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Reading Time in Stone: Deep-Time Evidence for Africa's Decisions

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Across the continent, public money is being asked to do hard work in a harsher climate: store water through longer dry spells, maintain soils on hillsides that erode faster, erect clinics and schools on ground that will not give way. The costliest mistakes do not begin in parliament. They begin in the baseline. Too often decisions are grounded on short, noisy records of twenty or thirty years at most—not long enough to know a landscape. Scratch that. A better record exists, in walls of calcite that grew drop by drop in a network of caves northwest of Johannesburg, and it is decipherable.

The science that reads those walls is not a curiosity. It is decision infrastructure. In the Cradle of Humankind, a Unesco World Heritage landscape, geologists reconstruct wet and dry phases, changes in groundwater, and the rate at which landscapes shed their layers. Our public-minded guide into this work is Dr Tebogo Makhubela, a geologist who specializes in dating cave minerals and surface histories. A senior academic based in Johannesburg, a recognised science communicator, he works at the seam where careful fieldwork, rigorous laboratory methods and clear storytelling meet.

Before the methods, the place. The surface is grassland and

koppies. Beneath it lies dolomite, a carbonate rock eaten slowly by water. Rain picks up carbon dioxide in the soil, becomes mildly acidic, and dissolves the rock along fractures. Think of it the way sugar dissolves in water: the dolomite does not vanish, it becomes a solution, carrying calcium and magnesium ions as the water moves deeper. Over thousands of years the cracks widen into conduits and chambers. Inside these rooms, each drop that reaches the air loses a little of its carbon dioxide and leaves behind a thin skin of calcite, the same mineral that breeds limescale in a kettle. Layer upon layer, those skins build into flowstone (curtains of calcite coating the walls and floor), stalactites (stone icicles hanging from the roof) and stalagmites (pillars that rise from the floor). A key note for the layman: each layer records the conditions that made it. A thick layer means water dripped freely from above, which means rainfall was generous. A thin layer means water slowed. A gap means it stopped. These are not decorative stones; they are a climate record for the ages.

One site shows the argument in full. Researchers catalogue it as UW105; among collaborators it goes by Demat, meaning "the cave of surprises". Lime mining in the nineteenth and twentieth centuries stripped many of its rooms: the icicles and pillars were burned into cement for an emerging Johannesburg, and the miners left a sealed floor behind them. Yet a single wall remains where the original rock-and-water record is intact. Close up, fine bands thicken in generous years and narrow in lean ones. The wall is an archive and, crucially, a timekeeper.

The first clock is inside calcite. When a fresh layer forms, a trace of uranium becomes part of the crystal. Uranium changes into thorium at a predictable rate across a scale of hundreds of thousands of years. Because thorium does not dissolve in the water that builds these layers, each new layer begins with almost none of it. Over time, thorium accumulates inside the sealed crystal. Measuring how much thorium has developed relative to the uranium remaining reveals when that layer formed. The method works be-

cause the crystal starts clean: there is no inherited thorium to confuse the reading, only thorium produced since the layer was laid down. What this yields for a planner is a dated climate record. A band that formed during a reliably wet period fourteen thousand years ago and a band that thinned during a prolonged dry stretch eight thousand years later are not merely interesting: together they tell a water engineer how bad the droughts in this watershed have been, across a timescale no rain gauge ever recorded. Reputable labs verify this by dating bands from bottom to top to check that ages step forward in order, running duplicates, and looking for chemical signs of disturbance. Certainty is earned through methodical doubt.

A second clock sits in daylight. High-energy particles from space, cosmic rays, strike exposed rock and create rare atoms inside the mineral grains at a rate that scientists have measured carefully. Those atoms accumulate while a boulder or a soil grain sits at the surface. Once buried, production stops and the accumulated atoms slowly decay. Counting what remains tells us how long that material was exposed to the sky, and from that, how fast the slope above it has been shedding rock and soil. For a land manager, this is directly actionable: a hillside with very low concentrations of these atoms has been losing material quickly, which means its soils are thin and its cover needs urgent attention. A hillside with high concentrations has been stable for a long time. That distinction changes where effort goes, whether in terracing, grazing controls, or tree planting, without relying on visual guesswork.

Together, these two clocks produce something a short instrumental record cannot: a map of what this specific landscape has already survived and lost. The cave layers show wet periods when dripstone grew quickly and dry phases when growth slowed or stopped, stretching back hundreds of thousands of years. The surface record shows which slopes have clung to their layers for centuries and which have shed material in pulses after heavy rains.

A planning authority working only from recent gauges sees a slice. Working from both clocks exposes a range: the realistic worst-case drought, the realistic erosion load, the realistic recovery time. That range is what sizing decisions, allocation rules and restoration priorities should rest on.

If the clocks are the argument's bones, Demat provides its muscle. When researchers broke through the mine's cemented floor, they found mud-rich deposits and more blocks below, material that could be dated and tied to wetter and drier phases recorded in the intact wall above. A damaged chamber still holds a legible sequence: muddy intervals that record sediment washing through during wet, energetic periods, capped by flowstone laid down in calmer, steadier dripping. These alternating layers connect the fossils and sediments inside the cave to the same climate beats that shaped the watershed above it. What looked like an industrial ruin turns out to be a reading room.

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The discipline required in dating is worth replicating in public life. Samples are logged and tracked; methods are documented in plain language; uncertainties are calculated and reported rather than smoothed away. The standard is not to be right once but to remain right when another team revisits the work. In a region where infrastructure decisions are often asked to carry political weight, the ethic of showing one's work and inviting scrutiny turns technical disagreement into an honest conversation rather than a contest over authority. Public planning needs exactly this quality: not the appearance of certainty, but a transparent account of what is known and what is not.

Scale is its own form of instruction. A band a few millimetres thick may store a century of changing drip rates. A boulder on a ridge may carry tens of

thousands of years of exposure history. When these threads are stitched together across a watershed, planning is pulled past the five-year budget cycle without losing practicality. Deep time becomes useful time, not because it predicts the future but because it establishes the realistic envelope within which the future will operate.

Critics sometimes argue that records this old cannot guide near-term planning. But the clocks do not predict next month's rain; they map what this landscape has already endured. They show which swings are possible here, how quickly thresholds have been crossed in the past, and how long recovery has taken. That context makes seasonal forecasts more actionable, not less. Knowing that a three-decade dry phase is within the range of this watershed's history gives an engineer a principled reason to size a dam for that duration rather than for the twenty-year average.

Two assumptions are worth setting aside. The first is that a landscape, left alone, returns to a single, stable state. The record in stone says otherwise: systems wander within limits and occasionally settle into new patterns after a large shock. The second is that nature and development sit in permanent opposition. In dolomite country, careful development is often protection. Revegetating an eroding slope keeps the topsoil that feeds households and protects the water moving through the rock below. Routing a road around a known cavity in the dolomite protects both the road budget and the cave record. These interests are usually aligned, not competing.

"[Caves] are part of heritage and living ecology"

Caves are not only data sources. They are part of heritage and living ecology. Taking only what research requires, recording what was taken and why, and reporting back to communities does more than satisfy permit conditions. It makes the science legible to the people who live

alongside it, and legible science is the kind that gets used.

The biggest practical constraint on applying this evidence is not geology but capacity. Too many African samples still cross oceans for analysis, returning as numbers detached from the places they describe. Building regional capacity, in labs, archives, field skills and career paths, keeps evidence close to the decisions it should inform. The model is a network: shared methods, shared quality control, open datasets, and career paths that seat geologists beside hydrologists and soil scientists beside policy analysts. That is not an expensive ideal; it is the difference between evidence that circulates and evidence that gathers dust.

Limitations deserve plain statement. Cave layers can be disturbed by later water flow; exposure histories can tangle if rocks were buried and re-exposed. That is why results carry uncertainty ranges and are cross-checked with independent methods. In policy the parallel is straightforward: design for a range of outcomes rather than a single number. Stage water restrictions so they tighten progressively as conditions worsen. Size drainage infrastructure for plausible extremes rather than historical averages. Build in review points so that choices tighten or relax as evidence accumulates.

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A word about the scientist whose work anchors this argument. Dr Tebogo Makhubela is part of a generation of African earth scientists turning caves into public knowledge. His presentations move between the technical and the practical without losing either. His fieldwork shows how to build a narrative from field notes, photographs and measured results, and then hold it up to scrutiny rather than shield it from challenge. He does not ask audiences to trust a person; he invites them to follow a process, from cave wall to sample to laboratory result to interpretation. That is scientific authority.

Africa's margin for error is shrinking. The decisions that remain are financially large and politically difficult. Those choices are safest when they rest on evidence that is explicit, auditable and shared. The underground and surface clocks supply exactly that. They expand the question from what happened last year to what this place has endured across centuries, and that shift is what turns a hunch into a workable choice.

In a time when the future feels compressed, reading time in stone slows the conversation just enough for judgement to keep pace with what the earth is actually telling us. **FS04**

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