

# UNDERLAND

*By the same author*

Mountains of the Mind

The Wild Places

The Old Ways

Landmarks

The Gifts of Reading

The Lost Words (*with Jackie Morris*)

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*A Deep Time Journey*

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ROBERT MACFARLANE



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Is it dark down there  
Where the grass grows through the hair?  
Is it dark in the under-land of Null?

Helen Adam, 'Down There in the Dark', 1952

The void migrates to the surface . . .

*Advances in Geophysics, 2016*

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dinghies to buzz us, ripping their Evinrudes and cutting across our bows. To the north the Apusijik glacier gleams its way down to the tideline. After a while we raft up and bob on the chop, looking back at the little village of Kulusuk perched on its bedrock, the white crosses of the shore-side cemetery showing clear in the sun.

When we return to shore, Nuka shows the harpoon proudly to Geo. Geo shakes his head.

'This is not a harpoon,' he says to Nuka in Greenlandic.

He looks at us, takes it, grips it by its wooden haft like a walking stick with the point lowermost, and makes a downwards jabbing motion, stepping cautiously forwards as he does so, looking enquiringly ahead of himself as he presses the point against the earth.

It is not a harpoon, not a weapon at all, but rather a tool used to probe the depth of the sea ice ahead. It is a means of telling if it is safe to proceed — of testing the near future.

When I return to Britain, I learn that during the weeks we have been on the glaciers the Anthropocene Working Group of the Subcommission on Quaternary Stratigraphers has recommended the formal adoption of the Anthropocene as the current Earth epoch, with a start date of 1950 — coinciding with the dawn of the nuclear age.



Birches, birches, pines, birches, clearing, blue farmhouse. Low river valley, wooden bridge. Everything frozen: rivers, trees, turf, fields. Pink crag of granite, yellow ice-fall spilling from it. Boulders big as houses between the birches, among the pines. Black crow pulling red flesh off the white ribs of a dead fox. Jackdaw, jackdaw.

*This is not a place for you.*

The pirate radio station plays Blondie's 'Atomic'.

Snakes of spindrift race on the blacktop. Snow whirls in the headlights. Grey air that will not brighten. A boy riding a bike with sit-up-and-beg handlebars, his back very straight, fast past a blue letter-box on a white pole. Gneiss, silver-grey, quick with mica and ice.

*This place is not a place of honour.*

Over the bridge to the island. Salt marsh to either side of the bridge. Sea in shattered slabs of ice. Wind skittering stiff reeds, and starlings moving black above the reeds. The sea is frozen for half a mile offshore. Far out in the gulf, beyond sight, there are thirty-foot-high waves moving west through the half-light.

*No highly esteemed deed is commemorated here.*

Snowfall like static when the wind drops, like warp-speed when it blows. Double-layer chain-link fencing. Three huge structures showing through the blizzard, across the bay, towards the island's

tip. Great grey outlines emerging and fading: dome, tower, slabbed walls. The sea has melted clear around them; the sea should not have done so. Two trucks crunch past on ice tyres.

*Nothing valued is here. What is here is dangerous and repulsive to us.*

The pirate radio station plays 'Disco Inferno' by the Tramps.

Snow flurries in the headlights. I have come to see a burial site and to bury something of my own. It will be dark when I reach the end of the world and it will be dark when I return to the surface.

*Pay attention. We are serious. Sending this message was significant for us. Ours was considered an important culture.*

*We are going to tell you what lies underground, why you should not disturb this place, and what may happen if you do.*

~

Deep in the bedrock of Olkiluoto Island in south-west Finland a tomb is under construction. The tomb is intended to outlast not only the people who designed it, but also the species that designed it. It is intended to maintain its integrity without future maintenance for 100,000 years, able to endure a future Ice Age. One hundred thousand years ago three major river systems flowed across the Sahara. One hundred thousand years ago anatomically modern humans were beginning their journey out of Africa. The oldest pyramid is around 4,600 years old; the oldest surviving church building is fewer than 2,000 years old.

This Finnish tomb has some of the most secure containment protocols ever devised: more secure than the crypts of the Pharaohs, more secure than any supermax prison. It is hoped that what is placed within this tomb will never leave it by means of any agency other than the geological.

The tomb is an experiment in post-human architecture, and its name is Onkalo, which in Finnish means 'cave' or 'hiding place'. What is to be hidden in Onkalo is high-level nuclear waste, perhaps the darkest matter we have ever made.

For as long as we have been producing nuclear waste we have been failing to decide how to dispose of it. Uranium was created in supernova explosions around 6.6 billion years ago, and is part of the space dust out of which the planet formed. It is as common in the Earth's crust as tin or as tungsten, and it is dispersed within the rocks on which we live. Slowly, expensively, miraculously, injuriously, we have learned how to convert uranium into power and into force. We know how to make electricity from uranium and we know how to make death from it, but we still do not know how best to dispose of it when its work for us is done. Over a quarter of a million tons of high-level nuclear waste in need of final storage is presently thought to exist globally, with around 12,000 tons being added to that figure annually.

Uranium is mined as ore in Canada, Russia, Australia, Kazakhstan and perhaps soon in the south of Greenland. The ore is crushed and milled; the uranium is leached out with acid, converted to a gas, enriched, consolidated and then processed into pellets. A single pellet of enriched uranium one centimetre in diameter and one centimetre long will typically release the same amount of energy as a ton of coal. Those pellets are sealed within gleaming fuel rods, usually made of zirconium alloy, which are bundled together in their thousands and then placed in the reactor core, where fission is initiated. Fission produces heat which is used to raise steam; the steam is ducted to turbines, turning their blades and producing electricity.

Once the fission process has slowed below a horizon of efficiency,

the rods must be replaced. But they are still intensely hot and lethally radioactive. The unstable uranium oxide continues to emit alpha and beta particles, and gamma waves. If you were to stand next to an unshielded bundle of fuel rods fresh from the core, radioactivity would plunder your body, smashing cells and corrupting DNA. You would be likely to die within hours, vomiting and haemorrhaging.

So spent rods are slid out of the reactor by machine, kept always under water or another shielding liquid as they are moved, then typically stored in deep spent fuel pools for several years, before being sent for reprocessing or dry cask storage. Down in the fuel pools the water patiently absorbs the particle hail from the rods. Because this hail heats the water, it must be continuously circulated and cooled in order to prevent it boiling off and leaving the rods disastrously unshielded.

Even after decades in the pools, however, the rods are still hot, toxic and radioactive. The only way for them to become harmless to the biosphere is through long-term natural decay. For high-level waste this can take tens of thousands of years, during which time spent fuel must be kept secure: segregated from the air, from sun, from water and from life.

The best solution we have devised for securing such waste is burial. The tombs that we have constructed to receive these remains are known as geological repositories, and they are the Cloaca Maxima – the Great Sewer – of our species. Into low- and intermediate-level repositories go the lightly radioactive materials that are the by-products of nuclear power and weaponry: the items that will remain harmful only for scores of years – the clothes, the tools, the filter pads, the zips and the buttons. All are barrelled up and lowered into holes in silos that have been sunk below ground at storage sites around the world. Each new layer is packed in concrete, ready for its successor. The Waste Isolation Pilot Plant (WIPP) – the intermediate-level repository dug into the salt beds

of New Mexico – is intended to receive 800,000 fifty-five-gallon soft-steel drums of military-origin transuranium waste, holding among other substances the radioactive shavings from US nuclear warhead manufacture. The WIPP drum chambers will in time form neat strata, standing as highly organized additions to the rock record – another taxon of Anthropocene future fossil.

The most dangerous waste, though – the toxic and radioactive spent fuel rods from reactors – requires even more secure burial: a special funeral and a special tomb. We have only ever attempted to construct a few such high-level waste repositories. Belgium has sunk a test site to research future deep repository possibilities, and has named the facility HADES. America's attempt at a high-level repository took place at an extinct super-volcano called Yucca Mountain in the Nevada desert, but construction was suspended after decades of controversy and protest, and the caverns tunnelled into the ignimbrite currently stand as empty halls. Among the reasons for the suspension of the project is Yucca Mountain's proximity to a 900-foot-wide earthquake zone, the Sundance Fault, which is itself undercrossed by a deeper fault called Ghost Dance. If Yucca Mountain were ever to be filled to capacity it would hold, writes John D'Agata, 'the radiological equivalent of two million individual nuclear detonations, about seven trillion doses of lethal radiation', enough to kill every human on Earth 350 times over.

By far the most advanced of all these deep storage facilities is Onkalo, the Hiding Place, set 1,500 feet down into 1.9-billion-year-old rock on the Bothnian coast of Finland. When the burial chambers of Onkalo are full with waste from the three power stations of Olkiluoto, they will hold 6,500 tons of spent uranium.

This is the way the world ends, this is the way the world ends, this is the way the world ends, this is the way the world ends — not with a bang but a visitors' centre.

'Welcome to Olkiluoto Island,' says Pasi Tuohimaa. 'You made it! I have come to Onkalo the winter after the summer of great melt in Greenland, after the autumn of the moulin.'

The reception area is clean and well funded. There are free-standing wardrobes, veneered on the outside with high-definition photographs of forest vistas. In the bathroom there is no piped music but there is piped birdsong. People piss to the calls of nuthatches, or perhaps they are tree-creepers.

Pasi takes me outside. A stepped boardwalk leads down from the back of the reception area to the sea marsh. Reeds brittle in the wind. The sea is frozen solid, yellow plates of ice piled among the blizzard rushes. Across the bay, passing in and out of visibility as the blizzard moves, are the outlines of three nuclear power stations. The third and most distant is mosque-like: a terracotta dome from which rises a minaret tower.

'The third is still under construction,' says Pasi. 'Not long now.'

The wind is very cold. We retreat to consider the scene from behind glass. The wide viewing windows have grey stickers of raptors on them to prevent bird-strike: generic falcon, generic hawk. The pressed timber frames of the windows present the scene of the bay beautifully. When the blizzard hides the power stations, we might be contemplating an early twentieth-century painting by Gallen-Kallela.

Pasi shows me around the permanent exhibition that explains how the nuclear power supply chain works from mine to consumer, and proves how radiation is a hazard only if incorrectly handled.

'People think nuclear waste is harmful for eternity,' says Pasi. 'It isn't! After 500 years, you could take spent uranium into your home.'

He opens his arms towards me. 'You could probably embrace it!'

He pauses, reconsiders.

'You would not want to keep it under your bed, but in your living room — no problem.'

He pauses again.

'You would not want to kiss it, but hugging is fine.'

He sounds like a father laying out the terms and conditions to his daughter's date.

'This is how we encapsulate the fuel rods for long-term storage,' he says, pointing to an eight-foot-long copper cylinder, a foot and a half in diameter. He raps it with his knuckles. It clunks.

'No fake — this is the real thing. Do you know how much copper trades for per kilogram? It is the best insulator: so inert.'

Inside the copper canister is a cast-iron canister which has been internally partitioned so that it resembles a noughts-and-crosses board, with gaps for the squares. Into these gaps will be slid the zirconium alloy fuel rods containing the spent uranium pellets. Each canister will weigh around twenty-five tons when complete; each canister will be nested in a bed of water-absorbing bentonite clay, inside a cored-out tube of gneiss, 1,500 feet down into the gneiss and granite bedrock.

I murmured the nesting order to myself, working ourwards: *uranium, zirconium, iron, copper, bentonite, gneiss, granite* . . . I think back to the beginning of my journeys in the underland, and to the beginning of time, down in the dark-matter laboratory at Boulby Mine. At Boulby they encased xenon in lead in copper in iron in halite in hundreds of yards of rock in order to see back to the birth of the universe. At Onkalo they encased uranium in zirconium in iron in copper in bentonite in hundreds of yards of rock in order to keep the future safe from the present.

One of the exhibits in the display area has a life-size model of Albert Einstein sitting behind a desk, pen in hand, paper on desk.

'See who's here!' says Pasi, leading me to Einstein.

Einstein looks the worse for wear. His rubber face, which would be a poor likeness under the best of circumstances, has come unstuck from his neck. There is a gaping hole in his throat, through which I can see metal struts and hinges.

'Push the button,' urges Pasi, pointing at a red button on our side of the desk, designed to facilitate audience interaction with the exhibit.

I push it.

Einstein's upper body lurches towards us and stops with a jerk that dislodges the right-hand half of his grey moustache, which droops slowly forwards over his upper lip. A recorded voice that I do not take to be Einstein's begins to speak to us in Finnish.

Pasi frowns, then leans across the desk and tenderly presses Einstein's moustache back into place with his thumb.

The day before I go to Olkiluoto Island and down to the hiding place, I wait in the little nearby town of Rauma, reading the great folk epic of Finland, the *Kalevala*.

The *Kalevala* is a long poem of many voices and many stories which – like the *Iliad* and the *Odyssey* – grows out of diverse and deep-rooted traditions, from Baltic song to Russian storytelling. It existed chiefly as a mutable oral text for more than a thousand years, until in the nineteenth century the *Kalevala* was collected, edited and published by the Finnish scholar Elias Lönnrot, giving us the mostly

fixed version we now have. Lönnrot's *Kalevala* is made up of many intertwining narratives that combine the mythical and the lyrical with the mundane and the logistical, and that together dramatize a northern people's engagement with a hard, beautiful landscape of forests, islands and lakes. In its layering of different ages of origin, the Finnish scholar Matti Kuusi compares the poem's own history of making with 'the numerous strata of a burial mound in which many generations . . . and their artefacts have been buried'.

The *Kalevala* is a haunting epic that has preoccupied me for some years, obsessed as it is with the power of word, incantation and story to change the world into which they are uttered. Its heroes are language masters and wonder-workers – and the greatest of them is called Väinämöinen, whose name translates memorably as 'Hero of the Slow-Moving River'.

In the room in which I read the *Kalevala* that day is a wall-sized photograph of Rauma, taken on a market day at some point in the late nineteenth century. The photograph has been blown up, so it is grainy. All the men have dressed for market day: they are wearing black suits and shoes and hats. They stand out clearly. All the women are wearing blinding white dresses and hats. The plate-camera's long exposure has drunk too deeply of the women's whiteness, though, so that they appear as ghostly, burned-out presences. I count the traces of eighty-seven of these overexposed women. They are leaning out of horse-drawn carts. They are clutching headscarves around their necks with one hand, while carrying shopping with another. Their dresses are ankle-length, and their hats are tall straw boaters with double bands. Here and there they have moved too fast and are blurred to the point of invisibility, lost in the blast.

I read the *Kalevala* for two hours in view of that photograph, and



as I read I come to realize something so unsettling that the back of my neck prickles: despite its great age, the poem seems to possess foreknowledge of what is presently being undertaken on Olkluoto Island.

Partway through the poem, Väinämöinen is given the task of descending to the underland. Hidden in the Finnish forests, he is told, is the entrance to a tunnel that leads to a cavern far underground. In that cavern are stored materials of huge energy: spells and enchantments which, when spoken, will release great power. To approach this subterranean space safely Väinämöinen must protect himself with shoes of copper and a shirt of iron, lest he be damaged by what it contains. Ilmarinen forges them for him. Clad in these insulating metals Väinämöinen approaches the tunnel mouth, which is disguised by aspens, alders, willows and spruce. He cuts down the trees to reveal the entrance. He enters the tunnel and finds himself in a deep 'grave', a 'demon . . . lair'. He has stepped, he realizes, into the throat of a buried giant called Vipunen whose body is the land itself.

Vipunen warns Väinämöinen not to bring to the surface what is buried in his caverns. He speaks of the 'grievous pain' of excavation. Why have you entered 'my guiltless heart, my blameless belly', Vipunen asks, 'to eat and to gnaw / to bite, to devour'? He warns Väinämöinen that he will end up visiting terrible violence upon humans if he continues on his course, that he will become 'a wind-borne disease / wind-borne, water driven / shared out by the gale / carried by chill air'. He threatens to imprison Väinämöinen by means of a containment spell so powerful that it is unlikely ever to be broken. It will take nine ram lambs born of a single ewe, together with nine bull oxen born of a single cow, together with nine stallions born of a single mare, pulling together to free him.

But Väinämöinen will not listen to Vipunen. He sings of his

conviction that the power buried underground should be returned to the surface:

*Words shall not be hid  
nor spells be buried;  
might shall not sink underground  
though the mighty go.*

The *Kalevala* is fascinated by the underland; by the safe storage of dangerous materials and the safe retrieval of precious materials. At the poem's heart is a magical object or substance known as 'Sampo' or the 'Sammás'; constructed by the blacksmith Ilmarinen, another of the *Kalevala*'s supernatural heroes, and stored inside the 'copper slope' of a 'rocky hill', protected by a gate with ten locks. This enchanted artefact, most often figured as a mill or quern, brings power, wealth and fortune to whoever controls it. It is – in modern terms – a weapons system, a rich raw resource, a nation's organized industry, or a nuclear power station. The Sampo grinds out flour, it grinds out money – and it grinds out time. One of its given tasks is to grind out the age of the world, causing epochs to yield to one another in an immense cycle of precessions. *The world has changed too much . . . we are in the Anthropocene.*

We approach the entrance to the Hiding Place through flat, cleared land. The birches, pines and aspens have been felled and their stumps drilled out to make a square glade in the forest, close to the roadside. A doubled chain-link fence surrounds the site, to keep out moose, trespassers and terrorists. Snow settles on grey gravel. The blizzard

has eased. In the yellow corrugated-steel central building a vending machine sells energy drinks with the brand name of Battery.

The landscape below which the Hiding Place is sunk has been flattened by the glacial ice that has rolled repeatedly over it in the past 2 million years. Erratic boulders big as buildings lie among trees where the last ice left them. The glaciers do not feel long gone, as if they will be back soon.

The mouth of the Hiding Place is a ramp blasted down into the gneiss. Lichen has already begun to colonize the exposed rock around the entrance: orange lipstick-kisses of *Xanthoria*. A shutter-gate locks off the ramp in case of accident. Now the gate is raised – and below it a tunnel angles down into darkness.

Shotcrete walls, unnaturally smooth. Green side-lights diminishing in size. Signs declare the speed limit at the end of the world to be 20 kmh. Utilities cables droop between brackets. A gurgle of water runs down a gutter. Air moves coldly up from below, stirring stone dust. *The earth is our tabernacle, a receptacle for all decompositions . . .* From the threshold the tunnel leads down and around in a steady crooked three-mile spiral before levelling out at the burial chambers themselves.

Seen in abstract, as if the rock that encases it does not exist, the Hiding Place has an elegant simplicity. There are three central shafts dropping vertically downwards from the surface: ventilation in, ventilation out and an elevator. Around these shafts the transport ramp turns in its helter-skelter, descending at last to a complex excavated space nearly 1,500 feet deep. Outwards from the central space extends a network of storage tunnels, into the floor of each line of which are bored the receptacle wells for the fuel rod canisters. When Onkalo is ready to receive its first deposition, there will be more than 200 storage tunnels, which together will hold the 3,250

canisters. In their form these tunnels resemble to me the chambers and galleries that boring beetles make under tree bark, creating space in which to lay their eggs and rear their larvae, before they kill the tree that feeds them.

Sometimes we bury materials in order that they may be preserved for the future. Sometimes we bury materials in order to preserve the future from them. Some kinds of burial aspire to repetition and re-inheritance (storage); others aspire to oblivion (disposal). At the Barbarastollen underground archive near Freiburg im Breisgau, a disused mine has been converted to a safe-house for German cultural heritage. More than 900 million images are stored there on microfilm in caskets, more than 1,300 feet below ground. The archive is designed to survive a nuclear war, and to preserve its contents for a minimum of 500 years. At Spitsbergen the Global Seed Vault freeze-stores an immense variety of seeds and plant matter, anticipating an epoch after catastrophe when the Earth's flora and biodiversity may need replenishing. Both of these vaults look forward to a time of future scarcity; both implicitly read the present as a time of plenty.

Onkalo, by contrast, is constructed with the desire that its contents never be retrieved. It is a place that confronts us with timescales that scorn our usual measures. Radiological time is not equivalent to eternity, but it does function across temporal spans of such breadth that our conventional modes of imagination and communication collapse in consideration of them. Decades and centuries feel pettily brief, language seems irrelevant compared to the deep time stone-space of Onkalo and what it will hold. The half-life of uranium-235 is 4.46 billion years: such chronology decentres the human, crushing the first person to an irrelevance.

But to think in radiological time is also, necessarily, to ask not what we will make of the future but what the future will make of us.

What legacies will we leave behind, not only for the generations that succeed us but also for the epochs and species that will come after ours? *Are we being good ancestors . . . ?*

The tunnel curls around and back. The air hums oddly. Unseen machines undertake obscure tasks. At a depth of 1,000 feet we enter a series of big side-chambers. In the first stands a yellow drilling engine, unmanned but with its eight halogen eyes glaring, its drill arms still drooling water. The keys are still in the ignition. The shotcrete chamber roof is slotted with silver and red bolt-plates. New drill holes in the roof weep onto us. The halogen casts hard shadows. I think of the lizard-machines in the drift-labyrinth at Boulby, waiting to be enveloped in their halite shrouds.

The bare walls of the chamber are covered in cave art: spray-paint markings in blue, red, apple green, nuclear yellow. The rock is adorned with numbers, pictograms, lines, arrows and other codes I cannot decipher, as remote in their meanings to me as the Bronze Age dancing figures of Refsvika.

The Greek word for 'sign', *sema*, is also the word for 'grave'. Around 1990 the research field of nuclear semiotics was born. As plans developed for the burial of radioactive waste, so the question emerged in America of how to warn future generations of the great and durable danger that lay at depth. It became important, the US Department of Energy decided, to devise a 'marker system' that could deter intrusion into a repository 'during the next 10,000 years'. The Environmental Protection Agency founded a 'Human Interference Task Force' charged with the imagining of such a system for the entombment sites under construction at Yucca Mountain and in the New

Mexico desert. Two separate panels were convened to consider the issue of the 'marker system', reporting to an overall Expert Judgment Panel. Among those invited to express interest in joining the panels were anthropologists, architects, archaeologists, historians, graphic artists, ethicists, librarians, sculptors and linguists, as well as geologists, astronomers and biologists.

The challenges faced by the panels were formidable. How to devise a warning system that could survive – both structurally and semantically – even catastrophic phases of planetary future. How to communicate with unknown beings-to-be across chasms of time to the effect that they must not intrude into these burial chambers, thus violating the waste's quarantine?

Several proposals developed by the panels involved forms of what is now known as hostile architecture, but which they referred to as 'passive institutional controls'. They suggested constructing above ground at the burial site a 'Landscape of Thorns' (fifty-foot-high concrete pillars with jutting spikes that impeded access and suggested 'danger to the body'), a 'Black Hole' (a mass of black granite or concrete that absorbed solar energy to become impassably hot) and 'Forbidding Blocks' (the bulks of which might intimidate a visitor into turning back).

The panel members realized, however, that such aggressive structures might act as enticements rather than cautions, suggesting 'Here be treasure' rather than 'Here be dragons'. Prince Charming hacked his way through the briars and thorns to wake Sleeping Beauty. Howard Carter excavated Turankhamun's tomb despite the multiple obstructions placed in the way of access, and the warnings given in languages other than his own.

Other proposals from the panels involved versions of a transcendental signifier. Human faces could be carved into stone: pictograms

or petroglyphs conveying horror. Munch's *The Scream* might be taken as a model, it was suggested, on the grounds that it could still somehow communicate terror to whatever being approached it in the distant future. Or a durable aeolian instrument might be constructed that tuned the far-future desert winds to a minor D, the note thought best to convey sadness.

The semiotician and linguist Thomas Sebeok argued on grounds of futility against the search for a transcendental signifier that could outlast all corruption and mutation. Such a sign did not exist, he said. Instead he proposed working towards what he called a long-term 'active communication system' that relayed the nature of the site using story, folklore and myth. Such a means of transmission – perpetuated by an elected 'atomic priesthood' – would be flexible, allowing retellings and adaptations to occur across generations. In this way what began as a simple set of warnings might be reconfigured as, say, a long poem or folk epic, made narratively new for each society in need of warning. Those ordained into the priesthood would have the responsibility of 'laying a trail of myths about the [burial sites] in order to keep people away'.

The Waste Isolation Pilot Project in New Mexico is currently due to be sealed in 2038. The plans for marking the site remain under development. Among those advising the project now are social scientists and writers of science fiction. Present plans for what Gregory Benford has called 'our society's largest conscious attempt to communicate across the abyss of deep time' include the following measures.

First the chambers and the access shafts will be backfilled. Then a thirty-foot-high berm of rock and tamped earth with a core of salt will be constructed, enclosing the above-ground footprint of the repository. Buried in the berm and the earth around it will be radar reflectors and magnets, discs made of ceramic, clay, glass and metal,

engraved with warnings: 'Do Not Dig Or Drill'. The berm itself will be surrounded by an outer perimeter of 25-foot-high granite pillars, also bearing warning texts.

Set flat near the berm will be a map measuring 2,200 feet by 600 feet. The map will be slightly domed so that it sheds sand in the wind, and does not itself become buried. The continents will have granite edges, the oceans will be represented by caliche stone rubble, and marked on the map will be the world's significant radioactive burial sites. An obelisk will indicate the WIPP site: You Are Here.

This map at the Earth's end has echoes of Jorge Luis Borges's cautionary story 'On Exactitude in Science', which imagines a world in which the art of cartography aspires to such representative perfection that the Cartographers of the Empire construct 'a map of the Empire whose size was that of the Empire'. But of course this one-to-one scale map proves both unusable and overwhelming. The 'following Generations', perceiving the danger of such a map, leave it to erode. 'In the Deserts of the West,' ends Borges's story, 'still today, there are Tattered Ruins of that Map, inhabited by Animals and Beggars.'

Close to the WIPP map what is called a 'Hot Cell' will be constructed: a reinforced concrete structure extending some sixty feet above the earth and thirty feet down into it. 'Hot' because it will house small samples of the interred waste, in order to demonstrate the radioactivity of what is buried far beneath.

Within the curtilage of the berm an information chamber will be built of granite and reinforced concrete, designed to last a minimum of 10,000 years. The chamber will carry stone slabs into which will be inscribed more maps, timelines, and scientific details of the waste and its risks, written in all current official UN languages, and in Navajo.

around 5,000 years old, when cuneiform first emerged. Our language systems are dynamic, our inscription systems vulnerable to destruction or distortion. Most ink is perishable in direct sunlight, fading within months towards invisibility. Even if lettering is inscribed in durable substances, there is no guarantee that it will be legible to future audiences. Today perhaps a thousand people in the world can understand cuneiform.

Those in charge of the burial chambers at Onkalo are largely unconcerned about how to communicate warnings to future generations. They know that, at their latitude, the forest will soon begin to grow over abandoned land, concealing the above-ground presence of the site. They know too that once the forest has grown it will not be long, in terms of Earth time, until the glaciers return to this region. They know that the passage of the ice will smooth out all signs of what has been done here, placing the whole terrain under erasure.

We reach the lowest point of Onkalo. An arched side tunnel leads off the terminal chamber. The tunnel's floor is flat and screeded. Sunk into that floor are two cored-out cylindrical spaces. These are burial holes awaiting their bodies. Each hole is eight feet deep and five feet in circumference, protected by a circular yellow guard-rail.

At the tunnel's mouth sit a grey melamine table and a brown plastic chair. Until the lethal canisters arrive this is a workplace, and as in all workplaces there are forms that require filling in and legs that need resting.

A series of brown plastic panels are bolted to the side of the

### *Haunting*

Buried directly below the information chamber will be a 'Storage Room'. This room will have four small entrances, each secured by a sliding stone door. In the room will be messages of warning cut into stone and simply phrased:

*We are going to tell you what lies underground, why you should not disturb this place, and what may happen if you do.*

*This site was known as the WIPP (Waste Isolation Pilot Plant Site) when it was closed in 2038 AD.*

*The waste was generated during the manufacture of nuclear weapons, also called atomic bombs.*

*We believe that we have an obligation to protect future generations from the hazards that we have created.*

*This message is a warning about danger.*

*We urge you to keep the room intact and buried.*

That configuration of berm, map, Hot Cell, information chamber and buried Storage Room – all set atop the casks of pulsing radioactive molecules entombed deep in the Permian strata – seems to me our purest Anthropocene architecture yet, and the greatest grave that we have so far sunk into the underland. Those repeated incantations – pitched somewhere between confession and caution – seem to me our most perfected Anthropocene text, our blackest mass.

But I know also that even those words will decay over the course of deep time – blasted from the stone by desert wind, eaten from it by atmospheric moisture, or lost in translation. For language has its half-life too, its decay chain. The written history of humanity is only

tunnel, and on them an unknown finger has sketched pictures in the stone dust that clings to the plastic. There are three panels. On the left-hand panel the finger has drawn a landscape with a storm, a tree, a house. On the centre panel, a rabbit sitting on a cloud. On the right-hand panel is a human face with a crinkled smile.

The belly of Onkalo is not the deepest place that I have been during the years of underland travel, but it seems at this point the darkest. I have a strong sense of the weight of time above and around us, bearing down on veins and tissue.

Far above us, waves crash eastwards through the Gulf of Bothnia, the sea shifts under its cracked jacket of ice, a multinational workforce prepares a turbine housing to receive the largest blades ever fitted in a nuclear power station, the sun swings over a shattered Syria, atmospheric CO<sub>2</sub> increases its parts per million and the Knud Rasmussen glacier hastens its calving into the fjord.

It all feels very distant, the busyness of another planet.

'There was a joke among the designers and engineers at Onkalo during the early years of its construction,' says Pasi abruptly, rapping the stone with his knuckles, 'that as they began drilling and blasting, the first thing they would uncover would be a copper canister, containing spent fuel rods . . .'

I think with a jolt of the *Kalevala*, with the powerful Sampo grinding out its epochal changes, with its embedded warnings from centuries ago about the dangers of disinterring from below ground, about the need for copper to insulate from harm, and about the dreadful disease that will ravage air, water and all life if it is brought in untimely fashion to the surface.

I think of Sebeok's 'atomic priesthood' charged with conveying warnings across generations in the form of folklore and myth. I think of the last line of the poem pinned on the tin sheet above the

sinkhole into which people had been clubbed and pushed and bayoneted up in the Slovenian beech woods. *A curse be upon anyone who might attempt to erase this record* . . . I have a swift, chilling sense of the *Kalevala* as part of a messaging system, the warnings of which we have not heeded or even heard.

The stillness of the stone around is now crushing. I remember being in the bedding plane in the Mendips with Sean, the pressure exerted by the unmoving black stone. Other memories arrive, from further back, rising unbidden in my mind. I am with my father, using the claw of a hammer to prise up the floorboard of the house in which I grew up, in order to lodge a time capsule in a jam jar there. What did we put in the jar? A little die-cast aeroplane, a bomber? Yes. A letter to an unknown future recipient. Rice to absorb moisture and prevent the perishing of paper and ink. A Polaroid photograph of me and my brother. Is that right? At this distance, details have decayed. I can only clearly recall the fact of placing the jar — fat jar, thin mouth, brass lid — and nailing down the floorboard above it. Gone. Safe. A message to the future.

Time begins to fission into overlapping shadow-times. Burial thoughts from the underland crowd in. Neil Moss, his body still there in the shaft in the Peak District, entombed in concrete to prevent future harm to others. The Mesolithic bodies in the Mendips, chrysalized by calcite, *almost converted into stone* . . . My father's wish that his ashes be scattered to the winds in three places, so that in this way there is no grave to which we will be tied after his death, and the medium of his remembrance will be an atmosphere, a skein of associations.

I sit down, tired, on the brown plastic chair at the end of the world. Pasi is still in the side tunnel, talking to a worker. I imagine walking down and around a corner in the main tunnel, where it turns

out of sight of Pasi. In the right-hand wall of the tunnel are three boreholes, each about the diameter of my shoulder. I imagine reaching as far as I can into the middle borehole, and I imagine that when I retrieve my arm a weight has been lifted from me and a promise has been kept.

Once the canisters of waste have been deposited in Onkalo and all the reception cylinders are replete, the spiralling access ramp will be backfilled, the ventilation shafts will be backfilled, the lift shaft will be backfilled and at last the mouth of the tunnel entrance will be backfilled – 2 million tons of bedrock and bentonite, sealing those canisters in place, keeping the future safe from the present.

Then I see that on another of the plastic panels bolted to the wall of the terminal chamber there is a handprint in the dust: spread fingers, the pad of the thumb pressed clear. It is the print of a right hand, left there at some point for the keeping of balance, for the taking of rest – or just for the making of a mark.

I think of the black and red hand-prints left on the cave walls at Chauvet, of the red figures of the dancers with their outstretched arms, of the spray-can hand stencil on the catacomb wall in Paris, of Helen reaching a hand down to haul me out of the moulin. I think of the many people I have encountered in and through the underland who have been committed to shared human work rather than retreat and isolation. Many of them have been mappers, really, of networks of mutual relation, endeavouring to stitch their thinking into unfamiliar scales of time and space, seeking not the scattered jewels of personal epiphany but rather to enlarge the possible means by which people might move and think together across landscapes, in responsible knowledge of deep past, deep future and the inhuman earth.

Suddenly, surprisingly, there is something hopeful – no, something *moving* – about this mundanely functional space I have

reached. The melamine desk and the moulded chair. The plastic panels with their doodled art. Pasi's passion for Onkalo. The copper canisters, the visitors' centre, Einstein's drooping moustache. Here a vast problem is being solved, gradually and practically, by a community of people to the best of their abilities. Here the hard labour of collective decision-taking and world-making is being carried out, imperfectly but necessarily, and with a care that extends not only for a decade or a generation but far forwards into a post-human future.

Maybe this is among the best things we can try to do, I think, as the Sampo grinds through the world's epochs: to be good ancestors. I remember a paragraph I have copied out into a notebook, from a book called *After Nature*:

People are best able to change their ways when they find two things at once in nature: something to fear, a threat they must avoid, and also something to love, a quality . . . which they can do their best to honour. Either impulse can stay the human hand, but the first stops it just short of being burnt or broken. The second keeps the hand poised, extended in greeting or in an offer of peace. This gesture is the beginning of collaboration, among people but beyond us, in building our next home.

When we return to the surface the wind has eased but the snowfall has strengthened. Dusk is coming. All sight is through fading grey light. Mid-afternoon and already the day is over.

Back over the bridge from the island. Salt marsh at either side of the bridge. The sea in shattered pieces. A blue letter-box on a white pole. Boulders big as houses among the pines, between the birches.

### *Haunting*

My headlights making tunnels in the dusk ahead. Birches, pines, birches, birches. Everything frozen.

On the way back to Rauma a yellow dashboard warning light pings on. The back right tyre is losing pressure. I can feel the car's grip on the icy road starting to loosen. I pull over, crunch to a halt, get out. The tyre is almost flat. Deep forest runs to right and left of the road. The car detects the air temperature to be  $-12^{\circ}\text{C}$ . I am getting cold fast. I don't have enough warm clothes with me. I look in the boot. There is a spare tyre but no jack. This is not a good situation. I do not know what to do.

Five minutes later I see the headlights of an approaching vehicle, the first to pass. I stand by my car and raise a hand into the air, asking for help, not expecting to receive it. But the car pulls over, and a man gets out. I explain the situation, my helplessness, that I was driving back from the island when it happened. He says he is a worker from Olkiluoto on his way home after finishing a shift.

'I'm sorry. You must be tired,' I say. 'Thank you for stopping.'

'It is just no problem,' he says.

He has a jack. Ten minutes later he has changed the tyre and stowed the flat in the boot. He cleans the oil and grease from his fingers with a cloth. Then he puts out a hand, I shake it in gratitude, and we drive off one after the other into the darkness.