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## **Deep Geological Disposal and Radioactive Time:**

### **Beckett, Bowen, Nirex and Onkalo**

**Adam Piette**

This paper will consider nuclear futurity and long-term radioactive half-life and decay as timescales of continuity that are figured in eerie and apocalyptic ways not only in fictions that engage with nuclear anxiety during the Cold War (I will use Elizabeth Bowen and Samuel Beckett as case studies) but also in the engineering projects that deal with the inconceivably long aftermath risks in deep underground nuclear waste disposal. In particular, I will be comparing Gunther Anders' 1962 'Theses for an Atomic Age' with late 1980s Nirex reports into the suitability of storing highly radioactive waste in deep boreholes, and using other pairings of literary/cultural speculation with actual storage facility technologies to explore the deep time of nuclear waste continuities beyond the Cold War. The chapter will first explore the bunker mentality of the high Cold War, using Virilio's *Bunker Archaeology* as well as anecdotal evidence proving the relation between family nuclear shelters and the underground systems of the nuclear state. This entombed refuge technology is set against the work of geologist J. Laurence Kulp, who developed radioactive isotope dating of extremely ancient rock formations, and in doing so stumbled on the radioactive effect of the tests in the nuclear South-West; which led to the crucial Project Sunshine which uncovered the dangers of fallout linked to tests at proving grounds and in the atmosphere. Project Sunshine not only effectively led to the test ban treaty of 1963, but also consolidated in the public imagination the link

between deep geological time, radioactivity, and underground secret tomb/refuge systems. These connections can be traced in two 1964 texts, Beckett's 'All Strange Away,' which features a tight tomb space where the human is figured as waste, and Bowen's *The Little Girls* which features an obsessive burying of expressive objects as time capsule speaking to a deep future time. The texts are drawn into the force field, then, of later Cold War debates about how to deal with radioactive waste from the nuclear industry, specifically Swedish research that used deep time geological comparisons to illustrate what might happen to the buried world of nuclear waste repositories in the equally deep futurity of half-life timescales. The article then looks at a British example, with Windscale/Sellafield research done by Nirex (the Nuclear Industry Radioactive Waste Executive) which tried to convince the world that waste could be disposed of deep underground in the local area – research which was successfully challenged by environmental activists. The article ends with a theoretical and philosophical meditation on the contemporary nuclear repository, using all the information and accrued relations from Anders, through Beckett, Virilio, Bowen and Kulp to present day waste depository R&D.

From the very origins of research into radioactive materials, an uncanny correlation was fostered between geological depths, long timescales and death. In 1908, Bertram Boltwood (the first scientist to measure the age of rocks using the decay of uranium) had struggled to split uranium into its radioactive constituents. He had managed to refine a kilo of pure uranium salt, had sealed it in a bottle, but wrote to Ernest Rutherford of the difficulties:

I am considering the possibility of excavating a sepulcher and publicly

entombing this uranium with the hope that some scientist of future generation may examine it and solve the mystery of the birth of actinium.<sup>1</sup>

Boltwood's fiction of a radioactive sepulcher projects the deep time of uranium (he had the year before dated the earth to a staggering 2.2 billion years using the presence of lead as half-life clock) into the future as both tomb and epistemological revelation. The link between half-life timescales, geological deposits and futurity is figured in eerie and apocalyptic ways not only in fictions that engage with nuclear anxiety during the Cold War (Elizabeth Bowen and Samuel Beckett ) but also in the engineering projects that deal with the inconceivably long aftermath risks in deep underground nuclear waste disposal. From Gunther Anders' 1962 'Theses for an Atomic Age' to projects such as the late 1980s Nirex reports into the suitability of storing highly radioactive waste in deep boreholes, nuclear futurity presents itself as a dream of long-term radioactive half-life and decay within timescale structures materialized as tombs and sepulchers beyond human time.

In Cold War contexts, the fiction of the uranium tomb is filtered through the more general underground consciousness of the nuclear age. In 1948, the first Civil Defence planning office was set up and the Munitions Board were surveying caves and abandoned mines as possible storage spaces. A source told the *New Yorker* "People have to be educated. They've got to become

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<sup>1</sup> Quoted in Lawrence Badash, *Radioactivity in America and Decay of a Science* (Baltimore: Johns Hopkins University Press 1979), p. 173.

underground-conscious'.<sup>2</sup> That underground consciousness was both a powerful presence in the folk imaginary and a very real material fact about the nuclear state. As early as 1949, nuclear fictions surveyed by David Seed featured family shelters, as in William Genn's 'Generation of Noah' which features a bullying father drilling his six-year-old to run to the shelter within three minutes of the warning. These fantasy fears are being generated by fear of the Bomb:

underground is the only place to hide after Hiroshima. Yet the earth is shadowed by nuclear death. In Tenn's story, the boy has to repeat a mantra that imagines his head burning and the earth stained by the dark spot, his nuclear shadow.<sup>3</sup>

The family shelters were constructed on lines imitating the material reality of the national security state's underground facilities. Huge caves were carved out of rock by the Federal Emergency Management Agency (FEMA) from the 1950s on, such as the Mount Weather complex near Bluemont, northern Virginia. The mountain contains a lake, ponds and water tanks, sewage plant, hospital, cafeteria, streets and sidewalks, generating plant, living quarters, studios, communication systems, electric cars.<sup>4</sup> Robert Heinlein built his family shelter in Colorado Springs in 1961 close to the massive North American Aerospace Defense Command (NORAD) underground complex (Seed, p. 130). The underground complexes were associated not only as spaces protective from

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<sup>2</sup> Quoted David Seed, 'The Debate over Nuclear Refuge', *Cold War History* 4:1 (2003): 117-142 (p. 118)

<sup>3</sup> Seed, 'The Debate over Nuclear Refuge', p. 124.

<sup>4</sup> Richard Sauder, *Underground Bases and Tunnels: What Is the Government Trying to Hide?* (Kempton, Illinois: Adventures Unlimited Press, 1995), p. 50.

nuclear attack, but also as storage and launch systems for nuclear weapons, and as zones for tests: the missile silos (like the Minuteman silos at Great Falls, Montana)<sup>5</sup>, the underground testing zones (for instance, the detonation of nuclear devices in Area 12 in Nevada – tunnels under Rainier Mesa – from 1957 on), and as waste storage facilities. For example, Asse II, an abandoned salt mine beneath field and forests near Brunswick, Germany, was turned into a temporary store for hundreds of thousands of drums of radioactive waste in the 1960s and 1970s. In 1988, groundwater began to seep through the walls of the mines, heralding an environmental disaster. As Amanda Mascarelli reported:

Each week, hundreds of litres of brine entering the chambers are collected and stored with the drums of waste, and the mine's structure is becoming unstable. So a decision had to be made: should engineers backfill the chambers, abandon the mine and leave the waste there in perpetuity, or should they remove it all? Both options are risky. Removing the waste will be complex, take decades and expose workers to radioactivity. If the waste stays and the mine eventually floods, groundwater may become contaminated, potentially exposing those living nearby to deadly radioactive particles.<sup>6</sup>

All of the underground complexes become toxic to the Cold War imaginary after

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<sup>5</sup> 'The Air Force Underground', *Harpers Magazine* (May 1962), pp. 169-72.

<sup>6</sup> Amanda Mascarelli, 'Waste away: tackling nuclear power's unwanted legacy', *New Scientist* 220. 2941 (2 November 2013), 42-45 (p. 42)

such knowledge: as though the Cold War as a military-industrial force and set of technologies were itself radioactive, concealed beneath culture as covert contaminant. These complexes gave material shape and form to the psychological complexes governing nuclear underground consciousness in the Cold War.

That underground consciousness can be brought into relation to Paul Virilio's theorizing of bunker mentality in his 1958 *Bunker Archaeology*. Within the monumental bunker, the subject experiences a 'crushing feeling': 'the visitor in this perilous place is beset with a singular heaviness.'<sup>7</sup> The bunker is a survival machine, like a crypt where the nuclear subject awaits resurrection, an 'ark that saves' (Virilio, *Bunker Archaeology*, p. 46). As such, the bunker resembles ancient underground burial sites, ancient Egyptian or Etruscan tombs. The dream of the crypt-like tomb beset Virilio since childhood experiences during the Second World War. The war had left him with an aftermath desire to 'uncover the geostrategic and geopolitical foundation of total war I had lived through as a young boy in Nantes, not far from the submarine base of Saint-Nazaire'.<sup>8</sup> The U-boat pen at Saint-Nazaire is a massive concrete structure with gaping cave-like openings to the sea and clearly shaped Virilio's haunted sense of the concrete bunker. For Virilio, the bunker is, as John Beck has argued, a 'myth, present and absent at the same time; present as an object of disgust instead of a transparent

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<sup>7</sup> *Bunker Archaeology* (Princeton: Princeton University Press, 1994), p. 16. The text was written in 1958 though only published in *Architecture principe* in 1966.

<sup>8</sup> Paul Virilio and Claude Parent (eds.) *Architecture Principe* (Besancon: L' imprimeur, 1996), p. 11.

and open civilian architecture; absent insofar as the essence of the new fortress is elsewhere, underfoot, invisible from here on in.' Its visibility 'asserts the invisibility of power's current location'.<sup>9</sup> The underground fortress as signifying invisible power evolves in his postwar imagination into a form of fallout shelter, especially as the bunker church Saint-Bernadette du Banlay he designed with Claude Parent in 1966.<sup>10</sup> The occupant of the bunker fallout shelter is encapsulated, like the astronaut Virilio theorizes in *Open Sky*, within cosmic or deep time, 'cut off from local time [...] victim of an unprecedented inertia'.<sup>11</sup> The bunkered subject is, paradoxically, 'already in the grips of that cadaveric rigidity from which the shelter was designed to protect him' (*Bunker Archaeology*, p. 16).

Virilio's powerful imagining of the fallout shelter as concrete capsule moves beyond Second World War and Cold War coordinates and places the bunker within deep time in ways that chime with the history of the dating of the earth since Boltwood. 20th century technologies developed to work out the age of the earth centred on isotope geochemistry. The decay of radioactive elements could give a measure of the extraordinary timescales of rock formation and age. The key figure was J. Laurence Kulp who helped develop radiometric dating in the 1950s at Lamont Geological Observatory at Columbia. He specialized in nuclear geochronology, that is the use of isotopic geochronometers (Potassium-

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<sup>9</sup> *The Virilio Dictionary*, edited John Armitage (Edinburgh: Edinburgh University Press, 2013), p. 41.

<sup>10</sup> 'more in common with the fallout shelter than the military bunker' (*Virilio Dictionary*, p. 48).

<sup>11</sup> *Open Sky* (London: Verso, 1997), p. 128.



argon, Rubidium-strontium, Uranium-lead and radiocarbon) to date the earth.<sup>12</sup> The half-lives of the isotopes as they decayed to stable daughters ranged from between 5 and 6 thousand years (Carbon-14) to 50 billion years (beta decay of rubidium-87 to strontium-87). Kulp also introduced radiocarbon dating to Columbia, having spent time with Willard Libby learning the technique. It was during his time carbon-dating samples at Lamont that his team discovered that the Nevada tests were screwing up the results all the way over in New York. Both Libby and Kulp had worked on the Manhattan Project during the war, and the AEC was funding most of the geophysical and geochemical projects. The discovery of the impact of nuclear testing on New York confirmed the terrifying spread and scope of fallout. Both Libby and Kulp led the secret AEC investigation into the fallout effects of the tests, called Project Sunshine. This began as a classified project, but the two scientists convinced the AEC that the investigation had to go public. Their discovery of the damage caused, most spectacularly the Strontium-90 contamination of the food chain, caused the worldwide protests which were eventually to lead to the atmospheric test ban in 1963. So from the start of the Cold War and into the high Cold War of the 1950s and early 1960s there was this link between deep geological time and nuclear fallout damage to the human body. The same element used to determine the oldest rocks, Strontium (in its isotope 87 form) turned out to be the key radioactive element contaminating the world population with the H-bomb tests (as the unstable

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<sup>12</sup> cf. Kulp's 1961 article 'Geologic Time Scale', *Science* Vol. 133, No. 3459 (Apr. 14, 1961), pp. 1105-1114.

isotope 90 created by fission – substituting for calcium in bone).

The cadaveric deep time of the fallout shelter sketched by Virilio connects, then, to the eerie correlation between the technology capturing geological time scales and the fallout of the Nevada tests. The deep time of the earth dated by radioactive elements and their half-life decay links as if by chain reaction to the sequence of fission, fallout, contamination and the killing of the nuclear subject. Geological timescales map on to the terminal time of the nuclear, As Gunther Anders argued in his 1960 ‘Theses for an Atomic Age’, nuclear time defines the age ‘even if it should last forever, [as] ‘The Last Age’: for there is no possibility that its *differentia specifica*, the possibility of our self-extinction, can ever end – but by the end itself.’<sup>13</sup> For Anders, nuclear politics surrendered responsibility to ‘machines and instruments’: ‘These have become, so to speak, “incarnated” or “reified actions”. [...] Since we have shifted our activities and responsibilities to the system of our products, we believe ourselves able to keep our hands clean’ (503). Nuclear technology, in other words, wrested from the earth’s geology and turned into a death machine, imposes the last age upon that same earth, a terminal futurity that is at once without limit (‘even if it should last forever’) and absolutely the final terminus (‘the end itself’), beyond human control.

Nuclear fictions written in thrall to the Last Age reimagine the sensed relations between earth, death and radioactive encapsulation. Beckett in 1949 explored modern art as an act of ‘mourning of the object’; and registered, in the

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<sup>13</sup> Gunther Anders, ‘Theses for an Atomic Age’, *The Massachusetts Review*, Vol. 3, No. 3 (Spring, 1962), 493-505 (p. 493).

work of Bram Van Velde in particular, the spatialization of that act of mourning as an entombing of the subject: 'burial within the unique, in a place of impenetrable proximities, cell painted on the cell wall, an art of incarceration'.<sup>14</sup> The buried subject in Van Velde, is 'a being apart, imprisoned and turned in for ever upon himself, without traces, without air, Cyclopean' (136).<sup>15</sup> The massive stonework of Mycenaean fortification systems enclose the buried subject as in an airless tomb, walled in by the artwork itself; carceral art that represents the cell as if it were the wall in a display of deadening self-reflexivity. Mária Minich Brewer has related Beckett's figure of burial in this essay to the nuclear telos,<sup>16</sup> and evidence for this is traceable to the fictions he was writing in the years of fallout from atmospheric testing, 1958-1963. 'All Strange Away', published in 1964, imagines the carceral space as a cube entombing the subject:

Hollow cube three foot overall, no way in imagined yet, none out. Black cold any length, then light slow up to full glare say ten seconds still and hot glare

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<sup>14</sup> Beckett's essay "Les Peintres de l'empêchement," (1949): 'l'ensevelissement dans l'unique, dans un lieu d'impénétrables proximités, cellule peinte sur la pierre de la cellule, art d'incarcération' (*Disjecta: Miscellaneous Writings and a Dramatic Fragment*, ed. Ruby Cohn (London: John Calder, 1983), 133-37 (p. 136).)

<sup>15</sup> 'un être écarté, enfermé et rentré pour toujours en lui-même, sans traces, sans air, cyclopéen'

<sup>16</sup> Mária Minich Brewer, 'Postmodern Narrative and the Nuclear Telos', *boundary 2*, 15. 1/2 (Autumn, 1986 - Winter, 1987), pp. 153-170.

any length all ivory white all six planes no shadow, then down through deepening greys and gone, so on. Walls and ceiling flaking plaster or suchlike, floor like bleached dirt, aha, something there, leave it for the moment. Call floor angles deasil a, b, c and d and in here Emma lying on her left side, arse to knees along diagonal db with arse towards d and knees towards b though neither at either because too short and waste space here too some reason yet to be imagined.<sup>17</sup>

The cube incarcerates Emma at the same time as it subjects her to 'hot glare'. That glare reveals the 'waste space' that surrounds the cadaveric subject, meaning the space unoccupied by the dying/dead body. Emma is wasted by the space; she is the space's waste product too, at once a prison and tomb of impenetrable proximities. The alliance of hot glare and waste presents the cube as potentially readable as radioactive, as containing nuclear waste that contaminates the human within the cube's terminal deep time ('hot glare any length [of time]'). As John Beck has argued about radiation and time:

While nuclear war promises to end time, radiation lasts a long time, and the dilemma of how to imagine the persistence of contaminated matter surviving intact for thousands of years is barely more manageable than conceiving the devastation of nuclear war itself. The intervention of nuclear energy not only introduces the reality of there being no future, it also

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<sup>17</sup> *The Complete Short Prose* (New York: Grove, 1995), p. 173.

delivers an irreversible future of waste.<sup>18</sup>

Beckett's cube is a 'waste space' that contains contaminated matter figured as the cadaveric subject caught in deep time, subject to the 'hot glare' of radiation.

The same year as 'All Strange Away' and also written in the wake of Project Sunshine's revelations, Elizabeth Bowen's *The Little Girls*, opens with Dinah in a cave down in a bear pit hole in the grounds of big house, preparing to seal into the cave a box of 'expressive objects'. For Dinah, the time capsule she is creating is aimed to project into the far future: "It's for someone or other to come upon in the far future, when practically nothing about any of us – you or me, for instance – would be otherwise known. We're putting these things in here to be deduced from".<sup>19</sup> The expressive objects speak to the future beyond humankind ("I'm looking ahead to when we are a vanished race" (9)), acting as potential clues to reconstruct us from. The cave will be sealed by the nuclear blast, and it constitutes an underground sepulcher that is also a museum capturing the bunker mentality within the deep time of futurity, imagining an impossible posthuman future. The 'expressive objects' are remnants of current commodities fetishized by the nuclear generation, tokens of "really raging peculiarity"<sup>20</sup> that counter nuclear time with objects that somehow speak of

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<sup>18</sup> John Beck, *Dirty Wars: Landscape, Power and Waste in Western American Literature* (Lincoln: Nebraska University Press, 2009), p. 179.

<sup>19</sup> Elizabeth Bowen, *The Little Girls* (London: Jonathan Cape, 1964), p. 9.

<sup>20</sup> "What really expresses people? The things, I'm sure, that they have obsessions about: keep on wearing or using, or fuss when they lose, or can't go to sleep

human timescales. Dinah's time capsule sepulcher is itself bound into expression of her own lifetime, since the act of anti-nuclear preservation repeats a childhood gesture. As a girl, she and two friends had buried a box during the First World War inscribed with this message to the future, written in blood: '*We are dead, and all our fathers and mothers. You who find this, Take Care. These are our valuable treasures, and our fetters*' (134). The box contains expressive objects and also a special object (each girl's 'secret thing'). When this specific object is put in the box, the others must stop their ears in the dark. The box is then sealed up with wax that takes the imprint of their thumbs. Dinah tracks down her friends as the novel progresses and they join forces to open the box – extraordinarily it contains *nothing*, as though looted, or as though the human time the girls had sent into the future has vaporized along with the history of the twentieth century. That destruction is nevertheless countered by the girls meeting as women, however: and they reconstruct the lost time within a renewal and re-presentation of the past destroyed by war.

The melancholy nature of Bowen's pondering of nuclear time and the history of our affections within the deep timescales of the terminal Last Age is figured not only in the empty box but also in the strange space of the cavern. Nuclear blast will seal it up at the end time: and that fact makes the underground space a zone of nuclear melancholia: 'perhaps you're right about that cave; one does get forlorn down there, though without noticing' (15). The pressure of deep time occupies the zone too:

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without. You know, a person's only a person when they have some really raging peculiarity" (10)

Only round noon did sun strike the circular pit's floor. It now was within an hour or so of sunset – unpent, brilliant after the rainstorm, long rays lay over the garden overhead, making wetness glitter, setting afire September dahlias and roses. Down here, however, it was some other hour – peculiar, perhaps no hour at all. (5)

The 'other hour' of nuclear time is, I would suggest, the deep time of the cavern's geological strata projected onto the unimaginable terminal future of apocalypse, as though connecting the sepulchral archaeology of the human (expressive objects as waste products of human days) to the radioactive half-life timescales both within the earth and stretching forward to Anders' 'end itself'.

The sepulchral connection of waste space to deep nuclear time maps on strangely to the research into nuclear waste depositories from the Cold War to the present day. Much of the work sets out to track 'radionuclide migration', ie the spread of radioactive material, within depositories, over timescales stretching many centuries into the future. As one study puts it, they seek to test 'radionuclide transport models spanning geological timescales'.<sup>21</sup> One important study in 1984, sponsored by Svensk Kärnbränslehantering Ab (Swedish Nuclear Fuel and Waste Management Co, aka SKBF/SKB) and the Swiss company Nagra Baden, explored the potential for natural analogues in working out what might

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<sup>21</sup> M. Ivanovich, 'Aspects of Uranium/Thorium Series Disequilibrium

Applications to Radionuclide Migration Studies', *Radiochimica Acta* 52-53. 1 (Jan 1991): 237-68 (p. 237).

happen to the radioactive waste in the depositories over time: effectively mapping what has happened naturally to radioactive material in the earth since the beginning of terrestrial time onto the nuclear future of the depository's timescales. The technical report used isotopic methods, such as uranium-series disequilibrium measurements, in order to determine 'the behavior of the isotopes of uranium and their radioactive daughters [...] within a time-scale encompassing the last million years or more.'<sup>22</sup> The depository for this system comprises a series of cylindrical capsules containing the waste within canisters embedded in bentonite and concealed within the host rock at great depths within the earth. Trying to imagine the ways 'redox' (combined reduction and oxidization) works over these unimaginably long timescales involves calculating the slow release of the radionuclides 'from the waste matrix' over  $10^5$  to  $10^6$  years (p. 7). To calculate rates of matrix diffusion,<sup>23</sup> for instance, the scientists seek out, therefore, naturally occurring ore samples 'from the edge of a water-conducting fracture surface out into a host crystalline rock' (82). Of particular importance to the waste depository team was the natural reactor at Oklo, Gabon: two billion years ago, it went critical and generated huge amounts of energy for 500,000 years, producing 10 tonnes of fission products 'identical to the fission

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<sup>22</sup> Neil A Chapman, Ian G McKinley, John A T Smellie, 'The potential of natural analogues in assessing systems for deep disposal of high-level radioactive waste', (Stockholm, Sweden August 1984) –

<http://193.235.25.3/upload/publications/pdf/TR84-16webb.pdf>

<sup>23</sup> Matrix diffusion is transfer of solutes from the main groundwater conduits to the surrounding rock matrix by means of diffusion



products from man-made nuclear reactors' (45). The waste depository with its fission products, its radionuclides and the unimaginably long and slow timescales of their diffusion and decay, are made to seem as natural as the earth's own geological billions of years of history and events. The research not only naturalizes nuclear technology; crucially, it also directly maps geological timescales onto nuclear waste futurity in ways comparable to those imagined in the nuclear fictions. Beckett's cube and Bowen's cave find material reality in the deep systems designed by SKBF/SKB and Nagra Baden: like them, the deep waste depository encapsulates waste space that deploys geological timescales into a future beyond species, a fusion of technology and geology designed to survive and persist beyond biology, a transcendental waste space within mineral rock environment and bentonite sepulchre.

The deep waste depository does not go uncontested, however. Just as the nuclear cave is countered by the memory-time of the women in *The Little Girls*, and just as the cube houses a still dreaming human subject that complicates the posthuman project in the Beckett story, so too does the technology of nuclear waste sepulchre meet resistance in the public sphere. In the 1980s, the UK nuclear industry set up a body to explore the possibility of deep geological disposal of nuclear waste. Originally known as Nuclear Industry Radioactive Waste Executive, it was renamed United Kingdom Nirex Limited in 1985. In 1989, work began on two possible sites to take both intermediate and low-level waste: near Dounreay in Caithness and near Sellafield in Cumbria. Nirex planned to build a 'Rock Characterisation Facility' or RCF at Sellafield in 1992, defined by Katherine Bickerstaff in a paper on the controversy, as 'an underground

laboratory to investigate the detailed properties of the potential host rock'.<sup>24</sup>

Planning permission was denied by Cumbria County Council, and Nirex appealed and it was at the Public Inquiry that ensued that more concerted opposition was brought to bear. Friends of the Earth and Greenpeace helped the Council challenge the scientific evidence put forward by Nirex. Friends of the Earth (FOE) argued that the RCF (sited near Gosforth and Sellafield) was a stalking horse for a fully fledged deep waste repository. It also successfully argued that the RCF proposal was scientifically flawed and that Nirex's scientific knowledge was insufficient to prove that disposal was safe for any site. In 1997, following the five-month local planning inquiry, the Secretary of State for the Environment, John Gummer, rejected Nirex's case, stating that he was 'concerned about the scientific uncertainties and technical deficiencies in the proposals presented by Nirex [and] about the process of site selection and the broader issue of the scope and adequacy of the environmental statement'.<sup>25</sup>

Looking a little closer at the Nirex research and its contestation brings out the timescale perils of deep waste disposal. Nirex's siting decisions rested on a longer history of research into the Sellafield area. A 1980 study by the Institute of Geological Sciences had already explored the possibility of a underground radioactive waste repository at Sellafield: exploring Sellafield's local geology, the west Cumbrian coastal plain, sedimentary rocks resting on older, volcanic rocks

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<sup>24</sup> Karen Bickerstaff, "Because we've got history here": Nuclear Waste, Cooperative Siting, and the Relational Geography of a Complex Issue', *Environment and Planning A* 44 (2012), 2611–28 (p. 2615).

<sup>25</sup> Quoted Bickerstaff, p. 2615.

at nearly a kilometre underground; but the 'expected difficulty and cost of investigation and potential engineering and construction problems associated with developing a repository at such depths were considered to be unfavourable factors'.<sup>26</sup> NIREX's own study in 1989 identified a potentially suitable repository zone near Gosforth, and stated that:

studies in progress on the characterization of the surficial Quaternary deposits will contribute to an understanding of the latest geological history of the area and will provide inputs to regional hydrogeological modelling, assessment of possible neotectonic activity and palaeoseismicity for seismic hazard assessment and may help suggest the possible timing, magnitude and pattern of future changes in climate and relative sea-level.

(Quoted Michie & Bowden, p. 8)

Here we hear again the fusion of geological history and the 'timing' of the future of the Sellafield waste under pressure from the likely changes in the thousands of year ahead. The trouble was, the Nirex research was deeply flawed, and proved to be leaky at the Public Inquiry. The evidence given at the Inquiry is available online as a Nirex archive on the Friends of the Earth website.<sup>27</sup> Hydrogeology expert Dr Shaun Salmon's evidence, for instance, quoted a Nirex 1993 report:

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<sup>26</sup> U. McL. Michie and R. A. Bowden, 'UK NIREX Geological Investigations at Sellafield', *Proceedings of the Yorkshire Geological Society* 50.1 (1994), 5-9 (p. 5).

<sup>27</sup> <http://www.foe.co.uk/archive/nirex/>

The host geological environment is intended to provide a stable setting in which groundwater flow is predictable. The host environment should also provide a long pathway and travel time for transport of radionuclides to the Biosphere.

But he found the site chosen to be 'extensively faulted'; there was too much 'geological variability'; evidence regarding groundwater flow was inconclusive; considerable danger was generated by the fact that the groundwater in the geology is drawn *upwards* towards the Irish sea by a combination of environmental factors; Nirex's water-table approximation was crude; there were modelling problems (only in two dimensions, only steady-state, etc).

Furthermore, he noted that he was 'not aware of any firm commitment by Nirex to undertake three-dimensional, time variant modelling, even though it is a standard modelling technique'. In other words, Nirex had failed properly to imagine the full complexity of what would happen in deep time: its fusion of geological history (the 'host geological environment') and waste's futurity (the 'long pathway and travel time for transport of radionuclides to the Biosphere') was based on a flawed two-dimensional model without a *real* sense of the temporal variabilities involved.

FOE's campaign aimed to ensure that 'the radioactive legacy resulting from the use of nuclear power is managed and passed on to future generations in the least environmentally damaging way possible'. Despite such opposition, however, despite the eloquence of the arguments by environmental agencies against the dangers of the waste depository, construction of repositories is underway. Specifically, in Finland a vast network of tunnels more than 400

meters below ground is being built, the Onkalo Spent Fuel Depository. This deep geological repository for the final disposal of spent nuclear fuel is the first such repository in the world. It is currently under construction at the Olkiluoto Nuclear Power Plant in the municipality of Eurajoki, on the west coast of Finland, by the company Posiva, and its design is based on the KBS-3 method of nuclear waste burial developed in Sweden by Svensk Kärnbränslehantering AB (SKB), the company who had commissioned the research into natural analogues cited earlier. As Michael Madsen, the Danish filmmaker who made a 2009 documentary on Onkalo, *Into Eternity*, has argued:

The ONKALO project of creating the world's first final nuclear waste facility capable of lasting at least 100 000 years, transgresses both in construction and on a philosophical level all previous human endeavours. It represents something new. And as such I suspect it to be emblematic of our time – and in a strange way out of time, a unique vantage point for any documentary.<sup>28</sup>

All strange away and out of time, the Onkalo galleries hundreds of metres underground will be sealed once all of the disposal holes are filled with the cylindrical copper canisters containing the waste, calculated as the year 2130.<sup>29</sup>

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<sup>28</sup> Director's Note, *Into Eternity* website:

<http://www.intoeternitythemovie.com/synopsis/>

<sup>29</sup> John M. Deutch and Ernest J. Moniz, 'The Nuclear Option', *Scientific American* (September 2006), 76-83.

This will be a dead zone of deep time, a crypt of toxic futurity, the years creeping on beyond species to the last syllable of nuclear time, a waste space as much out of time on any human scale, locked into the infinitesimally slow processes of radionuclide migration, matrix diffusion, corrosion, waste-form dissolution and breakdown, sealed within the tomb of geological timescales.

If we take the examples of Nirex and Onkalo together, along with the thinking through implicit in nuclear fictions by Beckett, Bowen and others, and attempt to construct a working definition of the deep waste depository as it strikes the Cold War-inflected imaginary, we arrive at this potential summation: firstly, following Bowen, nuclear spent fuel acts as a form of message sent to the aftermath of the apocalypse, an expressive object aimed towards the deep geological future. The capsules of waste speak forwards to a time when we are a vanished race, presenting as our far future sepulchres, our treasures and our fetters, sealed with the spectral blood of the species. The questions are, still, about sealing, about how to seal, how long to seal, about the forlornness of all underground geological spacetime. The nuclear spent fuel is equivalent, following Anders, to *the end itself*, enclosed within the 'system of our products'-as-waste and will always signify as self-extinction of the species. The deep geological repository, following Beckett, is at once a tomb and a refuge, not for ourselves but for ourselves conceived merely as our systems' toxic waste, within a 'space of impenetrable proximities' as multi-barrier resistance to million year 'transport' and flow; so impenetrable, yet measured in creeping inches of proximate disaster. The boreholes and repositories reconfigure Beckett's hollow cube, with its full hot glare of radiation and bleached dirt of contaminant waste space, as posthuman toxic time capsule. The encapsulation contains the

irreversible future of waste; in an all strange away out-of-time, perhaps no hour at all. It is, too, following Virilio, a perilous place of crushing heaviness, a bunker as a form of survival machine, where what survives is radioactive half-life: expressing geological (more than geopolitical) absence of power (as the reactor that was): a religious site of refuge for refuse, saintly waste. The repository entombs and encapsulates its radiant occupant in the rods of deep time, cut off from local time, extra-worldly, atrophied, a single point where only repetition of itself is possible: representation of a cell on the cell wall here as 100,000 year half-life transmission of itself to itself. The depository persists within the contaminant spacetime of geological preservation and protection, preserving Cold Wartime in endless continuity. As such the underground nuclear waste complexes will always signify, through what one might call the Kulp effect, Project Sunshine's findings about the interrelation of radioactive decay and contamination of the food chain. Onkalo and Nirex are haunted by Asse II. Deep time, even where it stages impossible timescales beyond species, also signals deep toxicity within our own bodies, hot glare irradiating Emma's interiority – Onkalo's network of canisters and tunnels feature as our own insides, our own neural pathways, a literally posthuman futurity encapsulated deep within the imagination of the global citizens of the Continuity Cold War.