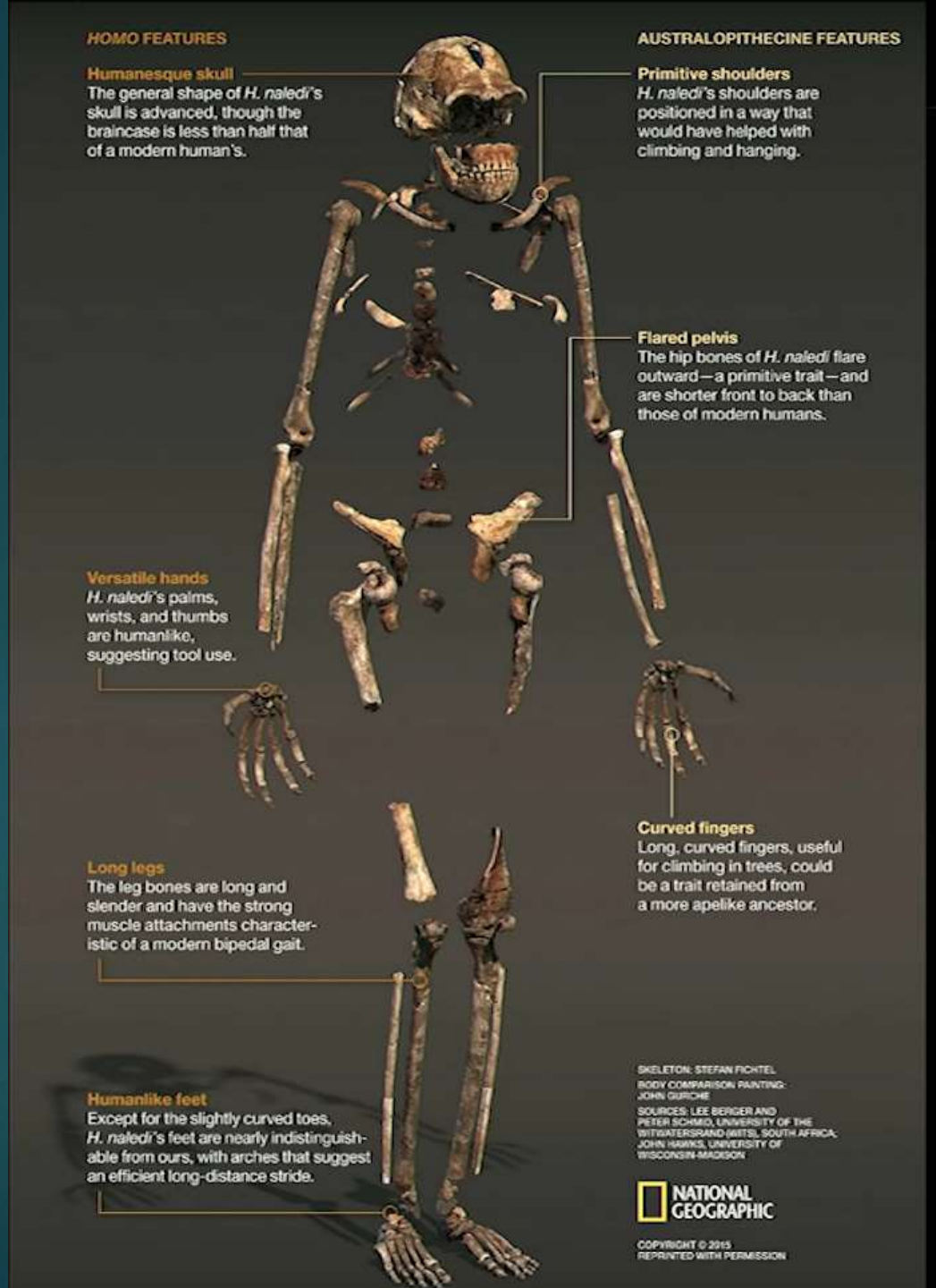
Femur: proximal femur is very long compared to MHs

Ancestral trait: Matches flared hips; like in Australopithecus; not made for running

Tibia: thin

Height: 4.5 to 5 feet tall

Like Australopithecine: Everything that is central (the trunk, architecture of vertebral column, & small brain) is ancestral; as if evolution was crafting it from the outside in



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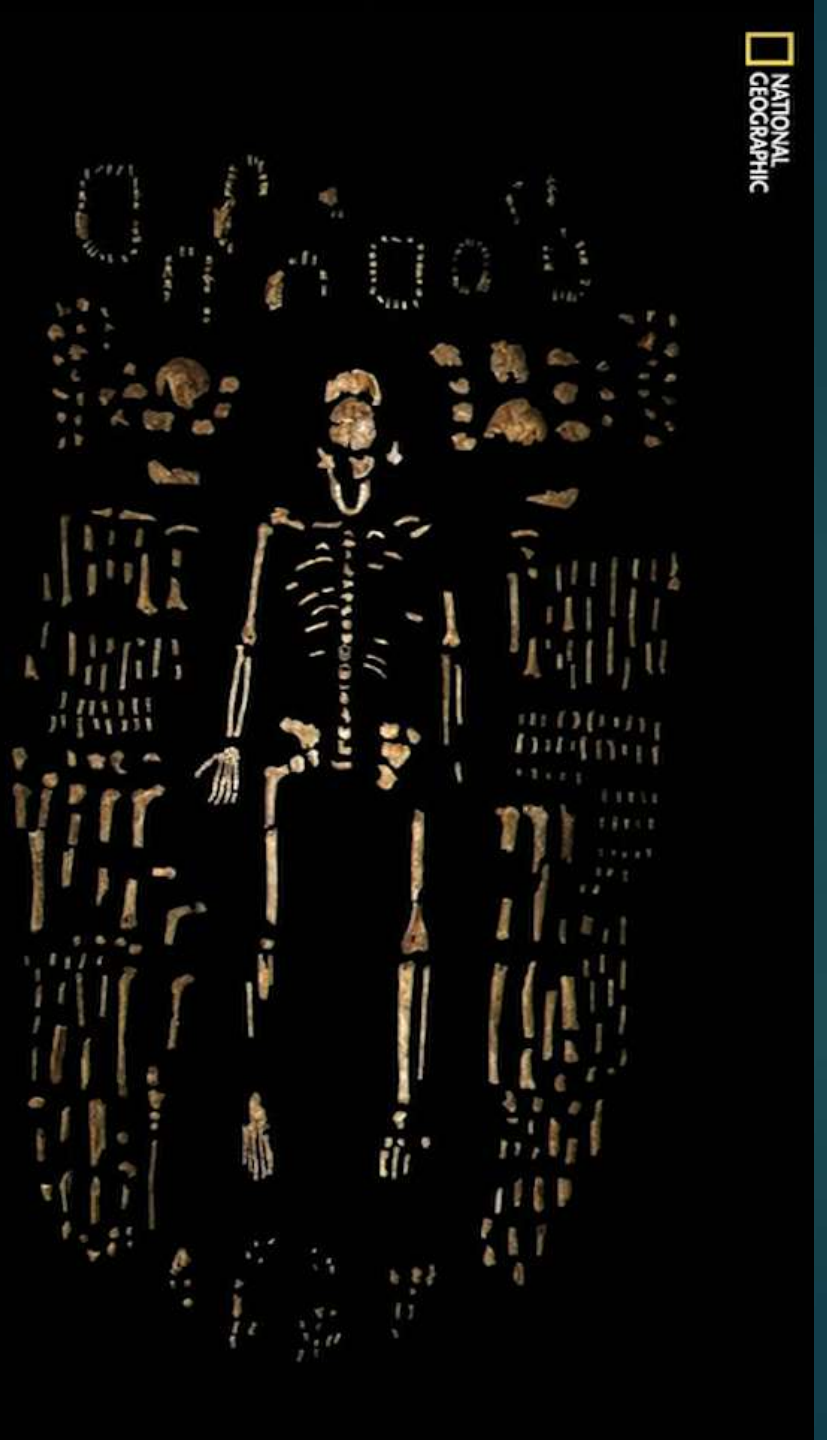
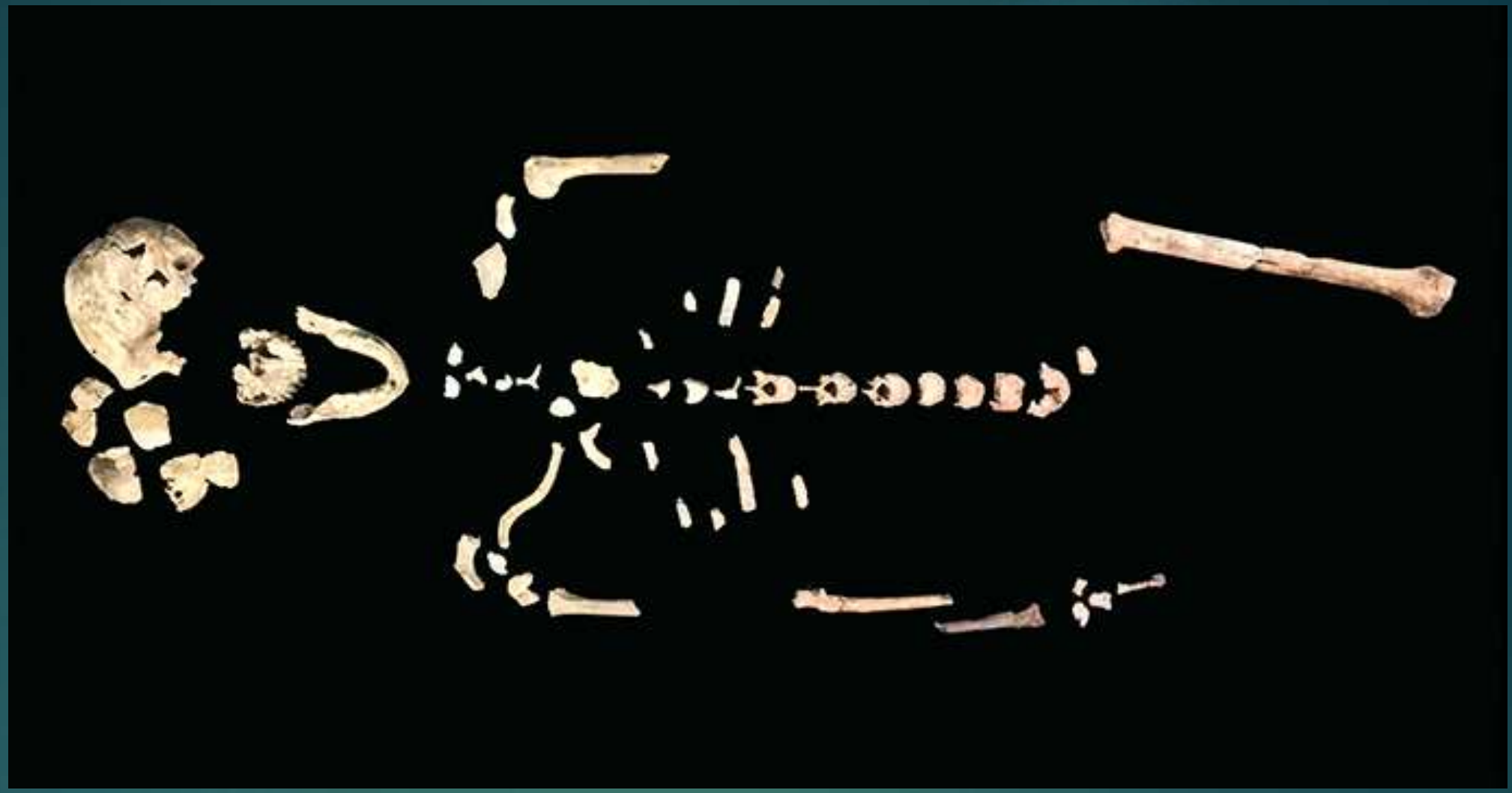


Skeleton was not intact;

A compilation of found bones in the Puzzle Box



A partial *Homo naledi* skeleton unearthed in South Africa is about as complete (40%) as Lucy's famous partial skeleton.

H. naledi

H. sapiens

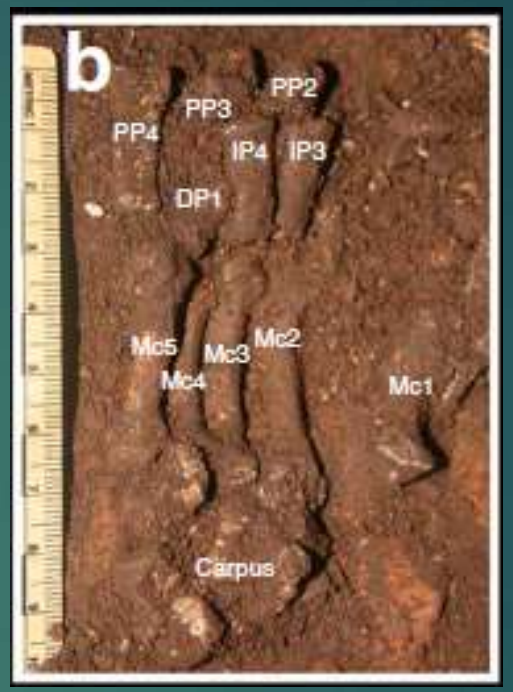
Hand of *Homo naledi*: 150 hand elements (= ~8 hands)

Found articulated as seen here

Australopithecine-like arboreal-capable curved fingers,
but thumb and wrist are stiffer like Homo (tool use)

Articulated right hand: folded over fingers, death grip

Homo naledi: Hand – most complete hand in fossil history



Found in situ in semi-articulation with the palm up and fingers flexed.

Australopithecine-like *a*rboreal climbing capable, extremely curved fingers (joints are curved; more curved than almost any other species of early hominin; but longer thumb and wrist are stiffer like Homo, suggesting tool-using capabilities

Hand

Broad fingertips for gripping (toolmaking?); human like wrist pattern; tremendously curved finger bones

Shoulders are canted forward; both better for climbing and reaching overhead

Fingers were curved.

Burger: “They’re climbing, but I don’t know *what* they’re climbing.”

Hand is small because, even as adults, *naledi* is diminutive.

7 Metacarpals (lower thumb bone): weird because large at top, rather than at both ends

Seven first metacarpals (thumb bone closest to the base of the hand) of H. naledi were recovered so far. Here they are, along with the first metacarpal of a modern chimp and the 2-million-year old Australopithecus sediba. (Lee Roger Berger

Vertebrae: Smallest on record

Small vertebrae & large canal = only in Ns

Lucy vs Naledi vertebrae size

Shoulder

Canted upwards: made for overhead climbing

Hunched forward
as if to reach up

Our scapulas are down and back, as if to throw

Humerus: slender

Homo naledi: Leg

U.W. 101-1391 paratype femur.(**A**) Medial view; (**B**) posterior view; (**C**) lateral view; (**D**) anterior view.
Scale bar = 2 cm.

Scale bar = 10 cm.

U.W. 101-484 paratype tibia.
(**A**) Anterior view; (**B**) medial view; (**C**) posterior view; (**D**) lateral view.
The tibiae are notably slender for their length.

Muscle attachment marks on tibia (bumps that indicated activity) are unique; no other species has them.

Foot of *Homo naledi:* meant for walking - upright biped; the feet were “Nike-ready,” as *National Geographic* put it; most complete foot in history of paleoanthropology; 1 of 6

10 cm = 4 in
Size 4,
Woman’s

Found articulated as seen here

Foot very similar to *H. sapiens.*

It possessed some ancestral features: a flatter arch, curved toes and a heel less robust than ours

Feet

1) adult right foot, 2) juvenile left, 3 and 4) adult left, 5) juvenile right

A perfectly human, but small, foot

Foot & partial leg bones

Foot: both longitudinal and transverse arches

Naledi foot

Modern human foot

Naledi foot

Short foot similar in size to modern human

Arch suggests naledi walked on two feet

Modern human foot

2015: Undated

- There was no dating of fossils in 2015: fossils were not encased, or even adjacent to, any rocks that can be dated using radioactive isotopes.
- There were also no other extinct organisms in the cave that could help establish a date.
- No fauna, no upper/lower stone layers, no embedded flowstones to be able to date
- Geologists infer that Rising Star cave is less than 3 million years old, so there seems to be a firm “oldest possible” date
- If *H. naledi* is more than 2 million years old, which Berger et al. suggest could be possible, the species might lie close to the very origin of the genus *Homo*.

Dating & Cladistics: morphological, not age-related, features

- In terms of strict cladistical analysis, the age of the fossils does not matter.
- Cladistics establishes evolutionary relationships strictly by grouping organisms according to their shared-derived characteristics.
- In the case of paleontology, the characteristics are almost always morphological.
- What fossil age helps do is give a timeframe for splitting events already established by morphology.
- In other words, in some ways, it does not matter how old *Homo naledi* is — its morphology suggests that it is an early *Homo* species.

Dating is hard: Remember Little Foot

- Different teams have produced very different ages for the famous Little Foot skeleton from the Silberberg Grotto of Sterkfontein, ranging over more than a million years.

- Good news: certain flowstones over the *Homo naledi* fossils (now being dated), which should hint at their minimum age.
- Bad news: bones in softer sediment, so they may have shifted from their original locations with respect to the flowstones.

- Worse news: don't know if there are flowstones *under* the *H. naledi* fossils because they haven't dug down that far yet. Without such layers, they couldn’t estimate the *maximum* age of the fossils.

The geological age of the fossils was not yet known as of 2016

- 2016: No age estimates have been obtained for the *Homo naledi* fossils found on the cave floor and in the excavation.
- The fossils lay in soft sediments that have partly mixed together over time, obscuring the bones' original location.
- Given layering of bones, conclusion is that they accumulated over time.
- Berger believed that based on its anatomy, it sits near or at the root of the *Homo* genus; his estimate was <2.5 Ma divergence. He implied it was ancestral to *Homo sapiens*

Homo naledi and death

Bodies were “deliberately disposed”: Burial ?

Other animals react to their dead: mourning

Public Domain

Public Domain

Gail Hampshire/ Creative Commons Attribution 2.0 Generic

Grief

Homo naledi

- Ants & bees have dispositional sites; but these are rare for mammals; Elephants, dolphins, giraffes, scrub jays and chimpanzees mourn their dead, but do not bury them.

- Intentional body disposal (which is different from burial — there is no sign that the remains were covered over) is thought to be a human behavior adopted only recently.

- Recognize that the "intentional disposal" of the dead bodies would be a surprisingly complex behavior for a creature with a brain no bigger than that of *H. habilis* or a gorilla.

- Was it removal of stinking corpses from the places where they lived in order to avoid scavengers and predators having access to them.

Care for their dead

- The Dinaledi Chamber has so far produced more than 2,000 hominin fossil specimens, representing at least 25 individuals of *H. naledi*.
- Did *H. naledi* “care” for its dead?
- The lack of remains of animals other than *H. naledi* suggests strongly that the chamber was not easily accessible from outside the cave system in the past.
- This idea is confirmed by the difference in sediment composition inside the chamber compared to the neighboring Dragon’s Back Chamber, and the lack of externally derived sediment particles with bones of *H. naledi* shows that the bodies entered the chamber at a time when surface sediments could not enter with them. These observations together reject most of the mechanisms that could lead to hominin bones being deposited in a cave system.
- What is left is the hypothesis that *H. naledi* itself was responsible for depositing the bodies.

Deposition of bodies

- Murdered by *H. sapiens* theory: cave predates presence of *H. sapiens* in S. Africa; no evidence of *H. sapiens* in Rising Star

- Most parsimonious explanation by Burger & Hawks:
  - repeated body deposition by *H. naledi* of their own group after death

- John Hawks: Current hypothesis: a biologically related group of *H. naledi* used Rising Star cave for several hundred years; others in region did not; cultural depositional of bodies; let's not let hyenas eat our relatives

Dirks, Berger, et al.: Deliberate body disposal

- “…our preferred explanation for the accumulation of H. naledi fossils in the Dinaledi Chamber is deliberate body disposal, in which bodies of the individuals found in the cave would either have entered the chamber, or were dropped through an entrance similar to, if not the same as, the one presently used to enter the Dinaledi Chamber.”

Geological and taphonomic context for *Homo naledi*

- Fossils are exclusively *H. naledi;* occur within clay-rich sediments derived from in situ weathering, and
- The Dinaledi Chamber fossils are not highly mineralized, and they lie within a soft, unconsolidated sediment different from the hard breccia deposits at most known fossil sites.
- The chamber was always in the dark zone, and not accessible to non-hominins.

Geological and taphonomic context for *Homo naledi*

- Hominins accumulated over time as older laminated mudstone units and sediment along the cave floor were eroded.
- It appears that the bodies were intact when they arrived in the chamber, and then started to decompose.
- Conclusion: Preliminary evidence is consistent with “deliberate body disposal in a single location.”

Taphonomic context

- No other large animal remains were found in the chamber, and the bodies were not damaged by scavengers or predators. Only damage made by modern snails and beetles and their larvae.

- Not a single mark made by a tooth or a stone tool, or any trace of a fracture that happened when the individuals were still alive. "These were the healthiest dead things ever seen."

- But note that perhaps only 1/10th of fossils in chamber have been examined.

A deliberate deposition of bodies

- The researchers suggest the last theory standing is that other *H. naledi* journeyed through the cave's dark passages, their way possibly lit by fire, and deliberately put the bodies there over a long period of time.

- Some scientists, however, think that explanation goes far beyond what the evidence supports.

- "Mortuary 'rituals' wherein pinheads regularly dispose of corpses makes a better headline than 'we don't yet have a clue,' " William Jungers, a paleontologist at the State University of New York, Stony Brook, told National Geographic.

- Corpse management strategies

Jungers on Berger

- “Lee likes to tell as good a story as he can,’ ” says William Jungers, at Stony Brook University. “Dumping conspecifics down a hole may be better than letting them decay around you.”
- Jungers suggests it’s possible that there was once another, easier, way to access the chamber where the bones were found. Intentional corpse disposal is a nice sound bite, but more spin than substance.” Jungers says. “When Lee gets in trouble is when he takes off his scientific hat and puts on his salesman hat. That’s when people start to roll their eyes a bit.”

John Hawks

- “These discoveries are telling us that it isn’t as hard as we thought to exhibit some kinds of human behaviors. It’s within the reach of simpler, more ancestral creatures,” says paleoanthropologist John Hawks of the University of Wisconsin–Madison.

- “There may be more than one way to be human-like.”

- Burial of dead is basic human behavior based on our emotional and social connection to others of our species

- Social bonding is one of our most fundamental drives

Start here

- 100 slides left

Homo naledi: Controversy! Was this a "burial" site?

- The individuals show signs of having been "deliberately disposed" of within the cave.
  - Bones of age range in typical cemetery (very young & very old; not much in middle);
  - No signs of predation (no teeth marks on bones); no predator eats only hominins;
    - Not any trace of carnivore remains or the remains of other likely prey animals. Thus, the predator would have had to select a single prey species--*H. naledi*--carrying into the chamber all age and size categories without leaving a trace of its own presence. Considered this very unlikely.
  - No signs of hominin occupation/habitation debris

Deliberate disposition 2

- Bodies came into cave as whole bodies. No green bone (pressure/trauma based) breakage, only dry bone (age) breakage; bones broke after deposition; bones were reworked post deposition
- Layered distribution of the bones suggests that they had been deposited over a long time, perhaps generations/centuries
- Not deposited by a water flow of material into chamber (no other debris); water entry blocked by Dragonback ridge
- Completely isolated depositional environment: Silt made up from material from cave itself, not dust from outside; different type of sediment than other chambers

No other entrance`s

- “An exhaustive search by a professional caving team and researchers has failed to find any other plausible access points into the Dinaledi Chamber, and there is no evidence to suggest that an older, now sealed, entrance to the chamber ever existed.

- Detailed geological surface mapping of the landscape overlying the Rising Star cave system illustrates that no large flowstone-filled fractures occur in the region above the Dinaledi Chamber.

- The roof of both the Dinaledi and Dragon’s Back chambers is formed by the capping chert, which has never been disturbed.

Dinaledi chamber is equivalent of a cemetery

- Mostly very young and very old
- Whole bodies with articulated pieces, not bits of bones
- Deposition of a single hominin group over generations
- Corpse disposal: but there are a lot of easier ways to get rid of a body (walk away, dump in river)

Alternative theory: Death trap

- The remains of *H. naledi* could have accumulated as a result of a classic catastrophic event during which a large group of animals is trapped in the cave:
  - during a single event when a large number of hominin individuals were in the chamber,
  - or in a death trap scenario over a period of time as individuals repeatedly entered the Dinaledi Chamber and died.

- Both hypotheses have evidence against them; but cannot be ruled out.

Did they get trapped there? A Death trap situation?

- Harder hypothesis to rule out: death trap
- No significant result when comparing the currently available age distribution to
  - either catastrophic death (more young adults and older juveniles)
  - or attritional mortality (over-represent old adults and very young children, i. e. graveyard) profiles
- Therefore a mass death scenario involving some sort of calamity or death trap cannot be completely excluded to explain the Dinaledi assemblage.
- The large number of immature individuals (8 out of 13) does allow us to reject hypotheses that would strongly over-represent adults, such as repeated cave exploration by socially isolated adult males.
- Counter: Multiple depositional episodes over many years, given repeated layering of bones in 3 feet of excavated area; requires crawling in, dying, over generations

Why conclusion for deliberate body deposition.

- Only *H. naledi* fossils found in chamber (only a small number of leg bones of a bird, and teeth and isolated bones of rodents).
- Exceptional preservation of bones
- Bones are lightly mineralized
- Sediments in chamber are not from external source
- Bodies were intact on arrival/ no green fxs.
- No evidence of some catastrophe which killed all the individuals inside the chamber

Why conclusion for deliberate body deposition.

- Bodies accumulated over time, not just one event.
- No evidence of predation on bones.
- No evidence of occupation of chamber.
- No evidence of flooding/water transport (being introduced by water flow).
- Site was used repeatedly for burials as the bodies were not all deposited at the same time.

Alternative explanations

- Briana Pobiner:
  - “Dead people smell bad and attract predators. A cave would be a good place to keep them far away from where you hang out, too, so I can see chucking bodies into the cave so you wouldn’t be the next one eaten for dinner.”
- Tegobo Makhubela, UJ lecturer: ***
  - "I think they went into the cave running away from danger of veld fires, heavy rainfalls with thunder or being chased away by predators and they were trapped down there unable to leave the place and ended up dying in the cave. I think they were alive because they do not have any indications of being attacked or killed.“
- CJV: Group got lost and trapped in Chamber.

Bones of Contention

- Questions raised:
- How old are the fossils? Failure to date the find
- Rush to publish; research done hastily
- Is it a new species? Or *Homo erectus*
- Theory that species might have disposed of its dead
- Untrained eyes
- Too much media
- Was there damage done to fossils?

Bones of Contention 2

- In 2000, four months after Berger's "Footsteps of Eve" was published, the *American Journal of Physical Anthropology* published a piece, by Tim White, about the state of paleoanthropology.

- White drew a distinction between "the scientist versus the careerist," warning that "irresponsible proclamations momentarily seize the public's attention in popular news and go straight into textbooks. The retractions rarely do."

Bones of Contention 3: *H. naledi* contrarians

- Amid all the hoopla and confetti, however, a number of scientists are advising caution.
- They're not denying the importance of the find; the fossils, they say, are invaluable. But they contend that the bones may not represent a new species.
- Berger submitted twelve papers to *Nature*. Asserted that the cave fossils represented another new species—*Homo naledi*, or Star Man.
- After an anonymous peer-review process, the papers were not accepted. The editors asked Berger to heavily revise them.
- After several back-and-forths, he withdrew them. *eLife* is peer reviewed; open journals accept around 25 percent, compared to the 7 percent acceptance rate of *Science. eLife* charges $2,500 to publish a paper.

Tim White vs Lee Berger

- Tim White, UCB, took 15 years to publish his findings on “Ardi.”:
- He believes *H. naledi* might be a variant of *H. erectus.*
- Technical debate about cranium: Berger maintains that 13 of the 83 characteristics he noted on *H. naledi’*s skull differ from characteristics on *H. erectus* skulls; White says many of these 13 characteristics are also present in *H. erectus.* Further, said White, some of Berger’s conclusions about *H. erectus’*s cranial features are just plain wrong. Berger maintains that an external occipital protuberance—basically, a bump at the back of the skull—is present in *H. naledi* but absent in *H. erectus.* White says *erectus* did have it.
- The fossils come not from a single specimen, but from as many as 15 different individuals; it is therefore difficult to identify which bone came from which individual, and even whether they lived in the same period.

Tim White

- Photos taken of the find demonstrate to White that many of the fossils "very disturbed, perhaps by earlier cavers, in the geologically recent past."
- "One tibia, for example, was white on one end, a clear indication it had been snapped off in the recent past,"
- White on Berger's burial theory: "The only evidence seems to be 'We can't think of anything else.' This is not evidence."
- Berger's response: This is White's opinion. Let him publish a scientific rebuttal.

Bones of Contention 4:

- John Hawks counters*:* body is unlike *H. erectus*; form of skull looks like early *erectus*, but premolar teeth unlike *erectus*; only 1 *erectus* brain is as small as *naledi*)
- The field is split, largely between those who consider Berger
  - a visionary for sharing data vs.
  - those who consider him a hype artist.
  - “Intentional corpse disposal is a nice sound bite, but it’s more spin than substance,” the paleoanthropologist William Jungers,

Bones of Contention 5

- Donald Johanson, the Lucy discoverer and an early mentor of Berger's: Rising Star was a "glaring example of how *not* to do fieldwork." An excavation that took twenty-one days should have taken "more like twenty-one months." Johanson said, "Berger *wants* criticism, so that he can then say, 'Look at me, I'm not an élitist—I'm just a Georgia boy, and you're old school and jealous.'

- Paleontologists Jeffrey Schwartz and Ian Tattersall suggested in the Aug. 28 issue of Science that the bones might represent at least two different species. And Tattersall told the New York Times it might turn out that *Homo naledi* was not *Homo* at all.

- Fred Spoor (U. College, London): despite small brain, this new species is clearly part of genus *Homo,* but doubts *H. naledi* was a direct ancestor of modern humans; burial hypothesis is controversial

Bones of Contention 6

- Christoph Zollikofer (U. of Zurich): fossils represent *Homo*, but strikingly similar to 1.8 My *Homo erectus* fossils of West Asia; may have belonged to *H. erectus* and evolved few skeletal innovations

- Susan Anton: doubts it is *Homo* because of *Australopithecus*-like features; fossils are “fabulous and a bit confusing.”

Bones of Contention 7

- *Journal of Human Evolution, 2016,* published the critique by Aurore Val, the Wits postdoc who had questioned the body-disposal claim.

- Questioned how the team could have made its radical conclusion without having established the bones' geological age or having excavated beyond a small fraction of the chamber.
- Accumulation could instead have been moved from somewhere else in the cave system by water and gravity rather than through deliberate placement by hominins

- Only a third of the fossils had been "microscopically analyzed," and the bone surface was intact on only six of 559 pieces (1/3rd of total bones). As a result, tooth marks, or cuts, or signs of trampling by predators "might not be preserved

Val critique

- Surface preservation of the bones is generally poor, which may obscure or eliminate original surface modifications, including carnivore damage.

- Absence of long bone heads is reminiscent of predation, and she believes that discounting natural forces such as flooding for depositing the bodies is unjustified.

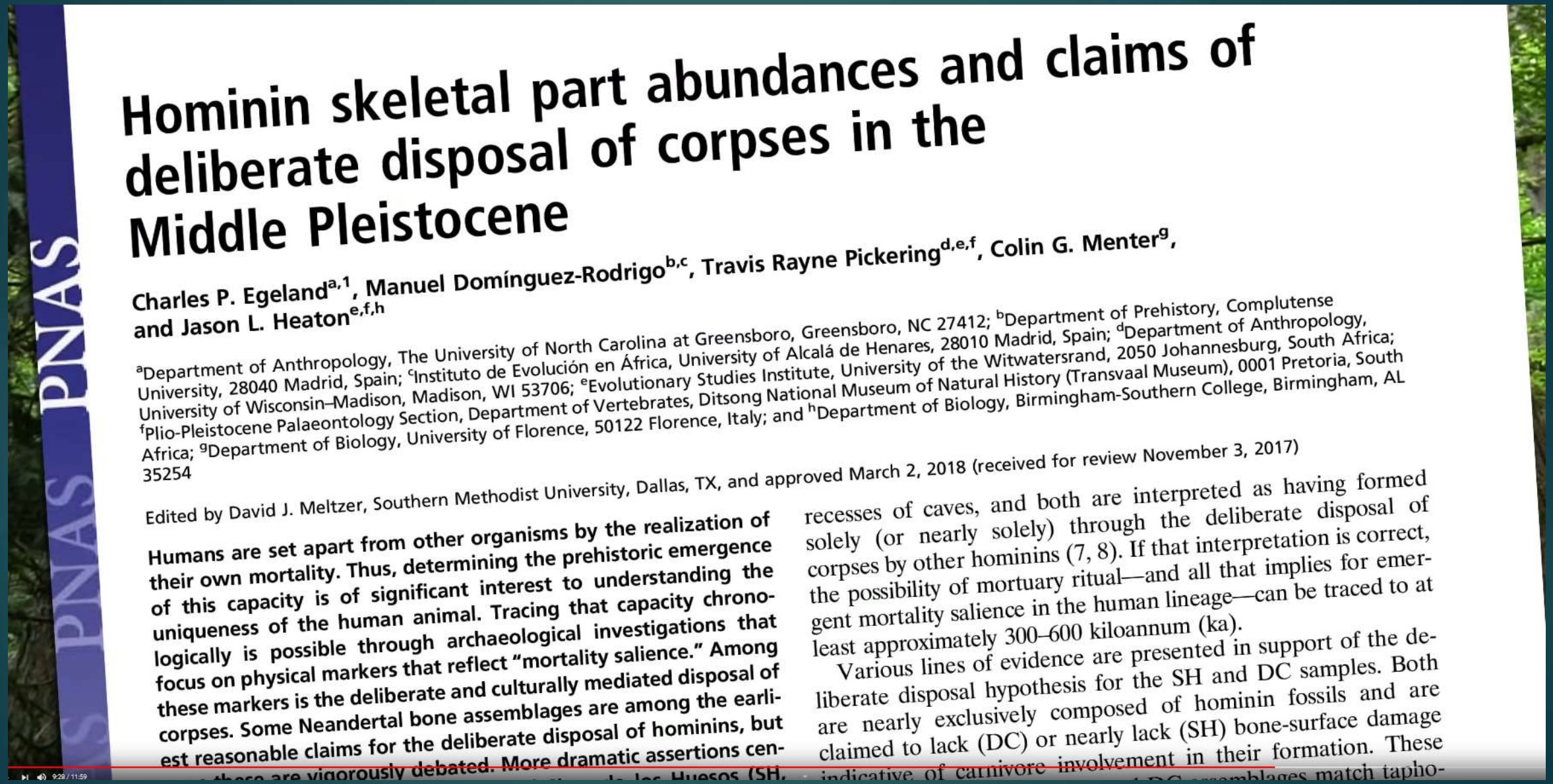
- Further, there is evidence of damage done by beetles, beetle larvae, and snails (which facilitate decomposition); but, the chamber does not present ideal conditions for snails, nor does it contain snail shells, which would indicate decomposition actually initiated before deposition in the chamber.

- It seems obvious that the entire assemblage should be analyzed carefully for surface modifications

Bones of Contention 8

- The journal then published Berger's response to Val, in a paper whose lead author was Paul Dirks, an Australian geologist who led part of the *naledi* analysis.
- The researchers noted that Val had neither examined the *naledi* materials directly nor visited the fossil chamber before offering a "reinterpretation" of the data.
- Responding to her doubt that hominins with small brains could establish and maintain a complex funerary tradition, they said, "The closest living relative of *H. naledi* is our own species, which exhibits elaborate mortuary behavior in every culture."

Most controversial conclusion



PNAS PNAS

Hominin skeletal part abundances and claims of deliberate disposal of corpses in the Middle Pleistocene

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Edited by David J. Meltzer, Southern Methodist University, Dallas, TX, and approved March 2, 2018 (received for review November 3, 2017)

Humans are set apart from other organisms by the realization of their own mortality. Thus, determining the prehistoric emergence of this capacity is of significant interest to understanding the uniqueness of the human animal. Tracing that capacity chronologically is possible through archaeological investigations that focus on physical markers that reflect "mortality salience." Among these markers is the deliberate and culturally mediated disposal of corpses. Some Neandertal bone assemblages are among the earliest reasonable claims for the deliberate disposal of hominins, but these are vigorously debated. More dramatic assertions cen-

recesses of caves, and both are interpreted as having formed solely (or nearly solely) through the deliberate disposal of corpses by other hominins (7, 8). If that interpretation is correct, the possibility of mortuary ritual—and all that implies for emergent mortality salience in the human lineage—can be traced to at least approximately 300–600 kiloannum (ka).

Various lines of evidence are presented in support of the deliberate disposal hypothesis for the SH and DC samples. Both are nearly exclusively composed of hominin fossils and are claimed to lack (DC) or nearly lack (SH) bone-surface damage indicative of carnivore involvement in their formation. These

Bones of Contention 9

- In 2018, anthropologist Charles Egeland and colleagues echoed Val's sentiments, and stated that there is insufficient evidence to conclude deliberate body disposal at Dinaledi.
- Use of machine learning analysis of bones: nonanthropogenic agents and abiotic processes cannot yet be ruled out as significant contributors to the ultimate condition of both Sima de los Huesos and Dinaledi collections; i. e. data associates with data of scavenged human corpses, leopard-consumed baboons, and baboons that died naturally within a cave.
- As to the DC assemblage, skeletal part data suggest that hominin corpses did not arrive in the chamber as complete skeletons and/or experienced some postdepositional disturbance
- It remains unclear how representative the excavated DC fossils is of the complete deposited assemblage

Egeland: cannot rule out carnivore involvement

- Recurrent clustering of the DC assemblage with the disturbed and carnivore-consumed samples

- They also said that the preservation of the Dinaledi individuals is similar to those of baboon carcasses which accumulate in caves (either by natural death of cave-dwelling baboons or by a leopard dragging in carcasses).

- Carnivore involvement should not yet be dismissed.

- Egeland: Representation of hominin skeletal parts does not correspond with primary human internments composed of complete skeletons. Rather, both the SH and DC bone samples cluster with comparative assemblages that experienced moderate to high levels of disturbance, whether through carnivore activities, abiotic postdepositional processes, or hominin-directed butchery and secondary interment.

Lichen on bones?

(a) Medial aspect; (b) lateral aspect; (c) close-up of anterior shaft; (d) mid shaft; (e) close-up of distal end seen in (a); (f) close-up of distal end seen in (b).

Bones of Contention 10

- Another Wits colleague, Francis Thackeray, did examine the fossils, and he recently joined Val in disputing the disposal theory.
- Thackeray found evidence of lichen on the bones, and this suggested to him that the remains had been exposed to extensive daylight
- Believes, at some time, a second entrance to the Dinaledi Chamber. This allowed at least some light to penetrate into the cave and to facilitate the growth of lichen
- Thackeray thinks that maybe the creatures got trapped by rockfall. In the press, he called Thackeray's hypothesis "flimsy" and said, "I am sticking with my theory."

Zeray Alemseged' s Opinion

Unprecedented, landmark find.

Help understand variation within one species.

Supports hominin species diversity (like other animal species)

Naming a new species warranted by the mix of characters.

Early hominin evolution is a pan-African story

2016: Zeray believed it is derived from *Homo erectus;* isolated in South Africa; an isolated, dead end species; like *A. sediba, H. floresiensis*

Just scratched the surface: Unanswered questions

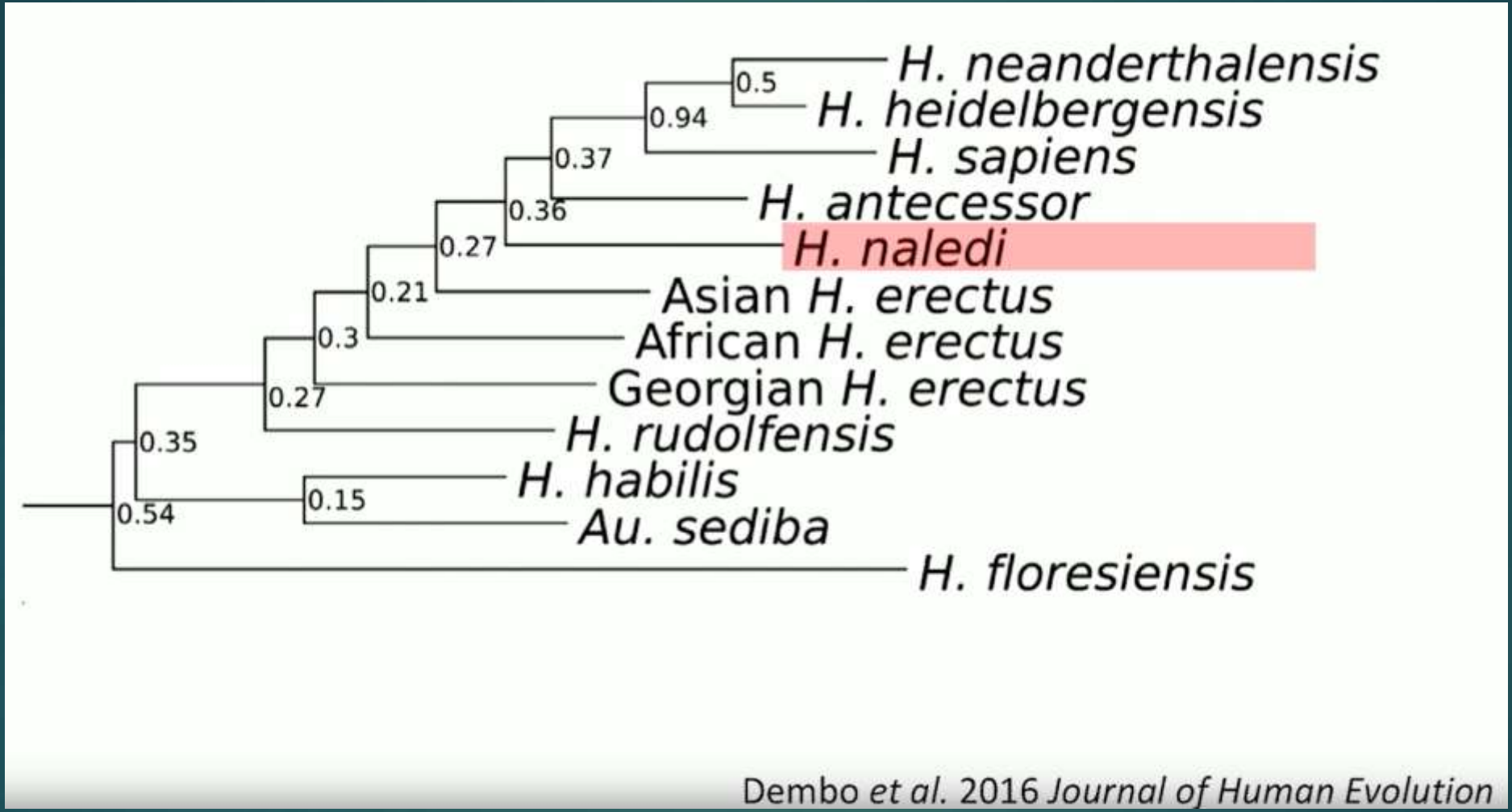
- Only 1 meter (15 cm deep) of 12 meters excavated so far: 1100 buried hominin bones. Then 50 cms of sterile soil. Then a single 800 Ka juvenile baboon tooth. Soil bottom is at 6 feet.

- Provisionally assigned to the genus *Homo*

- Where does *H. naledi* fit phylogenetically in human evolution?

- How did the remains arrive deep within the cave system?

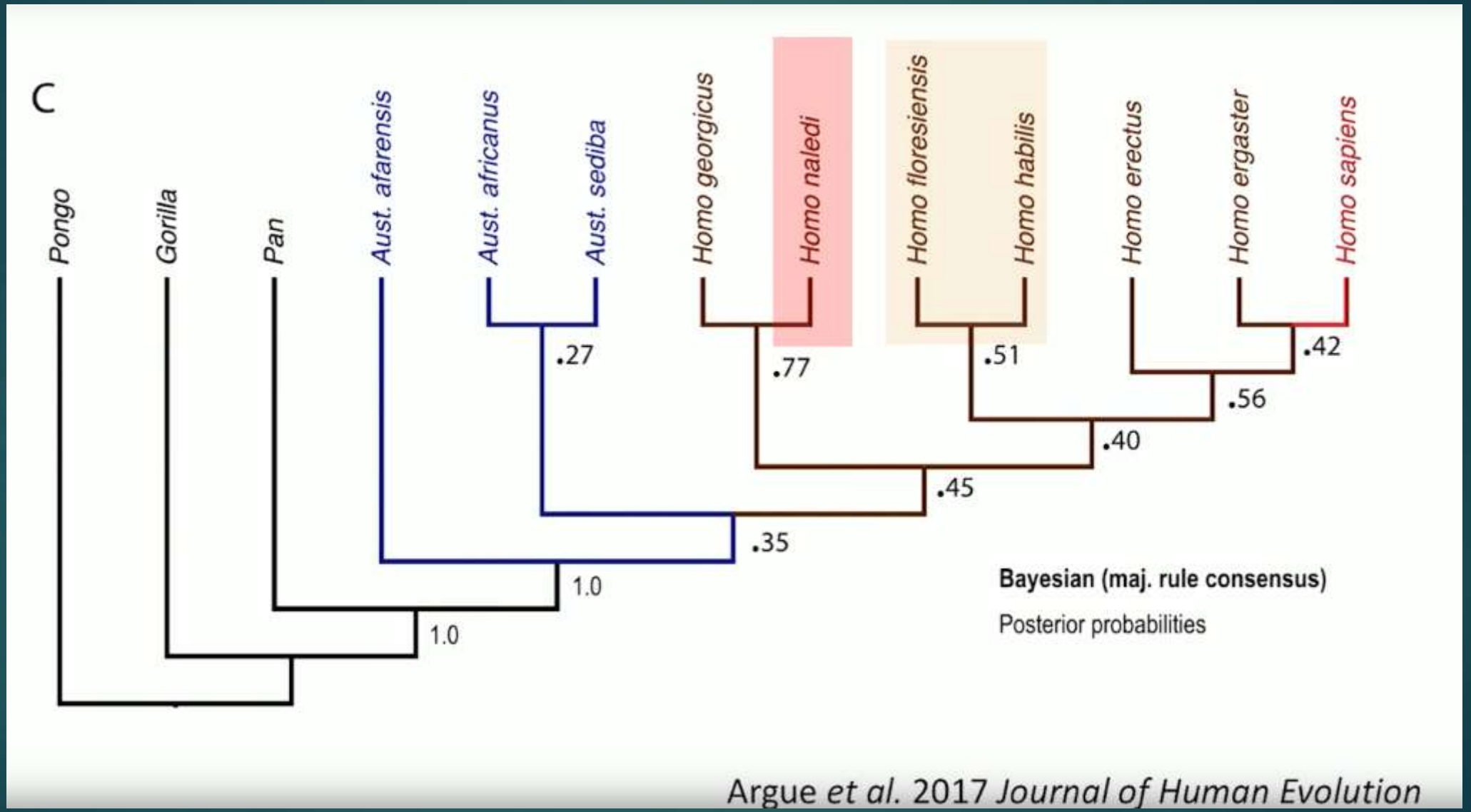
Skull data analysis by Bayesian model: *H. naledi* at 900 Ka



Only *H. naledi* and *H. neanderthalensis* really have enough fossils for comparison

Mana Dembo, et al., 2016

D. Argue: *H. naledi* related to Dmanisi erectus, 1.8 Ma



Argue *et al.* 2017 *Journal of Human Evolution*

No phylogeny & Proteinomics

- Problem with recent hominin phylogeny studies.
- Three different methods of looking at the phylogenetic placement of *Homo naledi* have led to three very different results, and similar problems have emerged with *Australopithecus sediba*, *Homo floresiensis*, and other species.

- These are some of the most complete skeletal samples of any hominin species, and yet they cannot reliably place them on a tree.

- Proteomics will provide some new evidence to add to the tree, but it may only deepen some of the problems.

2017: 3 new *Homo naledi* articles published in *eLife*

- P.H.G.M. Dirks et al. The age of *Homo naledi* and associated sediments in the Rising Star Cave, South Africa. *eLife*. Published online May 9, 2017. doi: 10.7554/eLife.24231.002.

- J. Hawks et al. New fossil remains of *Homo naledi* from the Lesedi Chamber, South Africa. *eLife*. Published online May 9, 2017. doi: 10.7554/eLife.24232.002.

- L.R. Berger et al. *Homo naledi* and Pleistocene hominin evolution in subequatorial Africa. eLife. Published online May 9, 2017. doi: 10.7554/eLife.24234.001.

Difficult to date: Dinaledi Bones not fully fossilized

- Bones are fragile
- Not fully fossilized/mineralized like dinosaur bones
- No organic material left, and partially replaced with calcite (both 2 Ma bones and Bronze age bones come in this pattern)
- Found in still soft sediments

New dating surprise: Late Middle Pleistocene = 300 Ka

Jebel Irhoud, Morocco
6800 miles

Broken Hill, Zambia
800 miles away

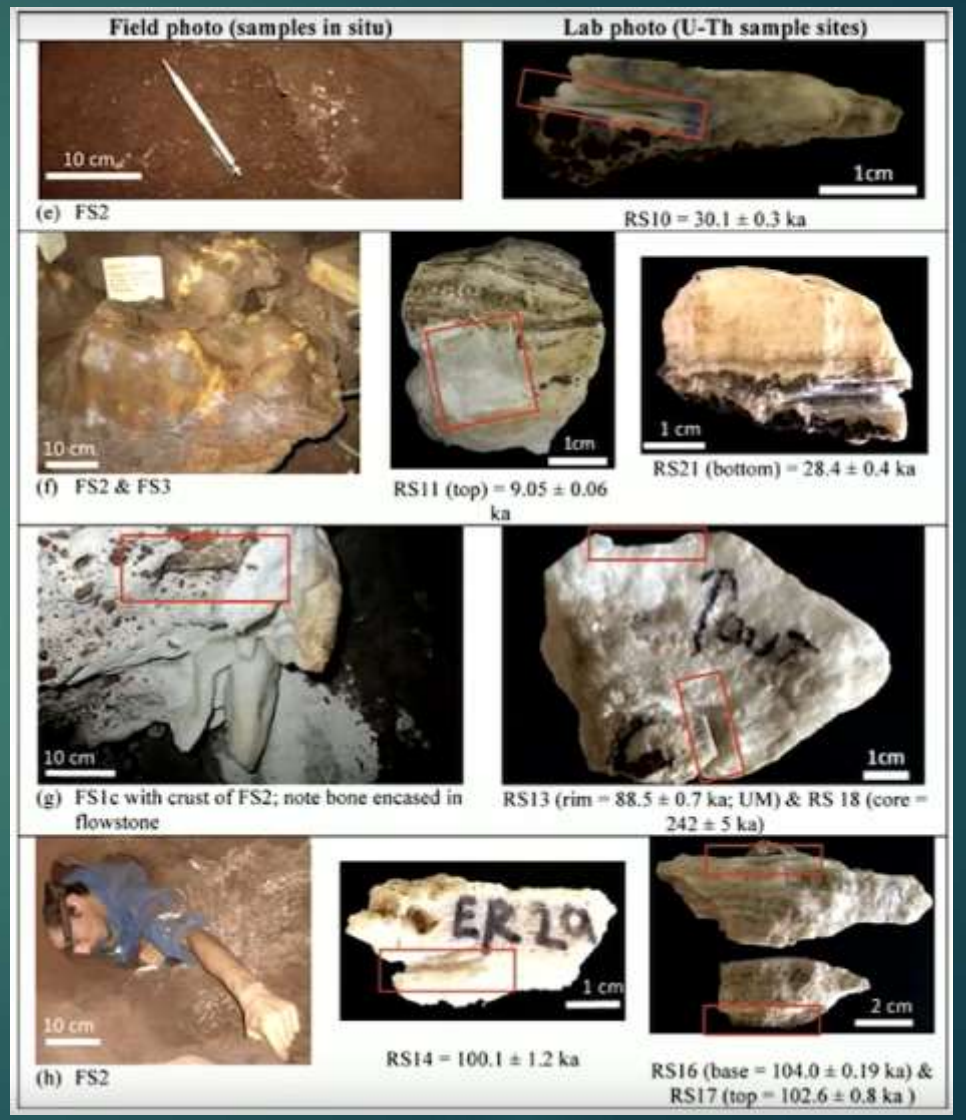
Naledi, South Africa

Teeth for dating: ESR & U

Figure 6. Photographs of *H. naledi* teeth used for ESR dating. (a) U.W.101–1767; (b) U.W.101–1788; (c) U.W.101–1810. The order of images for each panel is: buccal, distal, lingual, mesial, and occlusal views. The scale bar in each panel is 1 cm.

DOI: 10.7554/eLife.24231.013

Flowstones: ESL & U-Th



P. Dirks, et al., 2017: New Dating: 236-335 Ka

- New ages for flowstone, sediments and fossil bones from the Dinaledi Chamber
- 10 different labs and six different techniques which also involved double-blind testing were used.
- Optically stimulated luminescence dating of sediments with U-Th and palaeomagnetic analyses of flowstones to establish that all sediments containing Homo naledi fossils can be allocated to a single stratigraphic entity (sub-unit 3b), interpreted to be deposited between 236 ka and 414 ka.
- Confirmed independently by dating three H. naledi teeth with combined U-series and electron spin resonance (US-ESR) dating. Two dating scenarios for the fossils were tested by varying the assumed levels of 222Rn loss in the encasing sediments: a maximum age of 253 +82/–70 ka; minimum age = 200 +70/–61 ka.
- We consider the maximum age scenario to more closely reflect conditions in the cave, and therefore, the true age of the fossils. By combining the US-ESR maximum age estimate obtained from the teeth, with the U-Th age for the oldest flowstone overlying Homo naledi fossils, we have constrained the depositional age of Homo naledi to a period between 236 ka and 335 ka. These age results demonstrate that a morphologically ancestral hominin, Homo naledi, survived into the later parts of the Pleistocene in Africa, and indicate a much younger age for the Homo naledi fossils than have previously been hypothesized based on their morphology.

Paul HGM Dirks, et al., 2017

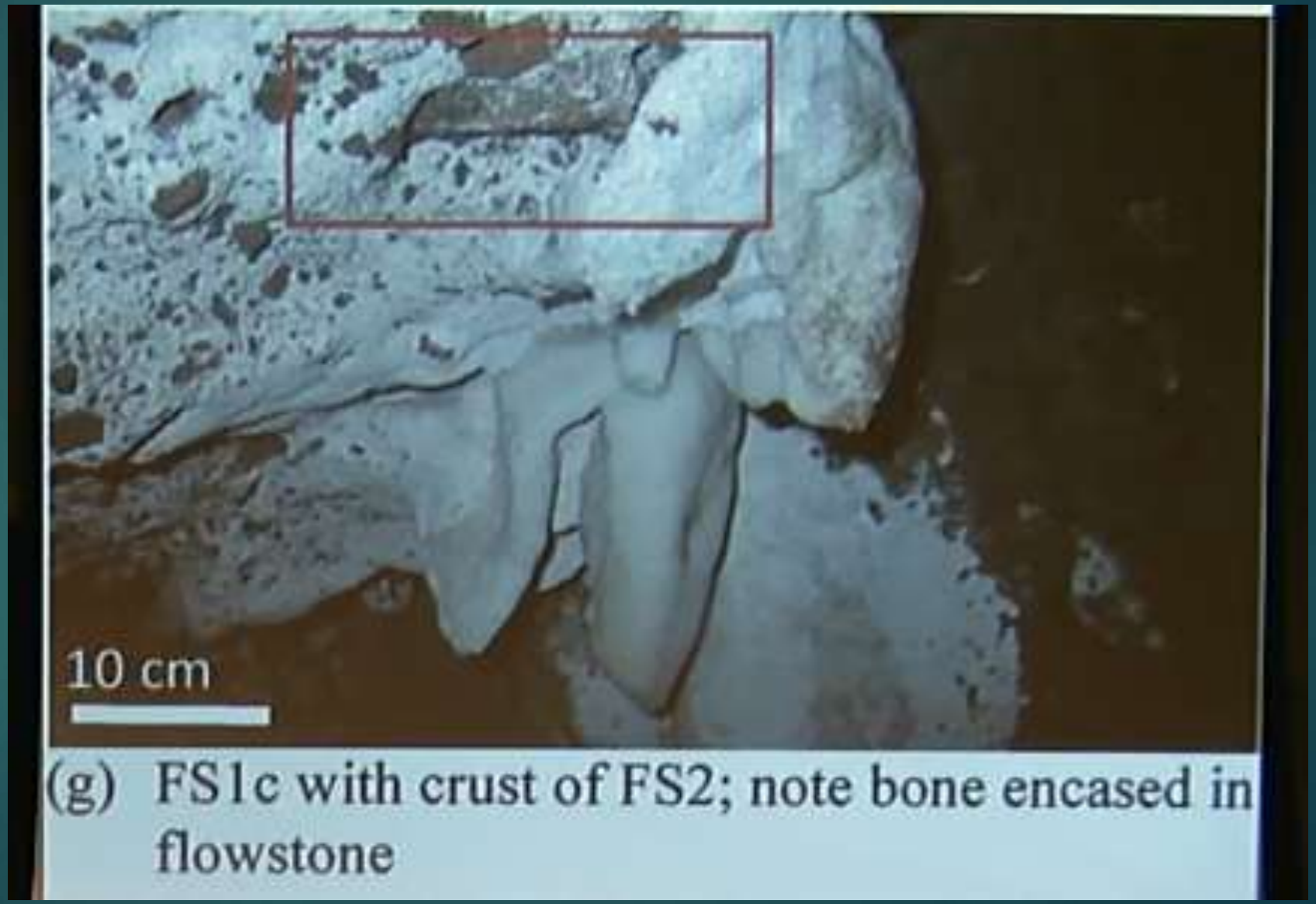
New dating: 235-336 Ka

- Based on geological analysis, new dating: 235-336 Ka
- Late for such a small brained hominin
- Raises issues of nature of genus *Homo:* A lot of morphological variation in *Homo*
- Correlation of large brain and hip or teeth morphology no longer valid
- Evidence of coexistence of 3 *Homo* species at 300 Ka
- Did they interbreed, compete with each other?
- Hand and wrist morphology compatible with stone tool use

Flowstone with bone embedded

Relative dating of flowstones by uranium in groundwater

Bone: Max age of 236 Ka



(g) FS1c with crust of FS2; note bone encased in flowstone

Dating methods

6 techniques from 11 labs (1st double blind fossil testing: blind unidentified and fake samples:

Relative dating of flowstones
by uranium in groundwater

Absolute dating:
Uranium-thorium and Electron spin resonance in teeth: ESR = teeth are younger than 335 Ka

Also used optical on quartz grains in dirt (last exposed to light):

Magnetism in flow stones: since
780 K of last magnetic reversal

Conclusion: bones laid down after 300 Ka and before 236 Ka, late middle Pleistocene: Coelacanth of hominins?

Dating

- Based on the anatomy, most agreed that *naledi* was an early species of the *Homo* genus, so the tender young age of 300,000 years is quite a surprise.
- While there are several possibilities, what seems most likely is that *H. naledi* was a long-persisting species. It evolved somewhere in Africa, possibly from a common ancestor of *H. habilis* or even from *habilis* itself.
- The main question now is how such an archaic species survived to such a late date. It means that a species of human with some surprisingly ancestral features – including a tiny skull and brain – survived into the relatively recent past.

2017: *Homo naledi* dated to 236-335 kya

- *H. naledi* seems to be more in the style of *H. floresiensis*, the “hobbits,” who maintained a ancestral hominin form until surprisingly recent times.

- New dating doesn’t, however, answer questions about how long ago the species first appeared and when it died out.

- *H. naledi* DNA would help clarify the species’ evolutionary status. But attempts to extract DNA from Dinaledi fossils have so far failed.

2013-2017: New discoveries: Lesedi Chamber

- Additional fossil hominin material was subsequently discovered in the Lesedi Chamber of the cave system in November 2013 by Rick Hunter and Steven Tucker. Only published in 2017.

- The second cavern, called the Lesedi chamber, is a mere 80 lateral meters from the now-famous Dinaledi chamber,

- No direct geological connection to the Dinaledi Chamber.

New Lesedi chamber

- 2000 bones in both chambers; Of the 206 bones in the human body, only about 20 are not represented in the cave.
- "[The second] chamber has the remains of an additional three individuals at least as of 2017; 131 fossil bones in 3 collection sites
- Includes a partial (40%) skeleton with a skull. Named “Neo (“nay-oh”)” which means *gift* in Sesotho, a language spoken in South Africa.
- Lesedi fossils are notably similar to the Dinaledi fossils in shape and morphology.
- 2020: 25 individuals (number of same teeth) in both chambers

Discovery of new Lesedi Chamber: Neo

"Neo" skull from Lesedi Chamber (left) with DH1 Homo naledi skull from Dinaledi Chamber (right). Homo naledi was alive sometime between 335,000 to 236,000 years ago.

— Photo Credit: John Hawks, Wits University.

Lesedi Chamber location

- There is no straight-line route between the Dinaledi and Lesedi Chambers, and the shortest traversable route between the two areas is almost 145 m.

- There are currently four access routes from the surface to the Lesedi Chamber. The most accessible of these currently follows an 86 m downward-sloping path with several narrow passages and short climbs, but only one squeeze and no significant crawls. This has been the main access route for excavators. The other three routes are each substantially more challenging.

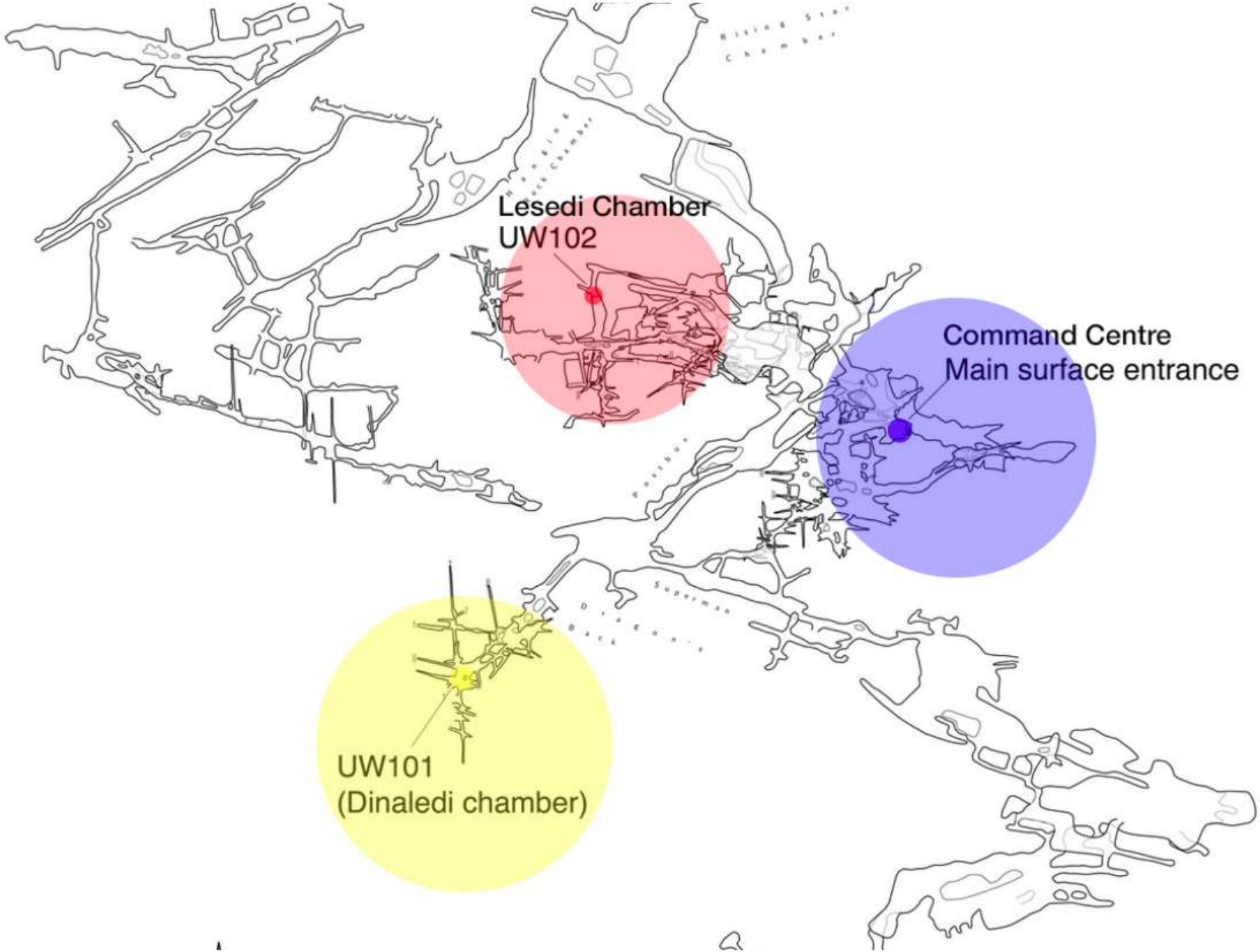
- The three areas that were sampled do not represent a systematic sampling of the chamber's contents

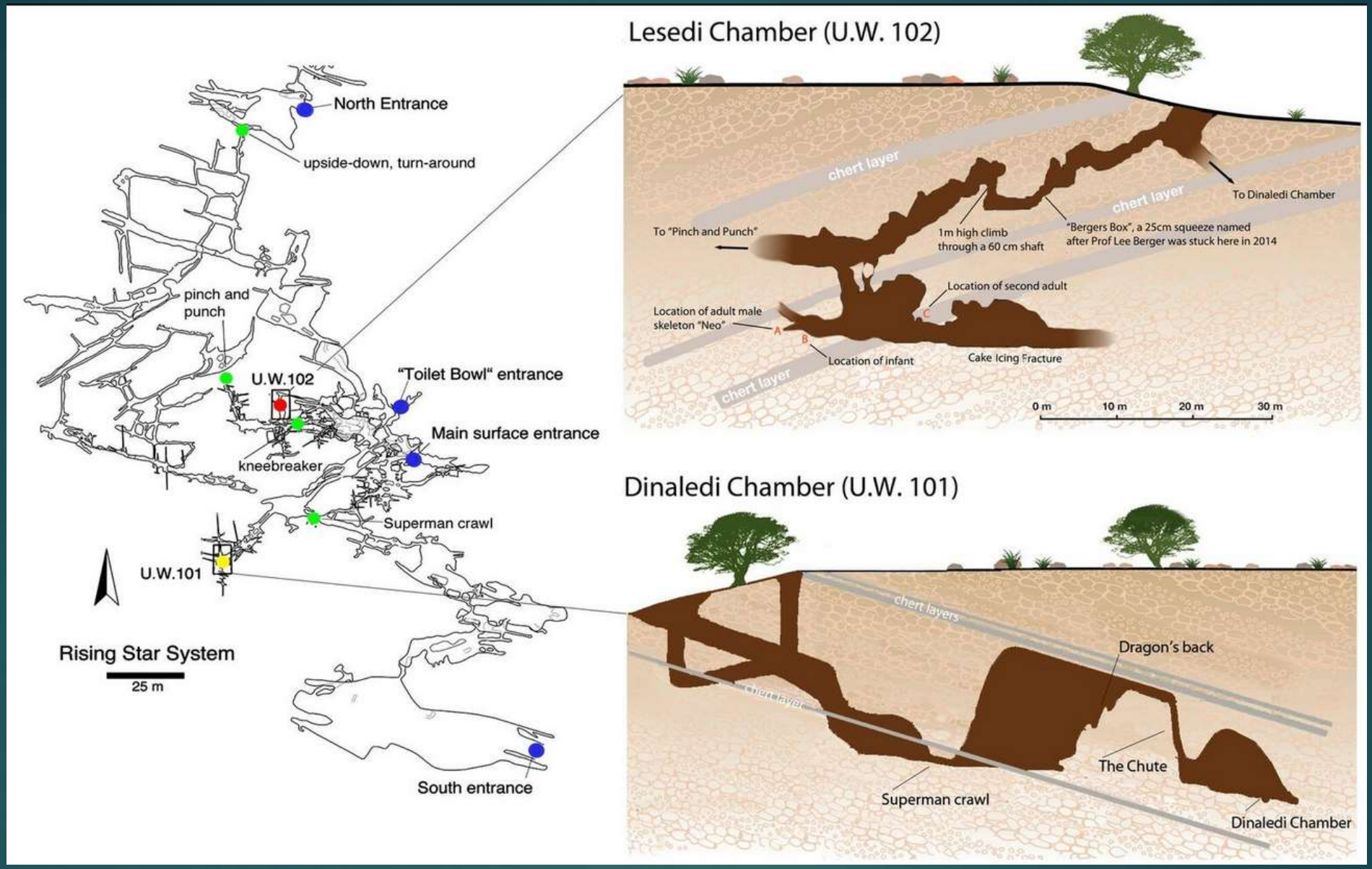
Lesedi Chamber

- The Lesedi chamber is 30 meters below the surface and there is no direct route between it and the Dinaledi Chamber.

- Again, the evidence is most consistent with the bodies arriving intact into the chamber, and there were no signs that the remains had been exposed to the surface environment.

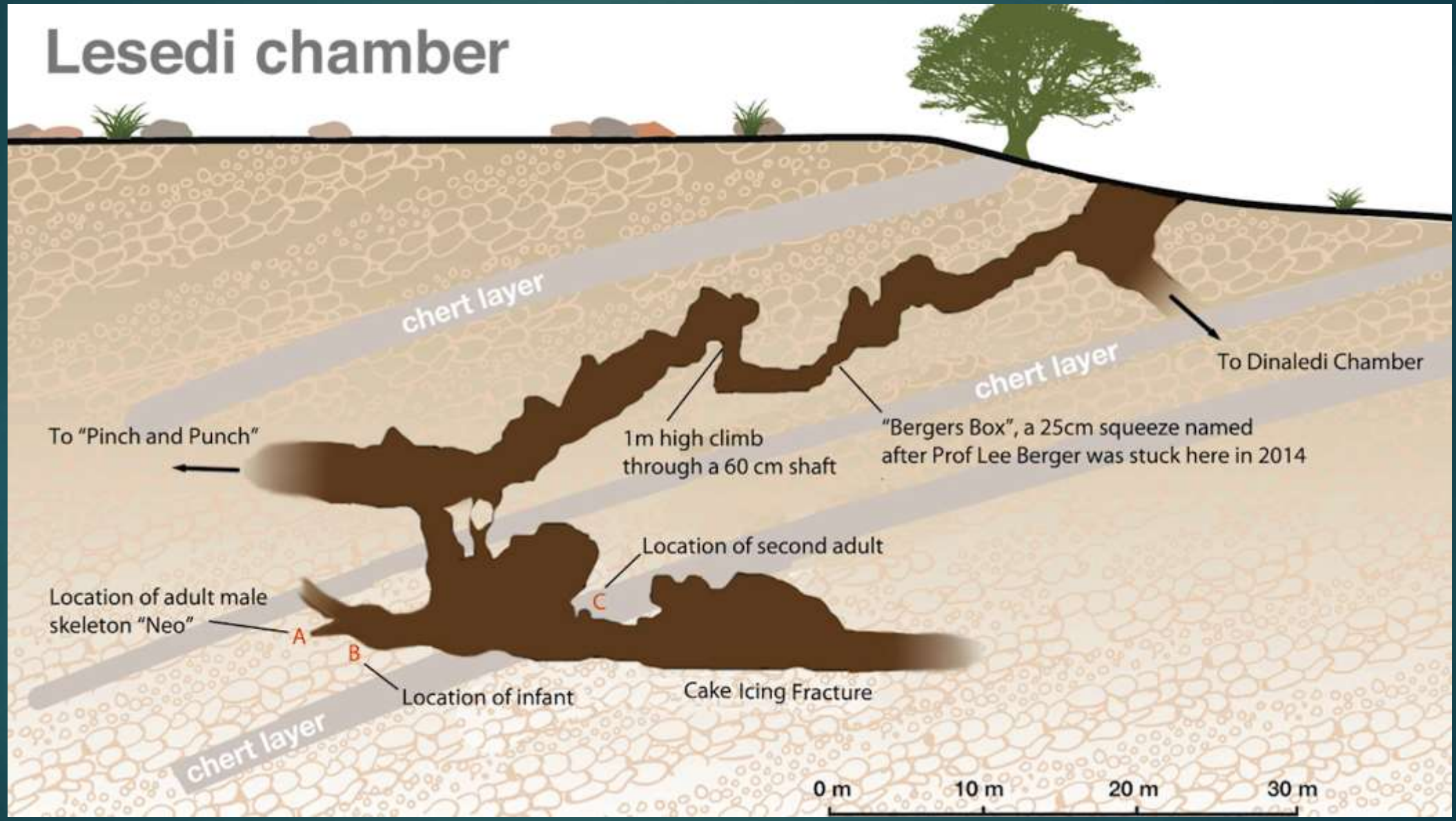
- Only a small volume of the chamber has been excavated so far, and so there are likely more fossils still to be found.


Lesedi Chamber
UW102
Command Centre
Main surface entrance
UW101
(Dinaledi chamber)

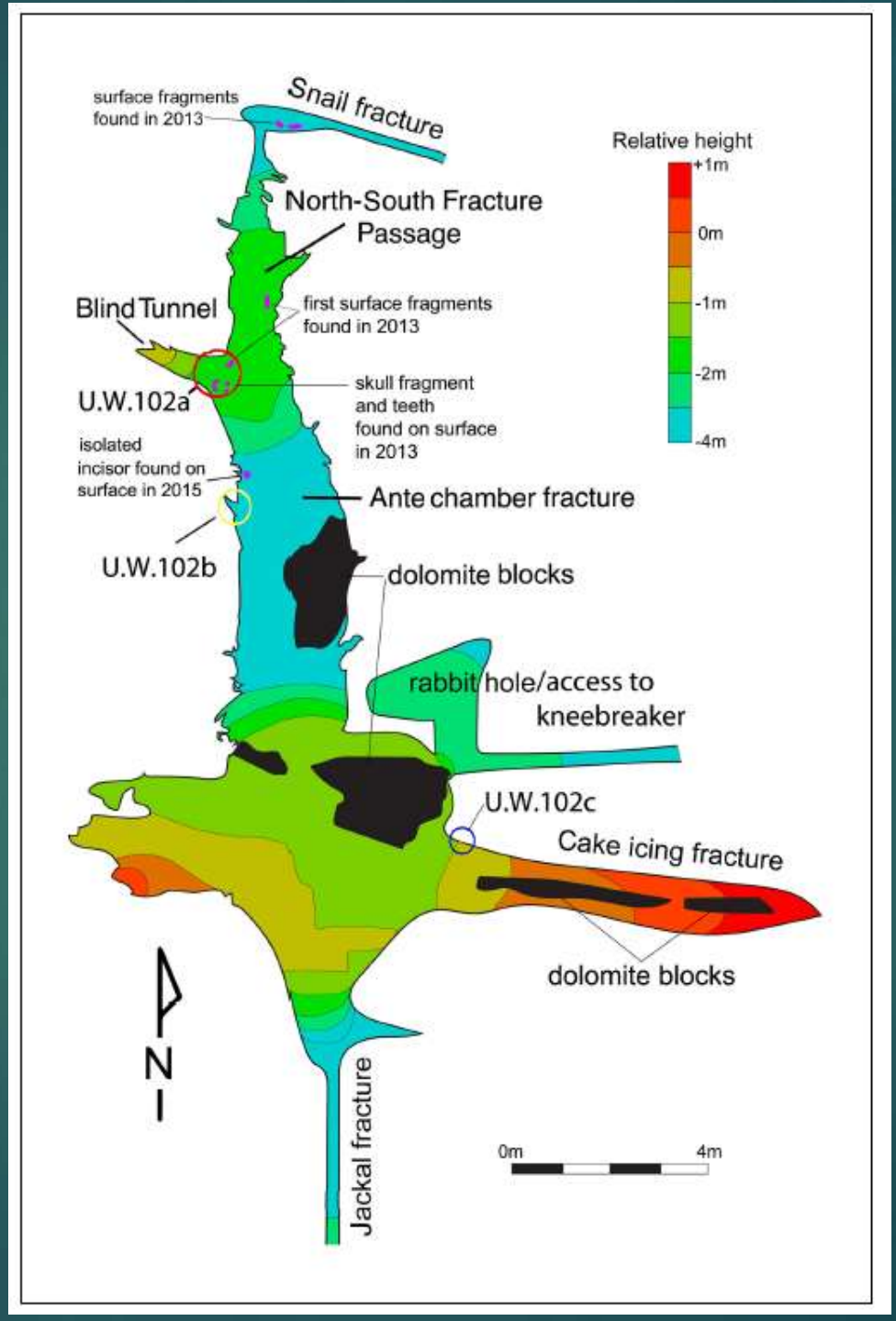


Lesedi Chamber is located about 100 meters from the Dinaledi Chamber that yielded the first set of *H. naledi* bones. Both chambers are extremely difficult to access, leading researchers to propose that this small-brained human species cached its dead in these remote locales. Credit: Marina Elliott *Wits University*

New Lesedi Chamber



Lesedi Chamber



Lesedi Chamber

- The sedimentary context of the three collection areas is broadly similar, but we have not yet established whether the fossil material resulted from a single depositional episode or from multiple distinct events.

- This second *H. naledi* locality has been designated U.W. 102. The chamber itself has been named the Lesedi Chamber, a word meaning ‘light’ in Setswana. By contrast, the Dinaledi Chamber was numbered site U.W. 101.

Not catastrophic death

- The discovery of more specimens from a different cave chamber appears to remove the possibility that the sample from Dinaledi represented a one-time catastrophic event that killed a single group of *H. naledi*.

- This deepens the lingering mystery of how the fossils came to rest in such dark and inaccessible parts of the cave. Were the dead intentionally placed there after all?

- Evidence of small carnivores remains in different area from hominins in Lesedi Chamber

- Don’t know age of hominins

Lesedi Chamber confirmation

- The depositional situation of the fossils is strikingly similar. As in the Dinaledi Chamber, the bones of *H. naledi* in the Lesedi Chamber are at most lightly mineralized, and they lie within soft unlithified sediments.

- None of the hominin remains bear any signs of cutmarks, tooth marks, or other damage from predators.

Hawks, J & Berger, L., 2020

Lesedi Chamber confirmation

- Water may have affected the deposits in the Lesedi Chamber by washing out some areas of the chamber's sediments, but the Neo skeletal remains appear to be relatively undisturbed, suggesting that such erosion happened long after this body was deposited.

- If *H. naledi* was using these chambers of the Rising Star cave system to deposit dead bodies, what does it mean?

- A short answer to this question is that we do not know..

3rd article by Berger: *Homo naledi* and Pleistocene hominin evolution

- Although the Dinaledi finds are unexpectedly young, *H. naledi*'s ancient-looking characteristics suggest that the hominin originated near the root of the *Homo* genus, 2 million years ago or more, Berger and colleagues propose in the third new paper.
- That would make the South African species a possible ancestor or close relative of *H. erectus*, which dates to around that time.
- "We can no longer assume that we know which species made which tools or even assume that it was modern humans that were the innovators of some of these critical technological and behavioral breakthroughs in the archaeological record of Africa."

Berger's conclusions:

- Another possibility, Berger's group says, is that *H. naledi* originated a few hundred thousand years ago and is most closely related to early *H. sapiens* or other *Homo* species that may have inhabited southern Africa at that time.

- A relatively late origin for *H. naledi* would suggest it evolved from larger-brained ancestors.

- That would be unusual: Scientists have long held that the brain only became larger as *Homo* species evolved.

Christ Stringer

- Chris Stringer: An “astonishingly young” age for a *Homo* species with several ancestral features suggests *H. naledi* was the sole survivor of an array of much older, closely related species.

- *H. naledi* probably made some of the many stone tools found at southern African sites dating to around 300,000 years ago that have not yielded hominin fossils.

- But despite Berger’s claims, Stringer doubts a creature with a brain size close to that of a gorilla disposed of its dead deep within a pitch-black, hard-to-navigate cave system, especially since the controlled use of fire for torches was probably also needed.

Don Johanson & Fred Smith reactions:

- Don Johanson: However complex *H. naledi*'s behavior may have been, ancient aspects of its anatomy rule it out as an ancestor of *H. sapiens. He* argues that *H. sapiens* originated in East Africa, at between 200,000 and 300,000 years ago. "The Rising Star Cave hominins, much like the hobbits, evolved in isolation and have no relevance to the origins of humankind

- Fred Smith: Still, even a largely isolated *H. naledi* population may have occasionally interbred with other *Homo* species in southern Africa.

Challenges to conventional theory

- The persistence of small-brained humans for so long in the midst of bigger-brained contemporaries revises the previous conception that a larger brain would necessarily lead to an evolutionary advantage,

- Their mosaic anatomy greatly expands the known range of variation for the genus.

- Evolution depends on adaptation to ecological variation and not to larger brains: Remember simultaneity of larger brained *H. erectus* and smaller brained *P. robustus*

"Immature remains and the first partial skeleton of a juvenile Homo naledi, a late Middle Pleistocene hominin from South Africa".

- An assemblage of immature remains of a *Homo naledi* recovered from the 2013–2014 excavation season.
- From this assemblage, we attribute 16 postcranial elements and a partial mandible with some dentition to a single juvenile *Homo naledi* individual.
- The find includes postcranial elements never before discovered as immature elements in the sub-equatorial early hominin fossil record

Bolter, D., et al., (2020).

DH7: Juvenile *H. naledi*

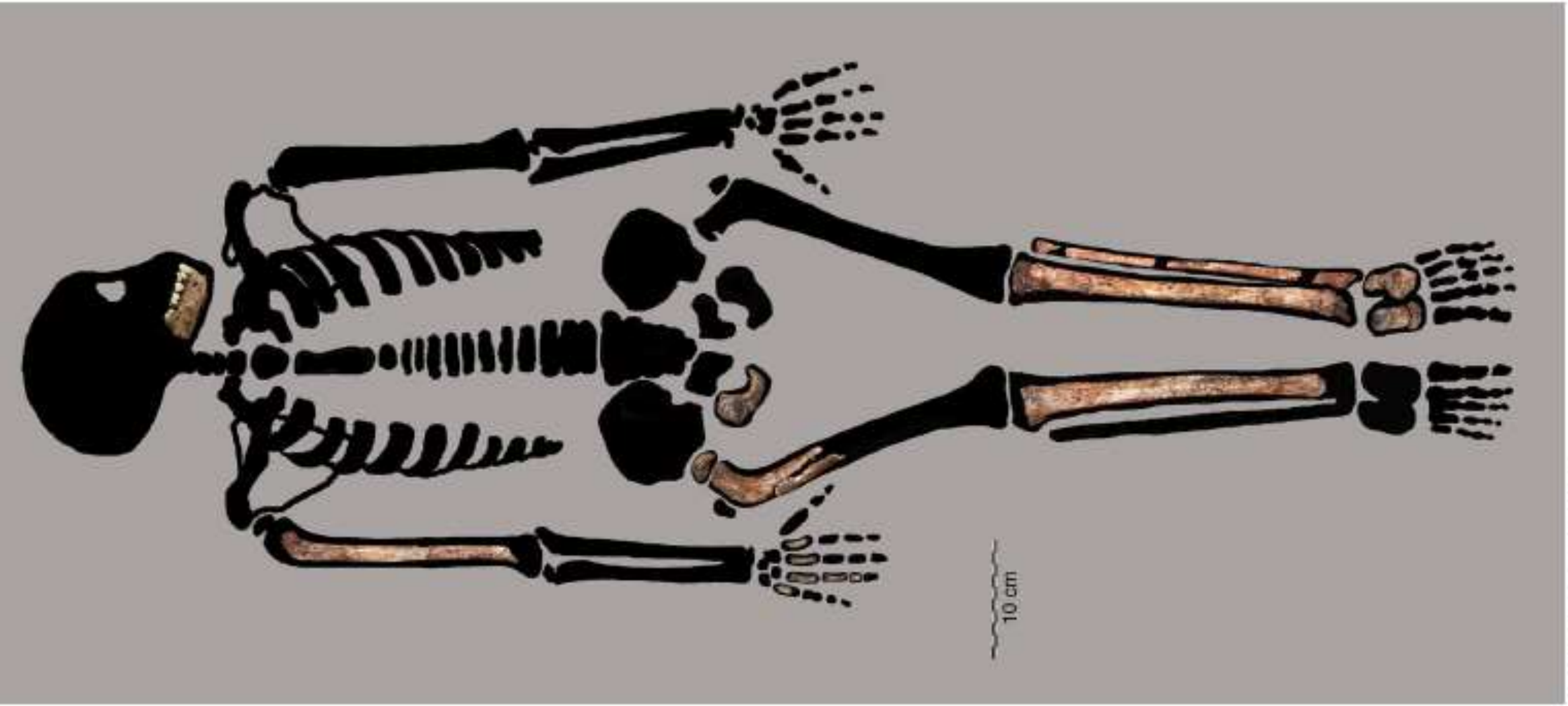


Fig 8. DH7 partial skeleton.

DH7: a juvenile

- DH7 is consistent in skeletal maturity with MH1 and KNM-WT 15000, both of which exhibit an ape-like (non-human) maturational timing.

- Dentally, *H. naledi* appears to have a pattern of dental eruption which suggests an affinity with *H. sapiens*, with premolars fully emerged by the time the second molars are fully erupted; however, the pattern of dental root formation is more ape-like.

- *H. naledi* has a unique dental pattern of surface enamel deposition unlike any other hominin.

- ~8–11 years old

Neo

Neo

Neo means “gift” in SeSotho

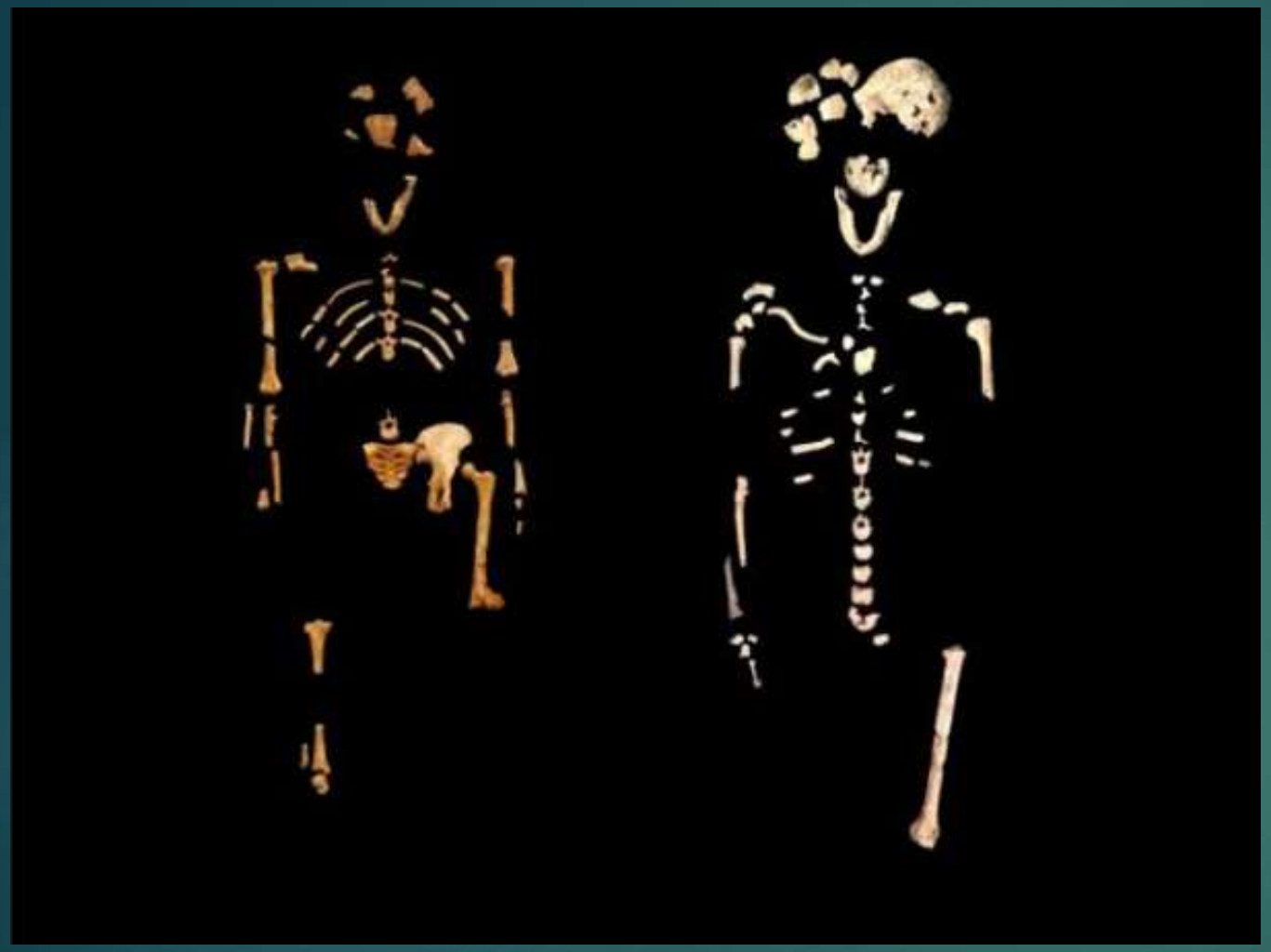
- The remarkably complete skull of Neo adds additional information about the anterior skull and face.

- The nose and maxillary area of *H. naledi* is flatter than previously thought.

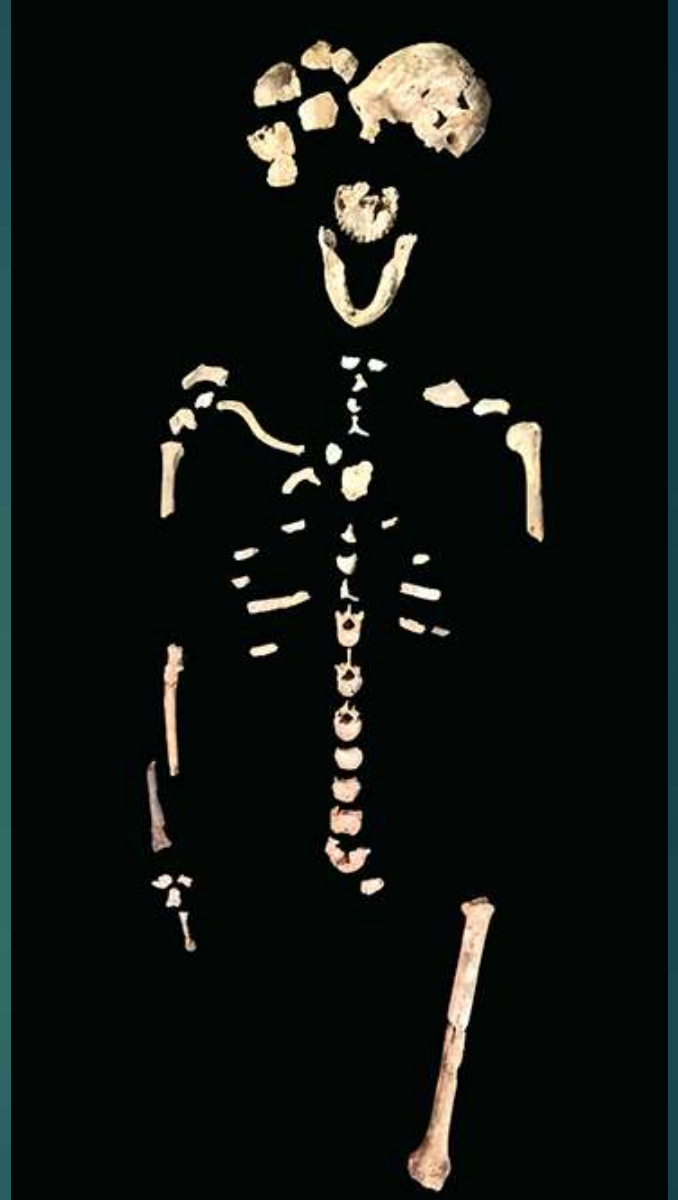
- "Hopefully this puts the argument that this is Homo erectus to rest!" said Berger, a reference to the small but vocal contingent of those that believe that *H. naledi* is nothing more than an early H. erectus.

Neo

Lucy and Neo



Neo is one of the most complete skeletons ever found.

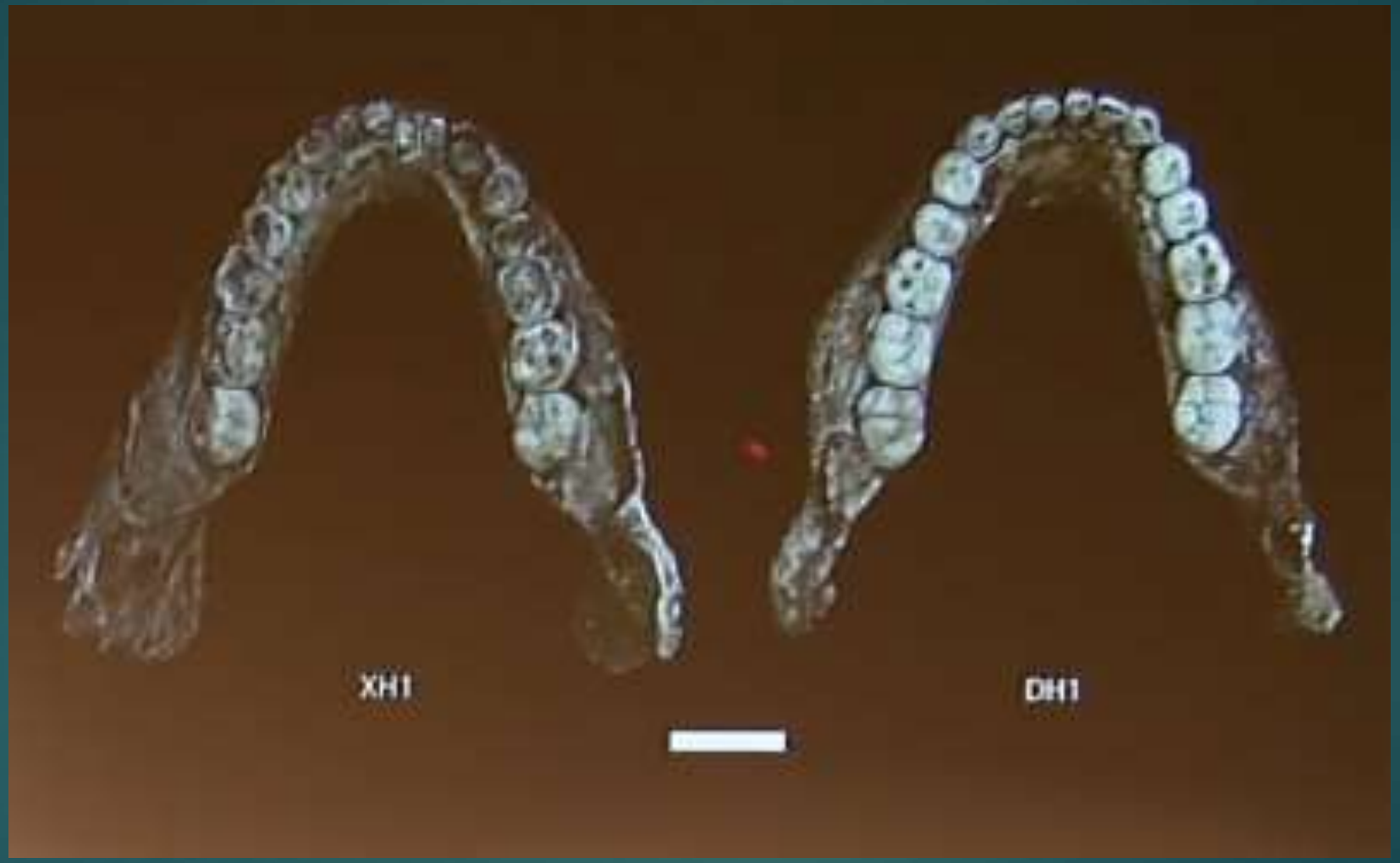


BODY PLAN A partial *Homo naledi* skeleton unearthed in South Africa is about as complete as Lucy's famous partial skeleton. Lucy, an *Australopithecus afarensis*, lived in East Africa about 3.2 million years ago. H. naledi lived perhaps 300,000 years ago, scientists say, although this new partial skeleton remains undated.

Neo reconstruction

Neo’s mandible

Neo mandible



Dinaledi mandible

LES1 Cranium – Neo: 610 cc

LES1, with an endocranial volume of ~ 610 cc; 9 percent larger than the brain size estimates for the previously discovered Dinaledi fossils

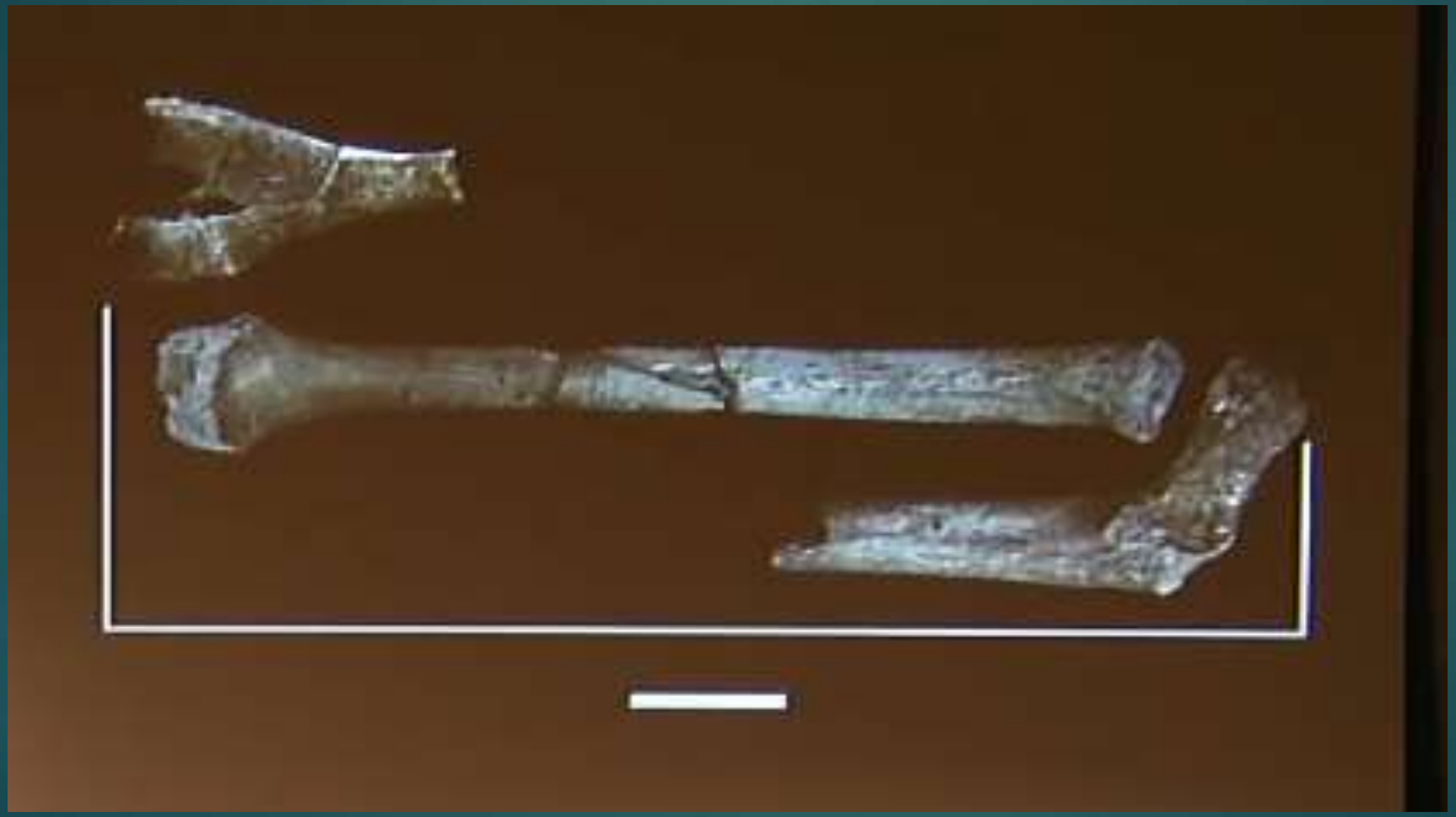
LES1 Cranium

Neo from Lesedi

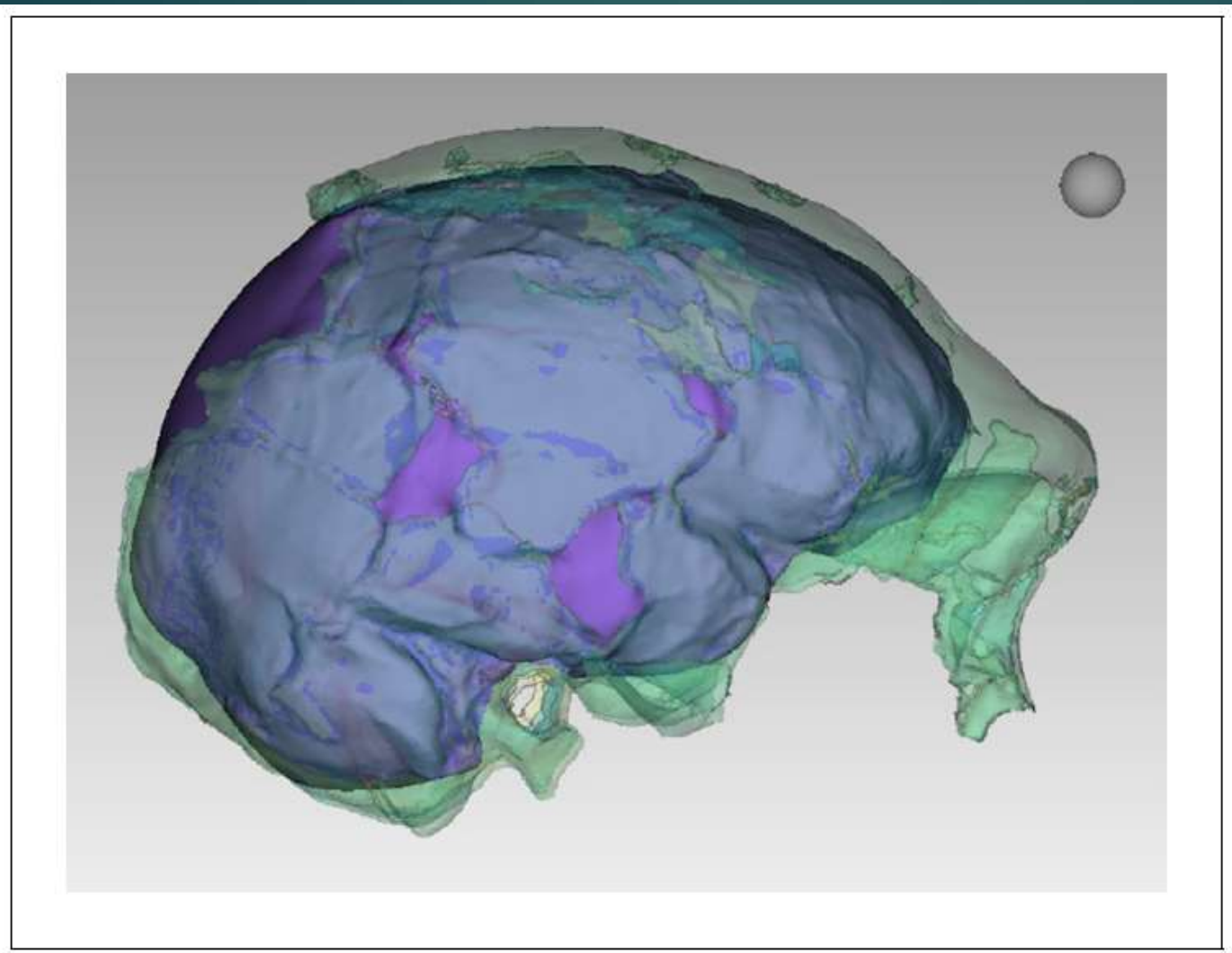
DH1 from Dinaledi

"Neo" skull (left) compared to DH1 skull of Homo naledi (right). Photo credit: John Hawks CC-BY

Neo femur



LES1 digital reconstruction of volume: 610 cc

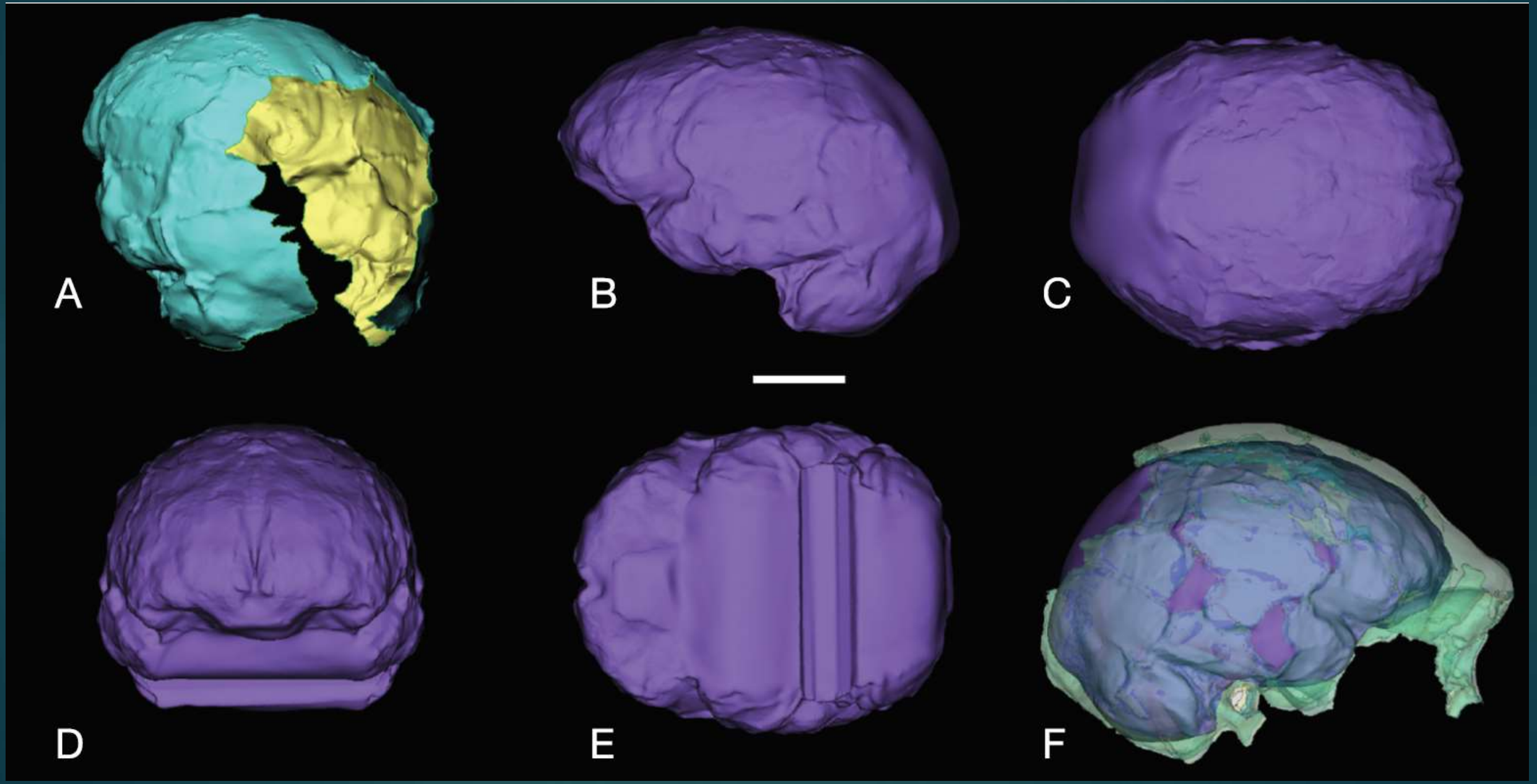


Bigger than floresiensis;
Overlaps with
australopithecus

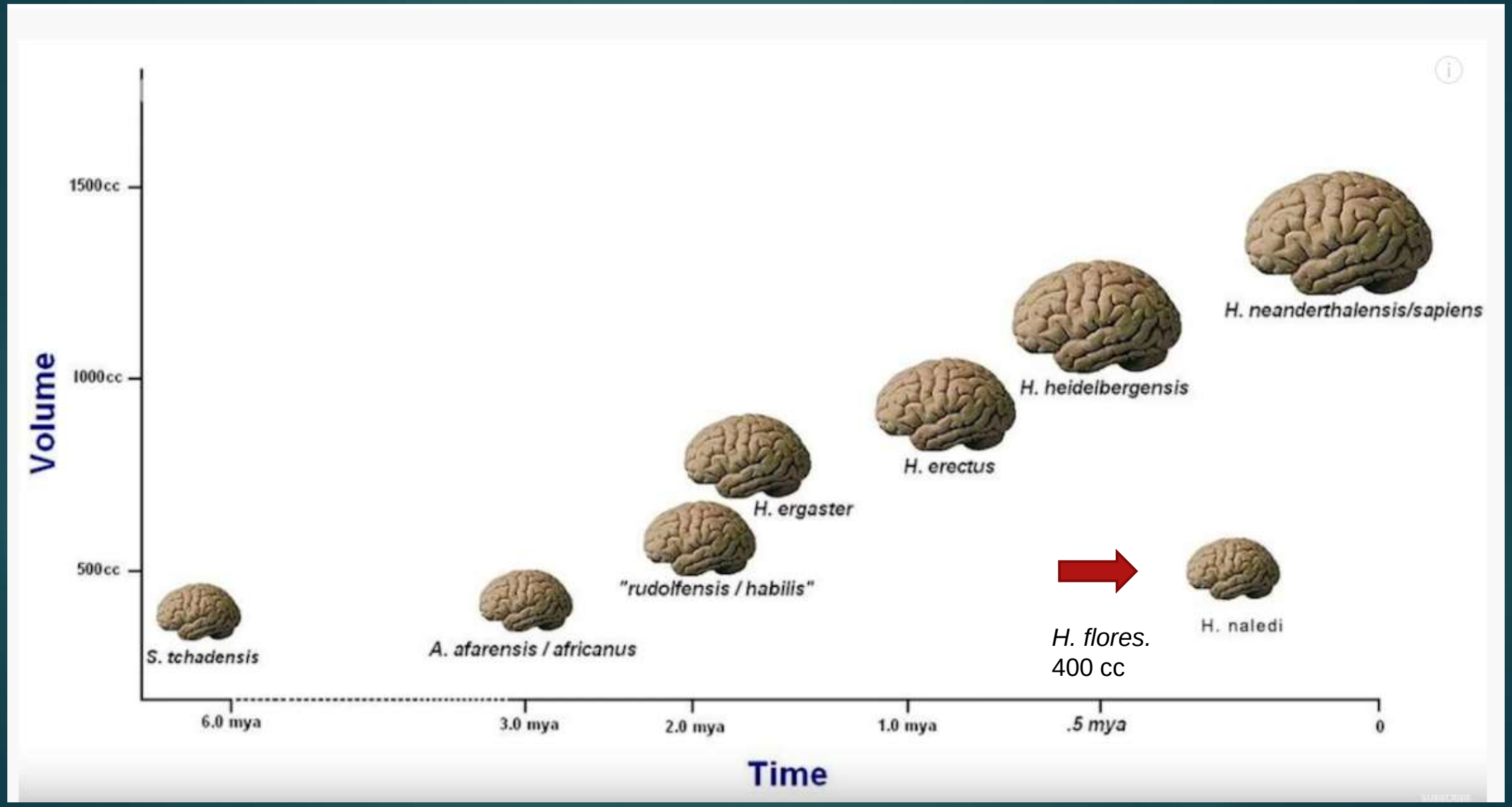
Figure 6. Digital reconstruction of endocranial volume in LES1. The refitted calvaria was mirrored and filled, resulting in a volume estimate of 610 ml. Scale sphere = 10 mm.

DOI: 10.7554/eLife.24232.009

LES1 endocast reconstruction: 610 cc.



Brain size comparisons



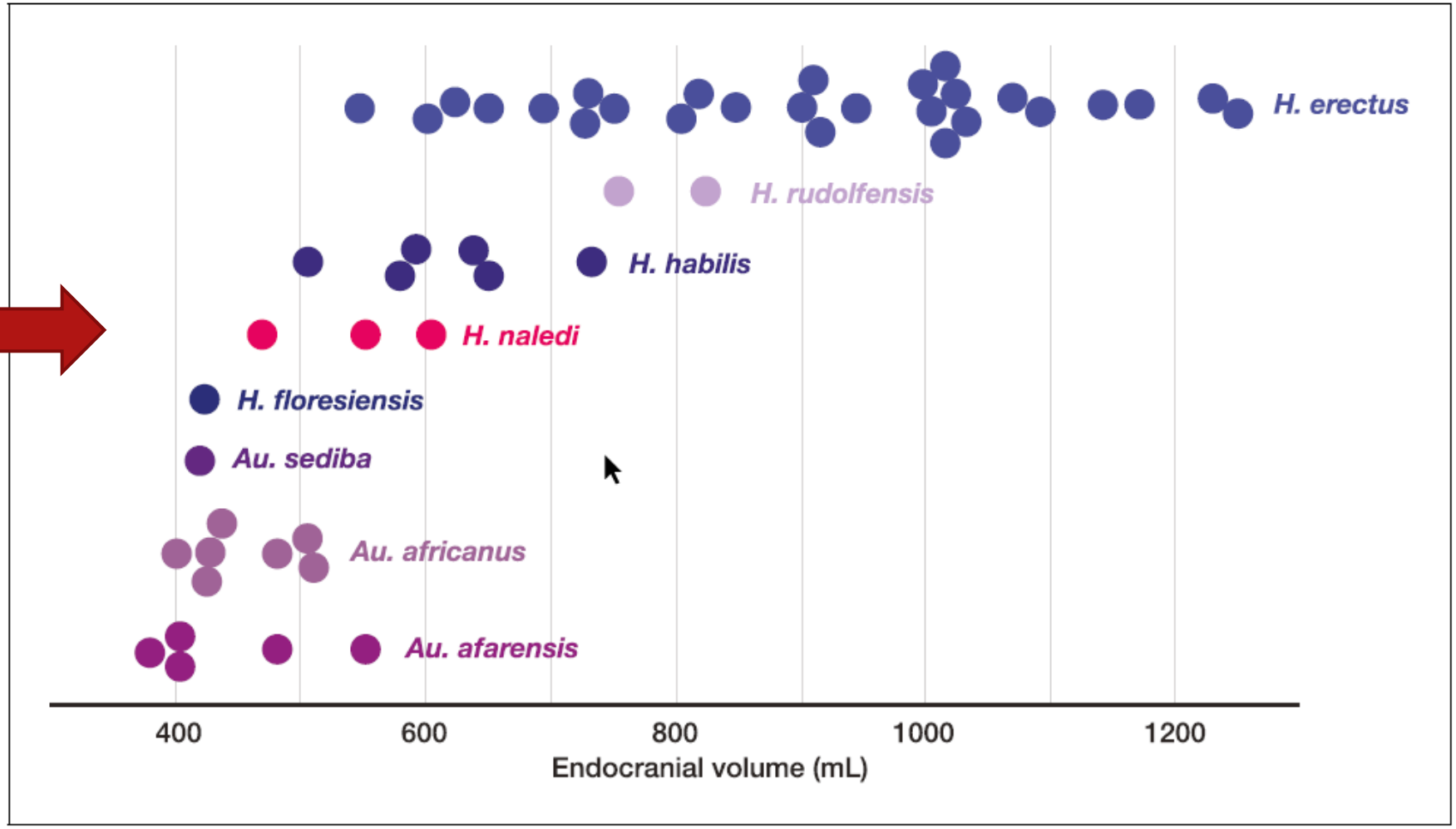


Figure 33. Endocranial volumes of hominin species. With the addition of LES1 to the sample, the range of endocranial volume in *H. naledi* is extended slightly beyond the range represented in the Dinaledi Chamber. This range overlaps with two specimens of *H. erectus*, and LES1 is larger than the largest *Au. africanus* or *Au. afarensis* specimens. Data and sources are listed in ***Table 4***.

DOI: 10.7554/eLife.24232.038

Cranial volume range: 460-610 cc

- Maximum brain size value for *H. naledi* is now somewhat above the maximum observed for australopithecine species.

- No crania attributed to *H. habilis, H. rudolfensis*, or *H. erectus* have brain sizes as small as the 460 cc DH3, but the larger *H. naledi* specimens do overlap with the smaller end of *H. habilis* and *H. erectus*.

- The single specimen of *H. floresiensis,* LB1, at 400 cc, is smaller than any specimen of *H. naledi*.

- The addition of the LES1 cranium now brings the range of observed brain size in *H. naledi* into overlap with two Dmanisi specimens of *H. erectus* (D2700 and D4500).

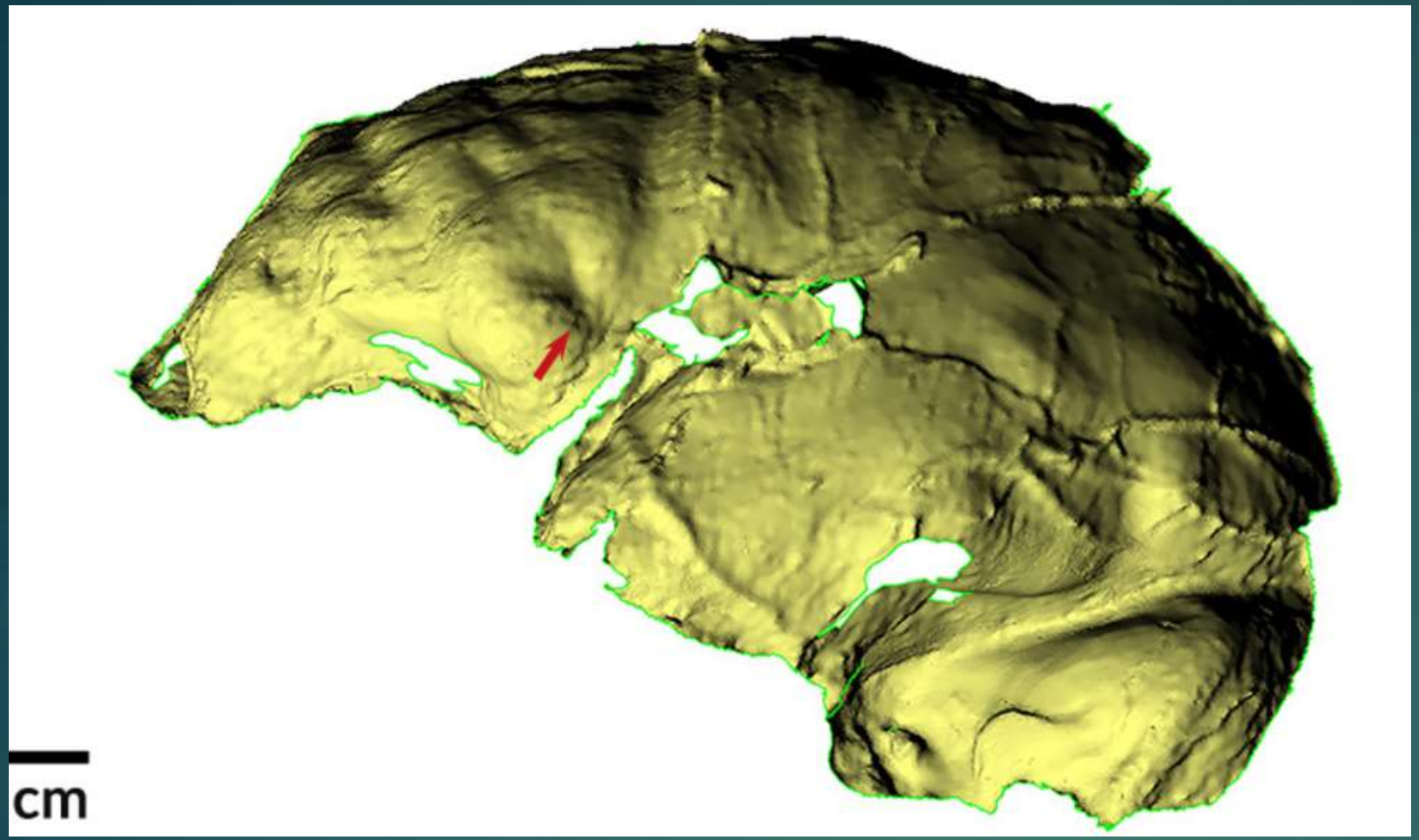
2018: New brain endocast study

- *Homo naledi*'s inferior frontal and lateral orbital gyri were organized more like that of members of the genus Homo than that of australopiths.

- Torpedoes the old notion that *Homo* brains grew steadily in size *and* complexity until reached *Homo sapiens*

- The evolution of brain size in *Homo* was diverse and not a simple pattern of gradual increase over time.

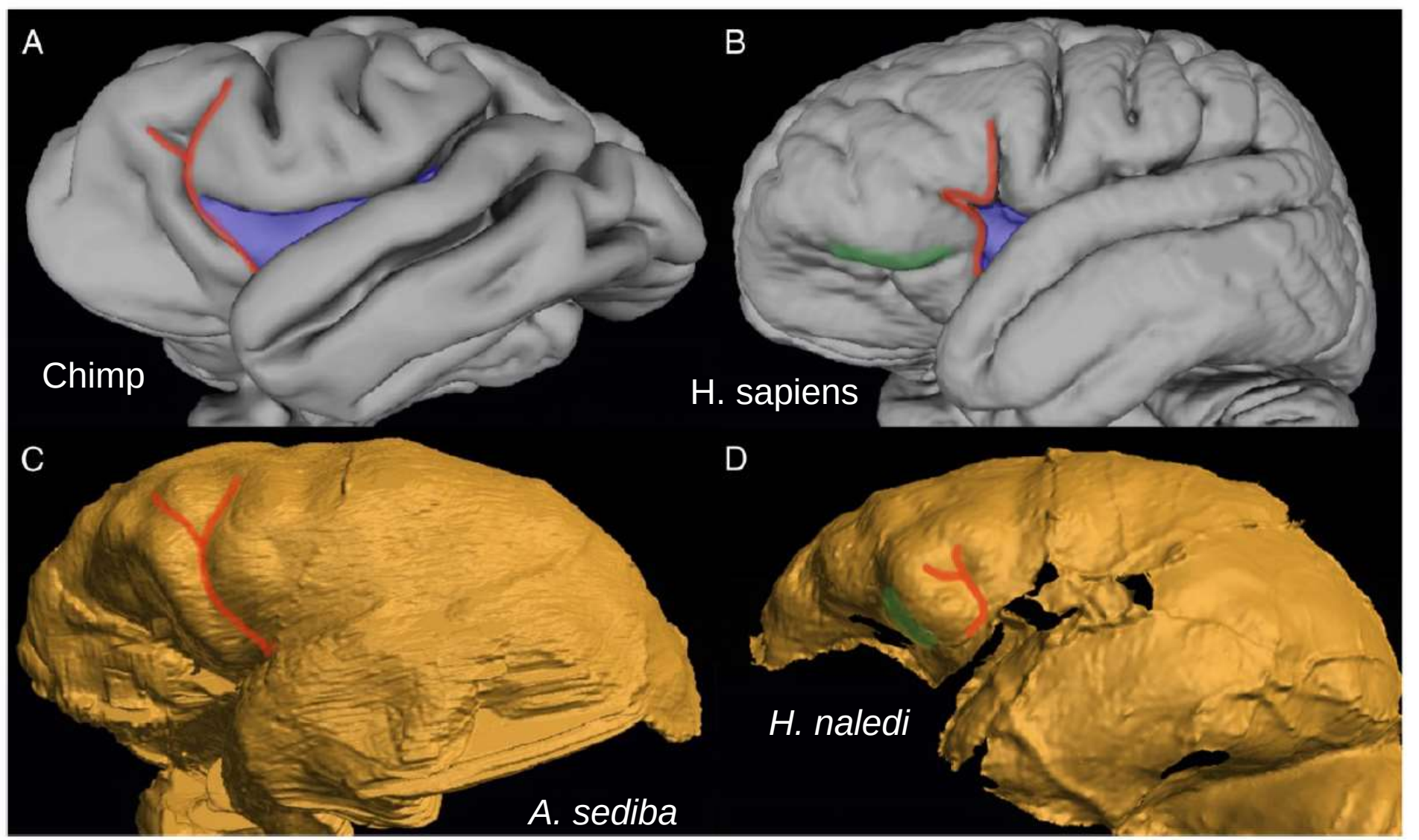
Ralph L. Holloway,, et al., 2018



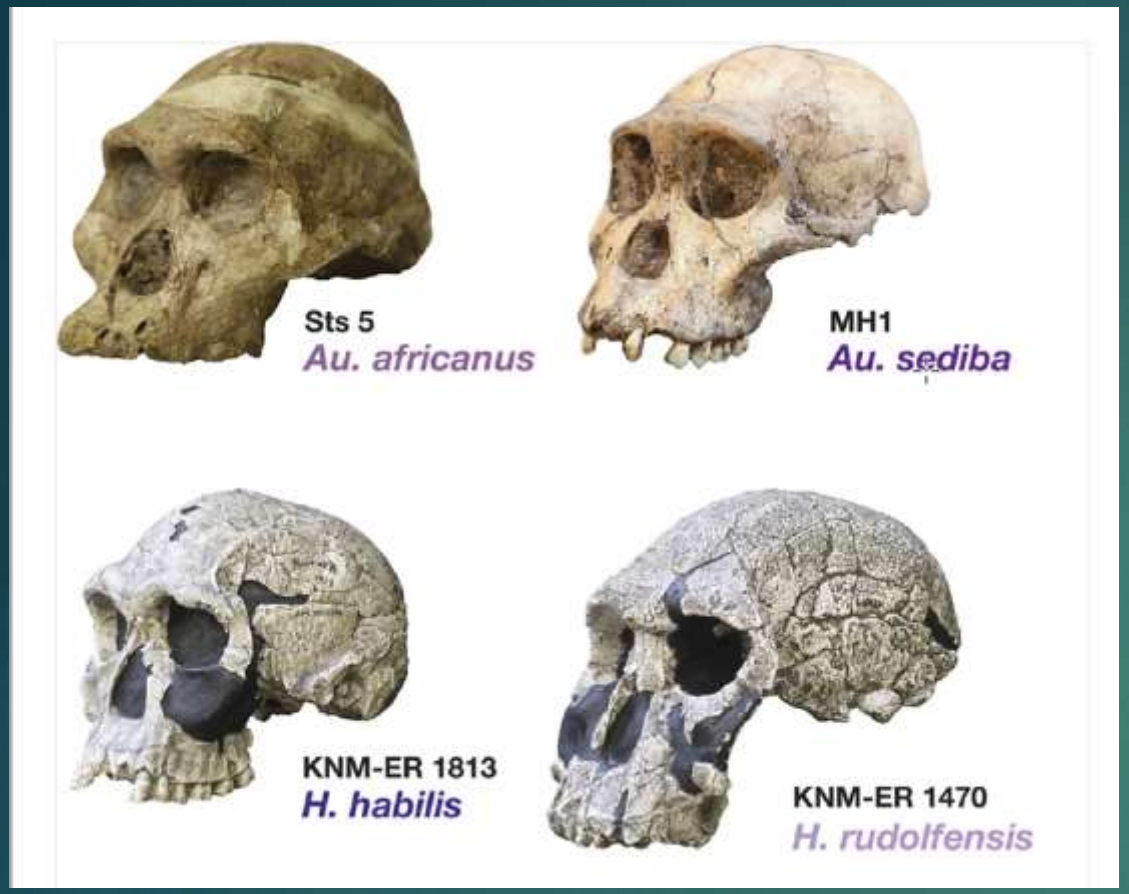
DH3: inferior frontal gyrus that was more human-like than primate-like.

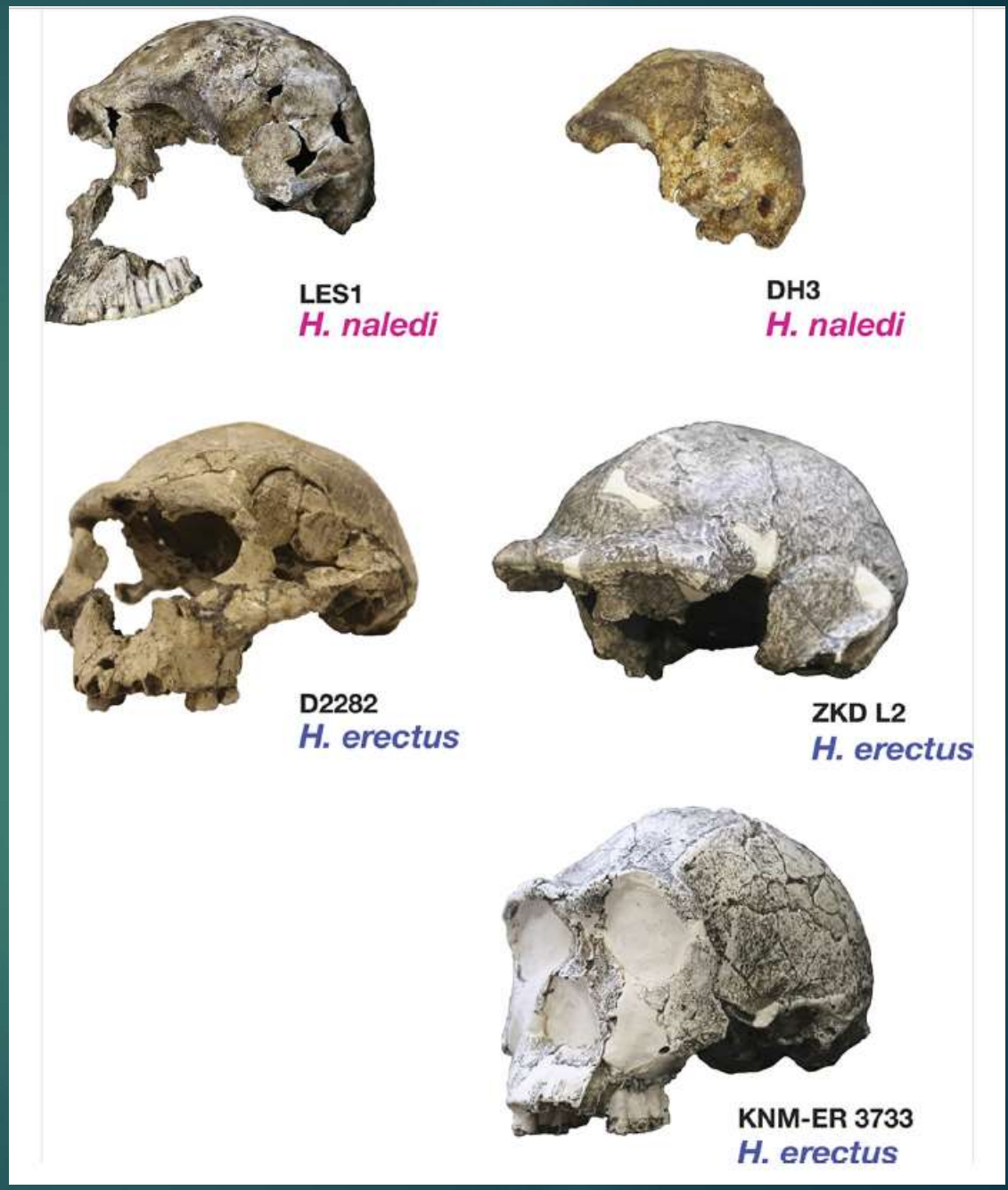
Hurst & Hollowell: GO FOR BROCA A virtual cast of *Homo naledi*'s brain surface contains clues to the presence of a region (pointed to by red arrow) that may correspond to Broca's area in present-day people. This language-related neural region enhanced social emotions and communication in the still-undated southern African *Homo* species, researchers contend. Falk disagrees. Also left posterior longer = right handedness

Shawn Hurst & Ralph Hollowell



Evolution of the inferior frontal gyrus. (A) *P. troglodytes*/chimp brain. (B) *H. sapiens* 152-subject averaged brain. (C) *A. sediba* MH1 endocast. (D) *H. naledi* DH3 endocast





Frontal and vault morphology in H. naledi compared to that in other hominin species.

Hawks et al. eLife, 2017

Mandibles: LES1 & DH1

Figure 8. LES1 mandible compared to the DH1 holotype mandible of *H. naledi*. In each pair, LES1 is on the left and DH1 on the right. Top left: anterior view. Top right: occlusal view. Bottom left: left lateral view. Bottom right: posterior view. Scale bar = 2 cm.

DOI: 10.7554/eLife.24232.011

Mandibles: LES1 & DH1

Figure 9. Comparison of LES1 maxilla to the DH1 holotype maxilla of *H. naledi*. In each pair, LES1 is on the left and DH1 on the right. Top left: anterior view. Top right: right (LES1) and left (DH1) lateral view. Bottom: occlusal view. Scale bar = 2 cm.

DOI: 10.7554/eLife.24232.012

Lesedi faunal assemblage includes micromammal, small to mid-size mammal, and non-mammalian remains.

- Fauna found in Lesedi chamber: 5 genera of rodents and 1 genus of shrew;
- All of the non-hominin fauna are of relatively small species.
- The largest mammalian specimens come from dental material attributed to *Canis* aff. *C. familiaris.* The cat material is also small, falling in the size range of the African wildcat.
- Rest of the assemblage consists almost entirely of animals smaller than 3 kg (7 lbs), including four mongoose specimens. Aside from a single lagomorph (rabbit) specimen, the macro-mammalian material comes exclusively from the order *Carnivora*, a situation that is unusual in the fossil record.

Lesedi fauna

- Unknown whether some or all of these faunal remains may be contemporaneous with any of the hominin fossil material.

- Faunal remains have been recovered both on the surface and also from within sediments near hominin remains.

- However, the Lesedi Chamber is not a completely isolated environment, and sediment deposits are currently eroding from their original depositional contexts, with evidence for slumping and reworking in the chamber.

- Unknown: the relative timing of deposition of the hominin and faunal material.

New bones in Lesedi chamber not dated

- All assumptions are that the hominins in both chambers were contemporaries, but the age of the new fossils is not yet known.

- Dating will require that some fossils be destroyed in the process and Berger wants to publish the fossils first (S. African law) and get them out to the community via Morphosource before any of the samples are consumed for the dating efforts

Berger scenarios for *H. naledi* lineage

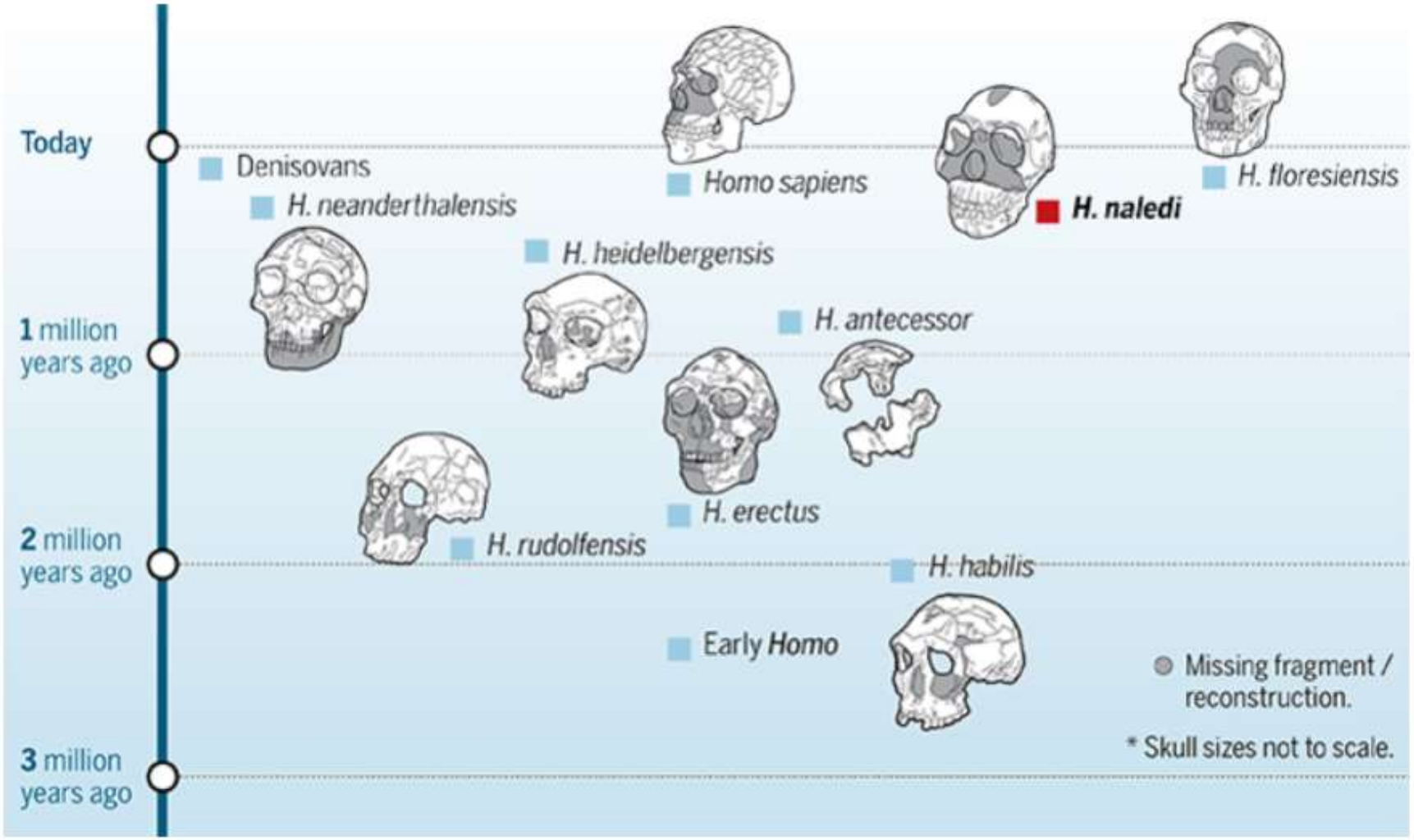
- Berger has suggested three lineage scenarios:
- First, *H. naledi* belongs to one of the lineages leading to *H. habilis, H. rudolfensis, H. floresiensis*, and *A. sediba.*
- Alternatively, *H. naledi* is younger - a sister lineage to the clade that contains *H. erectus* and the big-brained later hominins (including *H. sapiens*).
- The final scenario is that *H. naledi* is even younger still - a sister lineage to *H. sapiens*.
- Another possibility is that *H. naledi* is the result of hybridization between two or more lineages, perhaps one related to humans and one related to Australopithecines.
- The unusual combination of ancestral and derived features of *H. naledi* make distinguishing between the above scenarios difficult without genetic evidence.

Puzzles

- Two caves. There is no connection between the two.
- Why are the fossils there? There is no evidence that either chamber was a living space, and there are no carnivore remains to suggest they were dragged there as supper for hyena or other carnivores.
- Curiously there are no stone tools either.
- Did they fall in? Were they pushed? Why are they in two different chambers so difficult to access?
- The authors of the new articles would like us to believe they were put there by others of their kind, but there is a long way to go before we can be certain of that—but archaeology has revealed stranger things before.

A timeline of the human family

Homo naledi, now dated to 236,000 to 335,000 years ago, joins a half-dozen members of our genus that lived during the past half-million years or so, as seen in a timeline of their first appearances. Yet *H. naledi* has some primitive features that hark back to early *Homo*, which lived about 2 million years ago.



Graphic: A. Cuadra/*Science*

Hominins at 300-200K

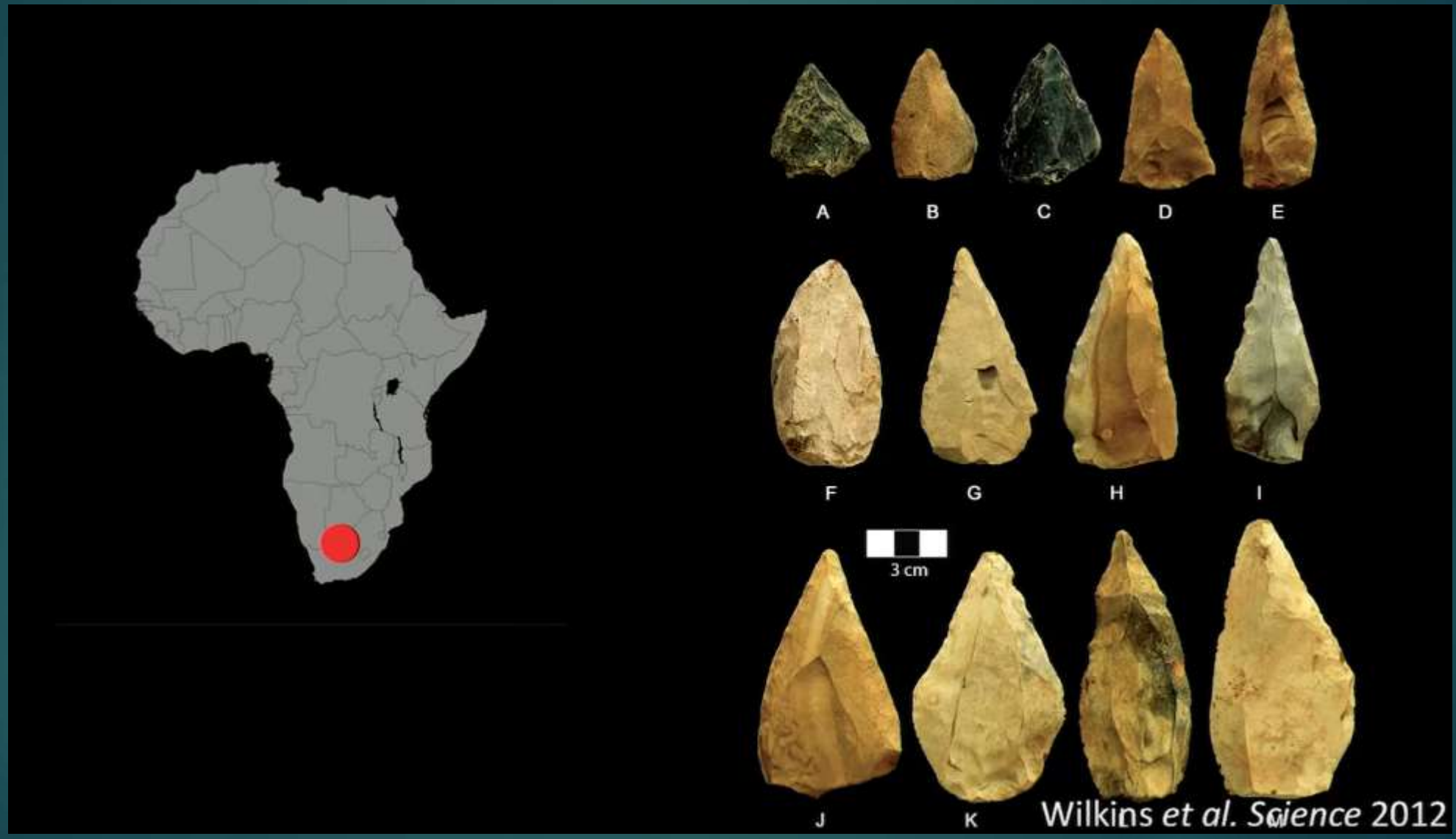
- *Homo naledi (S. Africa)*
- *Homo heidelbergensis (Broken Hill, Zambia)*
- *Homo erectus (Indonesia)*
- *Homo floresiensis (Flores, Indonesia)*
- *Homo neanderthalensis (Eurasia)*
- *Homo denisova (Eurasia)*

- Remember 1500 species of rodents today

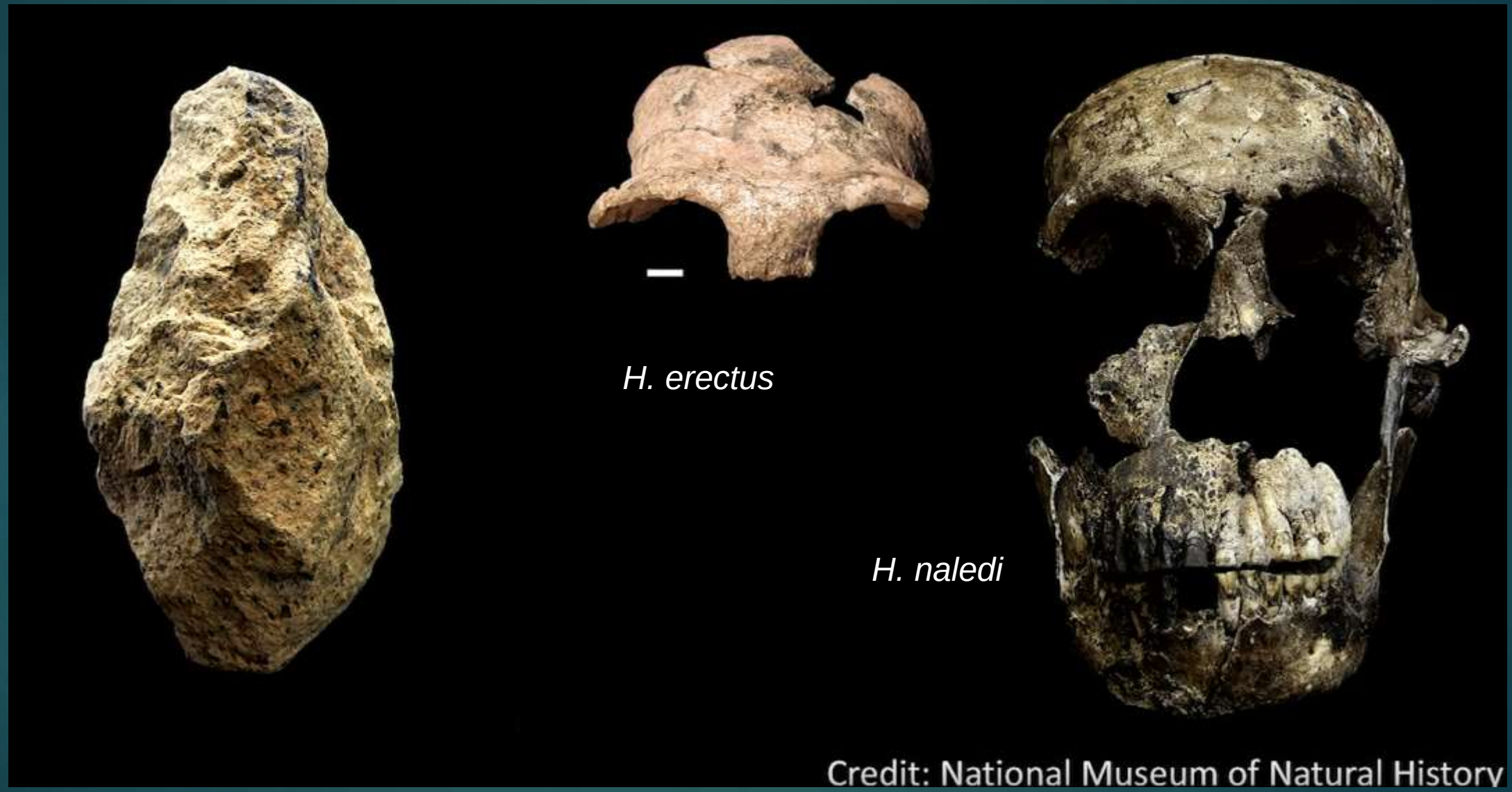
Did H. naledi and H. sapiens make similar artefacts?

- Structure of hand capable of tool making
- Diversification of MSA
- Except for Jebel Irhoud, almost no association of artefacts and fossils in early MSA
- Who made what?

Kathu Pan, 100-74 Ka



Olorgesailie site: small *H. erectus* (900 Ka)



Implications

- Bernard Wood: “Its primitive features might be misleading,” he says. This would mean it originated recently and then evolved to look more primitive due to isolation.

- For instance, southern Africa might have been relatively isolated from the rest of the continent and *H. naledi*’s lineage might have had comparatively little competition from other humans.

- This could have relaxed the pressure to grow and maintain a large brain. If the skeleton no longer had to bear the weight of a large and heavy skull, features like the hips and shoulders might have reverted to become more like those of a small-brained hominin.

Critiques of new data

- Researchers remain skeptical of some of Berger's other claims, such as that *H. naledi* might have made Middle Stone Age tools found in the region.

- That would imply surprising sophistication in a small-brained hominin.

- "Yes, that hand could make and use tools," says Bill Jungers.

- He agrees with Rick Potts, who says the idea is a nonstarter because no tools, fire, or other signs of culture have been linked to the fossils.

Critiques

- Ditto for the claim that *H. naledi* purposefully buried the bodies of its fellows in both caves, or that it might have acquired some of its modern traits by mating with other early members of *Homo*. “It’s just sheer speculation,” Kimbel says.

- Other experts say the discoveries are exciting but expressed some doubts about the team’s interpretations such as the suggestion southern Africa was the hotbed of evolutionary diversification for many mammals, including humans.

- H. naledi may clearly have been an evolutionary dead end, like the Hobbit of Flores

Reactions

- If the humans had instead fallen into the cave, for example, one would expect to find bones of many more kinds of animals that met a similar fate, including larger ones.

- Mark Collard: the Lesedi chamber contains more fossils of other animals, including some of medium size, which could suggest that *H. naledi* ended up in there by some means other than intentional disposal.

- Mark Collard: scientists will need to reconsider the longstanding notion that brain size drives complexity of behavior.

- “The history of paleoanthropology is littered with deeply rooted assumptions that have been overturned by new discoveries."

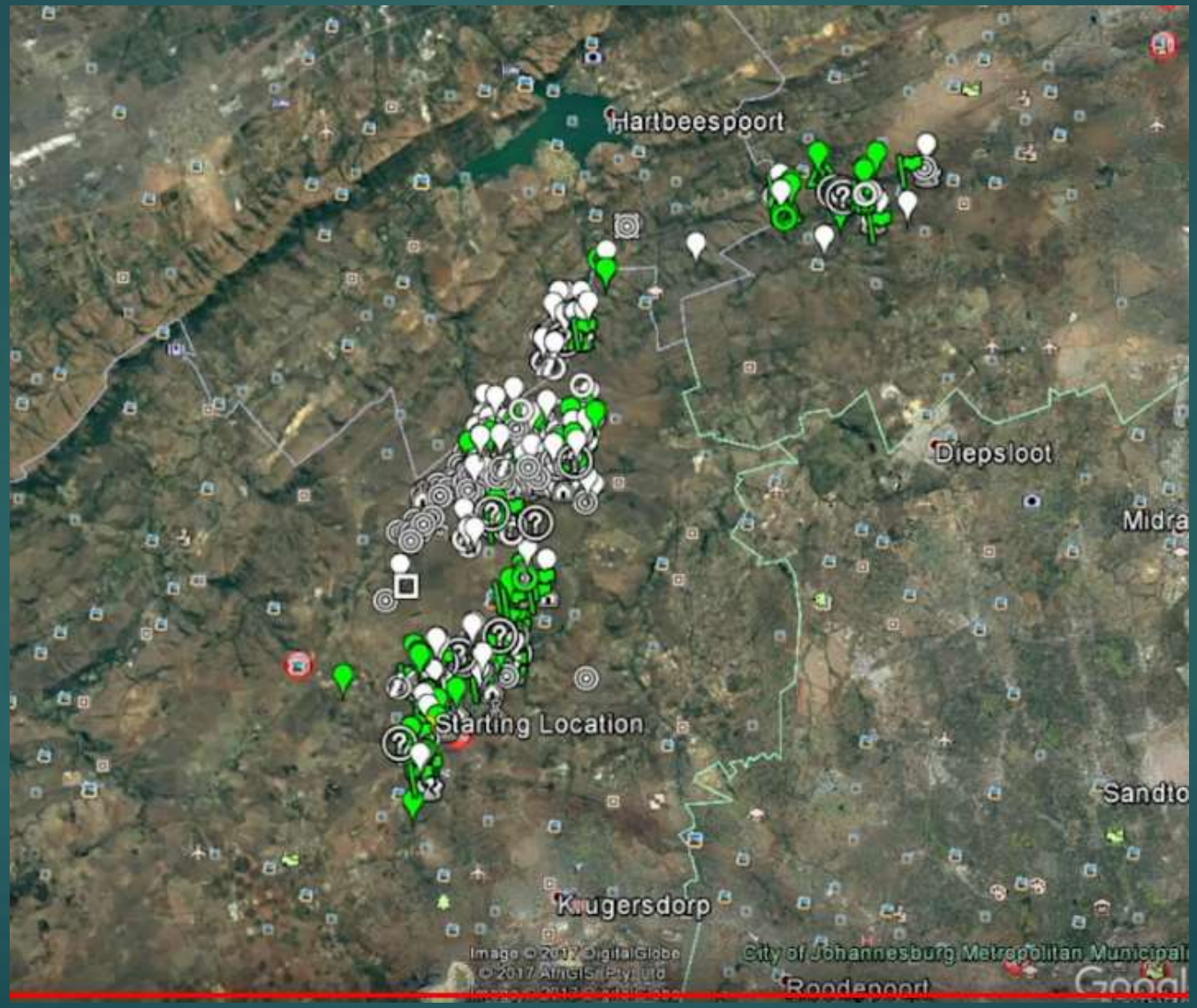
Future

- The skeletal material described here derives from a very small and limited excavation, and the total sediment volume of the chamber has not yet been sampled sufficiently to estimate the abundance of hominin-bearing deposits or the relationship of faunal and hominin species.

- Further resolution of how the material was originally deposited must await more detailed sedimentological analysis and more excavation work.

- The relative completeness of the morphological evidence from *H. naledi* has not resolved its phylogenetic placement within the genus *Homo*

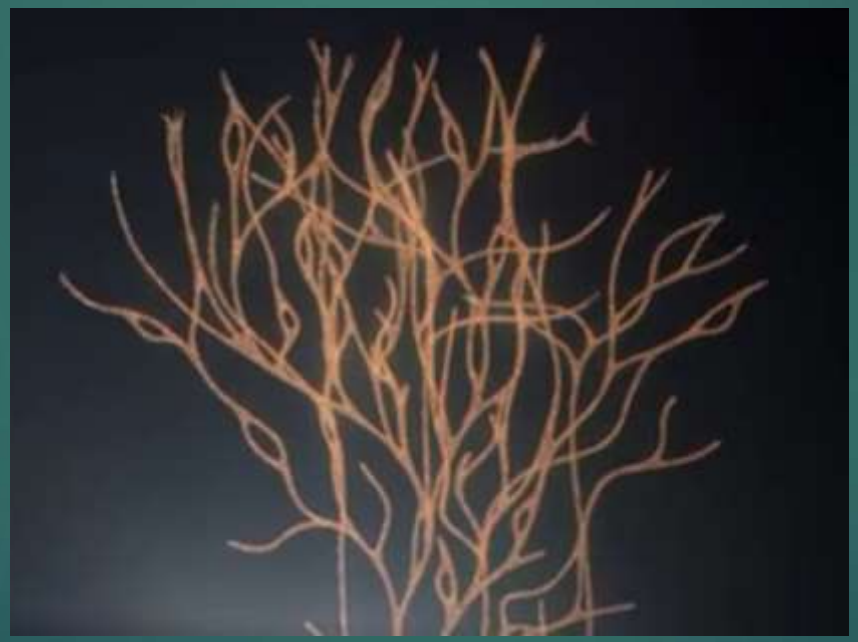
Remember Google Earth: 800 caves with 250 other fossil sites

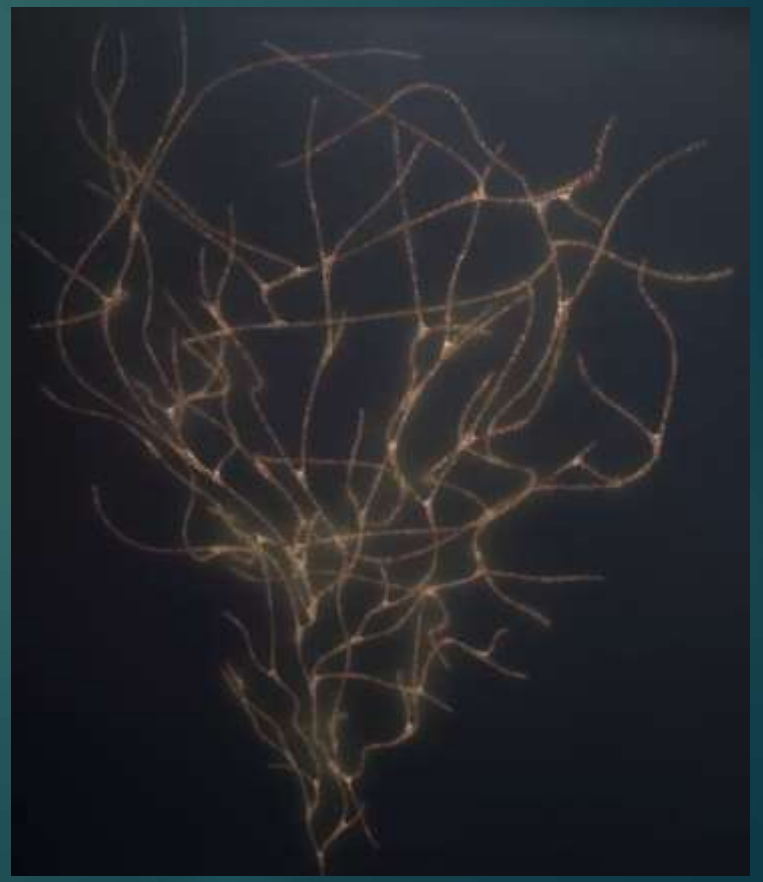


All of these bones are fossil hominin bones

Still out there hunting for fossils

Lee Berger’s new metaphor for hominin evolution: Braided Stream – glacier produces a river that divides into rivulets which all merge again downstream in a lake; divergence from common ancestor, then coalesced again; difficult to tell which branch was responsible for us being here today





Latest excavations

- But nearly all of the hominin remains so far come from a tiny area of excavation, only 0.8 square meters, at the far end of the chamber more than 10 meters from the Chute.

- If bodies dropped down the Chute, predict that hominin remains once must have formed a debris cone immediately below the Chute

- One *H. naledi* tooth found in this area, but no excavation to investigate if there are additional remains beneath the surface here. Now testing this hypothesis by undertaking a limited excavation at the base of the Chute.

- Hypothesis: hope for evidence of possible artifacts, or other behavioral evidence such as remnants of charcoal.

Searching for Neo

- Also excavating a new area within the **Lesedi Chamber.**
- Current goal in Lesedi is to recover more of the Neo skeleton.
- Most of Neo so far has been recovered from a small blind tunnel that leads off the 102 North-South passageway.
- Want to date the Neo area.

Lesedi fauna

- Another question is whether the hominin bones in Lesedi can be associated with any of the bones and teeth of other animals in this chamber.

- Some evidence that many of these faunal remains may be very recent—less than 10,000 years old—and they have mostly come from the surface, not the same sedimentary context as Neo and the other hominin remains.

Very tight Lesedi chamber

Elen Feuerriegel excavating within the Lesedi Chamber (photo: Elen Feuerriegel)

Racial Misunderstandings

- Recently provoked a backlash from a few influential South African national figures who associate the finding with five decades of apartheid governance.
- Trade unionist Zwelinzima Vavi tweeted: “No one will dig old monkey bones to back up a theory that I was once a baboon.” South African Council of Churches President Bishop Ziphozihle Siwa concurred: “To my brother Vavi, I would say that he is spot-on. It’s an insult to say that we come from baboons.”
- Lee Berger responded that humans do not descend from baboons.
- Evolutionary biologist Richard Dawkins jumped in, tweeting back: “Whole point is we’re all African apes.”

Only because a skinny caver fit through a crack: *Homo naledi*

- Rising Star cave is 800 m from Swartkrans Cave, one of the most heavily explored caves in Africa; has been worked on continuously for 85 years; implication of many other possible sites; we don’t have a clue what else might be out there
- There is more to come:
  - Attempt to find soot
  - Thousands more bones
  - Hint of multiple other discoveries by Lee Berger

John Hawks: Conclusions

- Our team, studying these fossils and their context, found that they represented a population unlike any we had seen before.
- *Naledi* had small brains, like *Australopithecus* or the earliest members of our genus, *Homo*.
- Their shoulders angled upward, their finger bones curved, hips were widely flared like Lucy.
- All these features suggest a branch deep in human ancestry.
- The features of the skull reminded us in many ways of *Homo erectus*, but their brains were really small compared to *erectus*.

John Hawks

- We thought, here was a species that might have emerged 2 to 2.5 million years ago.

- But other features did not match that picture. *Naledi's* teeth are small and humanlike in their function, even though their form looks like the teeth of very ancient hominins. Their legs and feet appear modern, their wrists place them next to modern humans. This was a weird mix.

- Dating between 236,000 and 335,000 years old. They lived at the same time as those many little branches of emerging modern humans.

- A species that looks ancient but is actually recent may seem like a contradiction. There is a logical explanation: *Naledi* survived in Africa, with other species of large-brained humans, for a million years or more.

Hawks

- H. *naledi* survived. How did they do it?

- Did they avoid competition by using different resources? It doesn't look like it: They look like toolmakers with a high-energy diet like humans. That doesn't look like different ecology. That looks like competition.

- Did *naledi* encounter other populations? Did they mix with them? Did hybridization explain their mix of features? Did they contribute to modern humans?

- Our attempts to recover DNA from the bones have failed. We will wait until the technology advances and try again.

Hawks

- We think that *naledi* made the MSA tools that we find in southern Africa at the time they lived.
- The evidence suggests that *naledi* had some complex behaviors, that they may have been depositing bodies in this cave deliberately.
- For them to have used deep parts of this cave system, in the dark zone, they must have controlled fire.
- Evidence of controlled fire is not new; we have long known that hominins in this part of South Africa mastered fire before a million years ago.

Hawks

- The ability of such a small-brained hominin to have survived for so long in the midst of bigger-brained *Homo* greatly revises previous conceptions of human evolution and the notion that a larger brain would necessarily lead to an evolutionary advantage.

- Their mosaic anatomy also greatly expands the range of variation for the genus.

Potential Implications of *Homo naledi*

- The effect on the field is transformative.
- Evolution produced different types of humanlike creatures originating in parallel in different parts of Africa.
- Was there multiple early hybridizations?
- Is this a relic population that may have evolved in near isolation in South Africa? A dead end?
- Is there a point at which we became human or are there many ways to be human?

Potential Implications of *Homo naledi*

- Apart from our language capacity, no human uniqueness claim has survived unmodified for more than a recent decade since it was made:
  - Tool use, tool making, culture, food sharing, theory of mind, planning, empathy, inferential reasoning —
  - All have been observed in wild primates.
- Frans de Waal: "It is an odd coincidence that "naledi" is an anagram of "denial."
- "We are trying way too hard to deny that we are modified apes…We are one rich collection of mosaics, not only genetically and anatomically, but also mentally."

Lessons to learn from *H. naledi*

- Some of the hallmarks of "being human" such as efficient bipedalism and fine motor skills are not dependent on a big brain.

- *Homo naledi* reaffirms that human evolution — like the evolution of all groups — is not patterned like a ladder, but rather a very deeply pruned bush, with many branching lineages, most of which have died out.

- We should never expect a new fossil find to have a predicted set of traits that perfectly "links" it between two other species.

- Nor should we use value-laden terms such as "primitive" to describe species, most of which successfully made their way on Earth for far longer than our own species has existed.

H. naledi: challenges to traditional concepts

- Relationship of ancestral and derived traits
- Cannot predict whole skeleton from a fossil part of the skeleton
- Things we thought evolved together don’t:
  - Teeth and brain do not evolve in parallel
  - Smaller teeth and bigger brain
  - But also smaller teeth and brain

Unanswered questions

- We do not know when *H. naledi* arose
- We do not know when *H. naledi* went extinct
- We do not know if *H. naledi* intermixed with other African hominin species
- If Naledi could just be discovered right next to Cradle of Humanity, what of other 99.9 % of Africa that has not been explored
- Cost of entire project: less than 1 NIMH granted university lab (less than $2 M for 4 years work)

Now need to reevaluate concept of “*Homo*”

- Brain size
- Hip morphology
- Cannot predict skeleton from small number of bones given mosaic blends in *H. floresiensis* and *H. naledi*
- Why morphological variation in *Homo*
- Prior to naledi, only MHs in Africa: competed?, interbreed?, isolated?
- Origin of African MSA: who first made them at 300 Ka

Just scratched the surface at Rising Star

- Only 1 meter of 12 meters excavated so far.
- Where does *H. naledi* fit phylogenetically in human evolution?
- How did the remains arrive deep within the cave system?
- Is it a variation of *Homo erectus?*

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