DAUGHTERS OF URANIUM MARY KAVANAGH

Peter C. van Wyck Reading the Remains

Directors' Foreword	24
Artist's Acknowledgments	33
Peter C. van Wyck Reading the Remains	45
Jayne Wilkinson A Radioactive Domestic	73
Christina Cuthbertson The Book Unbound	101
Lindsey V. Sharman Flu War Breath Cloud	133
Bibliography	154
List of Works in the Exhibitions	156
List of Images	157
Contributors' Biographies	158
Artist's Biography	159

Installation view, Southern Alberta Art Gallery, *Lead (Pb)*, 2019

Daughters of Uranium: Reading the Remains

Peter C. van Wyck Professor of Communication and Media Studies Concordia University Radioactivity is probably the most potent figure of metaphysics in our age.

Michael Marder¹

I felt my house shake—I suppose it was the bomb.

Georgia O'Keeffe²

After

In *Men in Dark Times*, Hannah Arendt writes "All sorrows can be borne if you put them into a story or tell a story about them." This, she continues, is because "story reveals the meaning of what otherwise would remain an unbearable sequence of happenings."³ If Arendt is correct about this, and I think she is, then Mary Kavanagh is a storyteller par excellence. And an archivist too, for story and archive share a deep and abiding kinship. In this sense, *Daughters of Uranium* is a *wunderkammer* for the nuclear age, gathering together an atomic archive, and the *ferment of something shared*. And yet none of what we see and hear in this exhibition is purely retrospective, none of it is allowed to exist purely in the past; as though we gaze upon these questions of atomic culture and exposure from the other side of the fence. As history. Indeed, we might say that Kavanagh's particular achievement in this case is her ability to blur the very possibility of neat distinctions between past and present in such a way that it troubles the very status of what it means to be "after."⁴ As Mariko Nagai quips at the conclusion of her *Irradiated Cities*, "We are still in the before the after."⁵ The not yet.

Uranium and its daughters, or perhaps her daughters.⁶ Such a complicated family romance and one that confounds the temporal civilities of the idea of afterward. Recall that the noun filiation is related to the Latin word *filia*: daughter. Recall too that U-238, the most abundant form of natural uranium, the isotope making up over 99% of all *in situ* uranium, is not fissile. That is, not capable of sustaining a nuclear reaction. Instead, it is said to be fertile. To make fertile U-238 into fissile material, it must procreate. Hence the breeder reactor. (Would it be overwrought to read a dark and unstable misogyny at work in all of this?) The sequence to bred fissionable plutonium is fairly straightforward. First of all, add a neutron to Uranium-238 to obtain Uranium-239. This particular uranium isotope has a very short half-life—twenty-three and a half minutes—and via beta decay, produces a daughter, Neptunium-239. This, in turn, decays—also producing beta particles—with a half-life of 2.3 days to produce its own extremely toxic and volatile daughter, Plutonium-239.⁷ Voila, uranium's daughters, or some of them at least.

Left to its own devices, however, uranium (U-238) follows a very different itinerary through an impossibly long sequence of birthings, eighteen filiations, daughters, in all—a kind of atomic parthenogenesis, driven by blind material compulsion. With afterlives (half-lives) ranging from minutes to millennia, through alpha and beta decay, it all meanders toward the stable heft of

elemental lead; a journey of unstable matter, the overall half-life of which approaches four and a half billion years; roughly the age of the planet.⁸ And along the way, of course, massive amounts of energy are produced.

Finality without end

A reckless analogy might be to suggest that we could say of uranium what surrealist André Breton (according to Walter Benjamin at least) said of art: that it is *vibrated by the reflexes of the future*;⁹ alive, that is, "to the reverberations of the future."¹⁰ Such matter leaves traces, imprints, images of itself in texts, in landscapes, in bodies of all kinds. Imprints, as though on a photographic plate.¹¹

This is what we see in one of the exhibition's vitrines, an archival and autobiographical material study. Traces and imprints. Yucca plant seed pods¹² from the desert of the White Sands Missile Range,¹³ family heirloom science books,¹⁴ and a tree fungus from Ontario.¹⁵ A rock sample of uranium, and uranium glass dishware.¹⁶ Red soil from Georgia O'Keeffe's New Mexico home¹⁷ with a tourist brochure from the Trinity site and blown chemistry-glass tubes filled with the breath of the artist.

Perhaps the question becomes: so, *just what* does *it mean, now, to be* after? As Jean-Luc Nancy notes in relation to the events in Fukushima,

Certain "afters" have the value of "that which succeeds," that which comes later on: that is the value we have given to the "post" prefix set next to, for instance, "modern," which designates the "after" of this "modern," which is itself conceived as an incessant "before," as the time that precedes itself, that anticipates its future ...¹⁸

But, he continues,

the "after" we are speaking of here stems on the contrary not from succession but from rupture, and less from anticipation than from suspense. ... It is an "after" that means: Is there an after? Is there anything that follows?¹⁹

Are we still headed somewhere?, he asks.

All of these afters, without closure. And not just the failure of narrative closure, unsettling though that is, but a failure of ontological closure. Strange loops these are: to be after something that is not in itself able to be completed; to be in the reign of a manner of finality without end. (Might the appropriate figure here be The Owl of Fukushima?)

But it is important, I think, to resist the urge to succumb to the critical and/or cynical seductions of a post-nuclear sublime. As Kavanagh's work so deftly demonstrates, we need a language larger than grief.²⁰

We come to these topics because it *isn't* over; we stay with this because it *can't* be over. Clearly, it didn't end with Nagasaki. Or Chernobyl. Or Fukushima. Thinking this to be true eclipses a lot. The war simply continued by other means, we might say, targeting, for the most part, bodies considered expendable, lands considered dispensable.

The principal authors of such nuclear practices (warfare, we might as well say) "are the United States (936 times), the former Soviet Union (715 times), France (192 times), the United Kingdom (44 times), and China (36 times)."²¹ These numbers are important; we should let these quantities matter.

And as Masahide Kato reminds us, the primary targets of this warfare ... "have invariably been the sovereign nations of Fourth World and Indigenous Peoples."²²

Today we are in the wake of nuclear wars against the "Marshall Islands (66 times), French Polynesia (175 times), Australian Aborigines (9 times), *Newe Sogobia* (the Western Shoshone Nation) (814 times), the Christmas Islands (24 times), Hawaii (Kalama Island, also known as Johnston Island) (12 times), the Republic of Kazakhstan (467 times), and Uighur (Xinjian Province, China) (36 times)."²³

Derivations

Kavanagh's work draws us toward an understanding of human entanglements with the earth that directs our attention not toward the past in obsessively seeking to place a spike or mark a calendar—the project of a brooding Anthropocene—but toward an understanding of the past as a record or archive of prior media, prior mediations—potentialities, shimmers²⁴ maybe—that are always and already at work in the present.²⁵

In the case of nuclear materials—materials made possible, that is, actual, at least partially through the deep infiltration of matter by the nearly infinite contingencies and entanglements of calculated human practice—these prior mediations stake a claim on the future as well, involving the present within the dizzying and strange ethical loops of causality and contingency.

We might imagine an arbitrary and discontinuous line of derivation ...

There is no plutonium without uranium—pitchblende—used initially for producing coloured glass and glaze for ceramics. And there can be no project at all without ready sources of uranium, which, by luck, had been an almost worthless by-product of the production of radium. And there can be no supply of fissionable uranium without technologies of enrichment and the ability to identify, breed and separate isotopes. And there can be no functioning nuclear pile without a considerable amount of mathematical, chemical and physical knowledge, experimentation, conjecture, and harmonic leaps of brilliance, all propped up by a myriad of epistemic pathways, institutions, charismatic individuals, laboratories, matters, and scientific diasporas leading back to the mid-nineteenth century. And there can be no war machine without simultaneous advances in aviation, transportation, refinement, trade, multinational cooperation, and inevitably, the ongoing and intensified colonial occupation of Indigenous lands configured as resource. And none of this can arise without the simultaneous invention of nuclear wastes²⁶ and the equally novel and interminable nuclear accident. And none of this could have happened without the (also calculated) extraction of mining-related labour from (mostly) Indigenous peoples, which, at the time the Bomb was developed, meant the Indigenous peoples of the Belgian Congo and the Dene of Great Bear Lake.

It's complicated.

(In)visibilities

If lead stands as the conjectural and ontological terminus, what Kavanagh has produced is a series of waypoints, stations, and suspensions. How else could we *see* any of this?²⁷ Objects suspended or arrested so we might glimpse the entanglements the artist brings into presence, into visibility. Uranium oxide suspended in glass in the form of a radiant pair of legs.²⁸ A replica of a research-subject pig in a radiation suit meant to protect it from fatal exposure.²⁹ Sand fused into a novel glass mineral in the infernal heat of the twenty-one kiloton Trinity detonation in 1945—trinitite it is called, or Alamogordo glass.³⁰ Documentary photographs from the Berlyn Brixner archives *with* their metadata attached (Kavanagh's attention to this kind of thing makes for some of the exhibitions most engaging moments).

I suppose that in one way or another, anyone working on questions pertaining to atomic culture, practices and history, anyone struggling with all of the afters, is mired in vexing questions of rendering the invisible visible. This is no simple matter.³¹ This is not the occluded visible—the something hidden, a secret perhaps—but the constitutive invisibility of matter not entirely on the order of the visible to begin with. Tim Morton calls such objects, which resist conventional forms of conceptualization, hyperobjects. Such things that arise from timescales and spatialities incommensurate with our assumptions about things in the here-and-now.³² And thinking about such things as hyperobjects lets us more fully appreciate the way that such entanglements call into question geometrical, temporal and topographic notions of scale and proximity: the very near and the very far; the big and the small; the very old and the new. The before and the after. Karen Barad suggests that topology, with its focus on connectivity and boundary, is a more apt analytical tool to think with. "It's not that scale doesn't matter," she says, "the point is that it isn't simply given, and what appears far apart [temporally or physically] might actually be as close as the object in question; indeed, it may be an inseparable part of it."³³

Climate change, for example. How can we conceptualize such a thing when we can't even agree on what or where it is? The same can be said for nuclear practices. As we try to imagine the predicament of atomic survivors in, for example, the Marshall Islands, we tend to think these colonized, contaminated, relocated, and then resettled peoples as enduring the legacy of something that happened to them during the American nuclear testing there between 1946 and 1958. This much is true. But the nuclear projects that both preceded and followed the exposures and displacements of the Marshallese, and the branching timescales of things like global climate politics, the half-lives of radioactive fallout, rising oceans, and the increasing probability that the ad hoc waste repository on Runit Island (Eniwetok Atoll)³⁴ is leaking radioactive materials into their ocean water, make for a strange object, equally past, present and future. It's pretty much impossible to think seriously about thyroid cancer, the half-life of plutonium, food safety and the Paris Agreement at the same time. While it is possible to *see* the connections, each requires a different depth of field, so to speak. To make something visible requires that other aspects and qualities become less so.

And there are many other modes of invisibility we can point to. We could be talking about political invisibility, that which is predicated on disavowal, nuclear as the energy future to address the pressing imperatives of climate change, and so forth. And there is archival invisibility (or silence, which comes to the same), where the archive incarcerates subjugated knowledges that might otherwise become matters of pressing concern, or evidence, or testimony. And there is social or economic invisibility, where no voice can be heard; agency arrested. And there is material invisibility, perhaps at the root of all this, where a contest arises over both the means and meaning of this emphatic material in time.

The Territorial Archive

To the difficulties we encounter with hyperobjects, invisibilities and other complex entanglements, there are workarounds, of course, as Kavanagh's work attests. "Tracing entanglements," as Barad notes, "is no easy task. It takes work."³⁵ Kavanagh calls her twochannel video piece *Trinity* a hyperobject precisely to signal the divergent, contradictory and weird nexus of people, stories, documents and landscapes that the location of the first atomic detonation evoke. Here, she writes, "so many bodies seemed heavy with the weight of history, this legacy of mass destruction and death contained in a narrative of national pride and scientific heroism."³⁶ Documentary, ethnographic, archival, and poetic, *Trinity* brings into proximity and conversation the multi-scalar elements that connect down-winders and cold-warriors, peace activists and curious tourists, scientists and humanists, with archival and contemporary footage.

What Kavanagh derives from all this invisibility we might understand as a radically different notion of archive. An archive subject to the prevailing winds, an archive for the down-winders, an archive we might properly call territorial; dispersed, yet nonetheless *in situ*. As I put it elsewhere, the territorial archive "includes all of the material and immaterial deposits, residues, and remnants from which the living may transform a past into the realm of active and ongoing memory. A territorial archive is that matrix from which the past is transformed by the present not as history, as mere record of past events, but as sites of active and ongoing concern. Concrete social practices—political, memorial—articulate with a territorial archive in the production of a site of memory."³⁷

And it is this territorial archive—upon which these things are etched at various locations, although the legibility of these inscriptions is difficult and contested—that preoccupies my thoughts as I survey the pieces that make up *Daughters of Uranium*. In Kavanagh's work, the archive as *site* shifts toward the archive as *practice*. It is a search for discursive figures, for regularities and discontinuities, and a deep engagement with types of material "evidence" that are as many and as varied as can be produced and located. No easy task, given that the very question of evidence, or the evidentiary, is itself subject to its own decay, half-life, and interpretations. The multiple and varied modes through which the nuclear archive is here conceptualized (material, gestural, narrative, documentary, memorial, etc.) tell us that such work

requires a methodological and conceptual openness, a subject position of bewilderment, and the cultivation of something we may call a hermeneutics of leakage; that is, reading the remains.

And yet, the basic problematic of this leakage—these remains, these entanglements—is what Kavanagh handles so skilfully. There is so little to be directly seen. In other words, there is nothing visible, sonorous, or electric; it can only relay into these orders via techniques for the production of signs (signals, sounds, symptoms). That is, something that will stand for and ratify an equivalence, a contrast or calculability amongst a broad set of forces, products, agents and actors, meanings and values. Everything requires mediation, requires a mediation in order to be disclosed: that is, following the "event," whatever that may be—a Chernobyl, a Fukushima, a Trinity, a Runit Island—there is *only* representation. Which is to say, a translation into a different idiom, a relay into some other semiotic regime.

Conventionally speaking, there are two broad categories of such translations. Some manage matter in bulk, so to speak.³⁸ Heuristics. For example, a Geiger-Müller tube, sorting out the statistical dimensions of the many, in order to render sonorous, audible; or a dosimeter to absorb and transform radiation into light, into photons; or likewise, a scintillator to scintillate, to luminesce; or the electric charge produced by a semiconductor when exposed to ionizing radiation. All producing a kind of analogue sweep of more or less. While the clicking of a Geiger counter may *seem* purely indexical, as though signalling an equivalence between click and particle, this is but an artifact of the technology itself.³⁹

The other mode of translation is more directly indexical, imagistic, and mimetic. The vapour trails in a cloud chamber certify and index; allowing one to *see* that which is otherwise quite invisible—an imperfect analogue for hearing that which is quite inaudible; or a photographic film to also certify and index the *that-has-been* of emphatic matter; for many years prospectors used film to search for uranium; or a body or tissue—vulnerable to mutation—to be transformed by the absolute invisibility of alpha and beta particles and gamma radiation; or, scaling outward, the medium of a city, rendered instantaneously photographic, with forensic shadows, melancholic, abandoned by their objects, as the only means of symbolic reconstruction of the event.⁴⁰

Kavanagh's work, on the other hand, engages with a far richer palette of techniques of translation in assembling her territorial archive, some heuristic, some mimetic, and some with harmonic leaps that challenge the viewer to *complete the thought* ... a resistance to interpretive

closure that operates to interpellate, to hail the viewer.⁴¹ For example, the incandescent legs we see in one of the darkened exhibition spaces seem to be suspended in a sort of sci-fi, medicosurgical space. We realize that the glass legs are infused with uranium oxide, and that when exposed to ultraviolet light, they glow. Incandescent toxicity. My first thought upon seeing the luminous legs was Ken and Julia Yonetani's monumental, uranium-beaded Crystal Palace. That piece is a map of sorts, and like Kavanagh's it also relies on the radiant property of uranium oxide. Thirty-one chandeliers for thirty-one nuclear nations, with the size of individual chandeliers scaled to the number of operating reactors in each nation. Although the work was conceived in response to the disastrous events of Fukushima, they see it as referencing the "grandiose building designed for the Great Exhibition of 1851 in London, hinting at the tension between human ambition, technological development, and its costs and consequences."⁴² Beyond the spectacle of the chandeliers themselves, one must make a whole series of conceptual leaps to see what it is that they are doing; the signified-the earthquake, angry waves and triple meltdowns to which they hint-remain at a considerable distance, lost in the visual pleasures of the spectacle itself. Kavanagh's work also requires these conceptual leaps, but there is a centripetal force, a force that draws us back to one of the artist's main preoccupations: the body as a site of exposure; a part of an atomic territorial archive; a radiant anatomy lesson.

Daughters of Uranium, with its experiments with duration, with volume and breath, with watercolour, line, and documentary video, with collections, formal juxtapositions, conjectures and probes—all these things bring into view modes of unrepresentability, exposing us to the present and the presence of the Nuclear.

We are all exposed—in the gallery and elsewhere.

Nullarbor, Australia, & Montréal, Canada

Notes

¹ He continues, "The struggle against nuclear proliferation, atomic energy, and metaphysical dictates is one and the same fight. It behooves us to recover the body as an object and a subject from its violent reduction to sheer objectivity, to a passive material substratum at the mercy of radiation and abstract spirit that arrogate to themselves the right to shape it at will." Michael Marder and Anaïs Tondeur, *The Chernobyl Herbarium: Fragments of an Exploded Consciousness* (Ann Arbor: Open Humanities Press, 2016), 62.

² From a letter written to Alfred Stieglitz, dated August 7, 1945. Found by Kavanagh in the Alfred Stieglitz / Georgia O'Keeffe Archive, Beinecke Rare Book & Manuscript Library, Yale University. The entire letter appears in a vitrine in the exhibition.

³ Hannah Arendt, "Isak Dinesen," *Men in Dark Times* (New York: Houghton Mifflin Harcourt, 1970), 104.

⁴ Jean-Luc Nancy, *After Fukushima: The Equivalence of Catastrophes* (New York: Fordham University Press, 2014), 15.

⁵ Mariko Nagai, Irradiated Cities (Los Angeles: Les Figues Press, 2017), 129.

⁶ According to the *OED*, the first mention of elemental daughters is: "When the whole family has fallen into equilibrium, each atom of uranium which disintegrates implies the disintegration of an atom of each of the daughter elements." Arthur Holmes, "Radioactivity and the Measurement of Geological Time," *Proceedings of the Geologists Association* 26, no. 5 (1915), 292.

⁷ Extremely radioactive, highly complex chemically, incredibly difficult to handle, and can spontaneously ignite in the presence of oxygen and moisture. "Plutonium metal that will ignite spontaneously in air at a temperature of 150C or below in the absence of external heat, shock, or friction." Jerry L. Stakebake, *Plutonium Pyrophoricity* (Golden, CO: EG & G Rocky Flats, Rocky Flats Plant, 1992). See also Jeremy Bernstein, *Plutonium: A History of the World's Most Dangerous Element* (Washington, D.C.: Joseph Henry Press, 2007).

⁸ I loved that Kavanagh includes several bricks of lead in her exhibition, amounting to the only tangible—if cyphered—utopic moment. The optimism of lead.

⁹ This is from fn. 17 in Walter Benjamin, "The Work of Art in the Age of Mechanical Reproduction," in *Illuminations: Essays and Reflections* (New York: Schocken Books, 1968). Note that I have found no evidence that Breton ever said such a thing ... nevertheless.

¹⁰ As it is translated in a different version (the second) of the essay. Walter Benjamin, "The Work of Art in the Age of Its Technological Reproducibility," in *Walter Benjamin: Selected Writings, Volume* 4, 1938–1940, ed. Michael William Jennings and Howard Eiland (Cambridge, MA: Belknap Press, 2003), 280.

¹¹ "The future alone," notes Benjamin, "possesses developers active enough to scan such surfaces ..." Walter Benjamin, *The Arcades Project*, ed. Rolf Tiedemann, trans. Howard Eiland and Kevin McLaughlin (Cambridge, MA: Belknap Press of Harvard University Press, 1999), 482.

¹² Yucca (principally the Spanish Bayonet and the Joshua Tree varieties) has been used for millennia by the Indigenous peoples of the southwest, from food and medicine and fibres to tools, detergents, and shampoos. It is still used to produce brushes. But Kavanagh's Yucca pods are also a cypher for the Trinity site itself, while imbricated in a broader field of militarism. During the First World War, tons of Spanish Bayonet burlap bags were produced for military use: the "American Manufacturing Co. of Brooklyn produced at its St. Louis plant more than 80,100,000 pounds of burlap and bagging material from the fiber." Nell Murbarger, "Money in Yucca," *Salt Lake Tribune*, Sunday, August 19, 1951. Wood from the Joshua Tree was used in both world wars to produce splints "that were applied to broken bones." See Emory Dean Keoke and Kay Marie Porterfield, *Encyclopedia of American Indian Contributions to the World: 15,000 Years of Inventions and Innovations* (Infobase, 2009), 308.

¹³ The United States Army's 8300 km² White Sands Missile Range is also the site of the piously named Trinity detonation of July 16, 1945. It is also the former hereditary home of Apache and Navajo peoples and more than a dozen pueblos in the Jornada del Muerto Valley. The precise time of the detonation is the subject of some dispute. Bainbridge, the test director who was, of course, there at the time, reported "05:21:15 a.m. MWT plus 20 s minus 5 s error spread." K. T. Bainbridge, "Trinity," in *Los Alamos Technical Series, Volume 2* (Los Alamos: Los Alamos Scientific Laboratory, 1947). Yet the Wikipedia page cites 05:29:21 a.m., and other sources—such as Joseph Masco's essay "5:29:45"—report 05:29:45 a.m.; Zalasiewicz et al. report (without citation) 05:29:21 Mountain War Time (+/- 2 s); and Kyoko Hayashi also reports 5:29:45—see *From Trinity to Trinity*, trans. Eiko Otake (Barrytown, NY: Station Hill Press, 2010). With all the interminable hand-wringing about the commencement of the Anthropocene, this all seems rather ironic.

¹⁴ The books come from the library in the Toronto home of Kavanagh's grandparents. Both were chemists. Her grandmother, a Spanish flu survivor, chose the profession as a way of *giving back* for the medical labour involved in saving her from the flu. Her grandfather was born in Bancroft, Ontario, letting the story circle back to uranium. Mining for radium near Bancroft began in the 1930s, at the height of the global radium boom, although pitchblende (uranium ore) had been discovered there in 1922. Active interest in uranium in the Bancroft area did not take place until the mid-1950s; by the late 1950s, there were over one hundred mines producing uranium. Within a decade most of the mines had closed, and production had shifted to Elliot Lake, Ontario, and Northern Saskatchewan. See M. L. Proulx, "The Uranium Mining Industry of the Bancroft Area: An Environmental History and Heritage Assessment" (master's thesis, Trent University, 1998).

¹⁵ Also from the Bancroft area.

¹⁶ Uranium's use in glass, enamels, and glazes stretches back to the early nineteenth century. It became particularly popular in the mid-twentieth century in the production of dinnerware, glassware, and pottery glazes. Depending on the particular oxide of uranium and the kinds of

colorants used, it can be produced in a number of colours, from the loud red of Fiestaware plates and bowls to the delicate green and yellow colours we see in this vitrine. See also Maria Betti, "Civil Use of Depleted Uranium," *Journal of Environmental Radioactivity* 64, no. 2–3 (2003); Donna Strahan, "Uranium in Glass, Glazes and Enamels: History, Identification and Handling," *Studies in Conservation* 46, no. 3 (2001).

¹⁷ The artist did a residency at the Santa Fe Art Institute in 2005. Her love of the landscape around O'Keeffe's Ghost Ranch can be seen in Mary Kavanagh, Diane Karp, and Gerta Moray, *Seeking Georgia: Mapping O'Keeffe Country* (Lethbridge, AB: Southern Alberta Art Gallery, 2006). Elsewhere in the exhibition is a lovely letter Kavanagh found written by O'Keeffe to Alfred Stieglitz (see second epigraph above, and Figure XX).

¹⁸ Nancy, After Fukushima, 15.

¹⁹ Ibid.

 20 It strikes me that this line may not be my own. More than likely it was first uttered by my friend and long-time collaborator, Julie Salverson.

²¹ Masahide Kato, "Nuclear Globalism: Traversing Rockets, Satellites, and Nuclear War via the Strategic Gaze," *Alternatives* 18, no. 3 (1993), 348.

²² Ibid.

²³ Ibid.

²⁴ See Deborah Bird Rose, "Shimmer: When All You Love Is Being Trashed," in *Arts of Living on a Damaged Planet*, ed. Anna Lowenhaupt Tsing et al. (Minneapolis: University of Minnesota Press, 2017).

²⁵ See Peter C. van Wyck, "The Anthropocene's Signature," in *The Nuclear Culture Source Book*, ed. Ele Carpenter (London: Black Dog; Arts Catalyst, 2016).

²⁶ Virtually all the reactor waste that has ever been produced now sits in ponds and dry casks only metres away from the reactors that produced it. Nearly eight decades since the first selfsustaining nuclear reaction was produced by Fermi et al., there exists not a single functioning long-term repository for high-level nuclear waste.

²⁷ Berlyn Brixner was the lead photographer for the Trinity test in July of 1945. In 1942, Brixner, together with Julian Mack, began developing the first micro-second resolution cameras. Starting with cameras capable of 10,000 frames per second, they were able to increase the frame speed to a staggering 14,000,000 frames per second. See Brixner biography at atomicphotographers.com.

²⁸ These luminous legs occupy one darkened room of the exhibition. More on this below.

²⁹ Perhaps referencing the infamous "Pig 311." On July 1, 1946, as part of Operation Crossroads at Bikini Atoll, animals had been loaded onto ships in pens and cages within the blast radius of the test. Some were protected with various coverings, some were not. The military was trying to understand what happens to bodies subjected to a nuclear blast, and pigs are apparently a good research analogue for humans. Following the detonation, Pig 311 was rescued alive, swimming in the lagoon. She subsequently went on to gain considerable notoriety as an atomic survivor and spent her twilight years at the National Zoological Park in Washington, DC. Grant Powers, "Patty, the Atomic Pig," *Colliers Weekly*, August 11, 1951. See also Pamela M. Henson, "The Smithsonian Goes to War: The Increase and Diffusion of Scientific Knowledge in the Pacific," *Boston Studies in the Philosophy of Science*, 207 (2000): 27–50.

³⁰ "Contained within the trinity glasses [there are a variety of different kinds] is a record of the first atomic bomb. The radioactive elements distributed throughout the glasses reflect the nature of the atomic blast. Actual bits of the bomb and the surrounding material are found in the metallic chondrules from the red trinitite. ... Hence we can use the chemistry and radioactivity of these glasses to infer the type of device that was detonated and to estimate its explosive powernuclear forensics." Nelson Eby et al., "Trinitite-The Atomic Rock," Geology Today 26, no. 5 (2010), 185. Note that such forms of atomic glass are not unique to the Trinity site in New Mexico. Similar glass can be found at the Maralinga test site in Southern Australia and the Marshall Islands. More recently, in a fascinating article published in the journal Anthropocene, the authors report on a study to identify glass fallout debris at Hiroshima Bay, up to 12 km from the hypocentre of the detonation. What they call glass "Hiroshimaites" are described as "opaque, dull, aerodynamically-shaped debris" and other glass spherules. The study appears to confirm the previously unknown "presence of unique types of melt debris of high velocity and hightemperature origin (>1800 °C), in high concentration (thousands of metric tons per square kilometer), only a few kilometers away from the Hiroshima A-bomb hypocenter in Japan." Presumably this material is what became of downtown Hiroshima. See Mario M. A. Wannier et al., "Fallout Melt Debris and Aerodynamically-Shaped Glasses in Beach Sands of Hiroshima Bay, Japan," Anthropocene 25 (2019). See also Pravin P. Parekh et al., "Radioactivity in Trinitite Six Decades Later," Journal of Environmental Radioactivity 85, no. 1 (2006), and G. Nelson Eby et al., "Trinitite Redux: Mineralogy and Petrology," American Mineralogist 100, no. 2-3 (2015).

³¹ Akira Lippit writes beautifully about the problems of invisibility and visuality. Tracing a route between modes of visuality of the X-ray and the atomic bomb, he writes "X-rays transformed photography from an exercise in realism—the production of indexical images—into an allegory of avisuality." Akira Mizuta Lippit, *Atomic Light (Shadow Optics)* (Minneapolis: University of Minnesota Press, 2005), 93.

³² See Timothy Morton, *Hyperobjects: Philosophy and Ecology after The End of the World*, Posthumanities (Minneapolis: University of Minnesota Press, 2013).

³³ See Karen Barad, "Troubling Time/s and Ecologies of Nothingness: Re-turning, Remembering, and Facing the Incalculable," *New Formations* 92, no. 92 (2017), 63n13.

³⁴ The Runit Island dump (repository is far too grand a term) was constructed in the bomb crater left by the 18 kt Cactus detonation in 1958, as part of Operation Hardtrack. Between 1972 and

1980, contaminated topsoil and debris from the atoll (including "about 16,000 items of World War II ordinance, such as unexploded artillery projectiles, mortar shells, hand grenades, and small arms ammunition") were bulldozed into the crater, and a 45 cm concrete cap, or dome, composed of 347 trapezoidal panels was constructed on the surface. Terry Hamilton, "A Visual Description of the Concrete Exterior Structure of the Cactus Crater Containment Structure," LLNL-TR-648143 (Lawrence Livermore National Laboratory, 2013). As I write this essay media reports from *Forbes* to the *South China Morning Post* are reporting that the dome is now at risk of failure from deterioration, saltwater incursion, and vulnerability to typhoons. Cf. Kyle Swenson, "The U.S. Put Nuclear Waste under a Dome on a Pacific Island. Now It's Cracking Open," *Washington Post*, May 20, 2019.

³⁵ Karen Barad, "Troubling Time/s and Ecologies of Nothingness," in *Eco-deconstruction: Derrida and Environmental Philosophy*, ed. Matthias Fritsch, Philippe Lynes, and David Wood (New York: Fordham University Press, 2018), 223.

³⁶ Mary Kavanagh, "Atomic Tourist: Trinity Site, New Mexico," *On Site Review*, no. 29 Spring (Geology) (2012), 58.

³⁷ Peter C. van Wyck, *The Highway of the Atom* (Montréal; Kingston: McGill-Queens University Press, 2010), 35.

³⁸ I think here of Peter Galison's distinction between what he calls the image (mimetic) traditions of representation and the logic traditions. See *Image and Logic: A Material Culture of Microphysics* (Chicago: University of Chicago Press, 1997).

³⁹ Ibid. See chapter 6.

⁴⁰ In the weeks following August 6 and 9, 1945, engineers were able to calculate the location of the hypocentre by triangulating atomic shadows; the exact position of the explosion was in fact accurately determined by taking a number of sights from various objects which had been flash burned on one side only. Hiroshima and Nagasaki had been rendered photographic—where bodies and objects dodged sidewalks and walls—atomic sundials of sorts for the geolocation and symbolic reconstruction of the detonation. No longer quite an exercise in realism, this photography was purely on the order of the invisible.

⁴¹ Dot dot dot; the ellipsis – as elision and pause – here becomes a critical and political act ... both deference and deferral. See *Highway of the Atom*, §4.19, 204.

⁴² My emphasis. See kenandjuliayonetani.com/en/works/crystalpalace/. Note that uranium was indeed featured at the 1951 Great Exhibition. The catalogue praises its properties for colouring glass. In a note added by Robert Ellis: "The colour produced by mixing a minute potion of the oxide of uranium in a mass of molten glass is one of the most beautiful colours obtained by art. It is a charming golden green of an opalline lustre so peculiar as to distinguish it from all other colours in glass." Robert Ellis et al., *Official Descriptive and Illustrated Catalogue of the Great Exhibition of the Works of Industry of All Nations, 1851, Part I* (London: Spicer Brothers, 1851), 158.

Mary Kavanagh is a Professor in Art Studio in the Department of Art, University of Lethbridge, Alberta. She holds a BA in Fine Art from the University of Guelph, an MA in Art History from the University of Western Ontario, and an MFA from the University of Saskatchewan. For over twenty years, Kavanagh's artwork has been presented in solo and group exhibitions in Canada and abroad, and she has contributed artist projects to numerous publications including Through Post-Atomic Eyes (McGill-Queen's UP, 2020) and Prefix Photo 32: Occupying Forces (Toronto, 2015). Her research interests include feminist political ecology, technologies of war, and histories of science. She has documented military and nuclear sites in Utah, Nevada, New Mexico, Alaska, Japan and Canada. Her work has been supported by the Canada Council for the Arts, the Alberta Foundation for the Arts, the Saskatchewan Arts Board, and the Social Sciences and Humanities Research Council of Canada. Kavanagh's participation in artist residency programs includes the Center for Land Use Interpretation, the Santa Fe Art Institute, and the Canadian Forces Artists Program. She is an advisory member of the Atomic Photographers Guild, and an Associate Member of the Centre for Documentary Studies, School of Image Arts, Ryerson University, Toronto. In 2017 Kavanagh was awarded a SSHRC Insight Grant for her project, Atomic Tourist: Trinity, which explores nuclear anxiety in the twenty-first century. She was recently awarded a Tier I Board of Governors Research Chair by the University of Lethbridge and begins her five-year appointment in 2020.



Christina Cuthbertson is an independent curator and writer based in Lethbridge, Alberta. She held numerous positions at the Southern Alberta Art Gallery in Lethbridge, including Assistant Curator (2012-2014) and Interim Curator (2014-2017). Her curatorial projects of note include Still Move by Brendan Fernandes; Hospital Hallway by Sarah Anne Johnson; Portraits in Light by Petra Mala Miller, and Another Name for Everywhere by Miruna Dragan. Cuthbertson has contributed exhibition texts for Latitude 53, Trianon Gallery, and OBORO, and her writing has also appeared in Galleries West and Momus. She was curator-in-residence at the Banff International Curatorial Institute in 2018, and curator-in-residence at the International Studio and Curatorial Program (ISCP) in Brooklyn in 2019. Her current research interests focus on concepts of affect, embodiment and power structures, as defined through institutional and experiential relationships, and the translation and mediation of knowledge. Working within and beyond the boundaries of the museum or art institution, her projects have taken on many forms, including exhibitions, interdisciplinary collaborations, performances, workshops, sensory experiences, and artistic interventions.

Lindsey V. Sharman is a curator at the Art Gallery of Alberta and adjunct professor in the Department of Art at the University of Calgary. Sharman has studied Art History and Curating in Canada, England, Switzerland, and Austria, earning a BA in Art History from the University of Saskatchewan and an MA in Curating from the University of the Arts, Zurich. From 2012 to 2018 she was curator of the Founders' Gallery at the Military Museums in Calgary, an academic appointment through the University of Calgary. In that role she exhibited many contemporary projects that examined human conflict including several with recent participants in the Canadian Forces Artist Program. Her primary area of research is politically and socially engaged art practice. Curatorial projects of note include Seeing Soldiering: In Theatre with Those Who Serve by Althea Thauberger; TRENCH, a durational performance by Adrian Stimson that resulted in a land art piece located on the Siksika Nation; Felled Trees, an exhibition deconstructing national identity at Canada House, London; Gassed Redux by Adad Hannah; and the nationally touring retrospective and corresponding publication, The Writing on the Wall: Works of Dr. Joane Cardinal-Schubert.

Peter C. van Wyck is Professor of Communication and Media Studies, and Co-Director of the Media History Research Centre at Concordia University in Montréal. His research and writing arise from multidisciplinary training in forestry, ecological sciences, environmental and cultural studies, philosophy, and media studies. He has published and lectured widely on environmental themes including deep ecology, the predicaments of the Anthropocene, and nuclear history and culture. Recent writings include the award-winning Highway of the Atom (McGill-Queen's UP, 2010); a photographic essay "An Archive of Threat" in Future Anterior (2012); essays in Thinking with Water and Bearing Witness (both McGill-Queen's UP, 2013); "Theory in a Cold Climate," a special volume of Topia: Canadian Journal of Cultural Studies (2014); and "The Anthropocene's Signature," an essay for The Nuclear Culture Source Book, ed. Ele Carpenter (Black Dog, 2017). Forthcoming are: "The Lens of Fukushima," with Julie Salverson for Through Post-Atomic Eyes, eds. John O'Brian and Claudette Lauzon (McGill-Queens's UP); and "Signing the Holocene," for Critical Topographies, eds. Jonathan Bordo and Blake Fitzpatrick (McGill-Queen's UP). He is currently working on a monograph titled The Angel Turns: Memos for the End of the Holocene-completing a trilogy of nuclear-themed monographs.

Javne Wilkinson is Editor-in-Chief at Canadian Art, Toronto, She holds a BA in Art History from the University of Guelph and an MA in Art History and Critical Theory from the University of British Columbia. Her master's thesis investigated the politics of visibility in documentary and conceptual photography. Her interdisciplinary research practice examines surveillance culture, environmental politics, security, and representation, with a focus on contemporary art and photo-based practices. She has held curatorial and editorial positions at the Vancouver Art Gallery, Emily Carr University of Art + Design, Prefix ICA, Prefix Photo and the Blackwood Gallery (University of Toronto Mississauga). She has contributed art writing and criticism to publications including Canadian Art, C Magazine, Prefix Photo, Inuit Art Quarterly, Drain Magazine, and a variety of peer-reviewed and academic journals, and has developed curatorial projects, public programs and exhibition texts for galleries and artist-run centres across Canada. A recent project considers the visuality of oceanic networks through the material metaphors of digital infrastructure, forthcoming in a collection of essays titled Energy Cultures.

Published by the Southern Alberta Art Gallery, Lethbridge, AB, the Founders' Gallery at The Military Museums, Calgary, AB, University of Calgary, Calgary, AB, and the Kitchener-Waterloo Art Gallery, Kitchener, ON.

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Copy Editor: Cameron Duder Editing, Indexing & Evaluation Content Manager: Mary Kavanagh Publication Coordinator: Adam Whitford Designer: Derek Barnett and Emma Walter, Information Office Printed and bound in Belgium

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Title: Mary Kavanagh : Daughters of Uranium. Other titles: Daughters of Uranium

Names: Container of (work): Kavanagh, Mary, 1965-Works. Selections. | Southern Alberta Art Gallery, host institution, publisher.

Description: Catalogue of an exhibition held at the Southern Alberta Art Gallery from March 2, 2019 to April 28, 2019; the Founders' Gallery from September 27, 2019 to January 26, 2020; and the

Kitchener-Waterloo Art Gallery from February 13 to May 10, 2020. Essays by Christina Cuthbertson, Lindsey Sharman, Jayne Wilkinson, and

Peter C. van Wyck. | Includes bibliographical references.

Identifiers: Canadiana 20190175109 | ISBN 9781989523018 (softcover)

Subjects: LCSH: Kavanagh, Mary, 1965-Exhibitions. | LCSH: Atomic bomb in art-Exhibitions. | LCGFT: Exhibition catalogs.

Classification: LCC N6549.K35 A4 2020 | DDC 709.2-dc23

The Southern Alberta Art Gallery is supported by the Canada Council for the Arts, the Alberta Foundation for the Arts, and the City of Lethbridge.

Founders' Gallery is part of Libraries and Cultural Resources, University of Calgary.

The Kitchener-Waterloo Art Gallery is supported by the Canada Council for the Arts, the Ontario Arts Council and the Women of Influence for Women's Art.







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