The Oldest Finds on the Net

From the First Cell to the First Art, with a Mathematical Biology

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How to Read This Book

This book reads the oldest finds of life and of humans, one by one, beside the Vacuum.Net theory. Each find gets a place on the ladder, the carrier that kept it, the clock that dated it and the form of the net that shows in it. Where a find has two readings, both are given.

The History of Life on the Net tells the history. This book reads the finds themselves: why they were kept, how they were dated, and what they say about who came from whom. The earlier book is a source here; its references keep their numbers, written [n]. New sources carry a name and a year.

The forms are read in the finds. They are described beside them, not as their cause.

Status of this version

This is version 0.2, a draft. It holds Parts I and II and a provisional Appendix A. Later versions add Parts III to IX: the complex cell, the first animals, the move to land, the hominins and the oldest art, who came from whom, a mathematical biology, and an archaeology read through the net. Each version keeps its number on the title page and in the file name.

Part I. Why Anything Is Found

1. The Ladder and the Forms

This book reads the oldest finds of life one by one. It asks of each find four things. Where does it stand on the ladder? What kept it? How was it dated? Which form of the net shows in it?

The ladder is the one used in The History of Life on the Net [LB]. Every time has a position. The position is the logarithm, base 3, of the time over 1.520655×10^{-16} s. One step up is a factor of three. One year is 3.15576×10^{7} s. An age of A million years is placed as the time from then to now.

On this ladder the day sits at 43.50 and the year at 48.87. A thousand years sits at 55.16. A million years sits at 61.45. A billion years sits at 67.73. The oldest solids of the solar system, 4,567.30 million years old, sit at 69.12 [1].

The positions are coordinates. They are given to two decimals. A difference of one is a factor of three. A difference of 2.1 is a factor of ten.

The forms are those of the theory. They are named here once and used later.

What closes, stays. A window of three trits closes when its three values are all equal or all different. Of the 27 windows, 9 close. Three hold one value three times: the crystal. Six hold all three values once: the form in which the content changes while the window stays closed [LB; M, rung 5].

One direction. A living strand reads one way. Proteins are built of L amino acids only. Glycine has no hand [30].

The residue becomes the alphabet. The closed small molecules of one depth become the letters of the next.

Form and carrier. The form lasts while its carriers are replaced.

Opened once, filled many times. A new kind of union opens once. Then it is filled many times.

Shared prefix. Lines nest as addresses within addresses. What two lines share is the prefix.

Two names of one point. To go back, one must choose between two names of the same point [M, Beyond Rung 21 (c)]. A find that allows two readings stands at such a point.

The forms are read in the finds. They are described beside the finds, not as their cause.

What this chapter sets

Every find in this book carries a row in Appendix A. The row holds the age, the position, the carrier, the kind of trace and the source. The text refers to the row and adds what the row cannot hold.

2. What Closes, Stays: the Carriers

Most of what lived is gone. What is found is what was closed in time. This chapter names the carriers that kept the oldest record. It orders them by how long they kept it.

The scale of loss

The covalent frame of a peptide lasts about 1,000 years in water, position 55.16 [LB]. Without a carrier the molecules of life are gone within a few steps of the ladder.

The record is therefore a record of carriers. The question is not only what lived. It is also what closed around it.

Crystal

The zircon is the oldest carrier. One detrital grain from the Jack Hills, Western Australia, is 4,404 ± 8 million years old, position 69.08 [2]. Its oxygen records water and crust. A second set of grains records water by 4,300 Ma, position 69.06 [4].

A zircon of 4.10 ± 0.01 billion years holds graphite with $\delta^{13}C$ of −24 ± 5 ‰ [96]. The authors call it potentially biogenic. The graphite was sealed inside the crystal. Nothing could reach it.

The crystal is the first closure: one value three times. It holds its content without change. It is also the most lasting carrier known.

Silica, barite and carbonate

Chert is silica that set around cells. In the Apex chert of the Pilbara it holds microfossils of about 3,465 million years, position 68.86 [107]. Barite at North Pole, Australia, holds the sulfur isotopes of microbial sulfate reduction at about 3.47 Ga [105]. Fluid inclusions in Pilbara vent precipitates hold methane of more than 3.46 Ga [106].

Carbonate builds stromatolites. Layer is laid on layer as mats trap and bind grains. The Strelley Pool reef of about 3,430 million years shows seven forms along 10 km [108].

Each of these carriers set fast. Each closed a small volume and kept it.

Shale and pyrite

Fine mud closes slowly but deeply. Black shale kept the Francevillian structures of 2.1 Ga in pyrite [El Albani 2010]. Shale kept the oldest eukaryote microfossils of northern Australia, 1.75 to 1.4 billion years old [Lechte 2026]. Shale also kept the organic fragments that a learning machine read in 2025 [Wong 2025].

Enamel

Enamel is the hardest tissue of the body. It keeps protein where bone and dentine lose it. Six Homo erectus teeth of about 0.4 Ma, position 60.61, gave peptides from 6 to 11 proteins. Bone and dentine of 85 animals gave none [Fu 2026].

A rhinoceros tooth of 21 to 24 million years, positions 64.22 to 64.34, still held protein sequence [Paterson 2025]. That is 9.2 steps above the 1,000 years of a peptide in water (computed: $\log_3 24{,}000$). The closed tissue multiplied the life of the molecule by about 24,000.

Ice

Frozen ground closes by cold. DNA from the sediment of Kap København, North Greenland, is about 2 million years old, position 62.08 [Kjær 2022]. DNA from the molars of a mammoth from Krestovka, Siberia, is about 1.65 million years old [van der Valk 2021]. In both, cold and enamel together did what neither did alone.

Calcite crust and wet wood

Some carriers form on top of a find. A crust of calcite grows over paint on a cave wall. Its uranium dates the crust and so gives the paint a minimum age. A hand stencil on Muna, Sulawesi, is at least 67,800 years old in this way, position 59.00 [Oktaviana 2026].

Water closes wood. At Kalambo Falls, Zambia, two logs joined by a cut notch lay in waterlogged sand. They are at least 476,000 years old, position 60.77 [Barham 2023]. Wood of that age is known almost nowhere else.

The order of the carriers

Carrier	Oldest record kept	Position	Source
Crystal (zircon)	4.40 Ga	69.08	[2]
Crystal inclusion (graphite)	4.10 Ga	69.02	[96]
Silica, barite, carbonate	3.48–3.43 Ga	68.87–68.86	[104]–[108]
Shale (organic fragments)	3.33 Ga	68.83	[Wong 2025]
Shale (eukaryote microfossils)	1.75 Ga	68.24	[Lechte 2026]
Enamel (protein)	21–24 Ma	64.22–64.34	[Paterson 2025]
Frozen sediment (DNA)	2.0 Ma	62.08	[Kjær 2022]
Waterlogged wood	0.476 Ma	60.77	[Barham 2023]
Calcite crust over paint	0.068 Ma	59.00	[Oktaviana 2026]

The order runs from the most closed to the least. The crystal keeps the most. The crust keeps the least. Each carrier keeps its content as long as it stays closed.

What this part of the record shows

The record is a record of closure. What closed, stayed. What stayed open was lost. A find is therefore never a sample of life as it was. It is a sample of what life left in closed places.

This has one practical consequence. Where a carrier closes, there the record is. The search for older finds is a search for older closures.

3. Dating Is Reading

A find has no age written on it. The age is read from a clock. Each clock is a strand that changes in one direction at a known rate. Each has a range on the ladder where it reads well.

The clocks

Uranium and lead. Uranium-238 decays to lead with a half-life of 4.468 billion years. A zircon takes in uranium and rejects lead when it forms. Its lead therefore counts the time since closure. The Jack Hills grain and the first solids are dated this way [1, 2].

Uranium series. Uranium in water enters calcite. Its daughter thorium does not. The ratio grows from zero when the calcite closes. It dates cave crusts up to a few hundred thousand years [Oktaviana 2026].

Luminescence. Quartz and feldspar grains store charge while buried. Light empties them. The stored charge counts the time since the grains last saw light. The Kalambo wood was dated this way [Barham 2023].

Radiocarbon. Carbon-14 decays with a half-life of about 5,730 years. Its reach ends after about ten half-lives.

The reversals of the Earth's field. The magnetic poles have changed places many times. The last full reversal, the Matuyama–Brunhes boundary, is dated to about 773,000 years ago. The Casablanca fossils at Thomas Quarry I lie at that boundary, position 61.21 [Hublin 2026].

The molecular clock. Differences between living genomes grow with time. Calibrated with fossils they give ages for splits that left no fossil. The last universal common ancestor is placed this way at about 4.2 Ga, with a range of 4.09 to 4.33 Ga [97].

Where each clock reads

Clock	Reads best between	Positions
Uranium–lead	1 Ma – 4.6 Ga	61.45 – 69.12
Uranium series	1 ka – 0.5 Ma	55.16 – 60.82
Luminescence	100 a – 0.5 Ma	53.07 – 60.82
Radiocarbon	100 a – 50 ka	53.07 – 58.72
Palaeomagnetic reversals	10 ka – 100 Ma	57.26 – 65.64
Molecular clock	any depth, with calibration	—

The ranges are working ranges, not limits. They are given as positions so that they can be read beside the finds.

Two names of one point

Every clock reads a closure. It does not read the life inside it. Between the event and its closure there may be a gap. And the same trace may be read in two ways.

The record of the first life shows this again and again. Cones of 3.7 billion years at Isua were read as stromatolites [102]. A second study read them as deformed rock [103]. Filaments at Nuvvuagittuq were read as microfossils at least 3,770 million years old [98]. Others doubt them. The graphite in the 4.10 Ga zircon is called potentially biogenic, not biogenic [96].

The mathematics of the net gives this a name. Going forward to finer detail needs no choice. Coming back requires a choice between two names of one point [M, Beyond Rung 21 (c)]. A

disputed find is such a point. This book keeps both names side by side. It does not choose one where the evidence does not.

What this chapter shows

Dating is reading a strand that runs one way. Each clock covers its stretch of the ladder. Where two readings remain, both are given.

Part II. The First Traces of Life

4. Graphite in a Zircon, and the Last Common Ancestor

The oldest trace of life is not a fossil. It is a ratio of two carbon isotopes, sealed in a crystal.

The grain

Among more than 10,000 Jack Hills zircons one grain holds graphite [96]. Its age is 4.10 ± 0.01 billion years, position 69.02. The graphite has $\delta^{13}C$ of −24 ± 5 ‰. Life prefers the light isotope, carbon-12. A value near −24 ‰ is consistent with carbon fixed by life [96].

The grain formed 304 million years after the oldest known grain of 4,404 Ma (computed: 4,404 − 4,100). It formed 200 million years after the first recorded water of 4,300 Ma.

The ancestor read from the living

The last universal common ancestor, LUCA, left no fossil. It is read back from the genomes of the living. The most recent estimate places it at about 4.2 Ga, position 69.04, with a range of 4.09 to 4.33 Ga [97]. Its genome is reconstructed at about 2.75 million base pairs, coding about 2,657 proteins [97]. An earlier study gave more than 3.9 Ga [111]. A third gave 3.5 to 3.8 Ga [112].

Estimate	Age	Position	Source
Moody et al. 2024	4.2 Ga (4.09–4.33)	69.04 (69.02–69.07)	[97]
Betts et al. 2018	> 3.9 Ga	> 68.97	[111]
Boyd & Peters 2013	3.5–3.8 Ga	68.87–68.95	[112]

The form

The zircon is a crystal: the first closure. Inside it lies carbon that may have been part of the second closure, the cell. One closure holds the trace of the next.

LUCA is a shared prefix. Every living cell carries its address. No fossil of it is needed to know that it existed. The prefix is read from what all descendants share.

What this chapter shows

The oldest possible trace of life, 4.10 Ga, and the oldest estimate for the common ancestor, about 4.2 Ga, lie within 0.02 positions of each other. Both lie close to the first water of 4.3 Ga. If the graphite is biogenic, life began as soon as water stood on the Earth.

5. Isua and Nuvvuagittuq: the Disputed Oldest Traces

Between 3.8 and 3.7 billion years the oldest rocks of the crust hold traces that may be life. Each has been read in two ways.

Isua and Akilia

At Isua, West Greenland, a banded iron formation of about 3,800 million years holds carbon inclusions rich in the light isotope, position 68.95 [99]. Akilia, nearby, gives a possible age above 3.85 Ga [99]. Isua sediments older than 3,700 million years hold graphite globules 2 to 5 µm across [100]. A later study read Isua graphite as biogenic [101].

Isua also yielded cones 1 to 4 cm high in rocks of 3,700 million years [102]. They were read as stromatolites. That placed them 220 million years before the best-supported stromatolites of the 3,480 million-year Dresser Formation. A reassessment read the same structures as the product of deformation [103].

Nuvvuagittuq

The Nuvvuagittuq belt in Quebec holds filaments about 8.3 µm wide and tubes about 24.9 µm wide [98]. They lie in iron-rich rocks of hydrothermal vents. The authors gave a minimum age of 3,770 million years and a possible age of 4,280 million years [98]. The reading as microfossils is disputed.

The disputed traces side by side

Trace	Age	Position	First reading	Second reading	Source
Light carbon, Akilia	> 3.85 Ga	> 68.96	biogenic	uncertain age and origin	[99]
Light carbon, Isua BIF	about 3.80 Ga	68.95	biogenic	—	[99]
Graphite globules, Isua	> 3.70 Ga	68.92	biogenic	—	[100], [101]
Cones, Isua	3.70 Ga	68.92	stromatolites	deformation	[102], [103]
Filaments and tubes	≥ 3.77 Ga, possibly 4.28 Ga	68.94 (69.06)	microfossils	mineral growth	[98]

The form

These are points with two names. The rock is the same. The reading differs. The mathematics of the net says that such points arise exactly where one goes back. They do not show that the record is weak. They show where the record is deepest.

What this chapter shows

From the zircon graphite at 4.10 Ga to the Isua graphite at 3.70 Ga is 0.40 billion years, position 66.90 [LB]. Within that span every trace has two readings. The first trace with one reading comes later, in the Pilbara.

6. The Pilbara: Stromatolites, Microfossils and Four Metabolisms

Between 3.48 and 3.40 billion years the Pilbara of Western Australia holds the first traces that most readers accept. They come in many kinds at once.

Hot springs on land

At about 3.48 Ga, position 68.87, the Dresser Formation holds deposits of hot springs on land [104]. They contain stromatolites, a palisade fabric and gas bubbles in what the authors infer as exopolymeric substance. If the reading holds, life stood on land before it is known in the sea of the same age.

Sulfur, methane and nitrogen

Barite at North Pole, about 3.47 Ga, records microbial sulfate reduction [105]. Fluid inclusions of more than 3.46 Ga in Pilbara vent precipitates hold methane with an isotopic signature of methanogenesis [106]. Wacey and co-authors read microstructures in the 3.4 Ga Strelley Pool sandstone as microfossils of sulfur-metabolising cells [109].

Nitrogen fixation follows later. The $\delta^{15}N$ of rocks 3.2 to 2.75 billion years old is 0.0 ± 1.2 ‰, consistent with fixation by molybdenum nitrogenase, position 68.79 [110].

Microfossils with their own carbon

The Apex chert, about 3,465 million years old, holds microbial fossils of five species [107]. Their carbon isotopes were measured one by one in 11 fossils. Two species are read as photosynthesisers, one as a methane-producing archaeon and the others as methane users [107].

The reef

At Strelley Pool a reef of about 3,430 million years shows seven forms of stromatolite along an outcrop of 10 km [108]. Seven forms in one reef are hard to explain without life.

The Pilbara record in order

Trace	Age	Position	Source
Hot springs with stromatolites, Dresser	ca. 3.48 Ga	68.87	[104]
Sulfate reduction, North Pole barite	ca. 3.47 Ga	68.87	[105]
Five microfossil species, Apex chert	ca. 3.465 Ga	68.86	[107]
Methanogenesis, fluid inclusions	> 3.46 Ga	68.86	[106]
Reef of seven stromatolite forms	ca. 3.43 Ga	68.86	[108]
Sulfur-metabolising microfossils	3.4 Ga	68.85	[109]
Nitrogen fixation	3.2 Ga	68.79	[110]

The form

By about 3.46 Ga the rocks record four metabolisms: sulfate reduction, methane production, methane use and, inferred, photosynthesis [LB]. The form of the net here is the closed window whose content changes. Six of the nine closed windows hold all three values once. The content passes through. The window stays closed. That is metabolism.

The stromatolite shows a second form: rest and discharge. Each layer is laid, held and covered. The reef of Strelley Pool is a stack of such layers.

The Pilbara shows a third: opened once, filled many times. The kind of union called a cell had opened before 3.48 Ga. In the Pilbara it is already filled with many ways of living.

What this chapter shows

From the Isua carbon at 3.80 Ga to the Apex fossils at 3.465 Ga is 0.335 billion years, position 66.74 [LB]. In that span the record changes from single disputed traces to a reef, five species and four metabolisms. The cells are gone. The products of their flow remain.

7. Chemical Whispers: Fragments Read by a Machine

Most old rocks hold neither cells nor intact molecules. They hold broken organic fragments. In 2025 a study showed that these fragments still carry a pattern.

The method

Wong, Prabhu and co-authors heated 406 samples and separated their fragments by gas chromatography and mass spectrometry [Wong 2025]. The samples were fossil, modern biological, meteoritic and synthetic. Of these, 272 with known affinity and physiology were divided into nine categories. Each category was split into 75 % for training and 25 % for testing. A random-forest model learned to tell the categories apart [Wong 2025].

What it found

The model found evidence for biogenic molecular assemblages in Palaeoarchean rocks of 3.33 Ga, position 68.83 [Wong 2025]. It found evidence for photoautotrophy in Neoarchean rocks of 2.52 Ga, position 68.57 [Wong 2025]. Before this study such molecular information had not been found in rocks older than about 1.7 billion years [Wong 2025]. The authors write that the method roughly doubles the interval in which fossil organic matter keeps molecular information.

Press reports gave the oldest age as 3.3 billion years. One report gave 3.51 billion years. The abstract gives 3.33 Ga. This book uses the abstract.

The form

The fragments themselves are not life. The pattern among them is. The model does not read a molecule. It reads the relations among many broken pieces. The History of Life on the Net puts it in one line: reading keeps the relations and drops the rest [LB].

The photosynthetic signal is a sign of one direction. Photosynthesis turns light into carbon in one sense only. Its trace at 2.52 Ga lies before the rise of oxygen in the air.

What this chapter shows

The oldest traces are of three kinds: isotopes in crystals, shapes in silica and carbonate, and now patterns among fragments. The third kind reaches 3.33 Ga. It agrees with the first two. Three readings of different carriers point to the same span.

Sources for Parts I and II

How to use this list

Each entry gives the source and one line on what it adds. Numbers in square brackets are those of The History of Life on the Net, where the same source is cited. Sources marked with a name and year are new in this book.

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Appendix A. Catalogue of the Oldest Finds (provisional)

Each row gives the position on the ladder, the age, the find, the place, the carrier that kept it and the source. LB [n] is source n of The History of Life on the Net. The catalogue grows with each version.

Position	Age	Find	Place	Carrier	Source
69.12	4.57 Ga	Oldest solids of the solar system (CAIs)	meteorites	crystal (CAI)	LB [1]
69.08	4.4 Ga	Oldest zircon; crust and oceans	Jack Hills, Australia	crystal (zircon)	LB [2]
69.06	4.3 Ga	Water in contact with crust	Jack Hills	crystal (zircon)	LB [4]
69.04	4.2 Ga	LUCA, molecular estimate	—	genomes of the living	LB [97]
69.02	4.1 Ga	Graphite in zircon, δ13C −24‰ (potentially biogenic)	Jack Hills	crystal inclusion	LB [96]
68.95	3.8 Ga	Light carbon in banded iron formation	Isua, Greenland	graphite	LB [99]
68.94	3.77 Ga	Putative microfossils (filaments, tubes)	Nuvvuagittuq, Quebec	iron-rich vent rock	LB [98]
68.92	3.7 Ga	Cones read as stromatolites	Isua	carbonate	LB [102],[103]
68.87	3.48 Ga	Stromatolites in hot springs on land	Dresser Fm, Pilbara	silica/barite	LB [104]
68.87	3.47 Ga	Sulfate reduction (isotopes in barite)	North Pole, Australia	barite	LB [105]
68.86	3.46 Ga	Five microfossil species	Apex chert	chert (silica)	LB [107]
68.86	3.46 Ga	Methane in fluid inclusions	Pilbara	fluid inclusion	LB [106]
68.86	3.43 Ga	Reef of seven stromatolite forms	Strelley Pool	carbonate/ chert	LB [108]
68.83	3.33 Ga	Molecular biosignatures read by machine learning	South Africa and others	organic-rich rock	Wong et al. PNAS 2025 (122:e2514534122)
68.79	3.2 Ga	Nitrogen fixation (δ15N)	—	sediment	LB [110]
68.57	2.52 Ga	Molecular trace of oxygenic photosynthesis	South Africa	organic-rich rock	Wong et al. PNAS 2025 (122:e2514534122)
68.41	2.1 Ga	Macrofossils and traces of motion	Franceville, Gabon	black shale (pyrite)	El Albani et al. 2010; 2019
68.24	1.75 Ga	Eukaryotes in oxygenated shallow water	Northern Territory, Australia	shale	Lechte et al. Nature 2026
68.18	1.64 Ga	Oldest eukaryote microfossils, already diverse	McArthur Basin, Australia	shale	Riedman et al. 2024 (Pap. Palaeont.)
67.73	1 Ga	Seaweed fossils	Yukon, Canada	shale	Maloney (in Wong et al. 2025)
67.69	950 Ma	Oldest fungus (chitin)	Grassy Bay, Arctic Canada	shale	Loron et al. Nature 2019
67.32	635 Ma	Sponge sterols (26-mes, C30)	Oman, India, Siberia	oil/shale	Zumberge et al. 2018; Summons et al. PNAS 2025
67.21	560 Ma	Ediacaran biota	worldwide	sandstone (death mask)	LB

Position	Age	Find	Place	Carrier	Source
66.88	391 Ma	Oldest tetrapod trackways	Zachełmie, Poland	dolomite	Niedźwiedzki et al. Nature 2010
64.28	22.5 Ma	Rhinoceros enamel protein	Haughton crater, Arctic Canada	enamel	Nature 2025 (Epiaceratherium; LMU 3-6-2025)
62.53	3.3 Ma	Oldest stone tools (Lomekwi 3)	West Turkana, Kenya	stone	LB [1847]; Harmand et al. 2015
62.41	2.9 Ma	Oldowan with hippo butchery	Nyayanga, Kenya	stone	Plummer et al. Science 2023
62.38	2.78 Ma	First Homo jaw LD 350-1	Ledi-Geraru, Ethiopia	bone/enamel	LB [1851]
62.37	2.75 Ma	Oldowan, 300,000 years of continuity	Namorotukuna n, Kenya	stone	Braun et al. Nat. Commun. 2025
62.32	2.6 Ma	Paranthropus in the Afar (MLP-3000)	Mille-Logya, Ethiopia	bone/enamel	Alemseged et al. Nature 2026
62.08	2 Ma	Oldest DNA (environmental)	Kap København, Greenland	frozen sediment	Kjær et al. Nature 2022
62.08	2 Ma	Paranthropus enamel protein	Swartkrans, South Africa	enamel	Madupe et al. Science 2025
61.97	1.77 Ma	Dmanisi, first outside Africa (with enamel protein)	Georgia	enamel	LB [1855]; Welker et al. 2020
61.90	1.65 Ma	Mammoth DNA from a molar	Krestovka, Siberia	molar in permafrost	Van der Valk et al. Nature 2021
61.45	1 Ma	Fire inside a cave	Wonderwerk, South Africa	ash/bone	LB [1865]
61.30	850 ka	Homo antecessor (enamel protein)	Atapuerca, Spain	enamel	Welker et al. Nature 2020
61.21	773 ka	Grotte à Hominidés, basal to the sapiens line	Casablanca, Morocco	bone/ enamel; palaeomagne tism	Hublin et al. Nature 2026
60.77	476 ka	Oldest wooden structure	Kalambo Falls, Zambia	waterlogged wood	Barham et al. Nature 2023
60.61	400 ka	Chinese H. erectus enamel protein (AMBN 253G/ 273V)	Zhoukoudian, Hexian, Sunjiadong	enamel	Fu et al. Nature 2026
60.39	315 ka	Homo sapiens, Jebel Irhoud	Morocco	bone; thermolumin escence	LB [1877]
59.78	160 ka	Hafted stone tools, East Asia	Xigou, Henan, China	stone	Xigou study, Jan. 2026 (Archaeology 27-1-2026)
59.69	146 ka	Harbin, Denisovan (protein + mtDNA)	Harbin, China	enamel/ calculus	Fu et al. Science/Cell 2025
59.00	67.8 ka	Oldest rock art (hand stencil)	Muna, Sulawesi	calcite crust (U-series)	Oktaviana et al. Nature 2026
58.74	51.2 ka	Oldest narrative rock art (pig and figures)	Sulawesi	calcite crust	Oktaviana et al. Nature 2024