Susanne Kriemann. Pechblenden 1. *2015.*
Courtesy of Susanne Kriemann.

Atomic Ecology

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Heliogravure prints in earthy shades of green and gray capture wild carrot, false chamomile, and oxtongue. The prints were produced for the Berlin-based artist Susanne Kriemann's *Pechblende* series, which explores the entangled histories of photography, uranium extraction, and the slow violence of environmental damage.[1] Kriemann harvested the weeds from Gessenweise and Kanigsberg in the former German Democratic Republic, where the mining company SDAG Wismut mined pitchblende (*Pechblende* in German). Pitchblende, a type of uraninite, has a radiation level four times that of uranium. The uranium-rich mineral was primarily used as fissionable material for Soviet atom bombs. SDAG Wismut extracted more than 200,000 metric tons of yellowcake—partially refined uranium ore used in the production of nuclear weapons—from pitchblende between 1947 and 1990.[2] Today, the groundwater and soil in the region are laced with arsenic, sulfuric acid, uranium, and radium, and waste piles emit radon gas. Remediation projects are underway, but scientists estimate that environmental damage will continue to affect the regions for hundreds of years.

Visually, the prints have subtle changes in the gradation of color, which is typical of the labor-intensive process used to produce them. The intaglio printmaking process etches photographs into metal plates to reproduce prints with ink. Unlike most gravure prints, however, the pigments used in this series are toxic: They contain traces of uranium and other heavy metals that were absorbed by the plants depicted in the images.

Kriemann's heliogravure prints follow an earlier set of photograms of the same subject. The artist harvested false chamomile, wild carrot, and oxtongue and formed them into loose arrangements. The dried bouquets were placed on light-sensitive paper and exposed with a smartphone flash. The plants were displayed alongside the photograms, bringing together both the physical object and its representation. Kriemann describes how the photograms entangle distinct temporal

1. Rob Nixon, *Slow Violence* (Cambridge, MA: Harvard University Press, 2011).
2. John Tagliabue, "A Legacy of Ashes: The Uranium Mines of Eastern Germany," *The New York Times*, March 19, 1991.

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Kriemann. Wilde Möhre. *2016.*
Courtesy of Susanne Kriemann.

scales: the deep time of the uranium extracted from the earth, the hundreds of years it takes to recover polluted land, the seasonal life of a plant, and the instantaneous flash of a phone in the darkroom. Beside the photograms, captions list botanical information and the date and location of harvest. They also list the heavy metals and other elements found in the plants, absorbed from the polluted soil: lanthanum, gadolinium, germanium, uranium, mercury, lead, nickel, zinc, aluminum, and copper. The captions are written in earthy-hued pigments produced

from the pulp of the weeds, making a clear link between materiality and meaning.[3] The pigments are, therefore, material evidence of the damage left behind by resource extraction. Eventually the colors will fade, rendering the text invisible to the human eye. They will, however, continue to emanate energy from the metals and minerals the plants have absorbed, introducing a range of vision that lies beyond human perception.[4]

The list included alongside the photographs recalls Lothar Baumgarten's photo series *El Dorado – Gran Sabana* (1977–85). The sumptuous beauty of Baumgarten's tonally rich landscapes shot in sharp whites and velvety blacks is nuanced by the text stenciled onto the wall beside them. The wall text lists the metals and minerals extracted from the landscape. It also lists animals that were endangered or made extinct owing to the destruction of ecosystems by extraction. The title juxtaposes a mythical quest for gold (El Dorado) with an existing site of natural and cultural value (Gran Sabana). Baumgarten highlights the histories of colonization and the violent erasure of Indigenous cultures by European settlers as the exploitation of natural resources reshaped the landscape. In contrast to the horizontal orientation of Baumgarten's landscape photography, Kriemann orients our attention to the rhizomatic networks of root systems that elude human vision below the surface of the earth.

Kriemann selected the three plants featured in the photo series because they are so-called hyperaccumulators. Hyperaccumulators absorb, neutralize, or extract industrial contaminants in a process called phytoremediation. The artist Mel Chin initiated the first field study to use phytoremediation to remediate polluted soil in 1991. Working in consultation with Dr. Rufus Chaney, a senior research scientist at the US Department of Agriculture and funded by a National Endowment for the Arts (NEA) grant submitted by the Citizens Environmental Coalition (CEC), Chin installed *Revival Field* in the Pig's Eye Landfill in Minnesota. Chin described the conceptual artwork as an "invisible aesthetic," where plants "carved away" pollution so that "life could return to that soil," resulting in a "wonderful sculpture."[5] Chin's sculpture confirmed the scientific potential of this low-intervention, low-cost method of remediation. Traditional methods of remediation are faster, but they cause further disruption to land and ecosystems. *Revival Field* represents an example of how art can move beyond a symbolic exploration of environmental pollution to work with science and nature to reclaim devastated territories. Phytoremediation is a synergistic process of detoxifying, absorbing, and transforming. At the same time, it challenges an instrumental relationship to land centered on the extractive objectification of resources or subjectification of an abstract "nature." Phytoremediation as a metaphor and a process imagines and enacts new ways of being in common, recognizing the funda-

3. Before the discovery of the element uranium, pitchblende was primarily used to produce olive-green, gray, and ocher pigments.

4. Eva Wilson, *Exclusion Zones* (Vancouver: Fillip, 2017), p. 7.

5. Mel Chin, "Revival Field," interview by ART21, *ART21*, https://art21.org/read/mel-chin-revival-field/.

Kriemann. Falsche Kamille. *2016.*
Courtesy of Susanne Kriemann.

mental interconnections between communities, both human and natural.[6] In doing so, it moves (slowly) beyond the aesthetic into the possible.

In Kriemann's series, the plants become "the archivists of contamination in fallout zones deserted by humans."[7] Archives are perceived as being uniquely human preoccupations, concerned with the preservation of history, text, and institutions. The archive formed by seeds, by contrast, orients to the changing seasons, recording a constant process of death and renewal. Art historian Jill Casid uses seeds as a metaphor for renewal in archives, as seeds have the potential to "materially rework how the matter of the archive is physically remembered, raking over and reseeding the ground of the past for the materialization of a different future."[8] Changes in the geological layer form yet another kind of archive: an ancient record of life, death, adaption, and, occasionally, cataclysmic destruction.[9] Phytoremediation brings together the deep time of metals found in the soil with the seasonal cycles of seeds and weeds. Kriemann's weedy archives both decontaminate and reseed, tracking a literal process of detoxification and a metaphorical means of addressing the past to recover a history that was foreclosed. This article focuses on a series of exhibitions in which Kriemann assembles three multimedia archives that explore the mine, the body of the worker, and the mining landscape.

6. Here I reference Jean-Luc Nancy's theorization of the ethical possibilities of "being in common." See Jean-Luc Nancy, "Of Being in Common," Miami Collective, ed., *Community at Loose Ends* (Minneapolis: University of Minnesota Press, 1991).

7. Wilson, *Exclusion Zones*, p. 12.

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In 2016, Kriemann presented *Pechblende: Prologue,* a series of autoradiographs, camera-less exposures "taken" by uranium alongside archival records that documented the effects of radiation on plants, animals, and humans. In *Pechblende (Chapter 1)* (2016), tools used by workers in uranium extraction were illuminated by a camera obscura, projecting the mine into the gallery.[10] The exhibition was constructed as a research site that invited viewers to participate in the production of meaning by accessing screens that displayed the archival documents from *Prologue.* The third archive, *Pechblende (Volume), Cycles 1 and 2* (2017), turns to plants grown in contaminated soil. In *Prologue* and *Chapter 1,* the form of the archive is legible and familiar, linking images and text to produce meaning. In *Volume,* however, there is an orientation to the natural world that introduces ways of knowing and healing that exist outside of human knowledge structures. While the subject matter documents the destruction wrought by radiation and its applications in military technology, there is an implicit hopefulness in the gesture of building an archive. Kriemann proposes that something productive can be recovered from the ruins of history, an idea expressed in her description of the *Pechblende* series as "archives of the future." In this gesture, Kriemann's practice has resonances with Walter Benjamin's challenge to the conception of time as linear and progressive with his argument that moments from the past could "blast forward" into the present, introducing the possibility of future action.[11]

8. Jill Casid, *Sowing Empire: Landscape and Colonization* (Minneapolis: University of Minnesota Press, 2004), p. xiii.

9. For instance, geographers Simon L. Lewis and Mark A. Maslin propose that the Anthropocene started with "the golden spike" of the Columbian Exchange in 1610. The geologic layer reveals a drop in carbon dioxide that corresponds to the genocide of the peoples of the Americas and the subsequent regrowth of forests and other plants. In 1492 there were between 54 million and 61 million people in the Americas; by 1650 there were 6 million. See Heather Davis and Zoe Todd, "On the Importance of a Date, or Decolonizing the Anthropocene," *ACME: An International Journal for Critical Geographies* 16, no. 4 (2017), p. 766.

10. Christina Landbrecht and Friederike Schäfer, "Lamp," in *P(ech) B(lende) Library for Radioactive Afterlife,* ed. Heike Catherina Mertens (Leipzig: Spector Books, 2016), p. 51.

11. Walter Benjamin, "Theses on the Philosophy of History," in *Illuminations,* ed. Hannah Arendt, trans. Harry Zohn (New York: Schocken, 2007), pp. 253–64.

The impulse to make the past active in the present functions as a method to rewrite history from below, aligning with what Hal Foster identifies as an "archival turn" starting in the early 2000s.[12] The archival turn reflects a concern with histories and subjectivities that have been obscured, displaced, or dismissed. The archival impulse—to collect, preserve, order, and create meaning—reflects our contemporary state: a "utopian ambition" plagued by a "paranoid dimension."[13] The "emergency" that Foster identified as a defining feature of the present has only become more urgent since the book was published in 2015, as political, economic, social, public health, and, perhaps most existentially, environmental crises have multiplied. Narratives of catastrophe have taken hold in popular culture, artistic production, and academic discourse.[14] The paranoid dimension has precursors in the Atomic Age and the fear that a nuclear attack or nuclear meltdown would instantly destroy civilization. Indeed, the aftershocks of atomic blasts are a significant factor in climate breakdown. In 2019, the Anthropocene Working Group (AWG) voted in favor of declaring the Anthropocene a new epoch, locating the start date in the mid-twentieth century with the rise of plastic, the atomic bomb, and the chemical industry, amongst other factors.[15] While narratives of nuclear catastrophe typically focus on the potential of a singular catastrophic event, the Atomic Age left behind a legacy of what Rob Nixon calls "slow violence," damage that "occurs gradually and out of sight, a violence of delayed destruction that is dispersed across time and space, an attritional violence that is typically not viewed as violence at all."[16] Slow violence develops unevenly and moves between temporal scales and geographic regions. In both climate crisis and radiation, the past, present, and future cannot be easily separated. Karen Barad suggests that the temporal instability of radiation reveals "temporalities [that] are specifically entangled and threaded through one another," as radioactive decay "elongates, dispers-

12. The archival turn has roots in the prewar photomontage experiments by artists such as Alexandr Rodchenko and Hannah Höch, as well as in the appropriated images and mixed-media works of the postwar period. See Hal Foster, *Bad New Days: Art, Criticism, Emergency* (New York: Verso, 2015), pp. 31–32.

13. Ibid., p. 60.

14. This draws to mind a quote attributed to both Fredric Jameson and Slavoj Žižek: "It's easier to imagine the end of the world than the end of capitalism." Mark Fisher, *Capitalist Realism* (London: Zero Books, 2009), p. 2.

15. The geological record reveals a "Great Acceleration" in the mid-twentieth century: a dramatic increase in the human impact on the planet. However, the colonization of the Americas, the transatlantic slave trade, and the industrial revolution have also been identified as significant moments of socio-ecological transformation. To start the Anthropocene in the 1950s obscures the longer historical trajectories that have led to the current moment. See, for example, David and Todd, "On the Importance of a Date," 2017; Jason W. Moore, *Capitalism in the Web of Life* (New York: Verso, 2015); and Nicholas Mirzoeff, "The Geological Color Line," in *After Extinction*, ed. Richard A. Grusin (Minnesota: University of Minnesota Press, 2018), pp. 123–50.

16. Nixon, *Slow Violence*, p. 2.

es, and exponentially frays time's coherence."[17] Kriemann's archives explore these entangled temporalities and the "abyss of time" of the geological record: The timescale of the half-life of uranium is around 4.5 billion years, roughly the same as the age of the Earth.[18]

Can an archive of the future help us see new futures beyond the Anthropocene? Climate change is often framed as what T. J. Demos calls an "emergency temporality but a forgotten history" that obscures the record of choices that produced or exacerbated ecological breakdown.[19] These forgotten histories have wide-ranging implications and lessons, and archives are an entry point into them. For Jacques Derrida, the archive is "the very question of the future, the question of a response, of a promise and of a responsibility for tomorrow."[20] Kriemann's historical investigation of uranium extraction mobilizes the archive to question the inevitability of an extractive future. Kriemann's practice reveals complex networks by tracing the movement of uranium from the mine and its applications in cultural, medical, and military realms. This ecological approach proposes a fundamental entanglement between culture and nature, the pristine and the contaminated.[21] *Pechblende* invites the viewer to think critically about the material foundations of our world as it connects to environmental catastrophe, while proposing potential new ways of seeing and relating.

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The first exhibition, *Pechblende (Prologue)*, explores the material histories and visual possibilities of uranium. The history of radiation and the medium of photography have many unexpected connections. Experiments with uranium were common in early photography: Uranyl nitrate was used as a photosensitive salt and as a toner to tint and shade silver prints. In 1857, the French photographic inventor Abel Niépce de Saint-Victor reported that uranium salts left in the dark made marks on photographic plates. Niépce recognized that it was neither conventional phosphorescence nor fluorescence that was causing the exposure, as the salts

17. Karen Barad, "Troubling Time/s and Ecologies of Nothingness: Re-turning, Re-membering, and Facing the Incalculable," *New Formations* 92 (2018), pp. 67–68, 63.

18. The geologist John Playfair described the incomprehensibility of geological time as the "abyss of time." Geologic time was developed in the eighteenth century by the Scottish geologist James Hutton.

19. T. J. Demos, "The Agency of Fire: Burning Aesthetics," *e-flux* 98, February 2019, https://www.e-flux.com/journal/98/256882/the-agency-of-fire-burning-aesthetics/.

20. Jacques Derrida, *Archive Fever: A Freudian Impression*, trans. Eric Prenowitz (Chicago University of Chicago Press, 1996), p. 36.

21. For a discussion of toxicity and environmentalism, see Lawrence Buell, "Toxic Discourse," *Critical Inquiry* 24, no. 3 (1998), pp. 639–65; and Christine L. Marran, *Ecology Without Culture: Aesthetics for a Toxic World* (Minneapolis: University of Minnesota Press, 2017).

Henri Becquerel. Pitchblende exposed on photographic plates. 1896.

exposed photographic plates *without* sunlight.[22] The phenomenon Niépce was describing is radioactivity—the spontaneous emission of radiation—though it would not be named and understood for nearly forty years after his initial findings. While Niépce's experiments are an early linking of uranium to photography, it was the German physicist Wilhelm Röntgen's 1895 discovery of X-rays that fused photography to experiments with uranium, opening up a new realm of perception that called into question the boundaries of visibility and invisibility. A year later, Henri Becquerel discovered radioactivity after leaving pitchblende on a photographic plate.[23] The pitchblende essentially took a photograph of itself, thus establishing that uranium emitted radiation without an external source of energy such as the sun. These camera-less exposures, called autoradiographs, result in an indexical but abstract image. Film scholar Akira Mizuta Lippit argues that these

22. Fathi Habashi, "Niépce de Saint-Victor and the Discovery of Radioactivity," *Bulletin for the History of Chemistry* 26, no. 2 (2001), p. 104.

23. Following Becquerel's announcement, there was a debate as to who actually discovered radioactivity, as the process and results of Niépce's earlier experiments were quite similar to Becquerel's. Becquerel received the Nobel Prize and is widely credited with the discovery of radioactivity. A parallel can be drawn to his cousin Nicéphore Niépce, whose contributions to early photography were overshadowed by his collaborator Louis Daguerre. While Niépce distributed his results and exhibited the images, the material traces of the uranium salts were not as distinct as in Röntgen's X-ray image. After Röntgen's strikingly visual experiments clearly proved that there were forms of light that were invisible to the human eye, Becquerel's subsequent findings were more legible.

early discoveries, combined with the rise of psychoanalysis and cinema, "transformed the structure of visual perception, shifting the terms of vision from phenomenal to phantasmatic registers, from a perceived visuality to an imagined one. From visual to avisual."[24] Reflecting the fascination with this new realm of perception, the first question asked of Röntgen by journalists following his discovery was "is the invisible visible?"[25] The perceptual possibilities of radiation are, to borrow Walter Benjamin's phrasing, "nature that speaks to the camera rather than to the eye," what he termed the "optical unconscious."[26] Using psychoanalysis as an analogy, Benjamin's concept attunes us to "the unknown, the unseen, and the uncontrolled" in the making, circulation, and viewing of photographs.[27]

Although radiation is invisible, atomic power was quickly tied to the visual signifier of the mushroom cloud. Atomic power embodied progress and terrifying modernity, and photography was central to constructing the public record of the Atomic Age.[28] The Atomic Age began on July 16, 1945, when the US military dropped the Trinity bomb on the traditional territory of the Pueblo, Apache, and Navajo Nations in the New Mexico desert. Fifty different cameras took both still and motion-picture images, including pinhole cameras to document gamma rays, spectrograph cameras to record the wavelengths of light, high-speed Fastax cameras to document the explosion at 10,000 frames per second, and a 35mm Perfex 44 that captured the detonation in color. Many of the photographers suffered radiation exposure. The prominence of photography at the inception of the Atomic Age reveals that photography was central to the construction of the collective memory of atomic culture. Likewise, eighteen tons of camera equipment were present at Operation Crossroads, the first of a series of nuclear detonations at Bikini Atoll in the Marshall Islands.[29] More than one million photographs were taken, though the images selected for release hid any concerns about the effect of radiation.[30] Art historian Peter B. Hales argued that the aestheticization of the bomb through the visual language of the sublime recontextualized the weapon as a man-made marvel of nature, as "the manifestation of God's will."[31]

24. Akira Mizuta Lippit, *Atomic Light (Shadow Optics)*, (Minneapolis: University of Minnesota Press, 2005), p. 27.

25. Simone Natale, "The Invisible Made Visible: X-rays as Attraction and Visual Medium at the End of the Nineteenth Century," *Media History* 17, no. 4 (July 2011), p. 346.

26. Benjamin used this analogy to describe Karl Blossfeldt's close-up photographs of flowers and Eadweard Muybridge's and Etienne-Jules Marey's motion studies. Walter Benjamin, "A Short History of Photography," *Screen* 13, no. 1 (1972), p. 7.

27. Shawn Michelle Smith and Sharon Sliwinski, "Introduction," in *Photography and the Optical Unconsciousness* (Durham, NC: Duke University Press, 2017), p. 3.

28. John O'Brian, *Camera Atomica* (London: Black Dog, 2015).

29. Susan Schuppli, "Radical Contact Prints," in O'Brian, *Camera Atomica*, p. 280.

30. Julia Bryan-Wilson, "Posing by the Cloud: US Nuclear Test Site Photography in Process," in O'Brian, *Camera Atomica*, p. 114.

31. Peter B. Hales, "The Atomic Sublime," *American Studies* 32, no. 1 (1991), p. 12.

While the mushroom cloud is the visual icon of atomic culture, the autoradiograph is its material trace. The camera-less photographs make visible a type of disaster that often eludes vision. The release of invisible radioactive isotypes into the surrounding ecosystems polluted water, soil, and air, contaminating bodies and landscapes. On the photographic surface, these traces become visible. As Susan Schuppli notes, "The mushroom cloud separates the visual field from the material field it documents, the radiological contact print is immanent to and continuous with the event."[32] Kriemann's autoradiographs capture a ghostly white light emerging from a black void. The time of exposure shapes the visual form, ranging from 3 to 112 days.

Atomic light formed a haunting perversion of the photographic process at Hiroshima and Nagasaki, as the heat from the blast left material traces of the objects in its path. These traces—shadows burnt into walls, kimono patterns tattooed on the victims' flesh—are in essence photograms, images created through the direct exposure of objects. The shadows on walls and patterned flesh are a material trace of the bomb. At Hiroshima and Nagasaki, Lippit describes how the bombings became "a form of total photography that exceeded the economies of representation,"[33] as atomic explosions "turned those cities, in the instant of a flash, into massive cameras; the victims grafted onto the geography by the radiation, radiographed."[34] The city itself becomes an analogue to the photographic plate, registering the immediate and spectacular violence of the bomb—but not the slow carcinogenic mutations that would follow.

There is an aesthetic and material link between Kriemann's work and Sigmar Polke's experiments with uranium. In Polke's *Uranium (Pink)*, camera-less exposures of uranium are captured in vivid shades of pink. *Uranium (Pink)* evokes the color photographs from the Trinity bombings, which, over time, have faded to magenta as the less stable cyan and yellow pigments in the film stock degraded. In another installation, *Radioactive Rocks on Photographic Plates*, thirty autoradiographs were hung in three linear rows arranged by color: blues, greens, yellows. The gorgeous saturation of Polke's autoradiographs befits his reputation as the "alchemist of color," and the bright colors and irreverent presentation are playful, which hides the toxicity of uranium.[35] The gradations of color resemble aura photographs, which purport to capture energy that the human eye can't detect. Polke's photographs were exposed with a chunk of uranium that he collected in

32. Schuppli, "Radical Contact Prints," p. 281.

33. Lippit, *Atomic Light*, p. 95.

34. Ibid., pp. 95, 50.

35. Alchemy has direct connections to the history of photography: Alchemical experiments formed the basis of discoveries that led to photography. As Kathrin Rottmann notes, alchemy enjoyed a resurgence following the discovery of radioactivity, for "after the discovery of roentgen rays and radioactivity, it seemed possible that the philosopher's stone could be discovered as well." This framing approaches alchemy as the avant-garde wing of science. Rottman, "Uranium in the Studio," in *Alibis: Sigmar Polke 1963–2010*, ed. Kathy Halbreich (New York: Museum of Modern Art, 2014), p. 55.

Australia in 1982 and stored in a lead box in his studio and monitored with Geiger counters.[36] Polke's work with uranium reflects his interest in the "transformation and deformation of material," which is further evidenced in his copious references to alchemical traditions.[37] Polke's contribution to the 42nd Venice Biennale, *Athanor*, was named after the furnaces that were used by alchemists in the attempt to transform base metals like lead (the end of the radioactive-decay chain) into noble metals, particularly gold. Polke's material explorations reflect "a kind of exoticism—the artist traveling to faraway places and gathering resources to regenerate his painting practice," working with materials such as arsenic, meteor dust from Chile, and snail juice. This gave rise to the criticism that he was "appropriating substances for his purposes and giving little thought to the cost of their extraction."[38] While the link between extraction and materiality is more expository in Kriemann's and Baumgarten's work, Polke does invite reflection on the origins and nature of the materials of artistic production by making familiar material forms strange—a painting made with chemicals used in photographic processes, for example.

Polke framed and hung his autoradiographs on a wall, presenting them as singular (albeit serial) works of art. While overall the visual effect has resonances with abstract painting, the toxic origins of the images subvert a reading based purely on aesthetic appreciation. In contrast, Kriemann's autoradiographs are installed as components of an archive. The sparse, clinical installation of found and made photographs, text, and objects forms a counter-archive of atomic culture. A collection of eight-by-ten-inch photographs are hung between sheets of Plexiglas, resembling microscope slides from the laboratory and lantern-slide plates used in photography. Kriemann titles the four panels "(B)lende," "(F)ish," "(P)itch," and "(T)ools." Behind Kriemann's autoradiographs are X-ray photographs and archival autoradiographs from the records of Operation Crossroads. A fish cut in half and splayed on a photographic plate is given the title "'hot' supper."[39] The camera-less photograph was exposed by radioactive algae in the fish's stomach. The clinical minimalism of the installation disassembles the spectacular visuality of the Atomic Age.

After millions of years of radioactive decay, uranium turns to lead. Kriemann's use of parentheses in the titles—"P(ech) B(lende)"—alludes to Pb (plumbum), the chemical symbol for lead.[40] Kriemann's archive includes lead

36. Ibid.

37. Lanka Tattersall, "Eight Days a Week," in Halbreich, *Alibis*, p. 108.

38. Mark Godfrey, "From *Moderne Kunst* to *Entartete Kunst*: Polke and Abstraction," in Halbreich, *Alibis*, p. 135.

39. The darkly humorous title is taken from the original caption in *Operation Crossroads: The Official Pictorial Record*, released by the Office of the Historian Joint Task Force One in 1946. The caption explains that "this puffy sturgeon fish has gorged itself heavily on radioactive algae, the common seaweed of the Bikini Lagoon"; p. 216.

40. Kriemann's decision to separate *Pech* and *Blende* evokes the work of Lutz Seiler, whose poetry Kriemann includes in her installation. Writing about Seiler's poetry, Birgit Dahlke connects "blende"—which refers to the density of pitchblende—to the camera shutter, noting that the words *Verblendung*

shaped into letters for a printing press. Throughout the exhibition, text is used to link together the life cycle of uranium. In this sense, radioactive decay ends with the production of meaning.[41] At the same time, however, the material instability of uranium renders meaning itself unstable. Scientists have suggested that several artists—Michelangelo, Caravaggio, van Gogh, among others—may have suffered lead poisoning from pigments. Despite this, or perhaps because of it, the physical weight and material history of the poisonous heavy metal have inspired artists such as Richard Serra, whose monumental sculptures investigate the dense physicality of lead, and Cornelia Parker, whose *Bullet Drawing* sculptures are made of melted bullets reconstituted into grids of delicate wire. But the dynamic tension between the properties of lead and the vision of the artist is perhaps most tangibly expressed in Anselm Kiefer's technique of pouring lead on paintings, a process that "push[es] the representation of materiality further toward the material itself."[42] The seductive but ambiguous works often include dried flowers, contrasting the fragility and temporality of plants with the dense and unchanging materiality of lead. Kiefer describes lead as the material of alchemists, reflecting, "It's toxic! I like this. I like this poison thing. Because it has an edge."[43] Where Kiefer and Polke play with the trope of the alchemist, Kriemann's process and aesthetic bring to mind the scientist: minimal, contained, isolated.

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Kriemann's use of photography to explore environmental issues also responds to environmental art of the nineteenth and twentieth centuries. The mammoth print photographs of Carleton Watkins, for example, captured Yosemite's glacial valleys, soaring mountains, and waterfalls with remarkable precision and striking formalist beauty. It was partly due to the rugged aesthetic power of these photographs—which made a *visual* case for conservation—that President Lincoln set aside Yosemite for conservation and public use in 1864, initiating the blueprint for the National Park System. Ansel Adams's explicitly environmentalist work for the Sierra Club, a nonprofit organization dedicated to environmental conservation, played a significant role in promoting wilderness conservation. Eliot Porter's closely framed photographs of flora and fauna—also taken for the Sierra Club—celebrated the northeastern United States on an intimate scale. As Robin

(blindness, infatuation) and *Ausblendung* (fade-out, suppression) are also associated with the term. Dahlke suggests that Seiler "enriches the terminology of mining with the dimension of camera technology but also of psychological memory and thus poetics." See Birgit Dahlke, "Performing GDR in Poetry? The Literary Significance of 'East German' Poetry in Unified Germany," in *German Literature in a New Century: Trends, Traditions, Transitions, Transformations*, ed. Katharina Gerstenberger and Patricia Herminghouse (New York: Berghahn Books, 2008), pp. 183, 185.

41. Heike Catherina Mertens, "Chair," in Mertens, *P(ech) B(lende) Library for Radioactive Afterlife*, p. 39.

42. Karl Ove Knausgaard, "Into the Black Forest with the Greatest Living Artist," *New York Times Magazine*, February 12, 2020, https://www.nytimes.com/2020/02/12/magazine/anselm-kiefer-art.html.

43. Ibid.

Ernst Haeckel. Adiolaria, Stephoidea. *1904.*

Kelsey has written, the widespread use of photographs to promote conservation confirms the assumption "that the value of those places was primarily visual."[44] The motivation behind many strands of environmentalism, it would seem, was at least partially aesthetic—the desire to maintain a more attractive place to live and play. Using photography to raise environmental awareness reflects Aldo Leopold's observation that "we can be ethical only toward what we can see."[45] However, in redirecting attention to the "slow violence" that eludes human vision, Rob Nixon points to the limitations of photography-as-representation in making sense of environmental transformations.

Kriemann's emphasis on materiality orients attention to the natural world, aligning with the ecological turn in art. Ecocriticism is a diverse body of thought that emphasizes interconnectedness, conflict, symbiosis, change, and discontinuity. This approach situates artistic production within a dynamic interplay of materials, artistic and extractive labor, and histories.[46] In 1866, the zoologist and artist Ernst Haeckel coined the term *Oecologie*, which today refers to the scientific study of living systems and how different organisms interact. Haeckel wrote,

> By ecology we mean the body of knowledge concerning the economy of nature—the investigation of the total relations of the animal to both its inorganic and its organic environment; including above all its friendly and inimical relations with those animals and plants with which it

44. Robin Kelsey, "Sierra Club Photography and the Exclusive Property of Vision," *RCC Perspectives* 1 (2013), p. 12.

45. Quoted in Nixon, *Slow Violence*, p. 14.

46. Alan C. Braddock and Karl Kusserow, "Introduction," in *Nature's Nation: American Art and Environment* (New Haven: Yale University Press, 2018), p. 14.

> comes directly or indirectly into contact—in a word, ecology is the study of all those complex interrelations referred to by Darwin as the conditions of the struggle for existence.[47]

These "complex interrelations" between species are at the core of ecological thought. In this sense, it is distinct from environmentalism. Preservationist environmentalism used legislation and education to protect nature by promoting programs like recycling, establishing national parks, and placing emphasis on individual consumer choices. This way of relating to the natural world has been challenged by environmental-justice frameworks, which focus on the racial, class, and geographic dimensions of environmental damage. This is not to suggest that environmentalism can be neatly delineated from the diverse approaches that are broadly classified as ecological or eco-critical, and there are significant areas of overlap.[48] In drawing this distinction, however, I suggest that the dissimilarities in visual form between early environmentalist photography and Kriemann's practice reflect changing understandings of the relationship between humans and nature.

The Atomic Age quickly and decisively undermined any notion of an Edenic, uncontaminated nature as the Manhattan Project mutated environments. These mutations have revealed themselves unevenly: the instantaneous destruction of the bomb, the slow poisoning of ecosystems from the extraction and processing of pitchblende, the carcinogenic mutations inside workers' bodies, and the toxic landscapes left behind. Joseph Masco suggests that, following the Atomic Age, we can only really consider hybridization, a world of "radioactive tumbleweeds, contaminated fruit flies, and toxic alligators."[49] This prompts a reconsideration of where the boundaries between the natural and the human worlds lie.

What, then, is the visual relationship of Haeckel's ecology with what we might now call eco-critical approaches? Haeckel is best known for his book *Art Forms in Nature*. Its remarkable illustrations make a visual argument for his understanding of the unified natural world. The baroque, patterned groupings superimposed over a black void synthesized scientific knowledge visually to create a representative sample. Haeckel's maximization of symmetry and ornamentation influenced the Art Nouveau movement. For instance, René Binet's design for the Porte Monumentale of the 1900 Exposition Universelle in Paris was inspired by Haeckel's depiction of the radiolaria, a single-celled sea creature.[50] Max Ernst,

47. Ibid., p. 13.

48. For an analysis of the ways in which preservationist environmentalism has been contested in environmental thought, see, for example, Lawrence Buell, *The Future of Environmental Criticism: Environmental Crisis and Literary Imagination* (Malden, MA: Blackwell Publishing, 2005); Braddock and Kusserow, "Introduction," pp. 13–15; and Nicole Seymour, *Bad Environmentalism: Irony and Irreverence in the Ecological Age* (Minneapolis: University of Minnesota Press, 2018).

49. Joseph Masco, "Mutant Ecologies: Radioactive Life in Post–Cold War New Mexico," *Cultural Anthropology* 19, no. 4 (2004), p. 533. Italics in original.

50. Robert Proctor, "A World of Things in Emergence and Growth: Rene Binet's Porte Monumentale at the 1900 Paris Exposition," in *Symbolist Objects: Materiality and Subjectivity at the Fin-de-Siècle* (High Wycombe: Rivendale Press, 2009), p. 227.

Paul Klee, and Wassily Kandinsky also turned to *Art Forms in Nature* for inspiration. There is a visual resonance between the autoradiographs produced by Kriemann and Polke with Haeckel's specimens: singular forms emerging from a void. However, in contrast to the order and rationality that Haeckel saw in the natural world, Polke believed that "no geometry embodied the divine" and instead sought toxicity, decay, and hybridity.[51] By pushing materials beyond human control, Polke looked for the place "where things begin to find their form not through the artist's foresight or deliberate hand, but through non-rational conditions as gravity, accident, and the associative power of the unconscious."[52] Haeckel's illustrations emphasize pattern and order in the natural world, in contrast to the centering of decay, decomposition, and destruction introduced by the use of uranium.

An interest in material transformation and decay has emerged as a theme in contemporary photography, drawing attention to its material foundations. Materiality is the foundation of all mediums, but as William Schaefer observes, it is these material origins that "much photography works hard to render invisible as if the medium were transparent."[53] Media theorist Joanna Zylinska argues that photography's material forms can tell us something about the Anthropocene, even if its visual representations are limited as evidence. Zylinska points to "the interweaving of the matter (and materiality) of chemistry, minerals, fossil fuels, and the sun, but also of us humans, with this particular medium."[54] These connections are also highlighted by Schaefer in his study of the interactions of materials, technology, and labor in contemporary Chinese photography. For instance, in the Sichuan-based photographer Adou's *Horse, Building* (2006), the artist used expired film, underscoring the materiality of the image while using decay as a visual device. In this dynamic interplay, the human becomes one among many actors determining the contingent form and materiality of the object as photographs are understood as

> emergent from but not equivalent to the self-organizing processes of the silver salts clumped together because of the action of light, of the development by liquid chemicals, of the layers of gelatin and cellulose that constitute it and gradually decay, and of the natural and cultural environment of which the film and photographer and the landscape depicted are all a part.[55]

By foregrounding materiality, artists reveal that photography is not simply a tool of representation but also implicitly ecological. Kriemann's use of geological and biological materials in photography and her experimentation with different photographic processes draw attention to the objectness of the photograph, insist-

51. Kathy Halbreich, "Alibis: An Introduction," in Halbreich, *Alibis*, p. 66.

52. Ibid.

53. William Schaefer, "Photographic Ecologies," *October* 161 (Summer 2017), p. 45.

54. Joanna Zylinska, *Nonhuman Photography* (Cambridge, MA: the MIT Press, 2017), p. 5.

55. Schaefer, "Photographic Ecologies," p. 62.

ing on a photography that is both material and representational as well as oriented to questions of environmental justice.

One could point to other examples of photographers thinking materially about the complex intersections of climate, politics, and environmental justice. For instance, Warren Cariou's "petrographs" are made with bitumen from the Athabasca Tar Sands, one of the most ecologically destructive industrial sites in the world. Oil extraction is the subject of his images, but bitumen, an unrefined form of petroleum, is also the light-sensitive material that the photographs are fixed within. Louie Palu's portraits of Inuit and soldiers deployed in the Arctic are frozen in ice; as they materially transform and decay from exposure to sun and wind, the photographs draw links between militarization and the control of territory in a warming world. The materiality of the installation evokes the melting ice caps, as well as what Jeff Wall calls photography's liquid intelligence.[56] Finally, Atomic Photographers Guild member Takashi Arai produces daguerreotypes of the fallout zones around Fukushima, Hiroshima, and Nagasaki. The hand-polished silver plates have a strong affect. The imperfections in the images—black spots or a blue glow from chemical reactions—resemble signs of radiation exposure, while the reflective surface immerses viewers in the haunting scenes. The images make a less literal link between material and meaning than autoradiographs, but the objectness of the photograph is central to its meaning. Through the complex entanglement of material, process, and meaning, contemporary artists are responding to the conceptual, discursive, and material challenges of the Anthropocene by proposing new ways of relating, making, and seeing.

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A critical difference between environmentalism and ecology is the role that the human is perceived to play. The ecological turn has directed attention to the natural world, but labor remains an important area of analysis in environmental justice. The emphasis on materials and landscapes does not displace human history; instead, Kriemann identifies work as a key site of interaction between the body and the natural world. Gabrielle Hecht argues that "our fetishes have kept us close to bombs and reactors but far from other places," such as mines and laboratories, where the nuclear emerges.[57] In contrast to the tendency to focus on the spectacular aspects of the atomic, *Pechblende (Prologue)* guides the viewer through multiple sites of interaction in the life cycle of pitchblende—the archive, museum, laboratory, mine, soil—tracing a reverse journey back to the mine until only the photograms of the tools of the workers remain. In recognition of the limitations of photography in documenting the slow

56. Jeff Wall, "Photography and Liquid Intelligence," in *Jeff Wall: Selected Essays and Interviews*, ed. Peter Galassi (New York: Museum of Modern Art, 2007).

57. Gabrielle Hecht, "Nuclearity," in *The Nuclear Culture Source Book*, ed. Elle Carpenter (London: Black Dog, 2016), p. 127.

Kriemann. Pechblende (Chapter 1). *2016. Installation view, Schering Stiftung, Berlin, 2016. Courtesy of Susanne Kriemann. Photographed by Julia Zimmermann.*

violence of radiation to workers' bodies, Kriemann uses photograms of tools and an excerpt from a poem by Lutz Seiler, whose father worked at Wismut: "That is how he slid home, inventor of the slag / We can hear it ticking, it is the clock, it is / His Geiger counter heart." The ticking of the Geiger counter, a tool used to measure radiation levels on workers, is reimagined as the heart of the worker.

The emphasis on the worker is further developed in *Pechblende (Chapter 1)*, in which the tools of miners are projected onto the gallery walls through a camera obscura. The spectrum of colors references the chromatic range of pitchblende's byproducts: bright green, fluorescent yellow, gray. The darkly lit exhibition space itself becomes an analogue for the darkroom and the labor of the photographer.[58] The archival documents from *Pechblende (Prologue)* reappear in this archive, displayed on screens that can be accessed by the viewer. The juxtaposition of the workers' tools and the space of the researcher point to tensions and interrelations between intellectual labor and physical labor. For example, while Denis Diderot's *Encyclopédie* included both intellectual and manual knowledge, he nevertheless implicitly reinforces a hierarchy of skills, with intellectuals refining and improving the practices of

58. Landbrecht and Schäfer, "Lamp," p. 51.

artisanal workers.[59] The abstract equivalence proposed between intellectual and artisanal labor functions to hide the hierarchy that structured the perceived value of labor. In linking the two sites, Kriemann suggests a complex affinity. The mine, archive, and darkroom become analogous; all involving immersion and extraction, a form of labor performed out of sight. Through the lens of occupational disease, another link surfaces between the labor of the miner and the photographer, as both experienced high rates of industrial illness due to the use of often toxic chemicals in photographic processes. *The Photographic News* called disease one of the "special dangers of the profession," documenting the dismissal of the risks of certain chemicals by "high medical authorities" even though the "alarm has been sounded over and over again," a tendency also demonstrated in mining work sites.[60] While Allan Sekula has argued that "archives are not like coal mines: meaning is not extracted from nature, but from culture," Kriemann proposes a less binary division of nature and culture, presenting an archive where the synthetic and natural, the human and extra-human, the damaged and pristine, as well as intellectual, artisanal, and industrial labor become impossible to separate.[61]

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In 1947, researchers who worked on the Manhattan Project introduced the "Doomsday Clock" to symbolize how close human society was to destroying civilization. In 2007, the criteria were updated to include the risk posed by climate change. At the time of writing in early 2021, the clock is currently set at 100 seconds to midnight, the closest it has ever been. In explaining this decision, the Bulletin of the Atomic Scientists states that the existential threat posed by nuclear war and climate change has been further amplified by cyber-warfare, political inaction, and rising distrust in institutions. Karen Barad writes that in the symbolism of the doomsday clock, "time is synchronized to a future of No Future."[62] The dystopian hellscapes conjured by writers such as David Wallace-Wells coupled with media images of extreme weather all seem to confirm this "no future" future. If, as Franco Berardi suggests, the future in its most emancipatory terms is conceived as a "panorama of possibility," the future has become foreshortened by damage that is continuously being reinscribed through extraction, production, and consumption.[63] As the Anthropocene has

59. Allan Sekula, "The Emerging Picture Language of Industrial Capitalism," in *Mining Photographs and Other Pictures, 1948–1968*, ed. Benjamin H.D. Buchloh and Robert Wilkie (Halifax: Press of the Nova Scotia College of Art and Design, 1983), p. 214.

60. "The Health of Photographers," *Photographic News* 8, no. 312 (August 26, 1864), p. 409.

61. Allan Sekula, "Reading an Archive: Photography between Labour and Capital," in *The Photography Reader*, ed. Liz Wells (London: Routledge, 2002), p. 445.

62. Barad, "Troubling Time/s and Ecologies of Nothingness," pp. 56–57.

63. Franco Berardi, *Futurability: The Age of Impotence and the Horizon of Possibility* (London: Verso, 2017).

revealed, the past—especially the atomic past—is not simply present in echoes or memories, but rather is

> an integral part of existing material conditions. This past—nuclear time, decay time, dead time, atomic clock time, doomsday clock time, a superposition of dispersed times cut together-apart—is literally swirling around with the radioactivity in the ocean.[64]

At this point, I want to return to phytoremediation and the emphasis on the (slow) healing of a landscape damaged by extractivism. Phytoremediation proposes a way of understanding nature in the Anthropocene that moves beyond narratives of declension. Environmentalism directs attention to the preservation of old-growth forests, glaciers, and oceans. In this framework, polluted landscapes are often dismissed as damaged and, therefore, beyond saving. The slag heaps of mining sites are the most tangible marker of the distinction between what is valued and what is left behind: As metals and minerals are processed to create economic value, a differential is created between them and the accumulating waste. Places like Gessenweise and Kanigsberg become peripheral lands for peripheral metals. As Anna Tsing argues in her study of former industrial logging forests in Oregon,

> Industrial transformation turned out to be a bubble of promise followed by lost livelihoods and damaged landscapes. And yet: such documents are not enough. If we end the story with decay, we abandon all hope—or turn our attention to other sites of promise and ruin, promise and ruin.[65]

To imagine energy transitions, sustainable futures, and other ways of living and knowing, the stories we tell about our collective past and experiences of the present can't end in decay and ruin. In contrast to narratives of damage, phytoremediation is a reclamation process. As a means of reclaiming shattered landscapes, it operates through a markedly different notion of what is valued and how to draw it out. Phytoremediation is, on the surface, not the most efficient means of extracting toxins. It demands close attention, low intervention, and time. It requires a certain letting go of technological processes and a trust in natural ones. This method of remediation (or remedy) invokes notions of care.

Damaged landscapes contain "the small, partial, and wild stories of more-than-human attempts to stay alive. . . . The landscapes grown from such endings are our disaster as well as our weedy hope."[66] Using plants as a "weedy hope," the history proposed in *Pechblende* locates entanglements between the human and non-

64. Barad, "Troubling Time/s and Ecologies of Nothingness," p. 74.

65. Anna Tsing, *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins* (Princeton: Princeton University Press, 2015), p. 18.

66. Anna Tsing, Heather Swanson, Elaine Gan, and Nils Bubandt, eds., *Arts of Living on a Damaged Planet* (Minneapolis: University of Minnesota Press, 2017), p. G7.

Takashi Arai. A Maquette for a Multiple Monument of the Wristwatch Dug Up from Ueno-machi, Nagasaki Atomic Bomb Museum. *2012.*

human. In doing so, it inherits difficult pasts while locating a yet-to-come in a shattered landscape, working towards resurgence and growth. In Kriemann's practice, there is an excavation of the histories that got us to this moment, and, critically, an emphasis on resilience, healing, and connection. Kriemann denies any certainty, simple answer, or fixed meaning. But the desire to construct a counter-archive reflects a belief that, in the face of the overwhelming scale and the perceived inevitability of climate change, possible futures can be rewritten and called forward from the ruins of failed histories. Donna Haraway has called for us to "stay with the trouble" in the context of ecological disaster by "learning to be truly present, not as a vanishing pivot between awful or Edenic pasts and apocalyptic or salvific futures, but as mortal creatures entwined in myriad unfinished configurations of places, times, matters, meanings."[67] This "yearning towards resurgence" requires "inheriting hard histories."[68] Kriemann's ecological aesthetic is dark, toxic, and at the same time hopeful, moving beyond a damaged/pristine binary of understanding the natural world to consider hybridization and entanglement. In doing so, *Pechblende* works within a continuum that bears witness to histories of the past and their relevance for the future.

67. Donna Haraway, *Staying with the Trouble: Making Kin in the Chthulucene* (Durham, NC: Duke University Press, 2016), p. 1.

68. Ibid., p. 89.