2.8B420K

A Monument to the End of All Life

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2023

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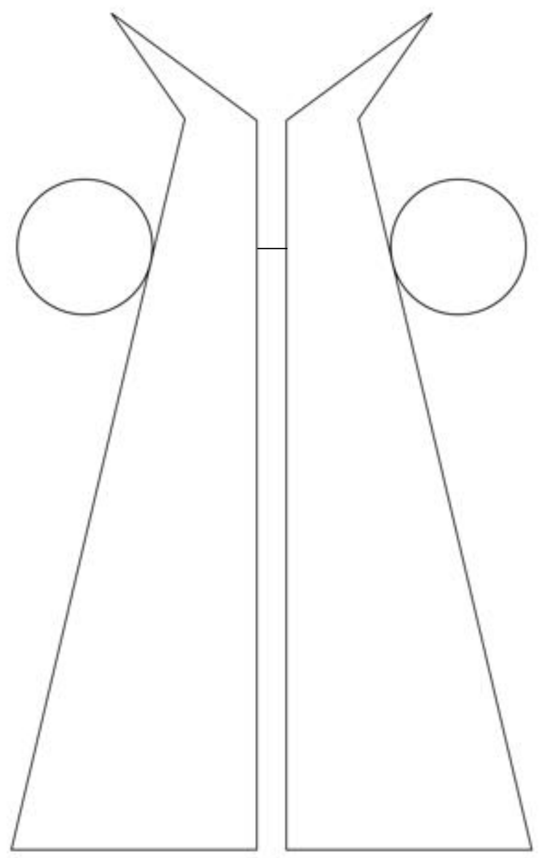
Outline:

The End of all Life
Marking the transition from biological to post-biological



In 2.8 billion years time, the increased luminosity of the expanding Sun will cause the Earth's average temperature to reach 420K (147C). At this temperature the final vestiges of life, simple sub-terrestrial microbes taking refuge at the poles, will become extinct, marking the planet's transition from biological to post-biological. This hugely significant moment in Earth's history will pass by unnoticed.

The project 2.8B420K proposes the design and implementation of a monument (also known as The Object) that, by triggering a material malfunction at 420K, will make a performative gesture to commemorate this transition. No living thing will witness this performance. The Monument performs to itself, to the lifeless Earth and to the wider Universe.

The proposal for the project 2.8B420K is complicated and probably impossible. At best it is faced with a complex web of virtually insurmountable issues, challenges and unknowns ranging from geology and climate to anthropology and material science. The timescales involved make empirical knowledge and decisions impossible. The critical moment lies in the deep future where speculation reigns over certainty. Over such deep timelines the Earth's surface is fluid and the forces of climate and erosion inexorably change and erase everything. We have already seen many such changes in the geological record. We don't know how long humanity has left, or how it would adopt or maintain such an object. No material as ever been tested over such timescales.

However, through combining both traditional and speculative threads of inquiry into geology, anthropology, material sciences, climatology, architecture and design, it is possible to attempt to get close to making the impossible possible. While there is a strong narrative in the combined threads of research, the project also generates speculative ideas that create a strong fictional counterpoint. By combining these fictions and nonfictions, the project becomes a rich and complex case study for how we consider the ends of all things on Earth and offers an opportunity to cast ourselves into a post-human future.

The Monument, and the idea of the Monument, anchor a thread in the present that stretches into the deepest future of life, over unknown cycles of change in what the planet actually is.

This document presents an overview of the problems and challenges that it faces. It also presents a series of propositions; ideas and forms in which these insurmountable problems might be answered. The problems included are possibly not the only problems, and the propositions are almost certainly not the only solutions. This book compiles the knowledge, plus background contexts, processes, speculations and visualisations generated during the project, with the aim of becoming a survey of what might be possible.
These propositions are sometimes attempts to find a practical solution, sometimes a survey of what might offer hope, and sometimes an exploration of ideas that might help our understanding.

This book serves two purposes. It is a survey of all the knowledge generated over the development of the work, and an anthology of ideas. And it is the closest possible thing to a genuine proposal and instruction manual for building a monument that waits 2.8 billion years for the end of the life on Earth.

The Action. The Performance. The Commemoration :

The Monument, also known and described as ‘The Object’, is sited in the location best equipped to protect it geologically during the next 2.8 billion years. Accepted as a globally important and ’post-scarcity’ project, it has been built with the most resilient materials known to humanity and sited within a geologically protective sarcophagus. The Object sits deep underground and waits beneath a protective mountain.

Over hundreds of millions of years, while continents shift and reconfigure, the protection is slowly eroded and weathered away. It is hot and the Earth is quiet. No creatures roam the surface or swim what is left of the seas. After a billion years, the mountain that protects The Object is gone, as are all mountains, all continents that were known in the time of humans. The Object now sits beneath its diamond dome. As it in turn slowly weathers away, the fierce sunlight penetrates and touches the surface of The Object for the first time. Deep into the future, it is released into a vastly different world. A world that is mostly desert, devoid of all animal and plant life, where only microbes remain. The world is hot, and slowly getting hotter. The Object waits, its own inherent strength and resistance protecting it over further tens of millions of years.

Eventually, some 2.8 billion years from now, the average global temperature reaches 147 Celsius, the temperature at which all life ends. At this same temperature, a material component reacts within The Object, deforming and melting. This material failure triggers the action. The action is a performance that commemorates the end of all life on Earth. A simple and final gesture to mark the transition.

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When I was a small child, I had a recurring vision. But it wasn’t really a vision. Nor was it a hallucination or a dream. It was a lucid and crushingly tangible awareness of something terrible and horrifying. It would leave me rigid with foreboding. I would suddenly become aware of the presence of two huge and massive spheres, incalculably heavy and immeasurably ancient. The spheres were connected by a thread finer than a human hair, finer even than gossamer - and they were moving apart, at sub-tectonic pace. The thread holding them together was, micron by micron, bearing more and more tension. If this thread were to break, and the spheres were to become separated, it would mean the unleashing of all the darkest horrors that humanity, its underworlds, nightmares and meta-realities could possibly imagine.

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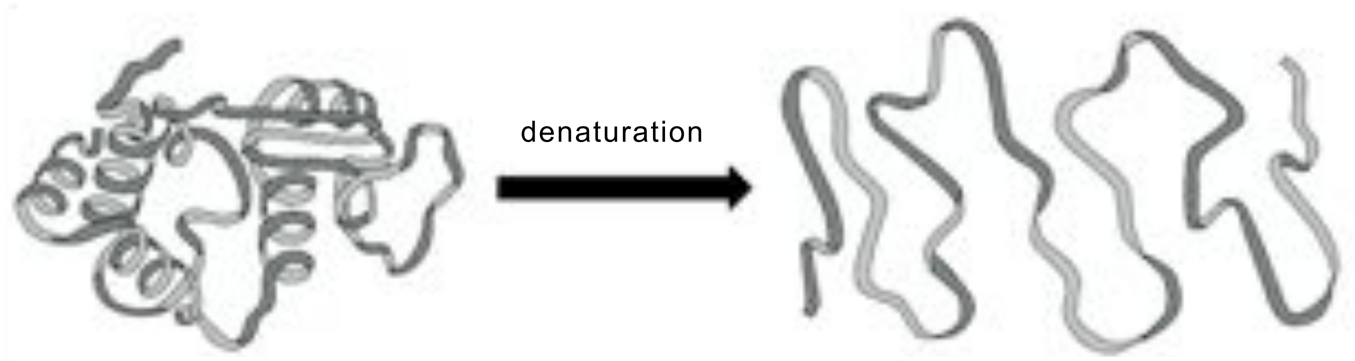
The Object’s task is to hold these spheres for 2.8 billion years. When all life ends then the spheres will finally separate and fall. All the darkest horrors can become unleashed, but nothing will exist to suffer them.

How Life Ends:

Terrestrial living organisms are characterised by three important features: a set of internal instructions encoded in DNA, a suite of proteins and associated macromolecules providing a boundary and internal structure, and a flux of energy. Temperature has a profound effect on all of these features, and yet life is sufficiently adaptable to be found almost everywhere water is liquid. The thermal limits to survival are well documented for many types of organisms, but the thermal limits to completion of the life cycle are much more difficult to establish, especially for organisms that inhabit thermally variable environments. Current data suggest that the thermal limits to completion of the life cycle differ between the three major domains of life, bacteria, archaea and eukaryotes. At the very highest temperatures only archaea are found with the current high-temperature limit for growth being 122C.

A global mean temperature of 147C will cause this upper limit to be exceeded at the poles, thus bringing about the end of all life.

Above a certain temperature, a cell will collapse and die. A straightforward explanation for this lack of heat tolerance is that the proteins essential to life — the ones that extract energy from food or sunlight, fend off invaders, destroy waste products and so on — often have very precise shapes. They start as long strands, then fold into helixes, hairpins and other configurations, as dictated by the sequence of their components. When temperatures become too high, the bonds that keep protein structures together begin to break. It is this loss of protein structure that is lethal.



folded, functioning protein

unfolded, non-functioning protein

As average global temperature passes 38C the planet begins to die at the equator. All life migrates north and south towards the poles.

As the mean passes 40C, animal life will see a series of relatively fast cycles of extinction and evolution over tens to hundreds of thousands of years, as it tries to find ways to endure the increasing temperatures.

When 45C is reached, the remaining animal life will begin to die off rapidly as their cells' mitochondria cease to function. A tough few cling on to survival at the poles.

At 70C all life has disappeared from land apart from the hardiest bacteria. More complex life clings on in the oceans, but they are quickly evaporating away and becoming more acidic.

As the temperature continues to rise, the bacteria also die off species by species. The last remnants of life cling on underground at the poles.

At 147C, these too are gone.

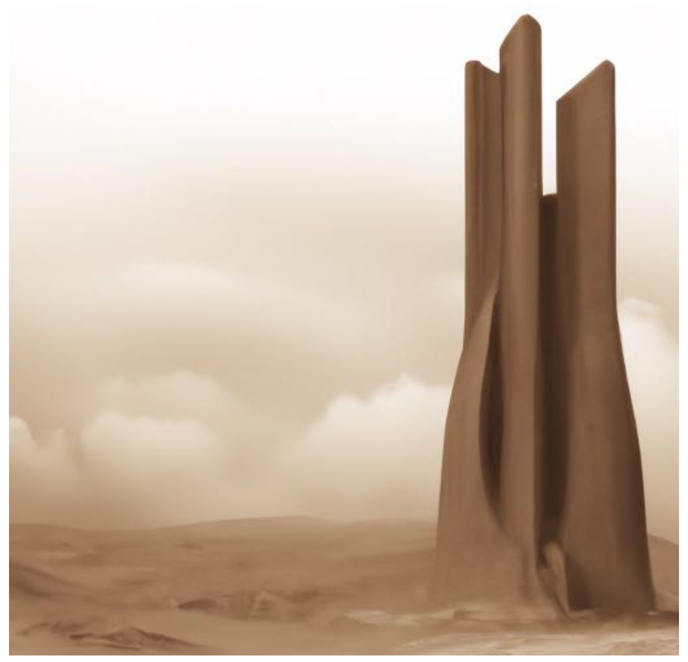
A Timeline for the End of Life:

A Timeline for the Monument to the End of Life:

YEAR	GLOBAL PHENOMENA	Monument STATUS
0 / 2025 CE		Work begins on the Monument and its initial location
10 / 2035 CE		Work completed. Lifetime caretakers assigned
50 / 2075 CE	Global mean temperature up by 2.5C minimum. Sea levels up by 1.5m	Care passes to the next generation
100 / 2125 CE	Human population 11 billion	Care passes to third generation
500 / 2525 CE		Origins of placement becoming forgotten. Obligation to care for Monument kept as written tradition.
2000 / 4025 CE		Society of caretakers begins to resemble a sect, apart from mainstream society. Language of Monument revised and updated
10,000 / 12025 CE	Most probable estimated lifespan of technological civilisation, according to Frank Drake's original formulation of the Drake equation. Humanity has a 95% probability of being extinct by this date, according to Brandon Carter's formulation of the Doomsday argument	The Monument is the sole remaining artefact from 21st C civilisation. Semiotics of Monument revised and updated
50,000 to 100,000	End of interglacial period and possible onset of new ice age	Monument complex threatened by glaciers.
100,000	High probability that super volcano has erupted and/or asteroid has struck	Protective mountain relieves impact from these events
200,000	All constellations have changed. 99% of human structures destroyed without trace. Only monolithic stone structures remain standing	
1,000,000	Estimated lifespan of Memory of Mankind (MOM) self storage-style repository in Hallstatt salt mine in Austria, which stores information on inscribed tablets of stoneware. Various public monuments composed of hard granite will have eroded one metre, in a moderate climate, assuming a rate of 1 Bubnoff unit (1 mm per 1,000 years). Without maintenance, the Great Pyramid of Giza will erode to nothing	New, evolved or post- human species takes over care of the Monument
10,000,000	Mt Rushmore has eroded and become unrecognisable. Last remnant of current human civilisation gone. Assuming Holocene extinction, full biodiversity is resumed. All current species disappeared through background extinction rate. Humanity has a 95% probability of being extinct by this date, according to J. Richard Gott's formulation of the controversial Doomsday argument.	Superficial layers of protective mountain have begun to erode away
50,000,000	African continental plate collides with Eurasian plate. Mediterranean sea closes and becomes new high mountain range Appalachian mountains eroded away	Superficial layers of protective mountain have eroded

YEAR	GLOBAL PHENOMENA	Monument STATUS
100,000,000	High probability of K-Pg extinction type asteroid impact. Future archaeologists should be able to identify an "Urban Stratum" of fossilised great coastal cities, mostly through the remains of underground infrastructure such as building foundations and utility tunnels.	Protective mountain almost half goneSurface erosion begins to cause relative rising of Monument towards surface.
250,000,000	Pangea Proxima has formed from merging of all continental plates. Results in a glacial period, lowering sea levels and increasing oxygen levels, further lowering global temperatures	Mountain mostly gone, revealing black diamond dome cover.
500,000,000	Between now and 600,000,000 years photosynthesis becomes impossible and plant life dies out. Super continent drifts apart Sun's increasing luminosity disrupts carbonate–silicate cycle and increases weathering of surface rocks, which traps carbon dioxide in the ground as carbonate. As water evaporates from the Earth's surface, rocks harden, causing plate tectonics to slow and stop.	Dome cover shows first signs of abrasion.
800,000,000	All multicellular life extinct	
1,000,000,000	End of multicellular life. Oceans begin to evaporate generating massive greenhouse effect. 1.1 by – Sun's luminosity increased by 10% and average temp 320K / 47C 27% of the modern ocean subducted into the mantle Estimated lifespan of the two Voyager Golden Records, before the information stored on them is rendered unrecoverable	Widespread desertification results in severe sandstorms. The diamond dome erodes more quickly. Monument platform level and Earth surface have equalised.
1,500,000,000	All eukaryotic life extinct. Only prokaryotes remain.	From this point the Monument becomes fully revealed.
2,000,000,000	Earth is dominated by desert and salt flats	
2,800,000,000	Average global temperature reaches 147C. All life ends.	Monument performs




Monuments And Messages::

The pyramids of Egypt. Stonehenge. The Ziggurat of Ur.
Monuments and complexes built between 4 and 5 thousand years ago. Their methods, context and deeper meanings belonging to other times and other peoples, blurred across history.

When we attempt to read the past we discover that we no longer speak their language or understand their symbols or traditions. We develop our own meanings. We speculate and ascribe magical significance.

The past is an alien culture.

Warnings devised by the Human Interference Task Force, designed to communicate danger 10,000 years into the future. A plaque designed by Carl and Linda Sagan and Frank Drake, with the purpose of telling distant alien cultures about who we are and where to find us.

When we attempt to communicate with the future we discover that we have no language.

The future is an alien culture.

Across time, meaning loses meaning

Time Capsules:

In 2014 the creators of EVE Online erected a trio of stone monoliths in Reykjavik, Iceland. Standing over 15 feet tall, the Monument consists of three differently shaped spires, two made of stone flanking a shining metal centre pillar. The obelisks stand on a wide base that is engraved with the names of every single player registered for the game as of March 2014. Buried beneath the statue is a laptop containing video messages, files, images and other data from the game as a digital time capsule. There are plans to unearth the laptop on May 6, 2039.

A capsule 6 Feet underground in the Chinook Centre in Calgary, Alberta; to be opened on December 31, 2999.

a 1.82m x 0.30m stainless steel time capsule, encased in a granite cap and cement pedestal, placed in December 2012 and intended to be opened in 2062.

Prisoners from the Auschwitz concentration camp concealed bottles containing sketches and writings that were found after World War II

Science Centre Singapore has been depositing gadgets and examples of significant technologies in a time capsule inaugurated by then Science and Technology Minister Dr Toh Chin Chye. The first 112 items deposited included a black and white television receiver, a camera and samples of pig feed.

Crypt of Civilisation in Atlanta, Georgia to be opened in 8113

The Expo '70 time capsule is located near Osaka Castle, donated by Panasonic and the Mainichi Newspapers. It was opened for the first time in 2000, and then the second time expected to be opened in 2100. The time capsule remains sealed until 6970.

100 Years, a film shot and produced in 2015 with release scheduled for 18 November 2115, is being kept in a high-tech safe behind bulletproof glass that will open automatically on the film's premiere

A time-capsule was buried in the premises of Lovely Professional University in Jalandhar, Punjab on the second day of Indian National Congress dated January 4, 2019. An 8x8 time capsule-box made of aluminium and wood with a glass door, 10 feet underground. A smart phone, landline telephone, VCR, stereo player, stop watch, hard disk, mouse, laptop, CPU, a motherboard, hard disk with documentaries and movies, a camera, science-text books and scientific equipment will remain buried for 100 years.

A glass time capsule buried at MIT in 1957 was accidentally unearthed during construction in 2015. Made to be opened in 2957, its condition was checked and then it was reburied.

The Bokri microrbital was joint-owned by a group of Secular Collectionary orders: institutionalised obsessive, only para-religious organisations, each devoted to one or other aspect of preservation. One order collected ancient farming implements, another chemical rockets and antique space craft, while another had specialised in household dust; its sheds and warehouses were packed with billions and billions of vials and other containers

The Biological and Environmental Specimen Time Capsule 2001 team hopes to bury a number of large ceramic capsules sixty-five feet deep in Antarctic ice, where the temperature is -60° C. In the capsules would be seeds, spores, human and other reproductive cells, human mother's milk, DNA, rainwater, sea water, air, and soil. Once the Antarctic cache is established, the team would like to place capsules on the Moon, where the temperature is -230° C. and there is neither air nor moisture to foster rot.

A time Capsule was to be opened in 2016 but was opened in 2014 instead. Within the time capsule was about two feet of water destroying most paper artefacts in the capsule.

On September 17, 2017 near the Polish Polar Station, Hornsund in the Norwegian Svalbard archipelago, scientific researchers buried a 60-centimeter stainless steel tube containing samples designed to tell finders as long as half a million years into the future, about the current state of knowledge in areas such as geology, biology, and technology.

"Earth's Black Box"—a city bus-sized structure with steel walls, battery storage and solar panels located at a remote site in Tasmania—will accumulate and electronically store comprehensive climate research and related data, including land and sea temperature changes, ocean acidification, atmospheric greenhouse gas concentrations, human population, energy consumption, military spending, and policy changes.

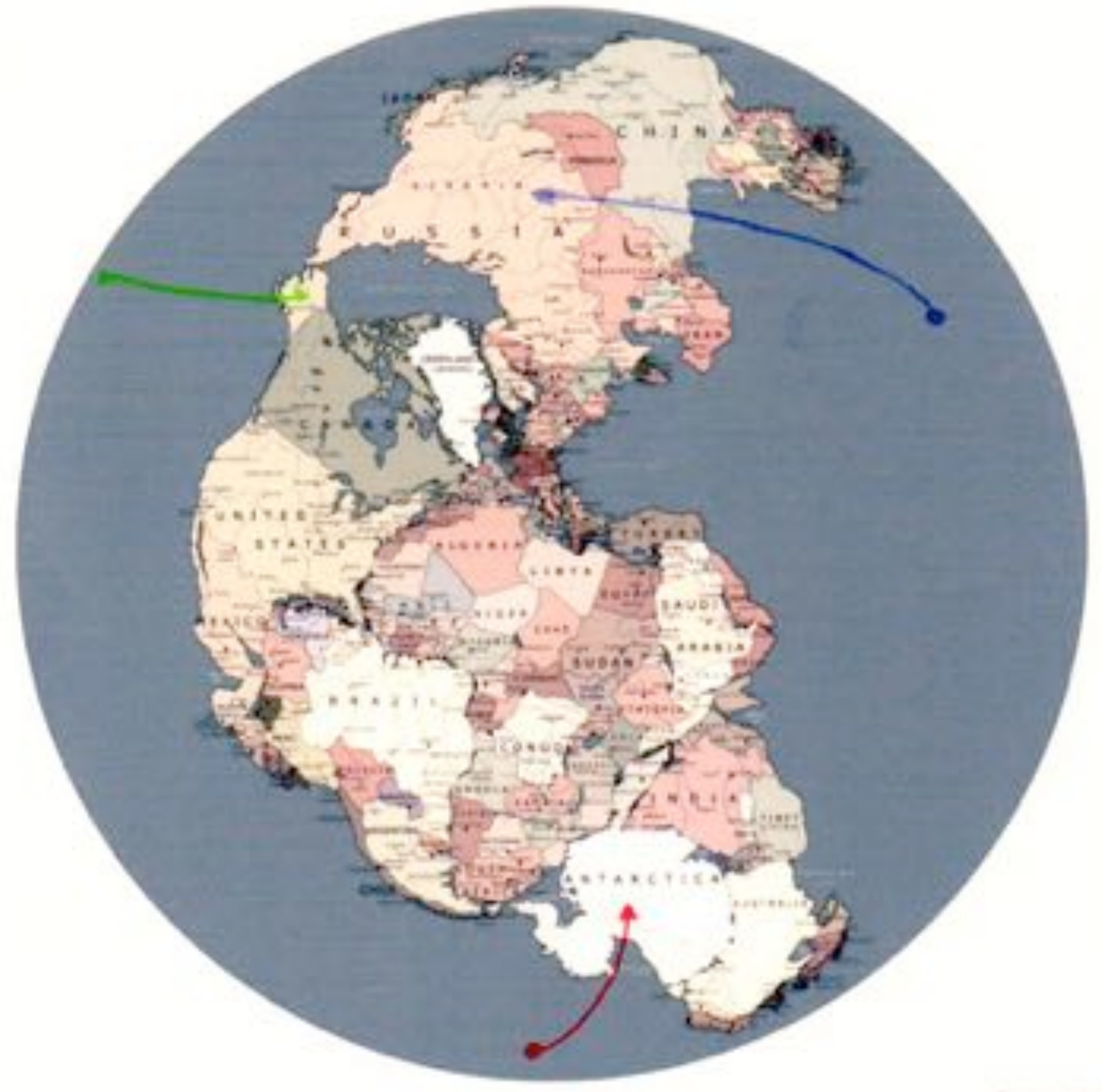
Southampton, Hampshire, UK: a 1935 message in a lemonade bottle, correctly portending difficult times lying ahead, was found in 2016 by masons restoring damaged Portland stone

Millennium Vault, Europe's largest time capsule was built in 2000 in Guildford, Surrey. The capsule is set to be opened in 3000. Contents include various 20th century items, such as a 'Mini' car, a postman's delivery bicycle, a microwave oven and a post box.

It is estimated that some 70% of time capsules that have been placed are lost

PROBLEMS

The Geological Problem:



PANGEA PROXIMA - 500.000.000 YEARS FROM NOW
MASSIMO PIETROBON - OPENCULTURE.COM

Solid ground is not forever. What seems stable is fluid.

For the next 1 billion to 1.5 billion years the Earth's tectonic plates will continue to move, leading to them breaking, colliding or subducting one beneath the other. These dynamics also lead to recycling of huge amounts of material. Colder or denser plates sink and subduct while while warmer or less dense plates 'stay afloat'. Plumes of hot material slowly rise towards the surface, driving tectonic movement. Slab Pull, Ridge Push and Viscous Drag create play between new hot rock and old hard crust. Supercontinents come together and break apart in cycles of hundreds of millions of years.

The hard, seemingly permanent rock we stand on and build our cities on, where we create borders and nations, is fluid and unsteady.

What we see as coherent surface today, the sites where we choose to place our Monument forever, will not be there 100 million years from now.

If the Earth's surface is fluid over geological time scales, how can we find a place that will still be surface in 2.8 billions years?

----- MECHANISMS -- o

Slab Pull

The force due to the weight of the cold, dense sinking tectonic plate

The main force on a subducting plate

Ridge Push

The force due to the buoyancy of the hot mantle rising to the surface beneath the ridge

Ridge push results from the elevation of oceanic ridges above the seafloor. This difference in height leads to pressure that 'pushes' the plate away from the ridge

Viscous Drag

The force opposing motion of the plate and slab past the viscous mantle underneath or on the side

The plate is being pulled or pushed by slab-pull and ridge push and drags the asthenosphere with it. Therefore viscous drag oppose the motion of the plate (or slab) and acts to slow it down

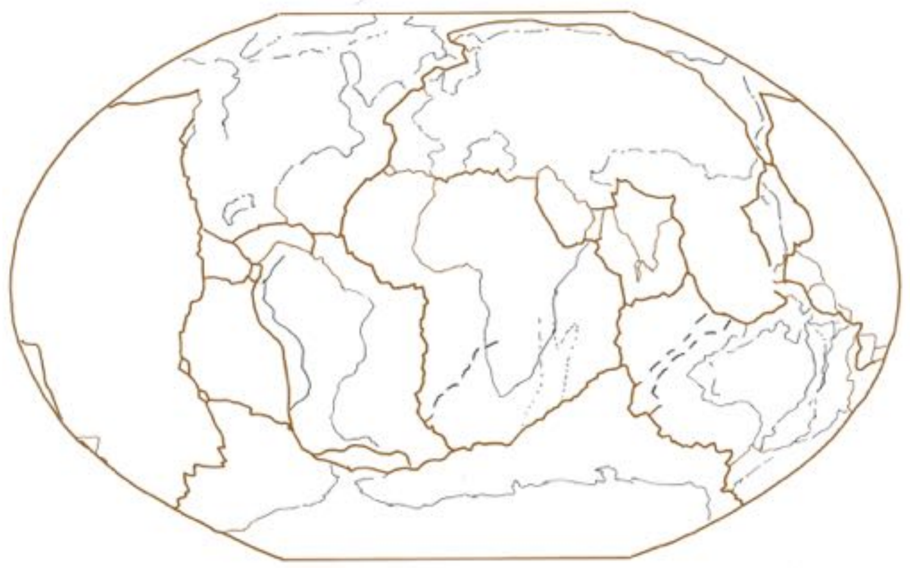
Isostasy

An equilibrium between the Earth's crust and its upper mantle

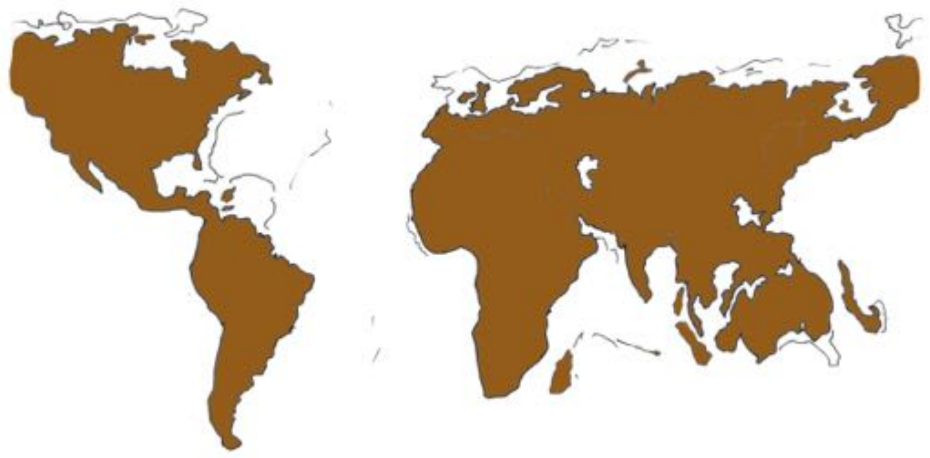
If weight is added to the Earth's crust, the crust sinks. If weight is removed, the crust rises. Tectonic stress and climate are both capable of redistributing weight and, therefore, both cause isostatic changes

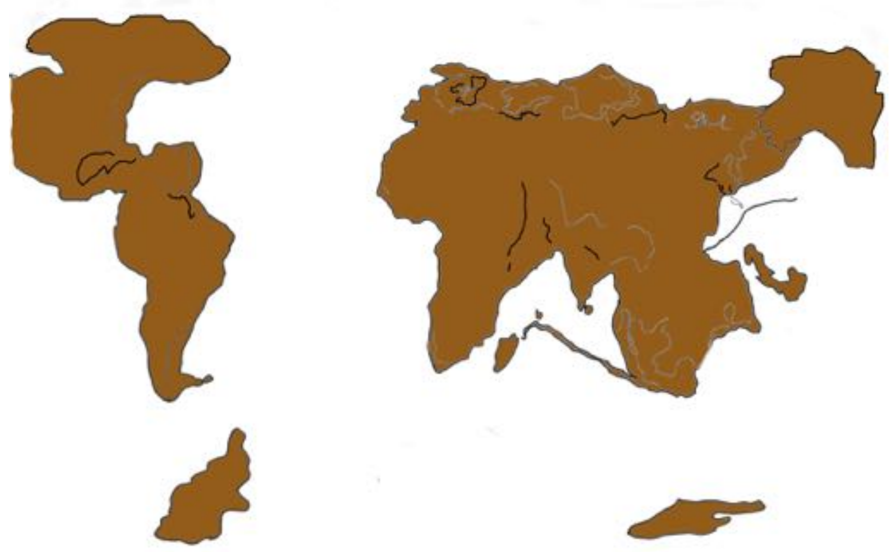
The Geological Problem:

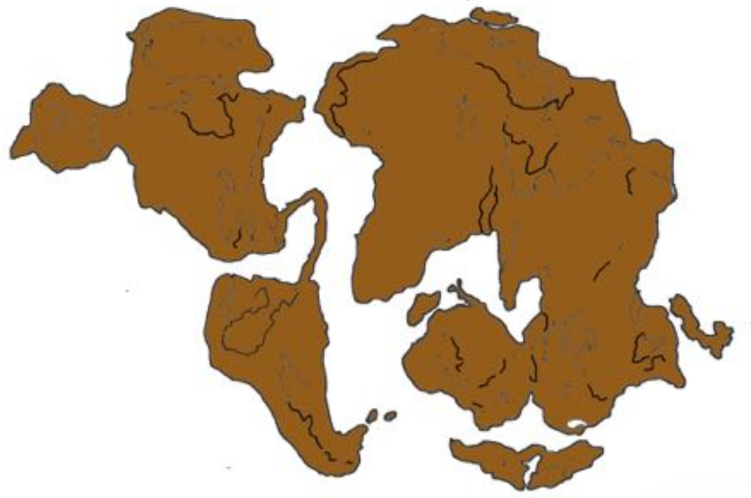
distribution of major
tectonic plates



continents at
present day







+50 million years:
The Red Sea and Gulf of Aden are completely closed as Africa collides with Arabia. The Mediterranean Sea is completely closed. Iberia rotates clock-wise consuming ocean floor in the Bay of Biscay and collides along the southwestern margin of France. The North and Central Atlantic Ocean contract and the northernmost portion of the Mid--Atlantic Ridge is subducted beneath Newfoundland. As Africa continues to plow northward into Eurasia, mountains rise along the northern border of this collision belt.

Climate - cooling greenhouse. 18C

+100 million years:
A intra--continental rift forms in northeast Siberia as Eurasia is pulled away from North America.with new mountain ranges formed between them. The North and Central Atlantic Oceans narrow as the last remnants of the Mid--Atlantic Ridge are subducted beneath the east coast of North America. The Afro--Asian continent is pulled toward North America. The Basin and Range stops stretching and the Californian mountain ranges are added to southern Alaska. The Himalayas and Tibetan plateaus begin to erode.

Climate - Warming Icehouse (only the Northern Hemisphere has an icecap). 16 ˚C

+150 million years:
Antarctica's northward motion is halted due to its collision with the island arcs of the Capricorn Trench. This is the first collision, in a series of four major collisions, that ultimately forms the supercontinent of Pangea Proxima. The mountainous areas of East Africa, Iran, northern India, Tibet and SE China occupy warm, wet, tropical latitudes are rapidly eroding. The Verkhoyansk Ocean opens as Chukotka and North America pull away from Siberia.

Climate - Mild Greenhouse. 21C

+200 million years:
Westward-directed subduction along the eastern margins of North America, the Caribbean plate, South America, and the Scotia plate has nearly closed the Atlantic Ocean. A circum-Pangean mid-ocean ridge system encircles the assembling supercontinent. The Himalayas are reduced in size comparable to the Appalachian mountains. The Medi-Pangean Sea, east of Africa, south of India, and north of Antarctica is nearly enclosed and continues to stagnate.

Climate - Hot House. 24C

N.B. All dates are approximate.....

+225 million years:
Newfoundland collides with West Africa. The eastern tip of Brazil collides with the southern tip of Africa. The last bits of ocean floor in the Atlantic Sea and Austral Sea are being removed by subduction. A nearly complete circum-Pangean subduction zone (the New Ring of Fire) encircles the assembling supercontinent (Pangea Proxima). Only the remnants of the Himalayas, Tibetan plateau, and Afro--Eurasia mountain belt remain.

Climate - Warming Hot House. 26C

+250 million years:
Greenland and North America have collided with western Africa forming the west-central portion of Pangea Proxima. The northeastern and eastern margin of South America has collided with South Africa and East Antarctica forming the southwestern portion of Pangea Proxima. Pangea Proxima, is surrounded by a global ocean, the Propanthalassic Ocean (meaning "future" Panthalassic Ocean). The mountainous areas of warm, wet, tropical latitudes have been worn down. Only remnants of the Afro--Eurasia mountain belt and Sino--Australian mountains remain. The completely enclosed Medi-Pangean Sea becomes a super-toxic inland sea that begins to poison the surrounding oceans, lands and atmosphere leading the next great extinction event.

Climate - Extreme Hot House. 28C

The Erosion and Weathering Problem:

The physical abrasive forces of wind and sand and rain and ice that grind and split and crack and degrade. The destructive and corrosive chemical potentials of atmospheric oxygen, and the corrosive drip, drip, drip of acidic rains….

This thing all things devours: Birds, beasts, trees, flowers;
Gnaws iron, bites steel;
Grinds hard stones to meal;
Slays king, ruins town,
And beats high mountains down.

Erosion and weathering rate is influenced by

- How reactive minerals in the rock are when exposed to chemical weathering
- Whether rocks are clastic (less resistant) or crystalline (more resistant)
- The degree to which rocks have cracks, fractures, and fissures (these weaknesses are exploited by weathering and erosion)

Physical Weathering

- *Wedging* - caused by substances that get into holes and cracks in rock and expand outwards, exerting pressure on the rock, causing further cracking and splitting apart. Water that freezes in cracks and forms ice, salt from evaporated seawater, growing plant roots.
- *Exfoliation* - when rocks that formed in high pressure environments are brought to the Earth's surface. When the pressure on these rocks decreases, they expand and split apart into sheets.
- *Abrasion* - when rocks rub together. Rocks on a riverbed smoothing as they collide in the current. Small particles of rock carried by the wind.
- *Thermal expansion* - expansion caused by heating - eg. by the Sun. If different portions of a rock expand at different rates, the heated parts will exert pressure on each other, and crack.
- *Denudation* - the geological processes in which moving water, ice, wind, and waves erode the Earth's surface, leading to a reduction in elevation and in relief of landforms and landscapes. Denudation is the sum of processes, including erosion, that result in the lowering of Earth's surface.

Chemical Weathering

- *Oxidation* - reaction of oxygen with chemicals in a rock. Oxygen reacts with iron to form iron oxide, or rust, which is soft and vulnerable to physical weathering.
- *Hydrolysis* - rocks absorbing water into chemical structure. A rock with a higher water content is softer, and thus easier for physical weathering, or even just gravity, to decay.
- *Carbonation* - caused by carbonic acid in water reacting with and degrading rock. This acid is especially effective at degrading limestone. Underground carbonation may form limestone caverns.
- *Acid rain* - caused by sulphur and nitrogen compounds in the air reacting with water to form acids that then fall to the ground. Particularly harmful to marble, chalk, and limestone, and cause damage to tombstones, statues, and **other public Monuments**

EXAMPLE ONE

Mount Rushmore is made of granite, a rock which erodes about 2.5cm every 10,000 years.
Each of the noses is about 600cm long and will erode in 2.4 million years.
The basic shape of the heads might last up to 7 million years.
In 10 million years, Mount Rushmore is once again just another mountain.
In 100 million years, it is gone.

EXAMPLE TWO

The great pyramid of Giza is 150 meters tall and four and a half thousand years old. It was built of four main varieties of rock - grey, hard, dense limestone; grey soft limestone; grey shaley limestone; and yellow limey shaley sandstone (in order of decreasing resistance to weathering). Since the facing was removed 1,000 years ago, products of weathering have formed talus slopes overflowing the blocks and banking against the base of the pyramid. An estimate of the rate of talus formation indicates that the pyramid annually loses only 0.01 percent of its total volume and could remain standing for 100,000 years.

Weathering of the Great Pyramid
Kenneth O. Emery - Journal of Sedimentary Research (1960)

The Erosion and Weathering Problem:

Bubnoff Units and erosion rates:

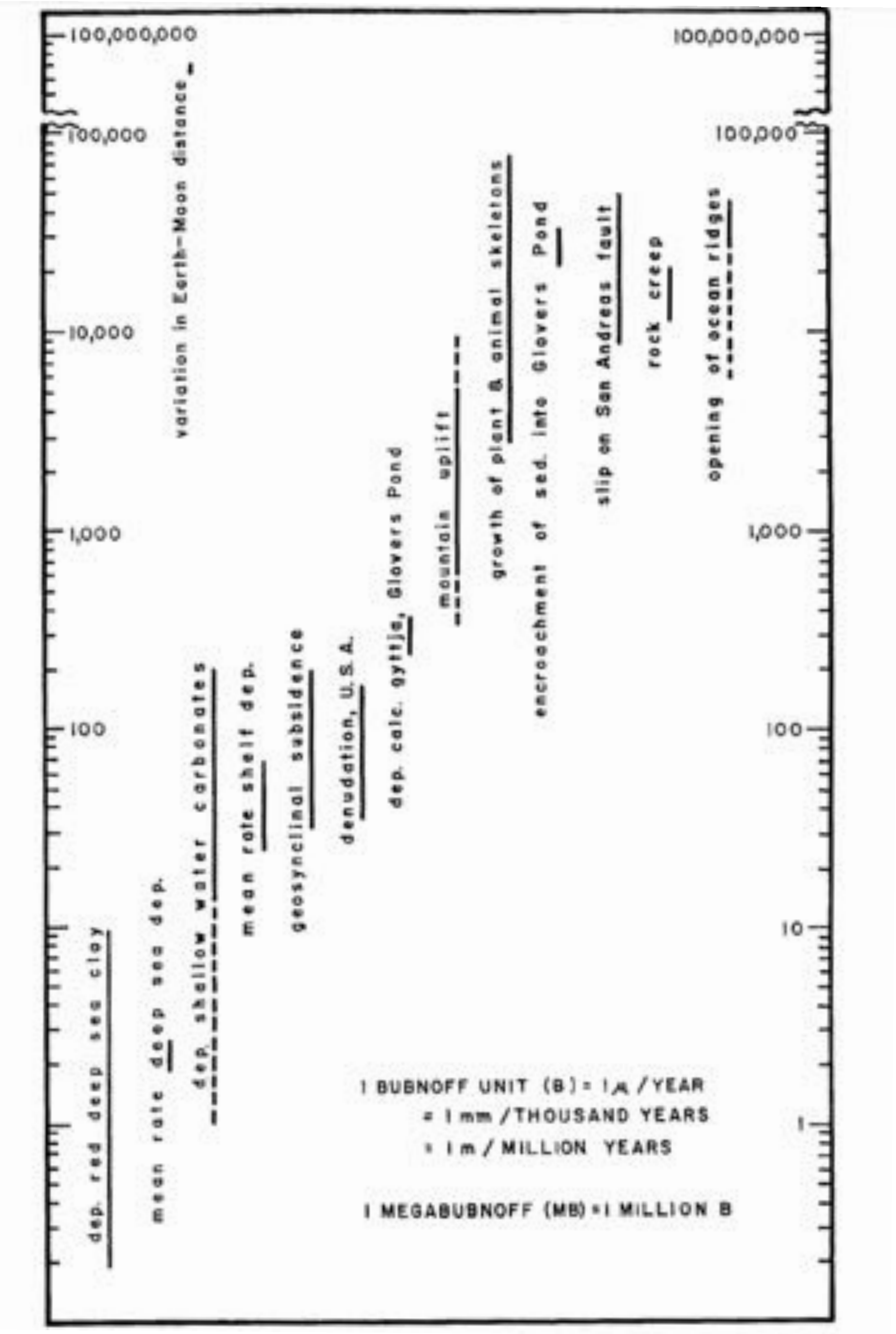
1 Bubnoff Unit (B) is equal to 1 meter in 1,000,000 years, 1 millimetre in 1,000 years, or one micrometer per year. While they can be applied to most things, the Bubnoff Unit is commonly used to measure rates of lowering of earth surfaces due to erosion. The current average rate of erosion over the Earth's landmasses has been estimated at 30 B (30 meters in a million years), however the rate can vary enormous depending on local conditions.

Tectonically stable areas tend to have lower erosion rates than tectonically active areas, sometimes as low as 4 or 5 B. Even so, in such an area at a constant rate of erosion, over 11,000 meters could be removed from the Earth's surface, While this could slow after the end of tectonic activity it still needs to be assumed that maintaining coherent surface rock is impossible over geological timescales.

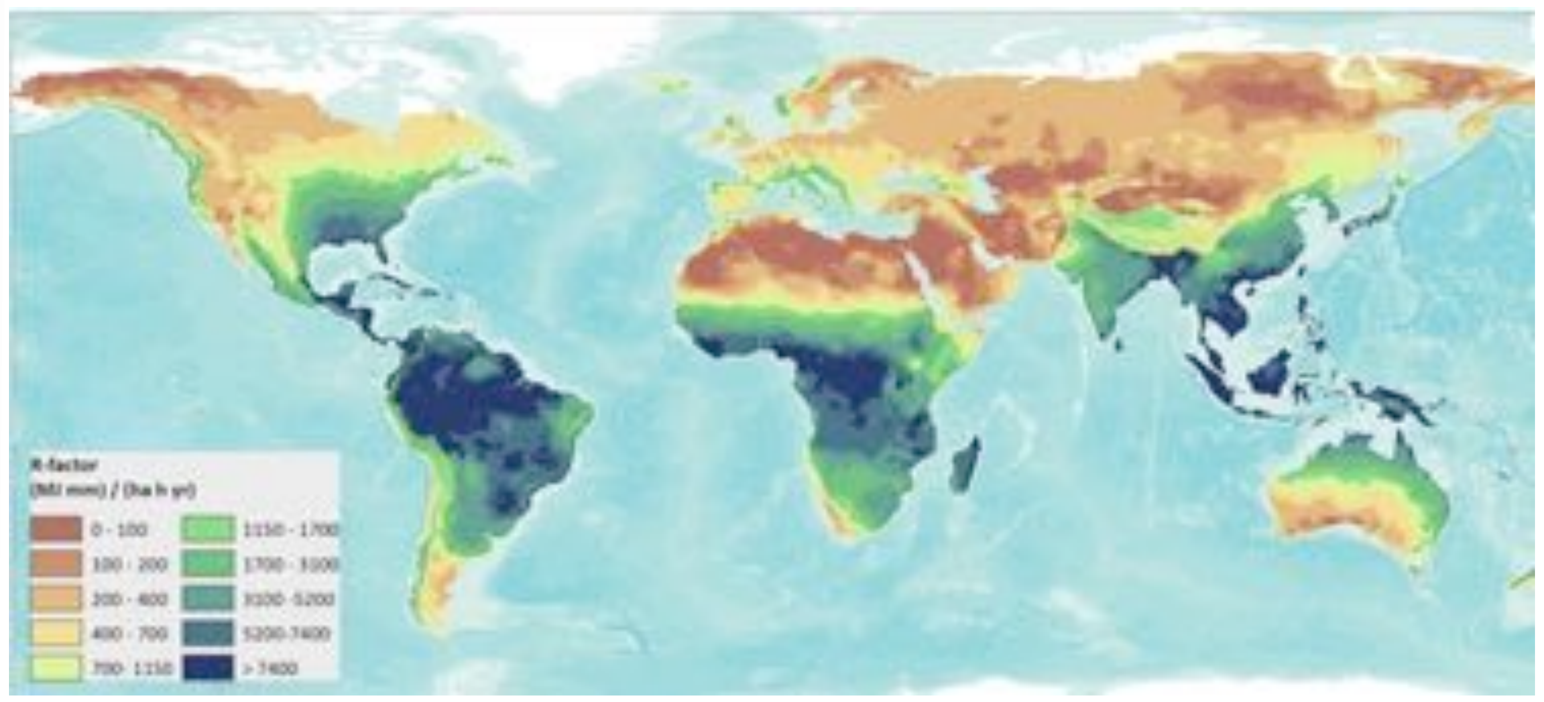
Denudation is the sum of all processes of erosion and weathering. The tendency and main ''goal'' of denudation process is to produce flat terrain. Denudation adheres to the second law of thermodynamics.

We have been able to calculate erosion rates of environment types that we know and that have familiar, measurable characteristics. Deeper into the future our calculations may not be so dependable as environmental conditions change and the Earth continues its transformations. Deeper into the future, conditions will not be the same.

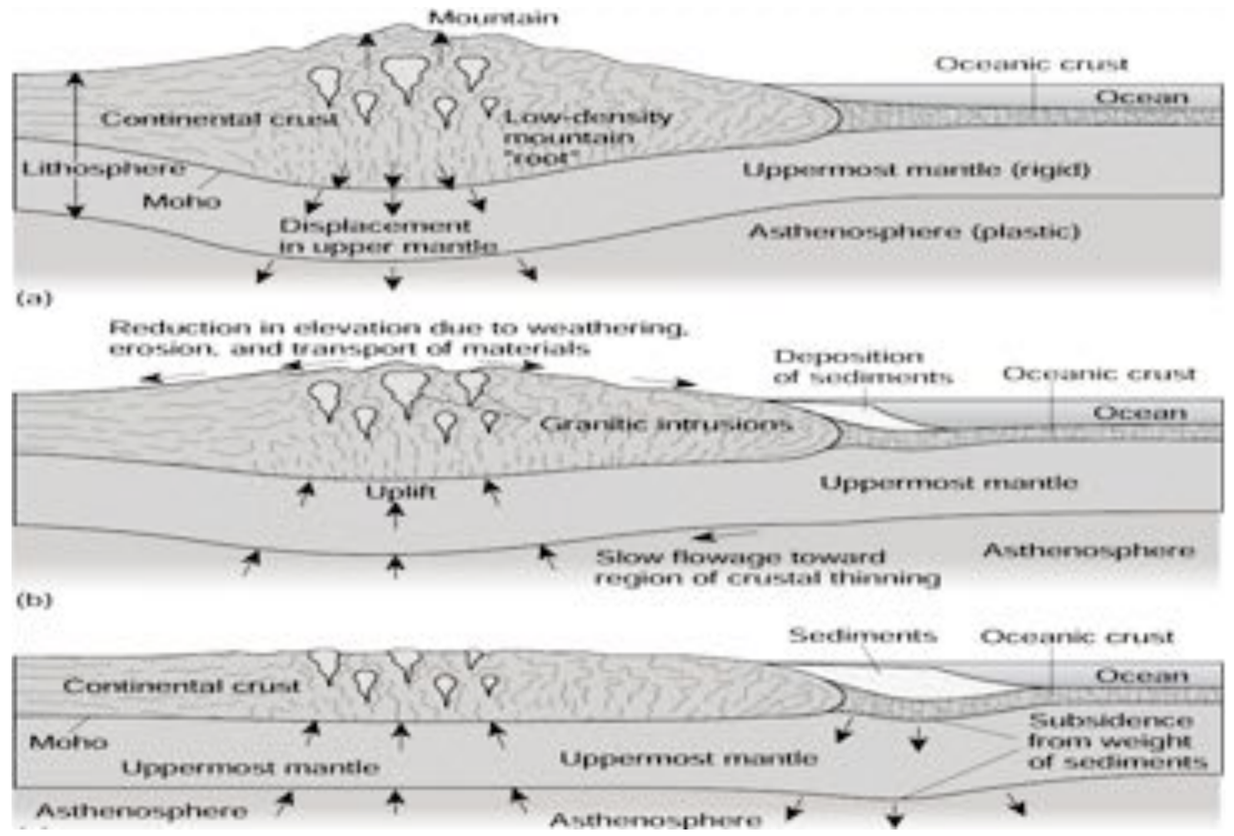
In one billion years when the plants die off the Earth will be plagued by huge sandstorms as the surface soil dries and is no longer bound by roots. At other points in time there will be threats of acid rains and biological weathering. The Monument would need to be protected against all known and speculated conditions, and the associated weathering effects they might produce.



from: Geological Rate Units by J. Mark Erickson 1969



Mean erosivity by continent, in blue areas with high erosion rates, in yellow and red areas with low erosion rates. Figure from Panagos et al. 2017, image CC 4.0 License. Panagos et al.



Forward Stepwise Regression Results

Probability to Enter: 0.250
Probability to Leave: 0.100

	Global Analysis	Igneous	Metamorphic	Sedimentary	Mixed	Arid	Cold	Polar	Temperate	Tropical	Active	Inactive
Outcrops												
n =	450	230	102	118	N/A	209	108	31	85	17	55	395
Mean (m My⁻¹) =	12	9	11	20	N/A	8	13	4	25	12	14	13
Median (m My⁻¹) =	5	4	4	11	N/A	3	7	1	16	5	8	5
Parameters: Latitude (°N/S)	.066	.146		.037	N/A	.055		.484	.089		.379	.021
Elevation (m)	.083	.007		.014	N/A	.088		.034		.336	.024	.056
Relief (m)	.012			.269	N/A	.075				.450		
MAP (mm yr⁻¹)	.138	.082		.010	N/A		.021		.099		.120	.142
MAT (°C)	.018	.100	.101	.012	N/A	.048					.053	.040
Seismicity			.134	.061	N/A			N/A	.127		.050	
R^2 =	.316	.335	.236	.402	N/A	.267	.021	.518	.314	.786	.626	.259
Basins												
n =	1149	302	307	243	297	229	287	71	482	80	221	928
Mean (m My⁻¹) =	218	148	281	188	246	100	161	537	277	111	367	182
Median (m My⁻¹) =	54	52	36	63	75	35	50	375	84	48	154	42
Parameters: Latitude (°N/S)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.046
Elevation (m)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Basin Relief (m)	.102		.133	.003	.117	.023	.467	.032	.174	.091	.061	.055
MAP (mm yr⁻¹)	.008	.075	.008	.016	.012	.185	.009	.017	.007		.056	.035
MAT (°C)	.023	.020	.007	.037	.044	.007	.008	.111	.016	.032		.015
Seismicity	.045	.039	.016	.061	.020		.007		.414	.550	.021	.314
Slope (°)	.346	.450	.484	.384	.355	.254	.180	.637	.053		.377	.127
% Vegetation	.028		.092		.030		.070		.040	.049	.019	.014
Basin Area (km²)	.001		.007				.009	.004		.020	.005	.005
R^2 =	.596	.627	.812	.590	.638	.544	.753	.801	.737	.790	.593	.613

Subdivisions of Categorical Data (Igneous through Inactive). Relevance: High ↔ Low.

from: Understanding Earth's eroding surface with ^{10}Be
Eric W. Portenga and Paul R. Bierman - University of Vermont

The Materials Problem:

There are two materials problems:

Problem #1:
How to overcome the effects of 2.8 billion years of erosion and weathering on the material of The Object. What materials are strong enough? Resistant enough? Abundant enough? Adaptable enough?

Problem #2:
What materials exist that quickly melt or deform at 147C, in order to create the trigger for the performance of The Object? Does this material exist, or does it need to be invented?

Wood decays over months
Steel and Iron rust over years
Plastics decompose and degrade over centuries
Glass deforms and erodes over millennia
Rock and Stone erode over tens and hundreds of millennia

The fundamental aspect of the materials problem refers to The Object's ability to survive through extreme deep time and the elements that threaten its longevity.

For an Object to survive into the deep future it has to be able to resist the intensely aggressive actions of the environment upon it in the forms of erosion, weathering and the degradation of its own materials. The second law of thermodynamics tells us that entropy will always increase. Therefore over its 2.8 billion year lifespan, The Object will be subject to the universal imperative to reach its lowest state of energy. The lowest state of energy of any structure is to be eroded and collapsed, not resisting in any way the forces of gravity or the imperatives of matter and energy. The lowest state of entropy of The Object would be achieved through the disintegration of its materials and qualities.

Can we identify which materials have the highest resistance to entropy?

The Climate Problem:

While we know with reasonable certainty how the Earth's climate will gradually heat up, and that despite that there will inevitably be future ice ages, the overall climate over deep time is difficult to predict.

One major influence on climate will be the rate and time at which the oceans disappear. There are currently two possible scenarios - the moist greenhouse or the more severe runaway greenhouse. As the Sun heats the Earth, the oceans will begin to evaporate and stream into space. The moist greenhouse process would begin in about 1 billion years with Solar luminosity 10% higher than current values. This eventuality depends on the oceans evaporating rapidly. If the oceans evaporate later and more slowly, in some 2 billion years time with the sun 40% more luminous, then water vapour becomes a dominant component of the atmosphere. This will drive temperatures much higher much more quickly. The effects of either of these outcomes on the global climate will be broad and complex.

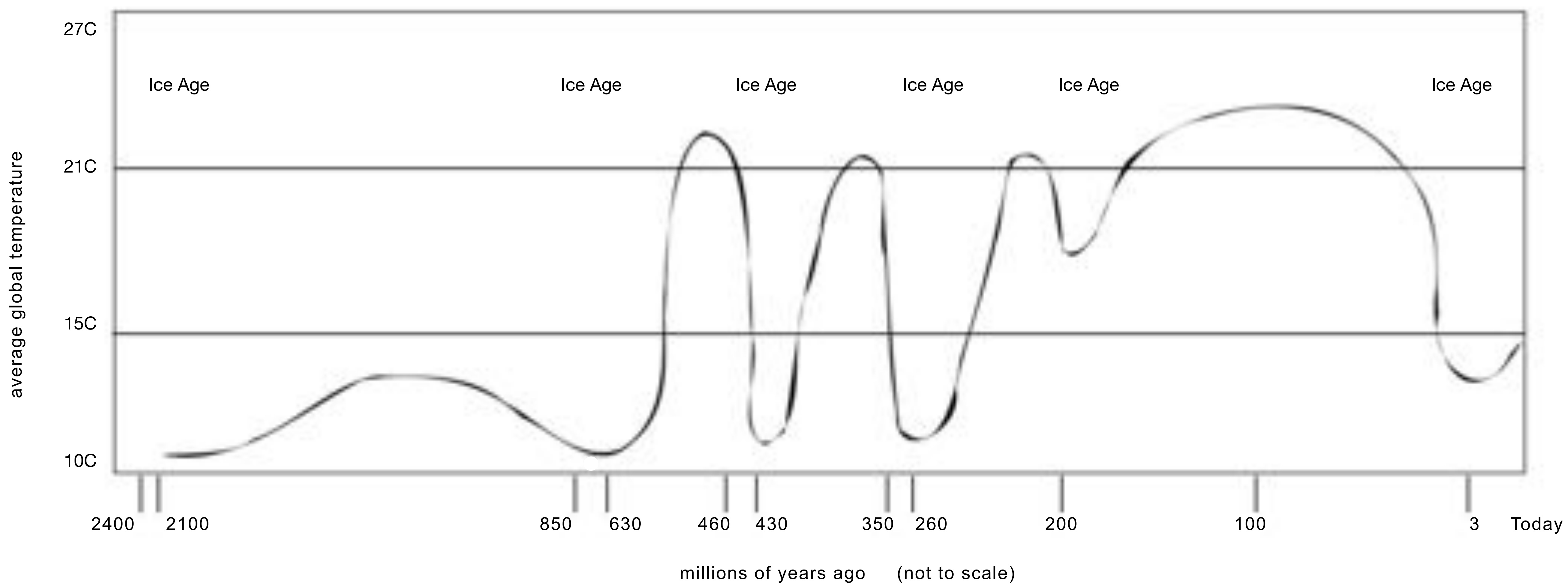
The loss of so much water into the heated air will drastically affect atmospheric composition. In the stratosphere, water molecules are broken apart - the lighter helium being lost to space and the heavier oxygen falling back towards the surface. The lower atmosphere becomes enriched with dense oxygen. This would be a climate ripe for wildfires, but there is nothing left to burn. Atmospheric nitrogen is turned to nitric acid, producing world wide acid rain. The vanishing seas will become increasingly salty and acidic, home to only the most extremophile, and beautiful, bacteria. When the oceans are gone, the Earth will be just rocky, sandy desert with salt flats and lingering pools of acidic water.

There have been 5 major ice ages in the Earth's history (the Huronian, Cryogenian, Andean-Saharan, late Palaeozoic, and the latest Quaternary Ice Age). The current interglacial period is known as the Holocene and has so far lasted almost 12,000 years. Factors that drive the Earth through colder and warmer cycles include greenhouse gas amounts, the positions of continents, fluctuations in ocean currents and variations in the Earth's orbit.

Research predicts that, under normal circumstances, the next ice age would be due about 50,000 years from now. However, anthropogenic warming will very likely push this back by tens or even hundreds of thousands of years.

As the Earth heads tens and hundreds of millions of years into the future it will inevitably go through further glacial and interglacial phases until the Sun's luminosity raises the constant mean temperature too high. At this point, when plants also die off, the general climate will shift from generally wet and tropical to hot, dry desert. Some 500 million to 700 million years into the future, the world will turn brown.

The Monument must be equipped to ride out all these fluctuations and related challenges. It must be protected against the crushing force of glaciers, against the dissolving actions of acid rains, and against the aggressive abrasions of windblown desert sands.



The Anthropological Problem:

How does a society coexist with a Monument that represents its own extinction and the extinction of all other present and future life?

How does the contemporary culture readjust to provide the resources and commitment to build such a Monument?

Under what circumstances does a predominantly capitalist and short-termist society come to build the Monument?

How does the Monument resist cultural hegemony?

Does a section of society of some kind grow around the Monument as caretakers?

Does this society turn into a sect or a cult? Does their relationship with and interpretation of the Monument remain constant or does it change over time?

What myths and stories grow around the Monument in wider society?

How does the Monument span the climate crisis and possible civilisational breakdown?

How does the contemporary language of the Monument maintain its meaning deep into the future?

Will there be other species of human that evolve over the next tens of millions of years and will they share our principles, culture and dreams?

How do the last humans send the Monument into the future?

Is the Monument still important at this time?

The Unknown Life Problem:

Life to come...

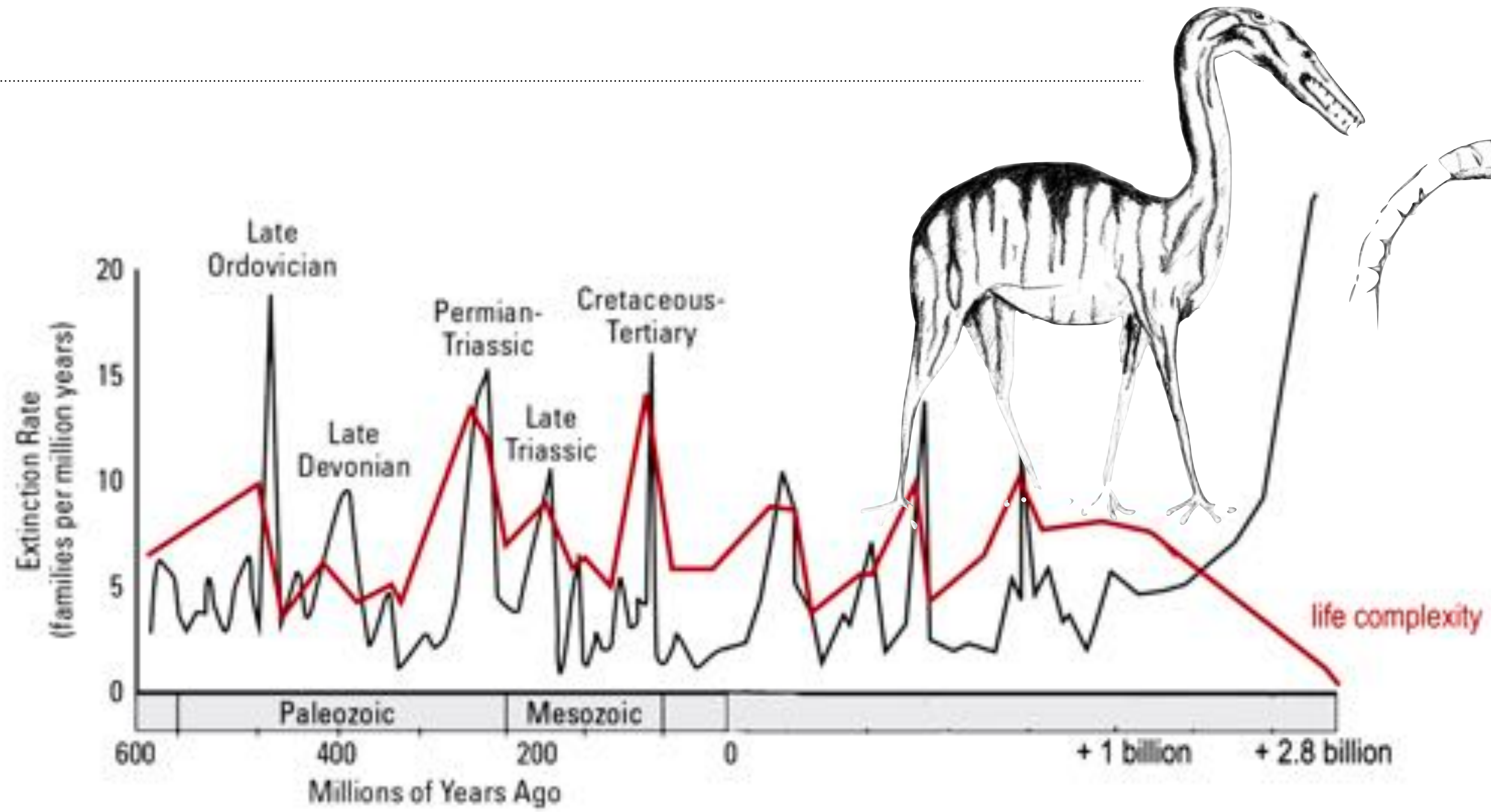
Complex life has about 800,000,000 to 1 billion years left, and over this time will go through several evolution and extinction cycles. Environmental and selective pressures will change and the last forms of life on Earth will very probably be unrecognisable from those we know today. Over the last 400,000,000 years (less than half of the time life has left) life moved out of the sea and onto the land, dinosaurs evolved and became extinct, and an intelligent biped mammal came to dominate everything. Such massive change and diversity can be expected in the future.

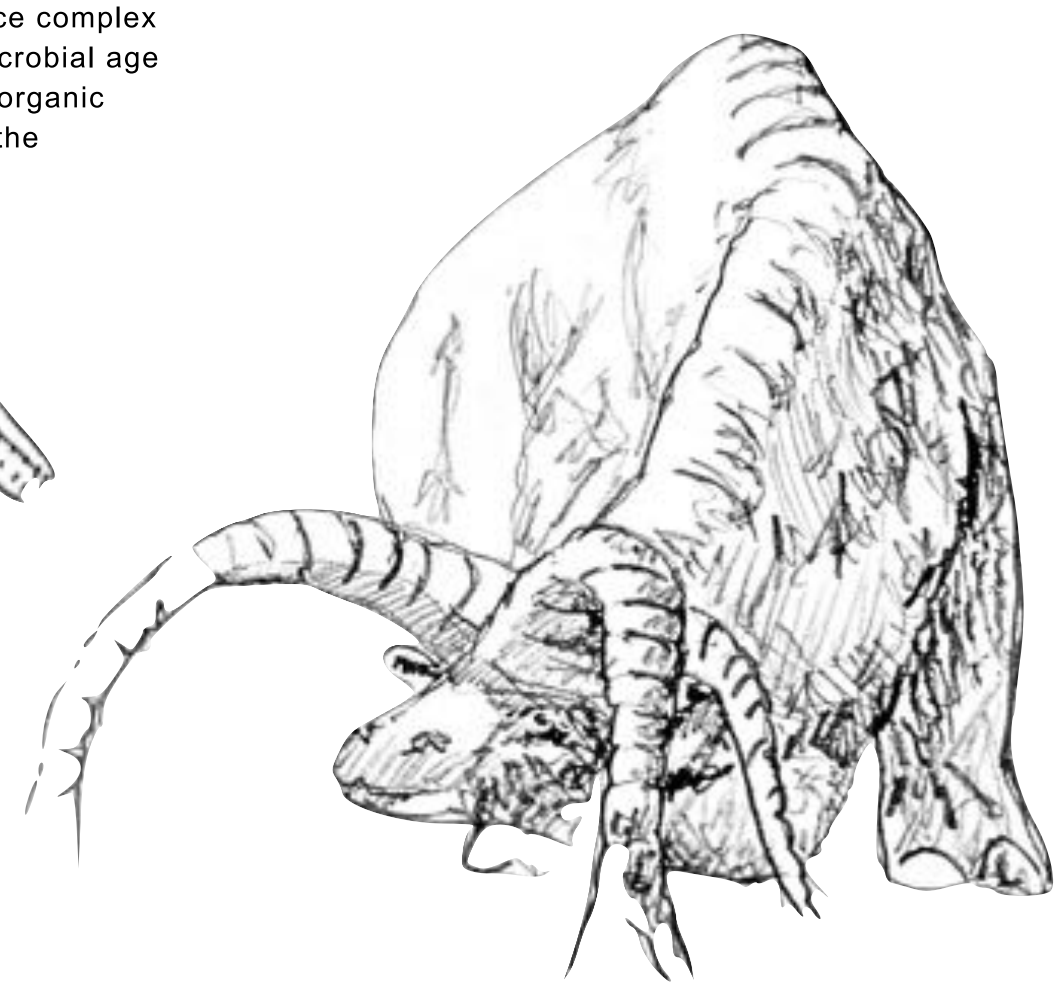
We can not know if another life form will become dominantly intelligent. We can not know what life forms will be lost when all life has ended.

Speculative evolution (or speculative biology, or speculative zoology) is focused on hypothetical scenarios in the evolution of life. Its basis on terrestrial evolutionary mechanisms sets it apart from the imaginings of aliens from science fiction. A key figure within this movement has been Dougal Dixon, who is maybe best known for his classic book 'After Man'. His work inspired later tv series such as The Future is Wild. However earlier examples are provided by late 19th century writers such as HG Wells. In his classic work The Time Machine, the time traveller encounters Elois (a future human) and Morlocks (a future primate). Further into the future, the protagonist finds large crab-monsters and huge butterflies.

Peter Ward's 2001 book Future Evolution attempts a more scientifically accurate approach to the prediction of patterns of evolution in the future. He tries to understand the mechanism of mass extinctions and the principles of recovery of ecosystems, a key point being that "champion supertaxa" who diversify and speciate at a greater rate, will inherit the world after mass extinctions

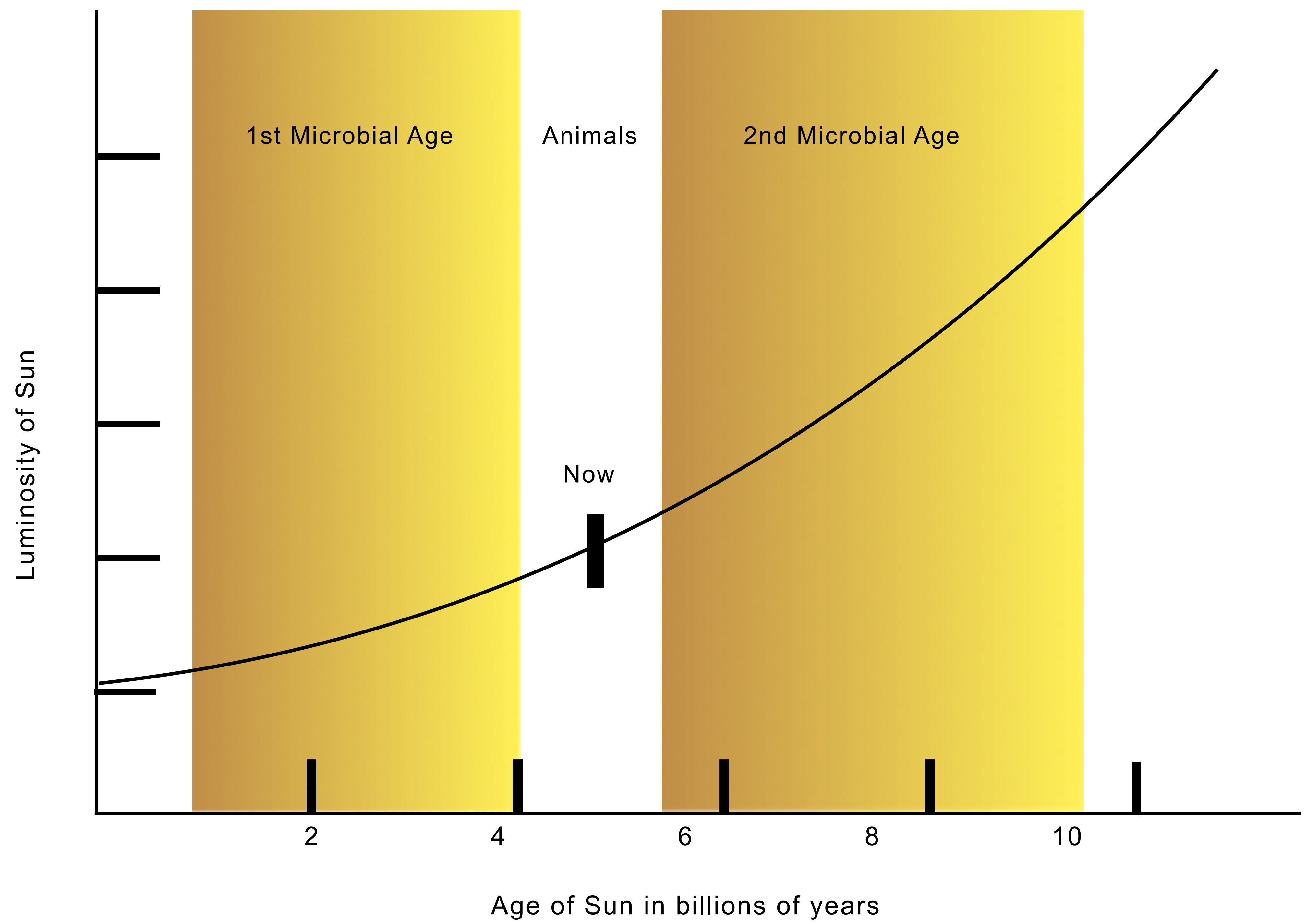
What we do know is that just as life started very simple and gained complexity over time, the reverse will happen as life moves towards its end. Once complex creatures die out in one billion years time, life will become increasingly simple and basic as it moves slowly towards total extinction. The second microbial age will be the last phase of life. Probably the last organism will be a subterranean autotroph (an organism that synthesises organic compounds from inorganic sources). It will make its stand beneath the surface of a mountain in the polar regions, where temperatures would stay the coolest. However, when the average temperate of the earth reaches 147C, this last survivor, clinging on to existence, will also perish and the Earth will become post-biological.





tures imagined by Dougal Dixon in After Man and in The Future is Wild tv series

The Unknown Life Problem:



adapted from The Life and Death of Planet Earth, Ward + Brownlee

The Unknown Life Problem:

Future Humans...

Just as there have been artists and scientists attempting to imagine the future evolution as life, there have been others imagining the future evolution of humans. While it is impossible to know the human timeline, it is inevitable that certain evolutionary changes will happen regardless.

Dougal Dixon, the author of the classic and pioneering book on speculative evolution After Man, also wrote and illustrated Man After Man. This book is a similar treatment of the evolution of various forms of human as the future unfolds and evolutionary pressures have their effect. He points out clearly that with advances in genetic engineering, natural selective pressures will not be the only processes to affect future humans.

The classic science fiction writing on the subject is that of Olaf Stapledon in his 1930 novel Last and First Men (also a film directed and scored by Icelandic composer Jóhann Jóhannsson in 2020). In Stapledon's book humanity is almost rendered extinct on several occasions but recovers to see flying species, giant brained species, aquatic species and post terrestrial species. The 18th and final species are the most advanced of all, dedicated to art and philosophy and sexual liberty, and with a range of sub-genders. Humans finally become extinct on Neptune 2 billion years into the future.

Assuming there will be numerous iterations of human and post human, how will they relate to this ancient Monument? Would they care for it? Demolish it? Replace it? Could a deep future society develop an immortal post-human species that could care for the Monument until all life ends?

"Thus the whole duration of humanity, with its many sequent species and its incessant downpour of generations, is but a flash in the lifetime of the cosmos" —
Olaf Stapledon, Last and First Men (1930), Chapter XIV: Neptune; Section 1, "Bird's-Eye View" (p. 206)

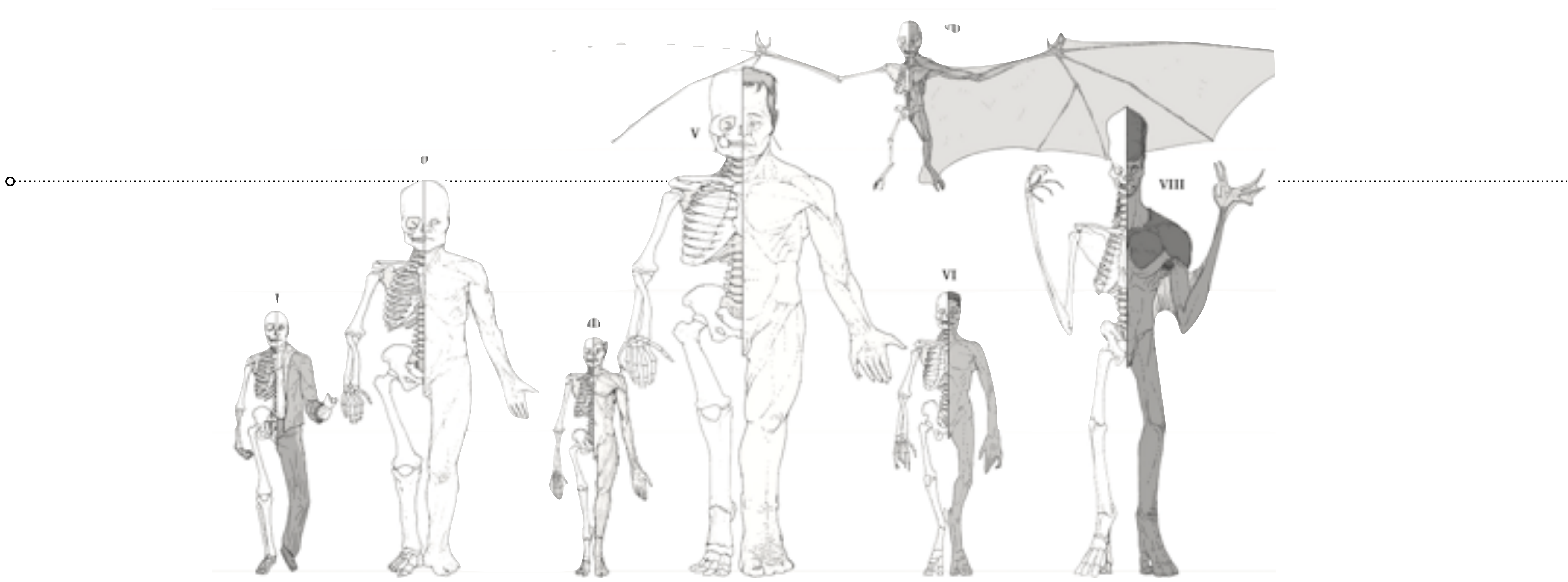


image by Alexander Mikhailov - @vanga_vangog

PROPOSITIONS

The Geological Proposition:

1: Cratons

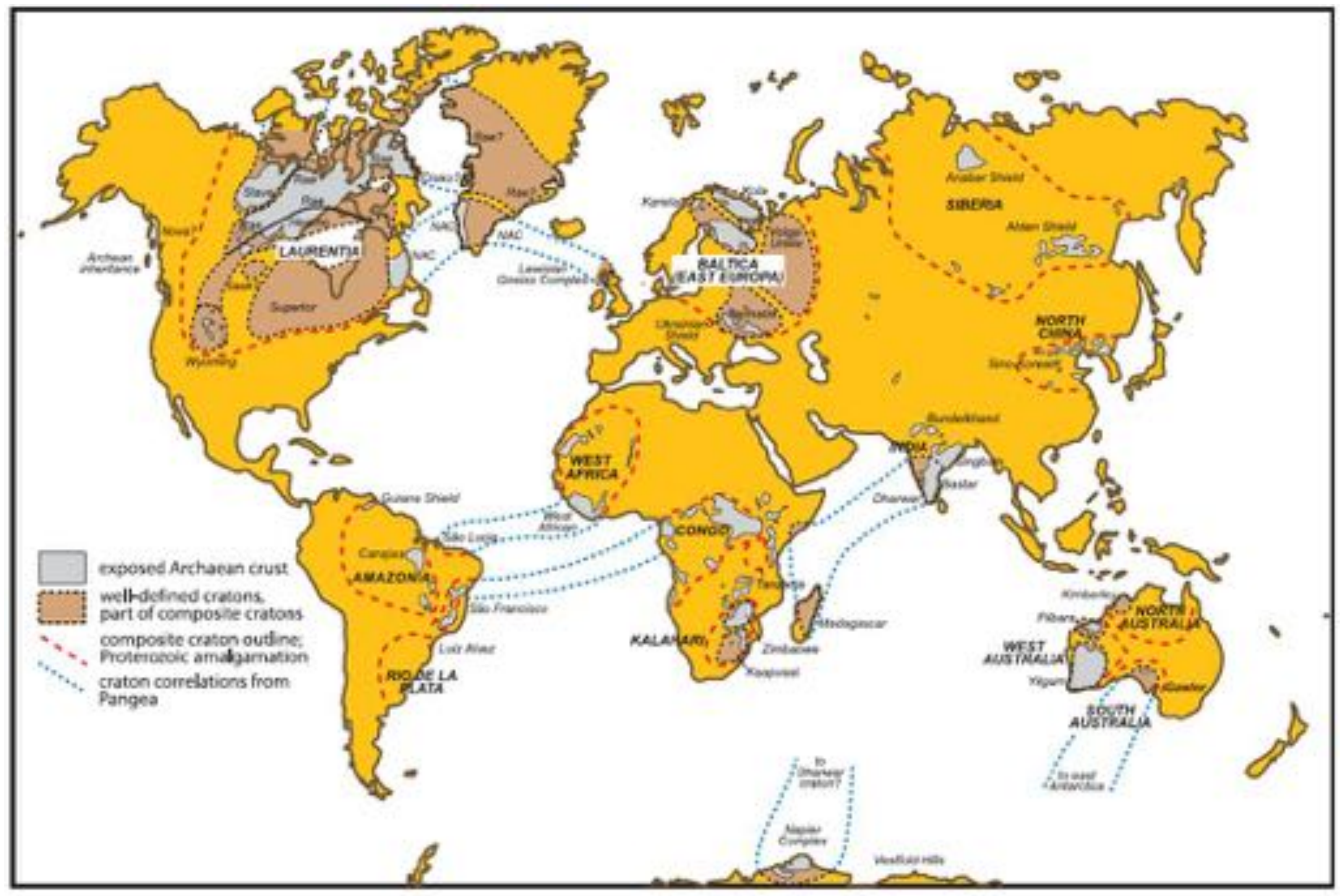


Fig. 1. Global distribution of the cratons (regions of crust >2.5 Ga old) modified after Bleeker (2003). Regional outcrops of Archaean crustal rocks are indicated in grey (those beneath Greenland are extrapolated under the ice cap) and other definable fragments of composite cratons in brown (from Bleeker 2003). The approximate outline of units that are relatively well defined as whole, composite cratons is shown by black dotted lines. Red dashed lines show the estimated extent of cratonic regions amalgamated from Archaean blocks during the Proterozoic. Blue dotted lines extended across oceanic areas show links between cratonic fragments that are thought to have once formed single cratonic blocks. NAC, North Atlantic Craton.

Craton map from Pearson and Wittig under Geological Society of London fair use policy.

The Dharwar or Karnataka Craton in South India is a piece of the earth's crust that dates back to the late Archean.formed between 3.6 and 2.5 billion years ago.

The North China Craton is located in northeast China, Inner Mongolia, the Yellow Sea, and North Korea.

The Sarmatian Craton or Sarmatia is the southern segment/region of the East European Craton or Baltica, also known as Scythian Plateau. The craton contains Archaean rocks 2.8 to 3.7 billion years old

The Kaapvaal Craton in South Africa, along with the Pilbara Craton of Western Australia, are the only remaining areas of pristine 3.6–2.5 Ga (billion years ago) crust on Earth.

The Pilbara Craton is an old and stable part of the continental lithosphere located in Pilbara, Western Australia. continent of Ur.

The Gawler Craton covers approximately 440,000 square kilometres of central South Australia.

Laurentia or the North American Craton is a large continental craton that forms the ancient geological core of North America. The metamorphic and igneous rocks of Laurentia were formed 1.5 to 1.0 billion years ago in a tectonically active setting.

Cratons are pieces of continents that have been stable for over a billion years. As earth's plates drift along, mountains periodically rise and fall, plate boundaries appear and disappear. But cratons are like great-grandmothers at family gatherings, while younger crust moves excitedly around them, they sit quietly, occasionally remarking on how different things were when they were young.

Simon Wellings - @metageologist

Cratons (from Greek: κράτος kratos "strength") are old and stable part of the continental lithosphere - the Earth's two topmost layers, the crust and the uppermost mantle. Having often survived cycles of merging and rifting of continents, cratons are generally found in the interiors of tectonic plates; except where geologically recent rifting events have separated them. They are characteristically composed of ancient crystalline basement rock, which may be covered by younger sedimentary rock. They have a thick crust and deep lithospheric roots that extend as much as several hundred kilometres into Earth's mantle.

Basic properties of the cratonic crust include being thick (around 200 km), relatively cold when compared to other regions, and low density.

The term craton is used to distinguish the stable portion of the continental crust from regions that are more geologically active and unstable. Cratons can be described in two ways - as shields, in which the basement rock crops out at the surface, and as platforms, in which the basement is overlaid by sediments and sedimentary rock.

The oldest cratons formed in Archean times, characterised by the presence of diamonds 2 to 3 billion years old. The cratons were formed by the end of the Proterozoic, 538 million years ago and contain rock much, much older.

The fact that many cratons have been present for billions of years already can lead us to assume that they will be present for billions of years to come. It makes sense that the areas most distant from rifting and subducting zones are the least vulnerable to their effects. This would suggest that the central area of a craton would be a prime location for the Monument. However, the effects of surface denudation are still a threat.

A suggested location could be the Pilbara Craton - an old and stable part of the continental lithosphere located in Pilbara, Western Australia. The Pilbara Craton is one of only two pristine Archaean 3.6–2.7 Ga (billion years ago) crusts identified on the Earth, along with the Kaapvaal Craton in South Africa. Both locations may have once been part of the Vaalbara Supercontinent or the continent of Ur.

A location in Australia has the additional benefit of minimising the effects and impacts of future ice ages.

The Erosion and Weathering Proposition:

2: Pits and mountains

To combat surface erosion (denudation) - the Monument will be built at the bottom of a purpose built stepped quarry at least 150m deep

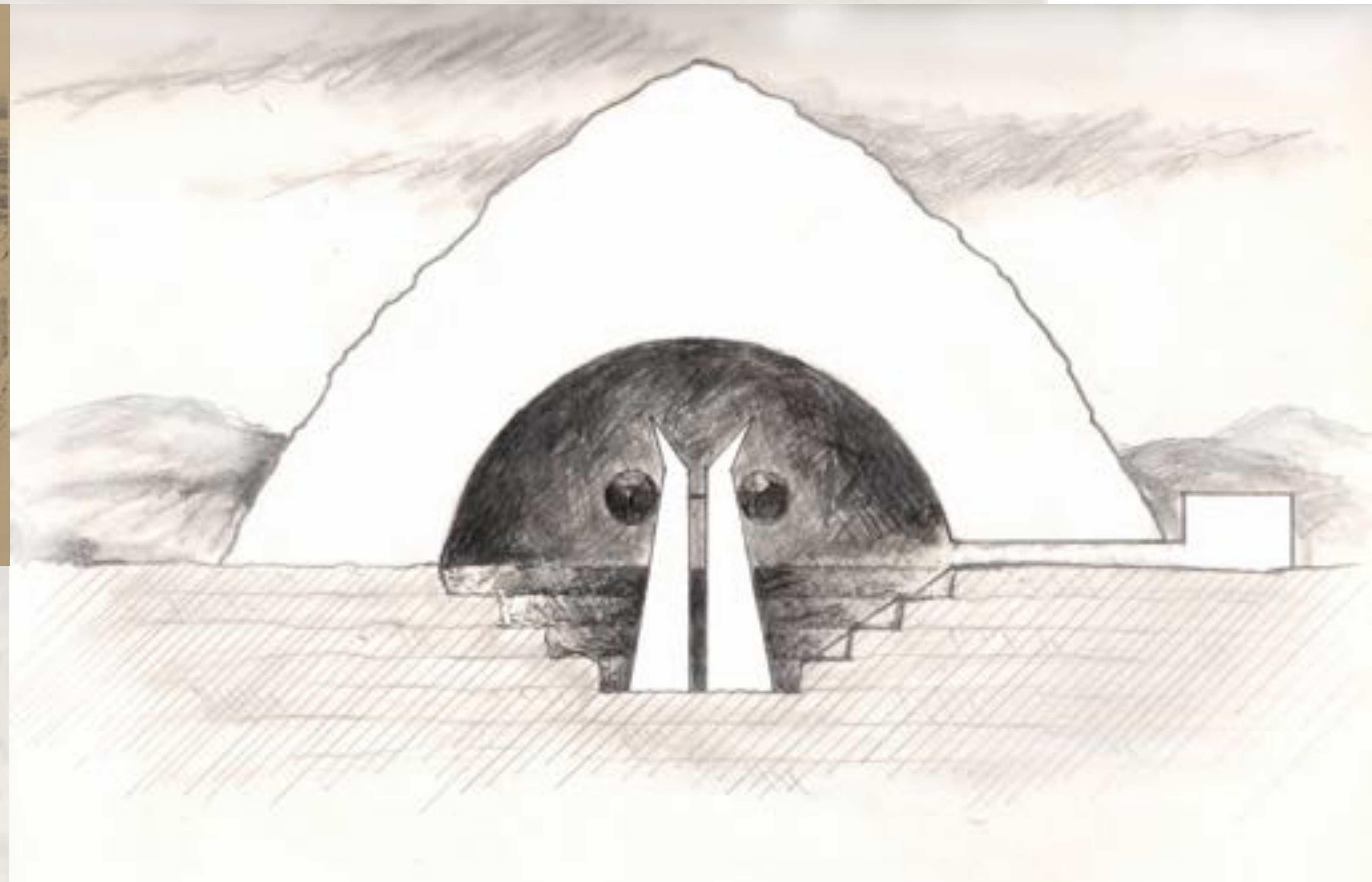
To combat environmental weathering and material erosion - a 300m meter artificial mountain will be built over the top of the Monument. Between the interior of the mountain and the Monument is a 50 meter tall dome made from black diamond (carbonado). The mountain forms an ablative[1] shell, eroding away over hundreds of millions of years. Eventually the dome is revealed, the diamond withstanding hundreds of millions of years more before finally revealing the Monument to the elements.

[1] Ablation - the removal or destruction of something from an Object by vaporisation, chipping, erosive processes or by other means.

The mountain should be built of igneous rock, which erodes and weathers very slowly. Igneous rocks such as granite, dolerite and basalt, are composed of interlocking crystals which form a hard and resistant material. They generally have fewer joints and weaknesses than other rock types.

It is also interesting to consider how the rock could be further reinforced with layers or scaffolding of diamond, silicon carbide or technologically advanced ceramics.

It is difficult to arrive at an average or generalised rate for uplift (the process by which the Earth's surface is raised) or denudation ((the process by which the Earth's surface is effectively lowered). A very rough estimate for the most 'protected' location sought for the Monument could be stated as an uplift of 5 meters per 1000 years with a denudation of 1 meter per 25,000 years. While uplift will carry the Monument site with it, the effective denudation over 2.8 billion years would be in excess of 100 kilometers. (extrapolated from The Disparity Between Present Rates of Denudation and Orogeny - S. A. Schumm)



could the mountain have layers, with each layer designed to optimise defence against specific future climate and weathering conditions?

could messages be hidden within layers, like time capsules being released at specific moments in the future?

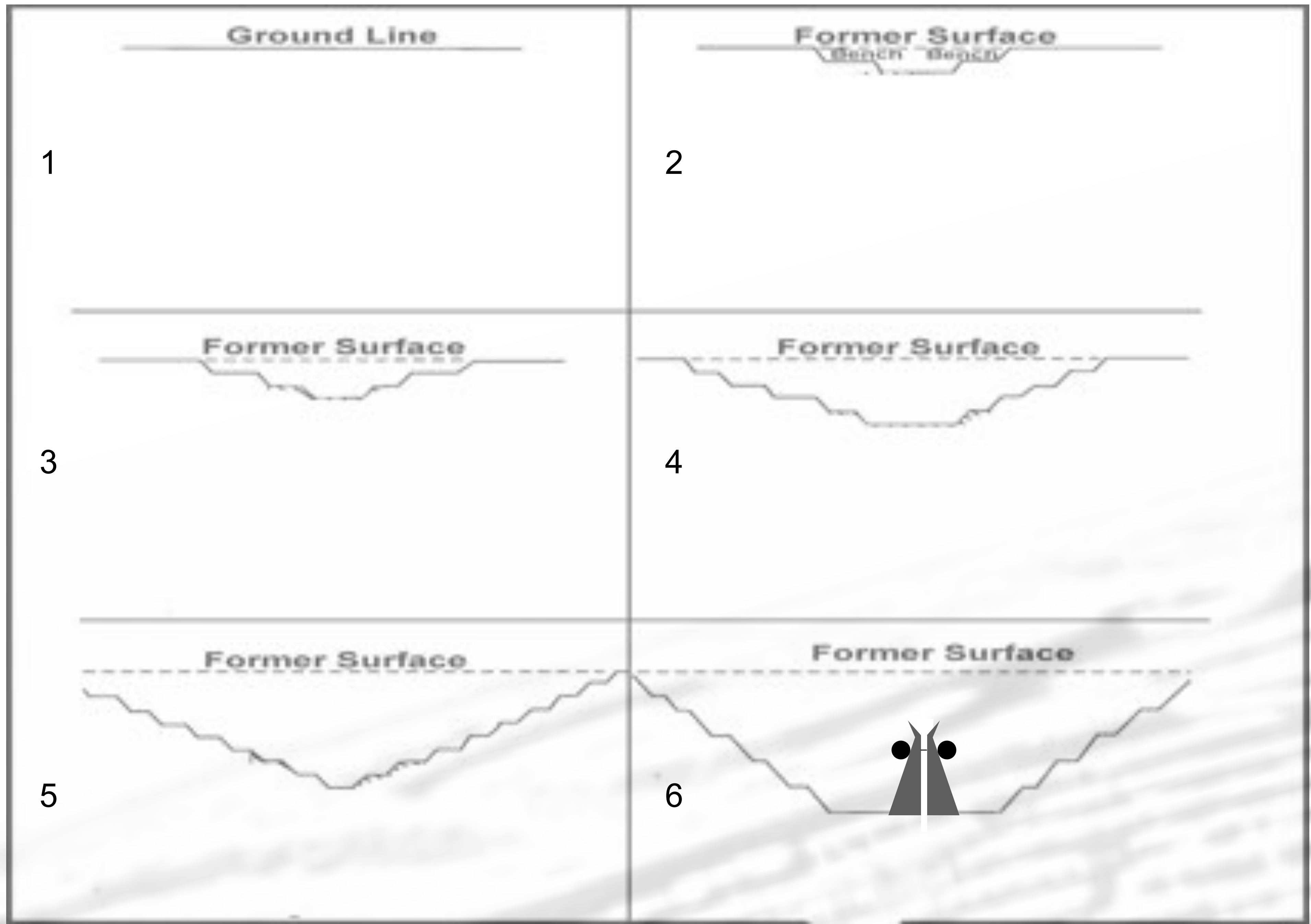
The Erosion and Weathering Proposition:

A Partial List of Artificial Mountains:

Loos en Gohelle spoil tip, France	-	180 meters
Monte Kali spoil tip, Heringen, Germany	-	200 meters
El Runam de la Democràcia (The Slag Heap of Democracy), Salient, Spain	-	400 meters
The Berg, Germany (abandoned)	-	proposal for 1000 meters
Mount Trashmore, Virginia, US	-	165 acre site with hills 20 meters high
Silbury Hill, England. 2400 BCE	-	39 meters
Pilsudski's Mound, Krakow, Poland	-	35 meters
Five Sisters shale bings, West Calder, Scotland	-	90 meters
End of All Life Monument protective mountain , possibly Australia	-	300 meters

background image adapted from Mountain by David OReilly

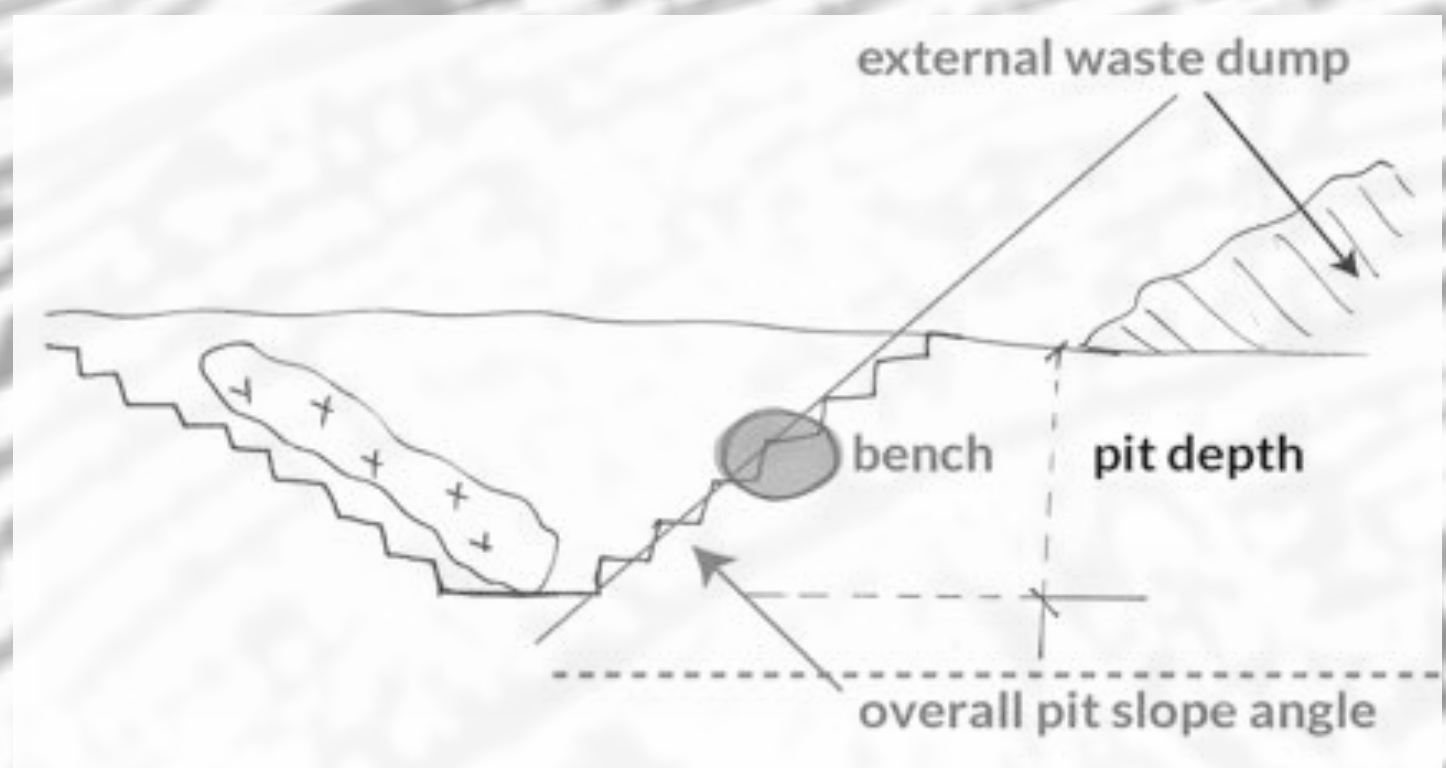
The Erosion and Weathering Proposition:

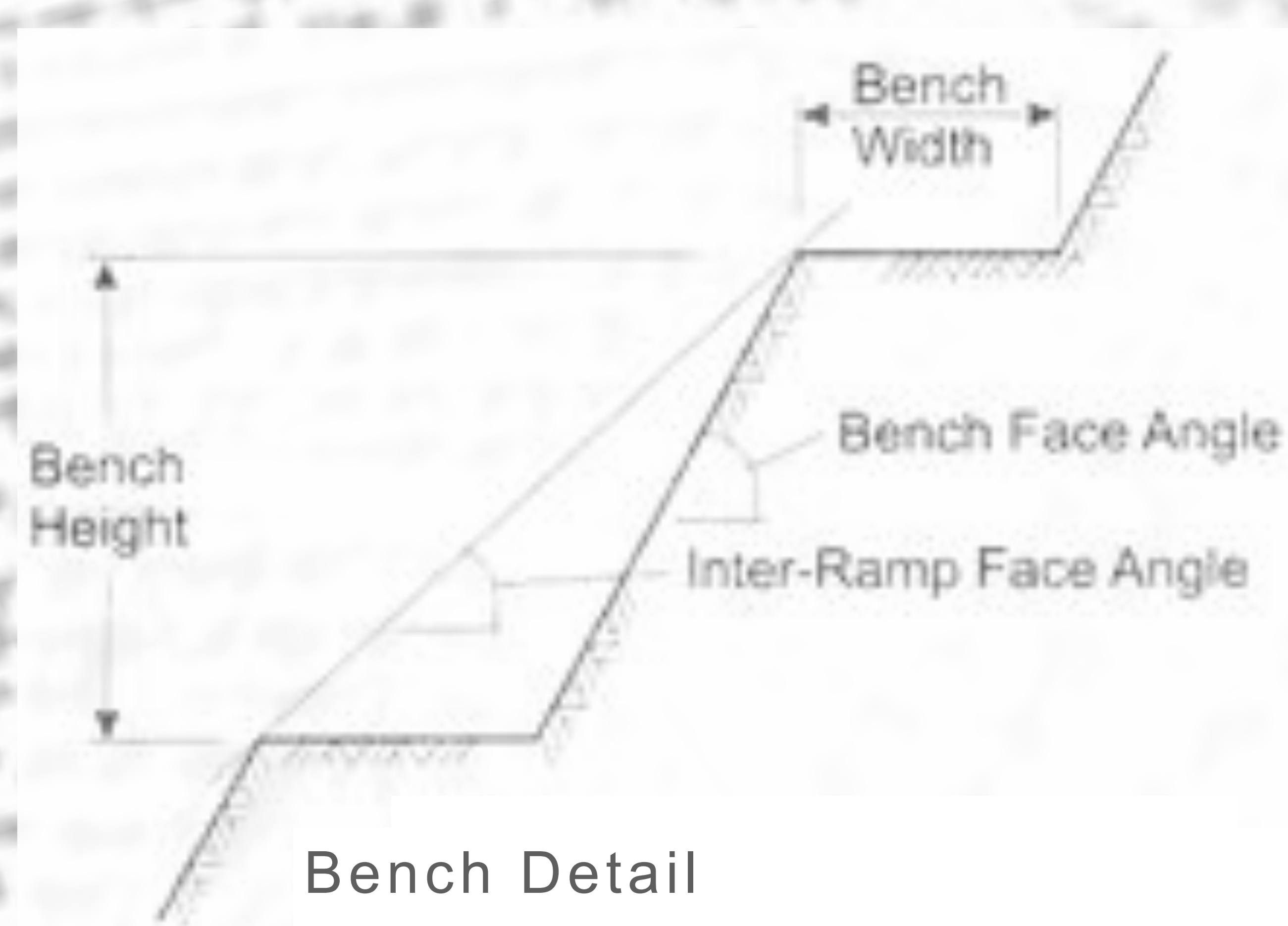


Application of Open Pit Mining techniques to the creation of a 100 meter deep pit for The Object.

As open pit mining is a common method of extraction of diamonds, it could be possible to use the same pit for both extraction of construction materials, and protective pit for The Object.

As hundreds of millions of years pass, the effects of denudation on the surface around The Object will effectively be a reversal of the process of making the pit. The Monument platform and the surface level will become the same.

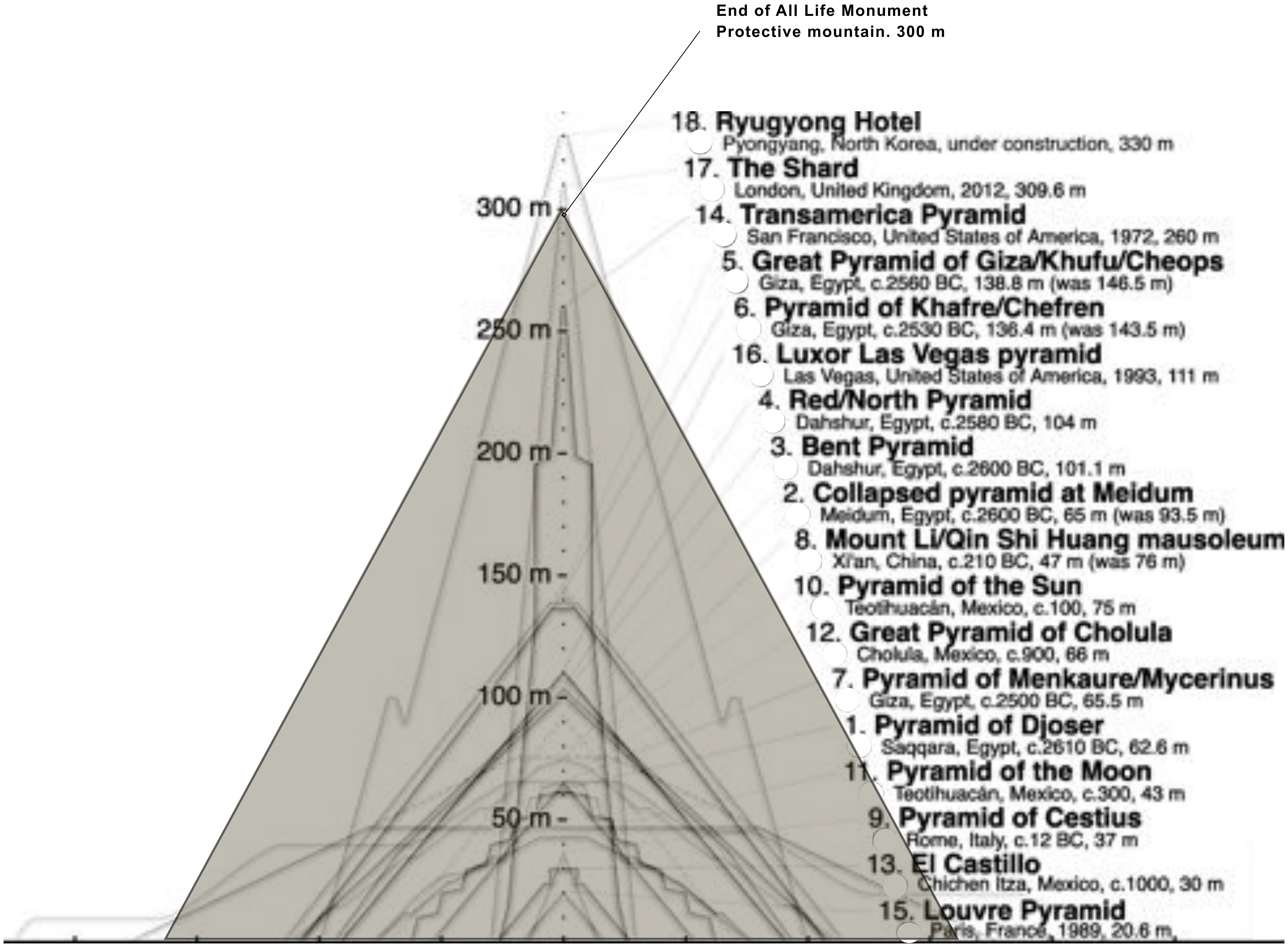




The Complex:

The complex is the context within which The Object and its site are positioned and integrated within contemporary culture. While The Object is hidden within the mountain, it is accessible via an entrance.. a portal… some stairs. A visitor can enter the vast black diamond dome and be with The Object. To contemplate its scale, its destiny, its challenges… to make the futile attempt to grasp the time it must span.

To fit comfortably within contemporary culture, the site must become a spectacle. It must be launched and feted and celebrated. It must have an identity, a visitor centre….. merchandising… a souvenir shop



End of All Life Monument
Protective mountain. 300 m
300 m
250 m
200 m
150 m
100 m
50 m
18. Ryugyong Hotel
Pyongyang, North Korea, under construction, 330 m
17. The Shard
London, United Kingdom, 2012, 309.6 m
14. Transamerica Pyramid
San Francisco, United States of America, 1972, 260 m
5. Great Pyramid of Giza/Khufu/Cheops
Giza, Egypt, c.2560 BC, 138.8 m (was 146.5 m)
6. Pyramid of Khafre/Chefren
Giza, Egypt, c.2530 BC, 136.4 m (was 143.5 m)
16. Luxor Las Vegas pyramid
Las Vegas, United States of America, 1993, 111 m
4. Red/North Pyramid
Dahshur, Egypt, c.2580 BC, 104 m
3. Bent Pyramid
Dahshur, Egypt, c.2600 BC, 101.1 m
2. Collapsed pyramid at Meidum
Meidum, Egypt, c.2600 BC, 65 m (was 93.5 m)
8. Mount Li/Qin Shi Huang mausoleum
Xi'an, China, c.210 BC, 47 m (was 76 m)
10. Pyramid of the Sun
Teotihuacán, Mexico, c.100, 75 m
12. Great Pyramid of Cholula
Cholula, Mexico, c.900, 66 m
7. Pyramid of Menkaure/Mycerinus
Giza, Egypt, c.2500 BC, 65.5 m
1. Pyramid of Djoser
Saqqara, Egypt, c.2610 BC, 62.6 m
11. Pyramid of the Moon
Teotihuacán, Mexico, c.300, 43 m
9. Pyramid of Cestius
Rome, Italy, c.12 BC, 37 m
13. El Castillo
Chichen Itza, Mexico, c.1000, 30 m
15. Louvre Pyramid
Paris, France, 1989, 20.6 m,

wikipedia

The Materials Proposition:

Main Structure

At the current stages of development of resistant materials, Boron carbide (B4C) is one of the hardest materials known, ranking third behind diamond and cubic boron nitride. It is the hardest material produced in tonnage quantities. Boron Carbide and Silicon Carbide (SiC) are known for their high hardness, chemical resistance and abrasion resistance. After these materials come Alumina based ceramics such as Zirconia Toughened Alumina. These materials are produced commercially as (for example) oxide bonded SiC, nitride bonded SiC, alumina bonded SiC and reaction bonded SiC. The wear resistance increases in that order, with reaction bonded SiC being the strongest.

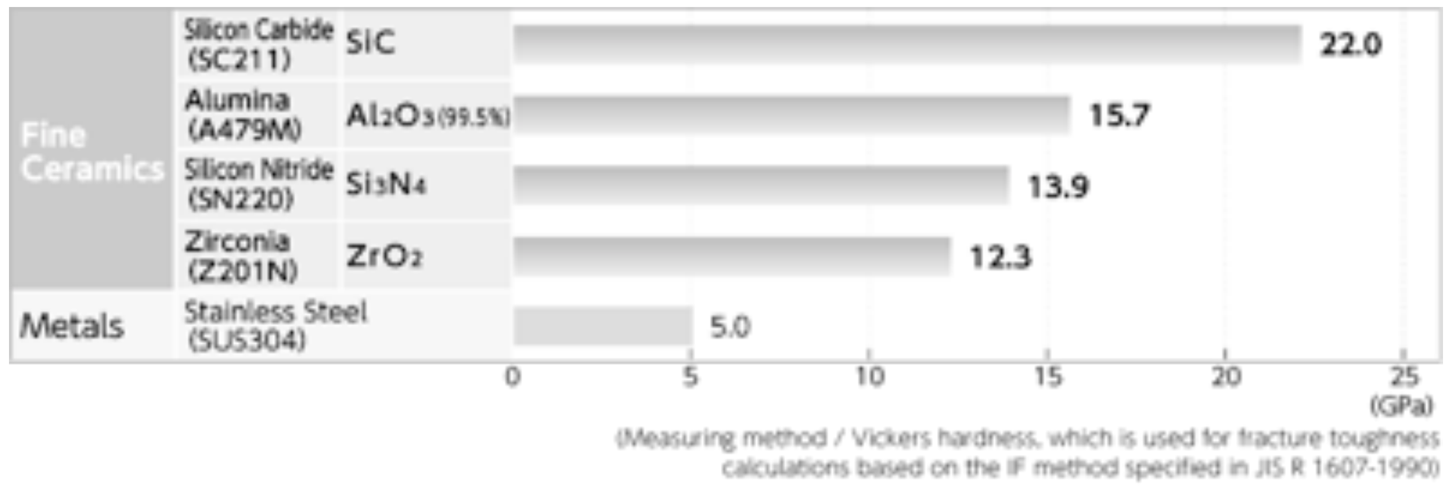
Ceramic materials have been used to meet many engineering requirements because of their chemical stability and high hardness, lower density compared to metals, high mechanical resistance and resistance to high temperatures. Compared to other materials, ceramics are also less prone to damage caused by corrosive environments.

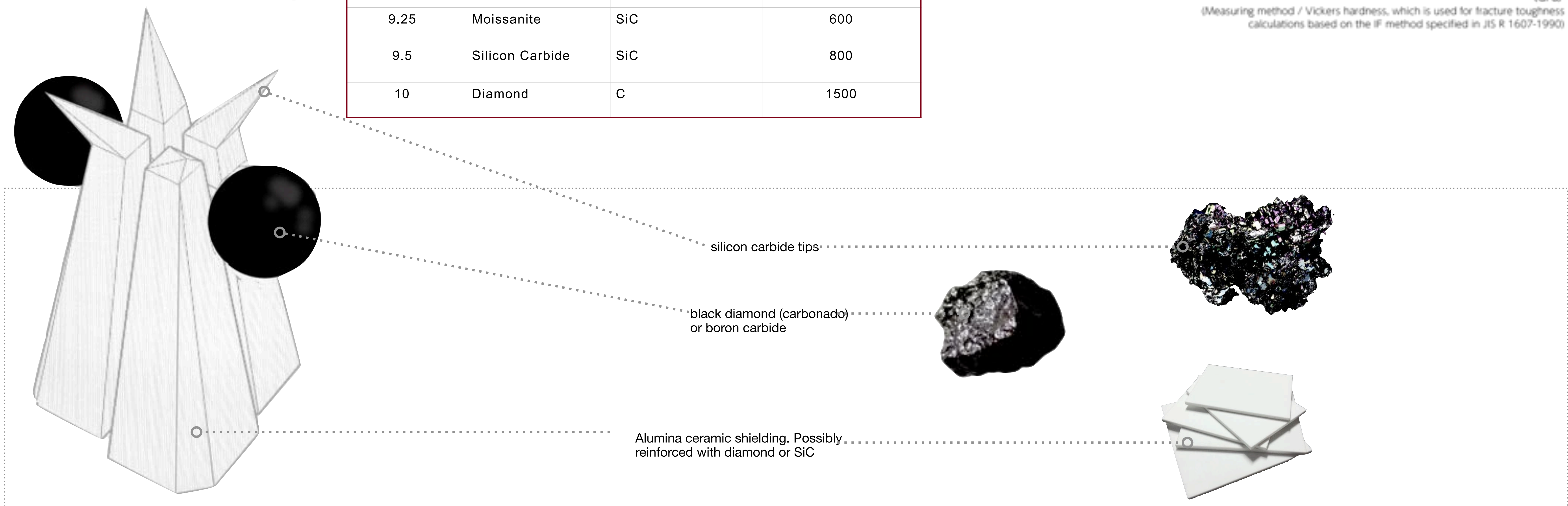
The strongest naturally occurring material is diamond. On the assumption that there is no limit on finance, industry or resources for the Monument, enough industrial diamond could be produced to fabricate a protective outer layer for the whole Monument, or to combine with Silicon or Boron Carbide based materials and ceramics.

For measuring mineral hardness the Mohs Scale is used. Introduced in 1812 by the German geologist and mineralogist Friedrich Mohs, the scale is based on which minerals can scratch or be scratched by others. The higher the number in the scale, the harder the mineral. While absolute hardness is a more proportionate scale, the non proportionate Mohs scale is often preferred.

For ceramic hardness Vickers hardness testing is the most used. Other static indentation hardness tests such as Brinell, Rockwell, Knoop and Berkovich are also used. Hardness is usually measured on conventional microhardness machines with diamond indenters. These machines make impressions whose diagonal size is measured with an attached optical microscope

Mohs Hardness	Mineral	Chemical Formula	Absolute Hardness
1	Talc	$Mg_3Si_4O_{10}(OH)_2$	1
4	Flourite	CaF_2	2
7	Quartz	SiO_2	100
9	Corundum	Al_2O_3	400
9.25	Moissanite	SiC	600
9.5	Silicon Carbide	SiC	800
10	Diamond	C	1500





The Materials Proposition:

The 'Action Material'

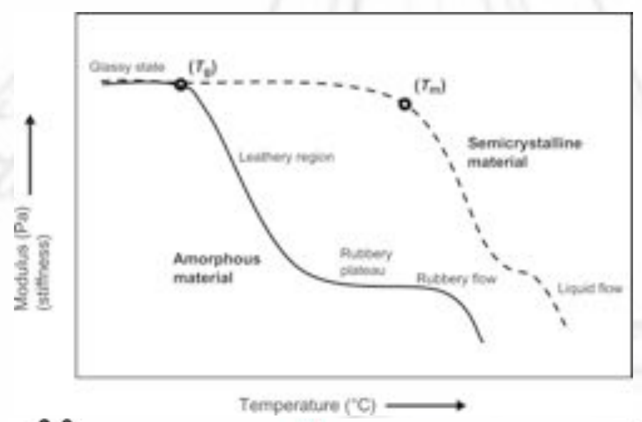
The action material is the material which, at 147C, will bend, melt or degrade sufficiently in order to trigger the action of the Monument. The action material is employed in the fabrication of the action mechanism. Materials that fulfil the necessary criteria are found within the group known as polymers. Some of these polymers have their melting or 'softening' point within the range needed by the Object. This relationship between temperature and viscoelasticity is known as glass transition temperature. A glass transition temperature (*Tg*) is the temperature at which a polymer turns from a ductile material to a hard, brittle material - the temperature at which carbon chains start to move. The material experiences a transition from a rigid state to a flexible state with the temperature at the border of the solid state changing it to more of a viscoelastic (rubbery) one. At this temperature the free volume, or the gap between the molecular chains, increases by 2.5 times.

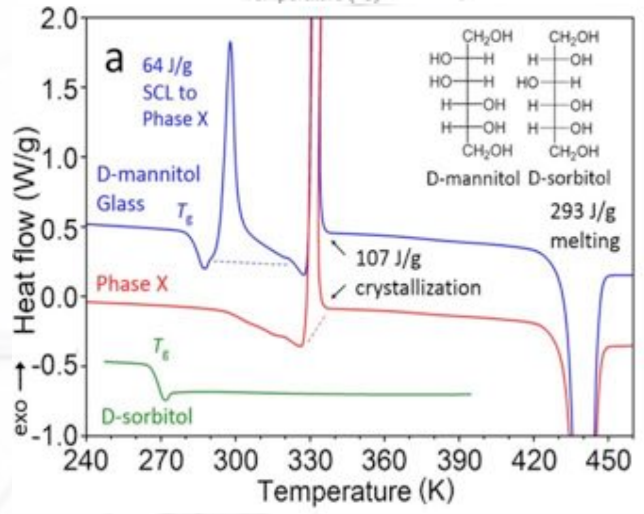
The main difference between glass transition temperature and melting temperature is that glass transition temperature describes the transition of a glass state into a rubbery state whereas melting temperature describes the transition of a solid phase into a liquid phase

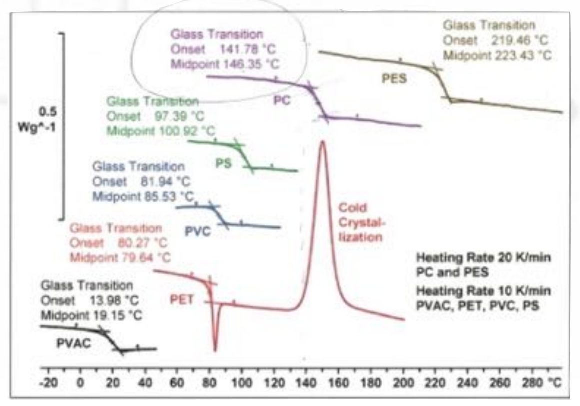
From the broad range of polymers, two possible candidates have been found:
Polycarbonate (PC) - thermoplastic polymers containing carbonate groups in their chemical structures
D-Mannitol - a type of sugar alcohol used in sweeting, medication and the drug trade. Can be extracted from natural sources.

These polymers are not characterised by especially high mechanical strength or resistance, and can also be weakened by UV light (exposure to sunlight). Therefore it would seem that they would be bad choices for such a long durational release mechanism. However, the polymer serves only to give sufficient additional strength to the main support structure. The main support structure would in turn be slightly too weak to support the spheres alone. By working together they give the strength necessary to maintain the coherence of the Object. When the polymer reaches its glass transition point the support structure fails and the spheres are released.

To protect the polymer hybrid support structure from erosion and UV light, it has a thin sheath of Alumina type ceramic (as in the main body of the Object), or materials infused with diamond or silicon carbide.







graphs showing glass transition points and melting points of various polymers.

D-Mannitol: $C_6H_{14}O_6$ - has its melting point at 166 °C and its Tg some 25° lower. Mannitol was first obtained from the European flowering ash, Caspian manna. Its name comes from the idea that the sugary sap resembled the biblical manna. The name Mannitol comes from the same root. In the present day it is commonly produced via the hydrogenation of fructose.

Polycarbonate: has a glass transition temperature of about 147 °C (297 °F), so it softens gradually above this point and flows above about 155 °C (311 °F). Polycarbonates are so named because they are polymers containing carbonate groups (−O−(C=O)−O−). A balance of useful features, including temperature resistance, impact resistance and optical properties, positions polycarbonates between commodity plastics and engineering plastics.

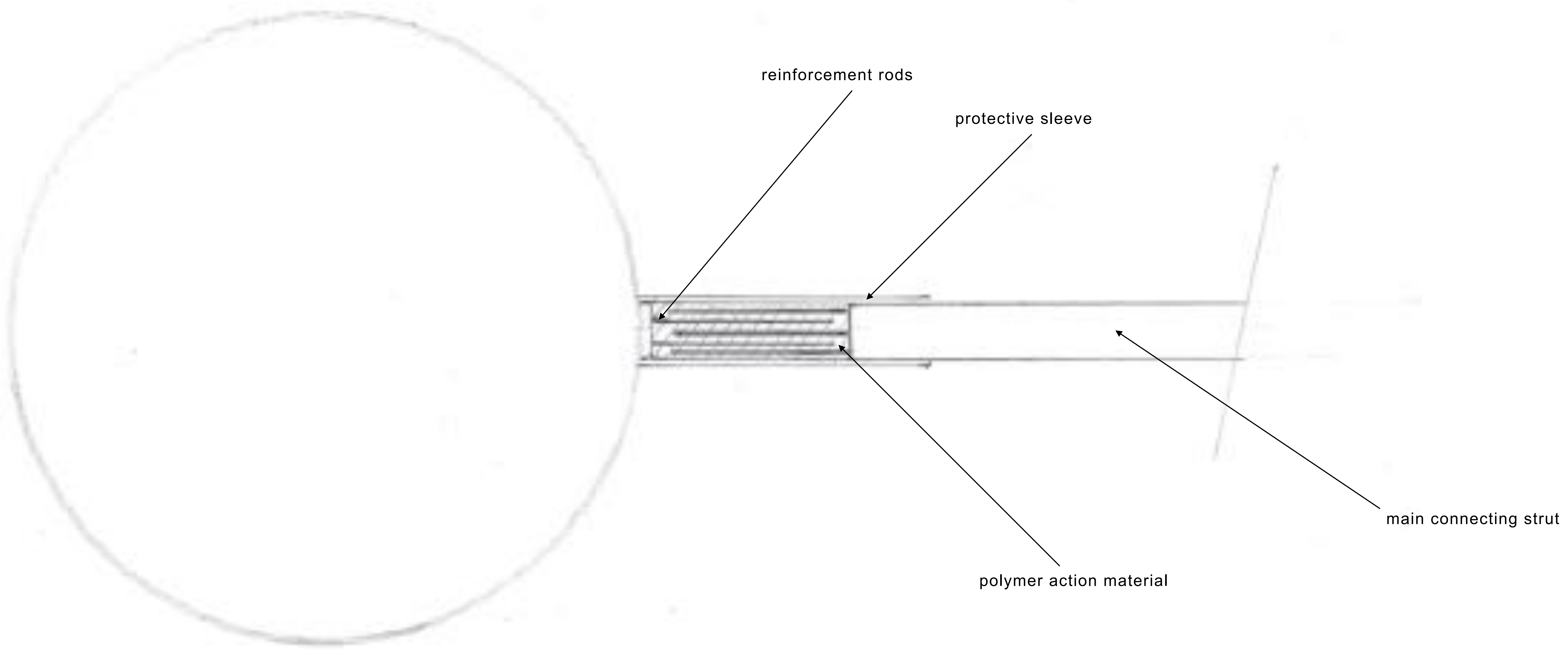
The Action Mechanism:

The action mechanism would be formed from a polymer with the glass transition point slightly below 147C such as polycarbonate or D-mannitol. As previously noted, the strength of these polymers alone is not sufficient for the load. Neither are they sufficiently resistant to the UV or erosive forces that will be experienced over the billions of years they need to exist.

Therefore, the polymer needs to work in unison with two other materials; one which will give the additional strength necessary, and one that will protect from UV and erosion. The added strength will come via the technique of using two materials to work together such as is used in reinforced concrete. Neither material is strong enough to hold the weight by itself, but in combination they can. If one of the materials fails, the whole component or structure fails.

Experiments in combining the polymer with carbon fibre rods, or powdered silicon carbide or industrial diamond, will determine which is the best approach for the action mechanism.

The polymer component would be protected with a thin sleeve of the same Alumina type ceramic used in the main structure. This sleeve would serve to protect the component from degradation from UV (which would become stronger as the Sun increases in luminosity) and from airborne erodents. An advantage of Alumina ceramics in this application (over diamond, for example) is that they have a high thermal conductivity in relation to more common ceramics. Therefore, the polymer will not be protected from ambient temperatures and there will be negligible effect on the action taking place at 147C.



The Anthropological Proposition:

A conversation between Andy Gracie and Matthew Wolf-Meyer

Matthew Wolf-Meyer is currently a Senior Research Fellow at Tampere University's Institute for Advanced Study and a member of the Faculty of Social Sciences. He also holds an Associate Professorship in Anthropology at Binghamton University in New York. His second book, Theory for the World to Come: Speculative Fiction and Apocalyptic Anthropology (2019), is an autoethnographic exploration of speculative fiction as a source of social theory in the context of global and local catastrophes. Building on contemporary debates about the Anthropocene, Theory for the World to Come addresses the shortfalls in imagining livable futures and engages with critical race theory and indigenous futures to articulate an inclusive politics of the future.

AG - Based on your ideas of extrapolation, intensification and mutation, I would like to ask how these processes could affect the Monument. Extrapolation would consist of imagining the Monument moving into the deep future more or less unchanged, its appearance and meaning intact. However, the possibility of this is highly questionable. Is it even feasible to imagine such a permanence of condition and interpretation across so much time? I feel that your concept of extrapolation works well for relatively near future scenarios. How do you see it working over deep time, where we can expect more profound changes in conditions?

MWM - I agree, but it might involve thinking about extrapolation a little differently. On one level, you could imagine that the Monument and the communities around it could be relatively stable - whatever else is happening in the world. Especially if the Monument and its people are protected from societal and environmental change, it could just persist with a robust set of traditions that hold its meaning in place. On another level, you could imagine how the stability of the Monument and its community might inspire the spread of similar projects - other Monuments anchoring other communities and providing a point of stabilisation. Those other Monuments might not be so costly or time-intensive in their construction, but might echo the first Monument in important ways that create a sense of continuity and community across time and space. In that way, the more stabilisation of the meaning of the Monument, the more likely its extrapolation is to occur in a straightforward way.

That all said, extrapolation can also be more piecemeal, and it may be the case that some element of the Monument and its communities persist in a relatively concrete way while other elements change in dramatic ways. In that respect, the extrapolation of the Monument into the future might involve some social element that develops in relation to it, even as the Monument itself undergoes transformations - or society at large alters significantly. That sounds rather abstract, but, by way of example, and this might seem a little strange, we might think of something like the Hollywood community and the media industry. The Monument is its own form of media, and there are people who structure their activities in relation to it, much like the communities in Hollywood organise themselves in relation to media production. The content of that media changes over time, and there are variations within it simultaneously, but the mission of the community has remained relatively stable for the last century. That has a lot to do with the political economy of entertainment in the U.S. and globally, but that laminates onto the meanings and aspirations of people in the community in important ways; as an industry, it's hard to see it persisting without the ways that community members support its mission. It simply depends on too many people having unfulfilled aspirations, levels of exposure and precarity that are psychologically risky, and huge sums of money. Likewise, the stewardship of the Monument might require different kinds of activities over time, but extrapolation allows for the persistence of something like the Monument's community even if the Monument itself changes in fundamental ways.

AG - Would this be related in some way to Timothy Morton's notion of HyperObjects? The Monument becomes a phenomena that encompasses other phenomena, pretty much creating its own ecosystem as in the Hollywood example you give.

MWM - That seems right to me. I always think of hyperObjects as Objects that transcend their material bounds, often despite still having one, and thereby being able to travel in unpredictable ways and bind themselves to unlikely partners. In those ways, I can imagine how the Monument might pretty quickly become a hyperObject, not so strictly limited to its physical location. It might inspire a whole secondary market of trinkets and tee shirts and narratives about the Monument, or set around the Monument, as its own kind of "actor" in the narrative. Whether that all erodes the potency of the Monument or more deeply entrenches it into human imaginaries would be another question.

AG - You describe intensification as an increased potency or pervasiveness. Is this where the Monument begins to take on some form of a life of its own? Maybe it becomes a sacred site, the meaning and symbol for a cult who were once caretakers and maintenance. Maybe they were just tour guides who over time adopted a deeper sense of connection and importance. How else might the future scenarios of the Monument become intensified?

MWM - The challenge with intensification and the Monument resides in what its meanings are taken to be at the outset - how does it get taken up by the communities around it, either locally or globally? If the Monument is really singular and localised, intensification would account for how its importance could spread and inspire duplicative efforts elsewhere. It could also account for how a more complex belief system might develop alongside the Monument. I hesitate to call it a religion, because it might not be anything like a deity-focused religion in the sense that we're familiar with, but as a system of belief it might bind communities to the Monument across time and space in important ways. In that respect, we could imagine whole sets of holidays and forms of pilgrimage that might develop in relation to the Monument, its production, and its opening. Which might all be to suggest that if one of the dangers of such a Monument is that it will be greeted with indifference, intensification might describe how its meaning could grow over time and compel significant amounts of human activity, both on site and globally.

AG - I'm interested in how commercialisation of events and Objects becomes a factor here. In our current short attention and hyperbolic society we tend to create a commercial and easily digestible semi-hysteria around any slightly significant happening. Parades, grand openings and traditions become increasingly superficial and corporate within this construct. Artists and organisations such as Welfare State International, Jeremy Deller and the KLF / K Foundation have worked closely with communities to create more personal and meaningful traditions and celebrations. I would hope that the 'launching' of the Monument would be more like this, and that this kind of practice would be hard coded into its future moments.

MWM - That seems possible to me, and I immediately think about how communities around the planet might be enrolled in being participants. I'm drawn to the idea that each community (and I'm a little vague about what that unit might be - it could be nations, or cities, or tribes, etc.) would select an extinct animal that would be incorporated into the Monument, either its bones or DNA. And local holidays related to the Monument might be based in that sacrificial animal—with local holidays maybe held on the day of its official extinction. That seems morbid, but it might not be any more morbid than many of our already existing holidays!

AG - Mutation: An unconventional "what if?" Is mutation now just a more extreme instance of intensification, knowing that things are going to become very extreme very soon? Or maybe aliens or other non-human intelligent life forms become active agents in the Monument's future?

MWM - The challenge with any mutation is that it's largely random and unpredictable. If intensification and extrapolation keep the variables relatively constant, mutation really upsets any assumptions we might bring to the situation. At its most chaotic, mutation might capture an event like an errant asteroid destroying the Monument and causing a nuclear winter; even if humanity reemerges, there won't be any Monument to recover, so conjecture about the future of the Monument and human society is moot. But mutation would also be a framework for thinking through how possible but unlikely events might interact with the Monument and the communities around it. You mention alien visitors, which is always a solid science-fictional possibility, but who they are and what they care about are impossible to predict. Instead, we might imagine how a Monument of significant size might become the locus for an alien visitation, and the meanings of the Monument would get muddled with its historical role in that epochal event.

Mutations are compelling to me as a thought experiment because mutation as a frame provides a way to smash together unlikely elements. One way I tend to approach mutation is to start by inverting assumptions. For example, we're talking about the Monument becoming central to communities that venerate it in some way and that its presence is meaningful as a long eulogy to humanity's end and what we've done to life on Earth. But what if, instead, CEOs of multi-national corporations decide to employ it in advertisements as a symbol of humanity's persistence and their corporate stewardship of the environment? That might be really frustrating for people who wanted the Monument to mean a particular thing—and implicate those CEOs and their corporations in the end of life on Earth. Or, entirely differently, what if the Monument has an effect that's unanticipated, like somehow it reverses the effects of climate change? Somehow it buries all of the excess carbon in the atmosphere and renders its message moot.

Those might all be rather deflating examples, but I always enjoy stories that have a "wait, what?" element to them—and Greg Bear's *Blood Music* is a great example of that. It starts as a pretty straightforward story about nanobots infecting humanity and all of the human concerns about trying to contain the nanobots. That's a decent enough story. But then the nanobots develop consciousness and use the natural resources that humanity provides as the nanobots liquify all life on Earth to send themselves into outer space in a search for extraterrestrial life. Throughout the second half of the book, it's a string of "wait, what?" experiences as the few remaining humans uncover what the nanobots are doing. If intensification and extrapolation serve as ways to game out future possibilities, mutations defy forecasting in any traditional way. And, like with Bear's nanobots, it's not simply that there's one mutation point where things become difficult to imagine, but that first mutation is just the first in a series of mutations, each of which brings about an unfolding set of conditions that trouble the initial situation.

AG - Based on the assumption that they are inevitable, and no longer in the real of speculative possibles, do climate disaster and mass extinction now sit more comfortably in extrapolation than in mutation?

MWM - To be frank, I'm not really sure. It feels like we're at a moment where many different futures are possible, and the trick is going to be which future we can get the world on board with. I increasingly feel like that future will be a plural one, marked by inequities between wealthy and poor countries, but also between countries that have some natural resilience to climate change and those that are especially vulnerable. It doesn't matter how rich a country is if it's at sea level! But it might mean that people from wealthy, low-lying countries end up as "climate refugees" in high altitude places. It might also mean that the rich will flee those low-lying places, and leave a shrinking archipelago to the poor people who also call it home. Which is all to say that climate disaster seems to fit all three categories: it's at once an intensification of already existing conditions (hot places keep getting hotter), extrapolation (these climate change-driving processes keep occurring with foreseeable effects), and mutation (who would have thought so many polar vortexes would be the byproduct of a warming planet?). We're definitely living through a mass extinction event, but what the actual results of it will be are unpredictable. Given that we're part of complex ecosystems, it's inevitable that humans will be affected by it. But, and I don't mean this in a strictly technology-driven way, humans are pretty adaptable. I frequently think about arcologies as the way forward—huge, self-contained cities. They seem entirely impossible from the standpoint of property-ownership, they're too explicitly communal, but as property begins to disappear and become a liability, property ownership as a form of consumption has to change too. But that high altitude property will still be worth a lot!

AG - Where would climate crisis and possible civilisation breakdown fit in with all this? Can we ignore them as a brief and not overly impactful moment in the lifespan of the Monument? I can't help feeling that any speculative future project cannot ignore the likely societal and ecological upheavals that we are facing in the near future. How do we work with this?

MWM - I often dwell on this quote from Antonio Gramsci, "The old world is dying, and the new world struggles to be born: now is the time of monsters." He was referring to a different set of monsters than we face today—although not too different, in that political upheaval and pandemic disease were both immediate concerns. So much of climate action these days is predicated on saving what we have, the problem of which is that what we have is a political-economic system that is predicated on extractive, exploitative forms of exclusion and resource hoarding, all of which have grown out of the racist colonial empires of the second millennium. Yes, saving as much life as we can is a good thing; no, keeping the institutions and people who are in power is not.

AG - I agree that trying to save ourselves while sticking to current political and commercial methodologies is madness. In a sense the Monument is an illustration of that and a comment on it. The scale of extraction and industry and capital necessary to build it would be quite immense. I'm really glad you mentioned Gramsci though. The concept of cultural hegemony he described is one of the biggest threats to a meaningful implementation of the Monument, I think. As we both mentioned a little earlier, one possible mutation could be that people in power adopt the symbolism of the Monument for their own purposes. I wonder how the Monument could remain neutral, a common, under the pressure of cultural acquisition and exploitation. Maybe it would be the site of numerous ideological battles.

MWM - In that way, I wonder how much such a Monument might enact a desire for change, the very threat of the project being a moment to raise awareness in some fundamental way that snaps people out of their climate change lull. That feels really fanciful. But the idea of a real scar on the landscape being made to represent the end of life on Earth might be charged in a way that compels notice. But how might upheaval be structured into the project? It seems to me that as long as the project embeds assumptions about society changing, even if it is agnostic about how society will change, there is the possibility that some core meaning is maintained over time. That meaning will become obscure, mutate, and might become clear again as society continues to change around the Monument, but something will remain, particularly if the material structure of the Monument is inviolable in some fundamental way. If its meaning is encoded in a variety of ways, it doesn't really matter what happens in the short term as long as people are able to reestablish some kind of connection to the Monument in the future, whether in 10 or 100 years.

AG - Humans seem to have a tendency to attribute deeper or even spiritual/religious meaning to Monumental Objects and ancient remains. This Monument, as with the pyramids or Stonehenge, will move from being known to being mysterious. It could possibly fade into curious antiquity as they have, or maybe humanity might strive to keep its meaning alive. I often imagine a cult or sect like society growing around the Monument, attributing their own mystical meanings to it, understanding only that it absolutely must be preserved for the future. The Monument would exist at the time of the last people, and I would imagine that the last people will know pretty much that they are the last people. How do you think attitudes might be towards this totem of extinctions at such a time? Would humanity attentively launch this into to the future, as a form of time capsule, or would it be otherwise?

MWM - This feels so challenging to me. It would seem to me that any public attempt to make a Monument about the extinction of life on Earth runs the risk of igniting potentially very strong reactions to its existence, as if the Monument embodies that which is seeks to represent, and if the Monument could be destroyed, then the future could be insured (or at least continue to be ignored). And it also feels like the more of a public project it is, the more of a target it becomes. It makes me think that the best short-term effect you could have is to have people largely ignore it—at least until such point that it becomes entrenched in people's understanding of everyday life and convention. But that might all assume that people have stronger feelings about the end of humanity and life on Earth than they do. It may very be the case that the Monument is met with a collective shrug at the time of its erection — with a side of conservative ridicule. I wonder how the strong reactions humans might have regarding their own end might play out against an empathy for the end of all living things. We must also bear in mind that the majority of these living things will be species that have not evolved yet. The Monument has to speak of deep future cycles of extinction and new speciations.

AG - I find the possibility of a collective shrug hilariously appealing.

MWM - I do think there would be some portion of the human population that develop a pretty robust affective connection to the Monument. It reminds me a bit of William Miller's *Canticle for Leibowitz*, which depicted a future monastic order that grounds their theology in a set of 20th century artefact left over from a nuclear apocalypse. Miller's supposition—on some level—is that people will find meaning in just about anything, and that artefacts that are affective charged from the outset are particularly effective in this. So the extinction Monument would seem to be immediately bundled with that kind of charge—for good and bad. The likelihood is that there isn't just one cult or sect or secular fan club, but a plethora of communities who exist in some sort of complementary and competitive relations with each other, with ebbs and flows in dominance that occur over time.

AG - In Death's End (The Three Body Problem pt3) Liu Cixin talks of groups of 'secular collectionary orders'. Peoples who become obsessed with collecting, categorising and commemorating artefacts and ephemera left behind by disappearing civilisations. There are also The Incast - a philosophical order dedicated to storing as much of the disputed, superseded or just plain long proved wrong knowledge that the Gilt civilisation and species had built up over the millennia, and any artefacts associated therewith'. These imaginations about how the future interprets the past are obviously hugely resonant for me.

MWM - Thinking with Miller again, and Mary Russell's *The Sparrow,* we see that kind of thing with religion all the time, which leads to a lot of tension, and potentially a sense of shared purpose across groups who might otherwise accept their differences as pretty significant. In that way, I can imagine that a core meaning of the Monument could last for a long period, even if its secondary meanings might fluctuate with some regularity.

But that all evades your question. Would people build such a Monument, allocating all of the resources and time that it would require? On one level, it feels like the ultimate vanity project, a way for humanity to claim our importance long after we're gone—an Ozymandias-like project if there ever was one. In that way, it's a little hard for me to imagine an individual government—or even a number of states—collaborating on such a project. The one way that I could really imagine it happening is as a gift, much like the State of Liberty, but in this case, a gift from the Global South to the governments in the North Atlantic, the latter having done so much to speed along global climate change, and the former so often the sites of extraction to enable those Anthropogenic transformations. As an added insult to the injuries of environmental degradation, the Monument makes a lot of sense—but might lead to those intense feelings mentioned above.

AG - The idea of it being a gift is fascinating and hadn't occurred to me. I had envisaged it more as a collective effort, supported by a widely international initiative. This international, collective identity could also go some ways to protect it from appropriation by any one entity. Maybe.
Another topic I mentioned to you that interests me in relation to this project is the research on communicating the danger of radioactive wastes in a manner that remains meaningful for the thousands of years of danger . One of the main points of reference for this is the research made by the Human Interference Task Force (which is also one of the best ever names for a think tank) for the Yucca Mountain Project. Francoise Bastide and Paolo Fabbri came to the conclusion that the most durable thing that humanity has ever made is culture. It may morph over time, but an essential message can get pulled through over millennia. The spoken word and narrative is highly adaptable and can keep pace with cultural transitions. Maybe it would be important to maintain a spoken tradition around the Monument.

Another reference has been Seboek's 1986 text 'Pandora's Box: How and Why to Communicate 10,000 Years into the Future'. 10,000 years seems like a good metric to use. We are 10,000 years from the beginning of civilisation and understand the problems of maintaining an understanding of written and spoken language over such timescales. We can only assume that 10,000 years from now it will be unlikely that spoken and written languages of today will be understood. I wonder whether there is any theory about how future civilisation and its information might change in respect to how past civilisation and its information has changed. Does our deeper understanding of society and semiotics ensure better longevity of information and the coherence of language systems?

MWM - Before I got to the 10,000 year metric, it was something I was thinking about—as a horizon for working through the future of humanity, maybe 10,000 years is the outer limit of anything predictive. After that, it's pure fabulation. 10,000 years is still incredibly long, but given that we're still working over texts from the ancient world that are a few thousand years old, it seems reasonable that there might be some level of continuity between the present and 10,000 years from now, particularly—as you note—that we're saturated with technologies that capture and communicate ideas over time and space.

That said, when you consider the linguistic drift that has occurred over the last 500 years, it may be the case that language will continue to develop in ways that make previous dialects increasingly remote. There's some play with this in science fiction, Russell Hoban's *Riddley Walker* and Norman Spinrad's *The Void Captain's Tale* both come to mind—but they're working with spoken languages as we know them today, whereas it's likely that a language like English will continue to mutate over time and become increasingly unrecognisable from our 21st century perspective. I imagine some people might argue that there's more homogeneity in language today - i.e. English has largely stabilised because it's not being pressured through colonisation and culture contact, which typify what happened between Old and Middle English. But we also know that language mutates through internal pressures, so it's likely that any Monument for the future will need some kind of Rosetta Stone to go with it - some key to decoder not only the texts related to the Monument, but language from the time the Monument was built.

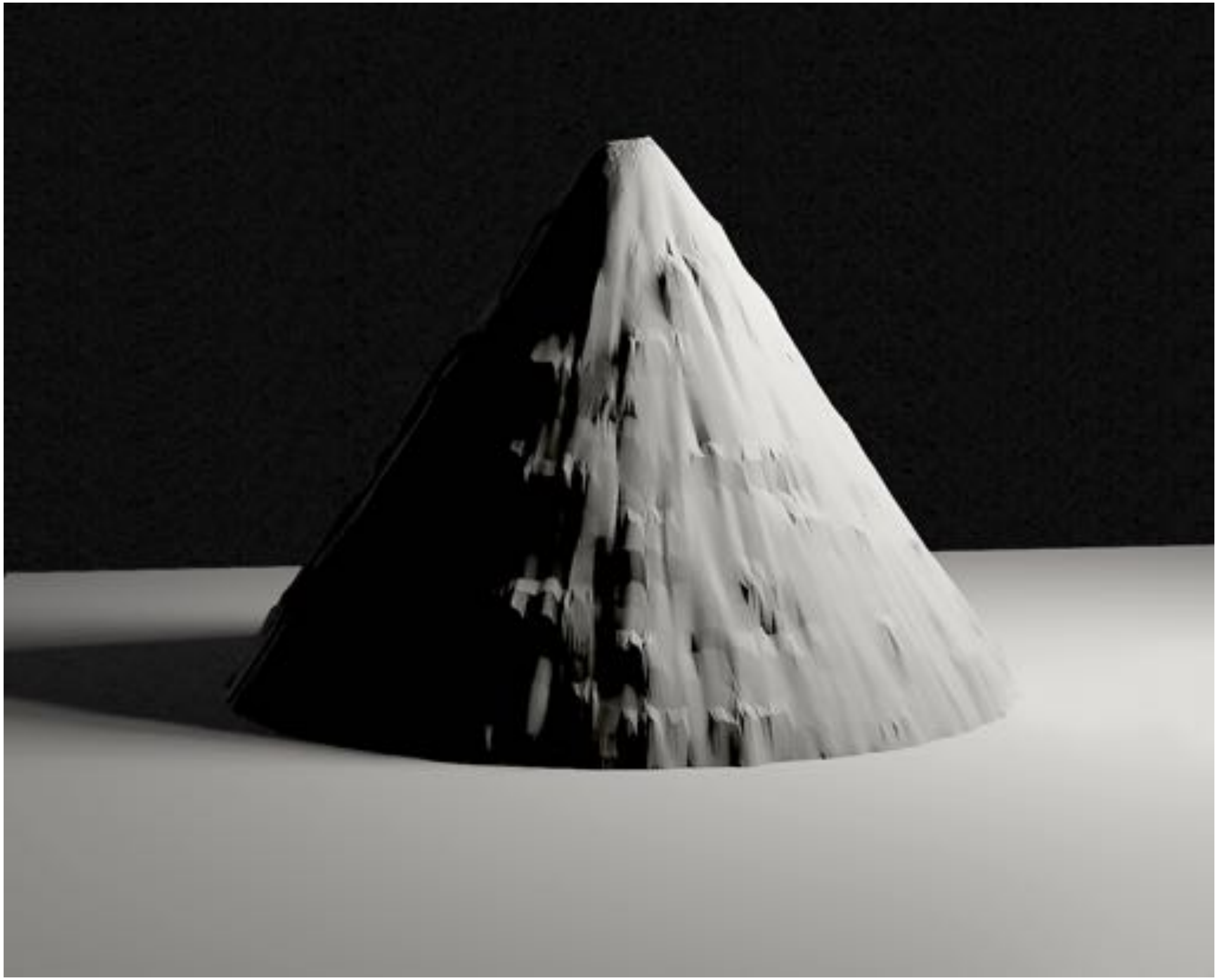
I've long been interested by the symbolism used on the plaques aboard the Pioneer and Voyager space craft. They show, for example, an arrow as an indicator of direction of travel. Of course, this only makes sense to a society that has actually invented to arrow and knows that the pointy bit is at the front. We can't guarantee that an alien civilisation will share this reference. Maybe it will also become lost to us within a few thousand years.

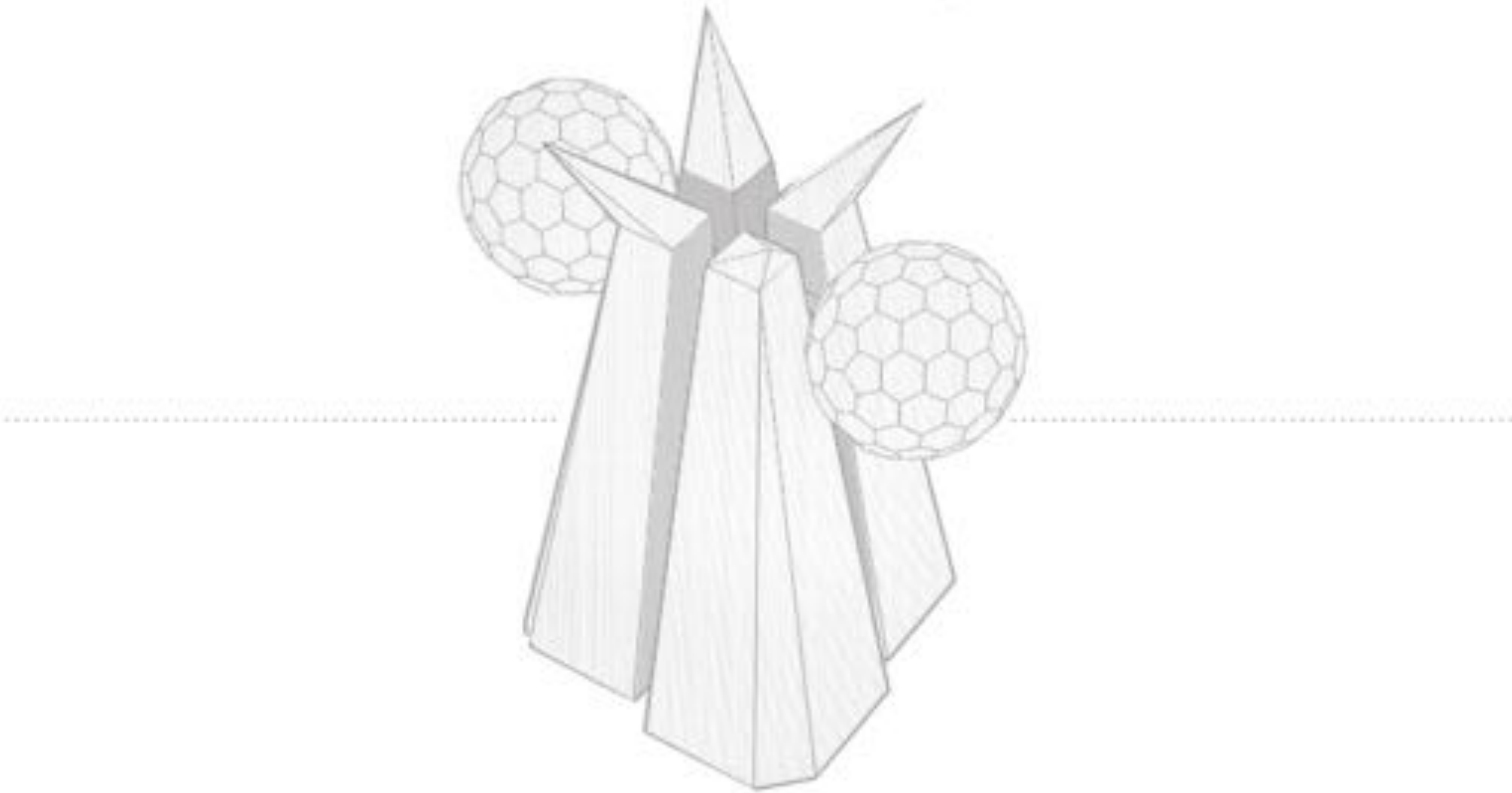
MWM - I was thinking about those plaques too. They really depend on a lot of assumptions about bodies, their senses, and their relationships with space and time. They really seem to grow out of a Star Trek-era of alien imaginaries, where all aliens are bipeds with recognisable faces and relatively similar forms of sensory experience and language. I've often thought about the possibility of totally alien species finding those plaques and having no sense of how to interpret them. But that all raises the question of whether one might be able to "Rosetta Stone" embodiment and spatiotemporality. How might we communicate complex phenomenological suppositions to a future humanity? Or to whatever species rise in our wake?

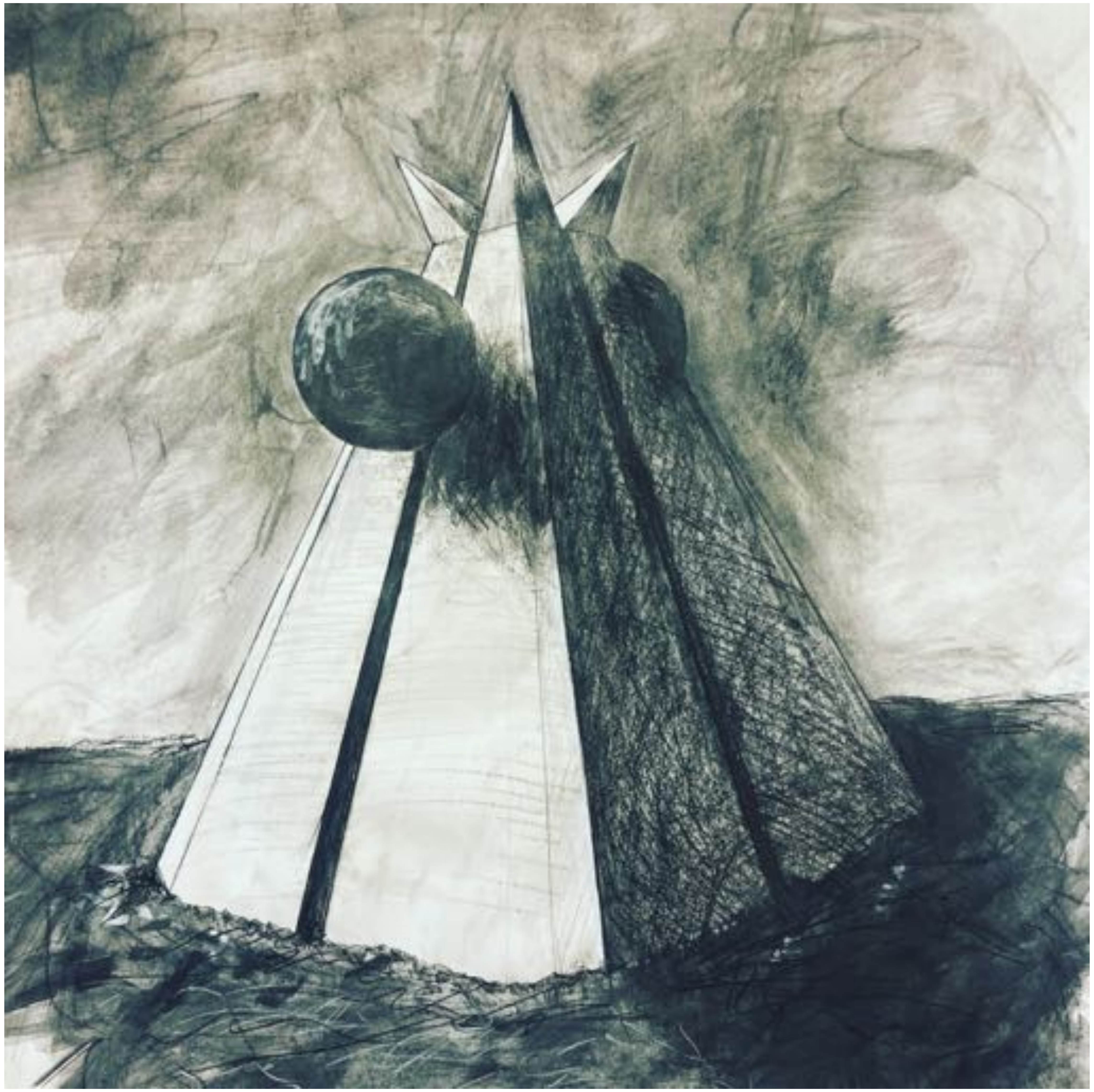
AG - Would you agree that a Monument such as this illustrates what Seboek calls an *iconic message* - one which resembles some agent of the real world to which it refers? Seeing as the symbolism and language will likely be lost, we cannot rely on symbolic or lexical meanings to be carried forward. I feel that so much of antiquity has lost its meaning to us, or we have lost our capacity to correctly interpret it, because histories were recorded in isolation and on time limited media. Do you think the concept of civilisation will be as transient in the future as it has been in the past? Might globalism and recorded information produce continuity in post collapse situations?

MWM - The hopeful possibility is that there is so much redundancy in content that it will serve as a back-up for civilisational collapse. Even if a lot of our media requires electricity to access, at least in the short term it seems like there's enough infrastructure to create the conditions for recovery and persistence. Like I mentioned above, there's a lot of linguistic and cultural drift to anticipate, and it seems like over the long term, even if the media persists, how its content is interpreted will inevitably change. That change could occur quickly or slowly, and it might be subject to forces of intensification, extrapolation, and mutation, but it seems like it has to happen. Especially when we're talking about 10,000 years—or longer. So much about the environment and society will change that it's impossible to imagine that people's interpretive apparatuses will remain the same. It makes me think of Charlton Heston at the end of "Planet of the Apes" and his reaction to seeing what remains of the Statue of Liberty on the beach. It means nothing to the evolved apes around him, but it's a testament to the follies of humanity—who erected it as a symbol of liberalism only to destroy it in an act of nihilism. Maybe the Monument we're talking about will be the same: an homage to the end of life on Earth that inaugurates something else entirely…

AG - I love having this mental image planted in my mind's eye at the culmination of this discussion. It was such a shocking moment the first time I saw it, and I love thinking about how it might resonate with this Monument… and also how it is more than likely doomed from the moment it is erected.

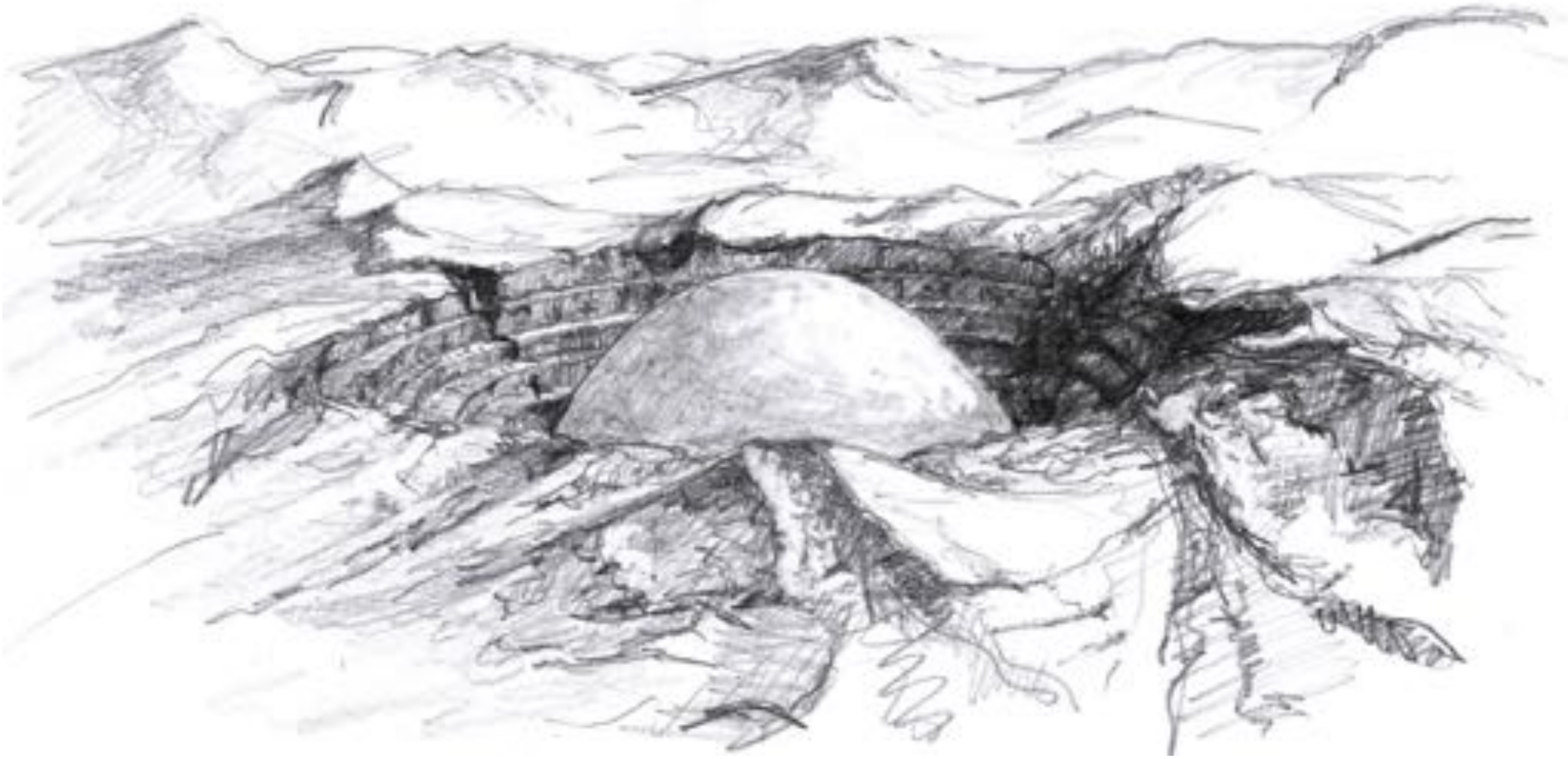






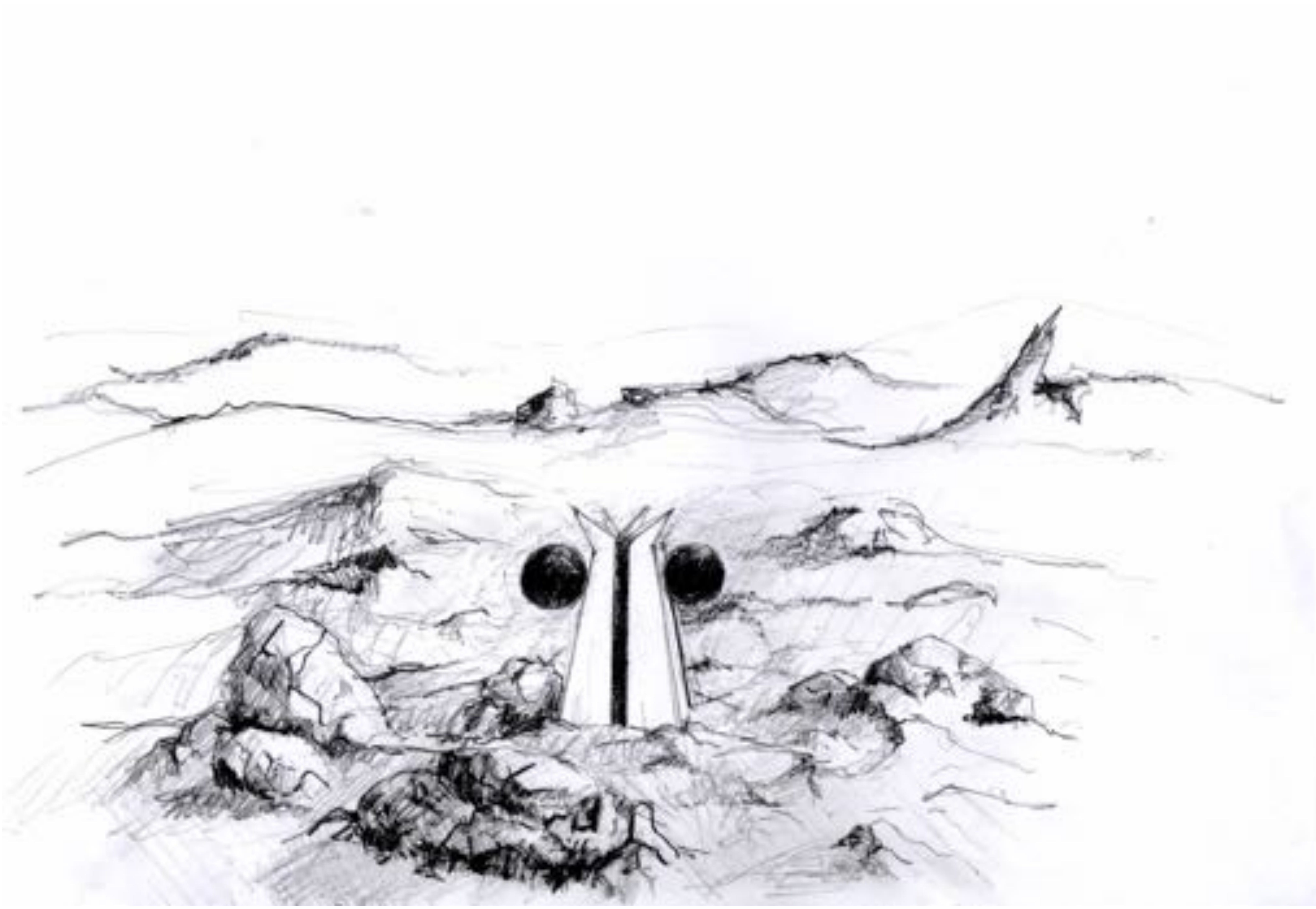
Monument at 0 years

Monument at 100,000,000 years



Monument at 1,000,000,000 years

Monument at 1,500,000,000 years



Monument at 2,000,000,000 years

Monument at 2,800,000,000 years

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