Eternal Care

Nuclear Waste as Toxic Legacy and Future Fantasy

by Tatiana Kasperski and Anna Storm*

In this article, we examine how human interactions with nuclear waste, with special regard to responsibilities and temporalities, have changed over time. Based primarily on historical and contemporary accounts, including interviews, we trace the history of how radioactive residue has been conceptualized and handled in Soviet and post-Soviet Russia and Sweden, from the Second World War to the present. By juxtaposing the practices and perspectives of dumping, management and care, our aim is to contribute to current efforts to make sense of waste in the Anthropocene. We conclude that to acknowledge a need for eternal care is to accentuate the interdependence of historical and geological temporalities.

The inconspicuous drinking water fountain stands in a corner, close to where we just entered the underground nuclear waste storage facility. Upon question, the guide tells with a little laugh that here we can try what 7,000 year old water tastes like, as the fountain gathers water from the surrounding granite bedrock, containing pockets of water originating from the Littorina period of the Baltic Sea. She adds that it might not taste very good, though, since it is rather salty. At a later visit to the underground storage, the water fountain has been removed. The guide explains that they decided to take it away since tests had shown that the water from the bedrock was not really 7,000 years old, but mostly mixed up with much younger sources of water. In addition, the plastic pipes tended to clog and give the water a brownish, unsavory appearance, which tempted few visitors.[1]

The invitation to drink the old, or not exactly that old, water surrounding the nuclear waste storage facility might be understood primarily as a way to convey trust. As visitors to the final repository for short-lived radioactive waste in Sweden, located in caverns blasted into the Baltic Sea seabed, we are supposed to feel confident in the chosen technology to store the radioactive materials safely. Ultimately, we are to rely on the performance of the bedrock to be a stable container, not only for water but also for toxic residues, into distant futures. Moreover, the invitation to drink the water is a possibility for contemporary bodily interaction with the deep time of the bedrock, in an

* The authors want to thank Jonas Anshelm, Mark Elam, Paul Josephson, Eglė Rindzevičiūtė, the editors of the special issue and two anonymous reviewers for valuable comments on earlier versions of this text.

1 Notes from author fieldwork at Slutförvaret för kortlivat radioaktivt avfall (SFR) in Forsmark in the municipality of Östhammar, Sweden, 12. 12. 2016 and 23. 5. 2019.

Geschichte und Gesellschaft 46. 2020, S. 682 – 705

ISSN (Printausgabe): 0340-613X, ISSN (online): 2196-9000

https://doi.org/10.13109/gege.2020.46.4.682

extraordinarily articulated nexus between geological and historical temporalities.[2]

The decision whether or not to perform this nexus is most probably dependent on the water's visual appearance and smell – does it seem to be clean or dirty? – but also on deliberations around potential future consequences. Could this water make me sick, in spite of reassuring statements from our guide? And if so, could such sickness, including elusive and frightening radiation diseases, remain in my body and possibly be inherited by my children? The bedrock and the human body, the past and the future, water and waste, reliance and risk – the possible sip in the underground cavern exposes a multitude of intricate linkages.

The radioactive leftovers from nuclear activities will stay with us for a long time. The most toxic substances will be dangerous for humans and other biota for about 100,000 years, and in many places of the world this industrial and environmental legacy is currently collected, sorted, classified, transported and stored with the aim to create its permanent isolation from living entities.[3] The imagined trajectory of these leftovers is to be moved out of sight, secluded from unintentional physical encounters and intentional misuses while, at the same time, critical information about their existence and characteristics is to be passed on from generation to generation. This double mission, to keep the toxic matter isolated and still remember where and what it is, makes up one of the most fundamental challenges of our time. Waste can indeed be regarded, Gabrielle Hecht suggests, as the "apotheosis of the Anthropocene," because of the unprecedented quantity, toxicity and durability of human-created residues and the slow violence they produce, unevenly affecting environments, communities and bodies.[4]

In this article, we will examine the belief in technological fixes to manage the danger of radioactive waste, including the logics of industrial and state nuclear organizations in relation to the vulnerability of humans and other living entitites exposed to radiation in the past, present and potentially in the future. How have different actors classified and physically handled nuclear residues from the end of World War II up to this day? What have been the underlying assumptions guiding their understandings and actions? And how have the wider implications of this human interaction with radioactive leftovers, with special regard to responsibilities and temporalities, changed over time? We will argue that the history of human interaction with nuclear waste reveals a necessity to approach radioactive residue not as something that can be moved

2 On deep time see Dan Wormald, Deep Time. A Public Engagement Literature Review, London 2017.

3 Nuclear waste produces radiation that causes damage when penetrating into any other matter. The higher the number of unstable nuclei contained in the waste and the higher the rate at which they decay, the more radioactive is the waste.

4 Gabrielle Hecht, Interscalar Vehicles for an African Anthropocene. On Waste, Temporality, and Violence, in: Cultural Anthropology 33. 2018, pp. 109 – 141, here pp. 111 f.

out of sight and disappear, but instead as an anthropogenic wound or scar of our shared living environment that we have to care about.

I. Caring for Waste

Two main practices have for a long time dominated the handling of waste: dumping and management. At first sight, they might seem poles apart. Dumping, on the one hand, is a way to get rid of unwanted entities in more or less haphazard ways, creating geographies of dumpsites, sinks and sacrifice zones.[5] The "ultimate sink" is a potent figure connoting a remote and isolated place, imagined suitable for dumping – like supposedly empty tundra, abandoned mining areas or urban wastelands.[6] Management, on the other hand, can be described, as Sebastian Ureta does, as "technology-based top-down actions for waste whose ultimate aim is to make it disappear both physically […] and politically by eliminating it as a matter of concern."[7]

However, the desired disappearance of waste seldomly works, either by dumping, or through management. Instead, waste is "apt to return, for systems of disposal are rarely perfect and matter is often more difficult to eradicate than imagined."[8] In fact, the envisaged ultimate sink is not providing some metabolic closure but is rather to be seen as a space of transformation and change. The dumpsites, haphazard as well as managed storages, invariably resist exclusion and assert to be an integrated part of the system of continuously moving matter.[9] Consequently, a key deficit of waste management practices is not that they are inherently bad or incorrect, but that the

5 For the first use of the term "ultimate sink" see Joel A. Tarr, The Search for the Ultimate Sink. Urban Air, Land, and Water Pollution in Historical Perspective, in: Records of the Columbia Historical Society 51. 1984, pp. 1 – 29. See also Jennifer Gabrys, Sink. The Dirt of Systems, in: Environment and Planning D. Society and Space 27. 2009, pp. 666 – 681; Danielle Endres, Sacred Land or National Sacrifice Zone. The Role of Values in the Yucca Mountain Participation Process, in: Environmental Communication 6. 2012, pp. 328 – 345.

6 Gabrys, Sink, p. 669; John Sandlos and Arn Keeling, Toxic Legacies, Slow Violence, and Environmental Injustice at Giant Mine, Northwest Territories, in: Northern Review 42. 2016, pp. 7 – 21, here p. 8; Matthew Gandy, Marginalia. Aesthetics, Ecology, and Urban Wastelands, in: Annals of the Association of American Geographers 103. 2013, pp. 1301 – 1316.

7 Sebastian Ureta, Caring for Waste. Handling Tailings in a Chilean Copper Mine, in: Environment and Planning A. Economy and Space 48. 2016, pp. 1532 – 1548, here p. 1532.

8 Tim Edensor, Waste Matter. The Debris of Industrial Ruins and the Disordering of the Material World, in: Journal of Material Culture 3. 2005, pp. 311 – 332, here p. 314 quoted in Duane Jethro, Liberated Waste. Heritage and Materiality at Robben Island and Constitution Hill, South Africa, in: International Journal of Heritage Studies 25. 2019, pp. 259 – 276, here p. 263.

9 Gabrys, Sink, p. 670.

underlying assumption that waste can be managed at all is misplaced.[10] Ambitions to lock waste in “ever more sophisticated containers, in the hope that they will remain there forever” can therefore be regarded as “managerial fantasies of total rational control.”[11]

Thus, waste is coming back, either as environmental menace or, perhaps surprisingly and provocatively, as a resource for reuse with new values. What was once discarded may turn out to be, if not a treasure, then something at least with value like, for example, scrap metal.[12] Similarly, as our empirical cases will demonstrate, the most highly radioactive leftovers from nuclear energy production, the spent nuclear fuel, have in many places and periods been understood as a precious resource for potential future generations of nuclear reactors, and have not at all been considered as waste. Nevertheless, this principally cyclic perspective on waste in general and radioactive matter in particular suffers from the same risk as adhering to the general assumption of rational managerial control, namely that the whole issue becomes apolitical and that non-technical actors are being excluded from the process.

To engage with more inclusive practices, complementing existing waste management rationalities, some recent studies propose “care” as a way to deal with, and even live with waste, in “material, ethical and political terms.”[13] Caitlynn Beckett and Arn Keeling, for example, pinpoint how waste management practices like remediation are pushed “beyond the act of cleaning up toxic and degraded landscapes, towards a focus on the ongoing processes of trust building, reconciliation, and perpetual care for humans, animals and environments alike.”[14] Along the same vein, Jennifer Gabrys notes how also “our bodies [are] sinks, collectors and amplifiers of pollutants, a role we share with all the plants and animals in the biosphere.”[15] Care is here seen as simultaneously ethical and practical, intimate and global. It comes with a potential to reconcile broken material and social relationships, and to heal wounds into scars that are possible to live with.[16]

Yet, care practices, like managerial practices, may turn out unethical as well. Care can become a means of governance, sometimes resembling colonial regimes, where justice for some can become discrimination of others.[17]

10 Ureta, Caring for Waste, p. 1533.
11 Ibid., p. 1533 and p. 1546.
12 Björn Wallsten et al., The Economic Conditions for Urban Infrastructure Mining. Using GIS to Prospect Hibernating Copper Stocks, in: Resources, Conservation & Recycling 103. 2015, pp. 85 – 97.
13 Ureta, Caring for Waste, p. 1532.
14 Caitlynn Beckett and Arn Keeling, Rethinking Remediation. Mine Reclamation, Environmental Justice, and Relations of Care, in: Local Environment 24. 2019, pp. 216 – 230, here p. 217.
15 Gabrys, Sink, p. 667.
16 Anna Storm, Post-Industrial Landscape Scars, New York 2014.
17 Aryn Martin et al., The Politics of Care in Technoscience, in: Social Studies of Science 45. 2015, pp. 625 – 641, here p. 627.

Sometimes it can even "perpetuate, rather than repair the social and environmental injustices associated with the original development."[18] Metaphorically speaking, scars may conceal infected tissue and wounds may reopen.[19] Nevertheless, in spite of these risks with care's darker and unethical sides, caring about waste means that we "do not allow it to became invisible nor do we easily delegate it to automatic systems and experts."[20] Care is therefore not about goodness but the only possible approach to waste, that is, to let waste move from being a "matter out of place" into a "matter of care," a readiness to respond and take responsibility.[21] Maria Puig de la Bellacasa suggests we talk about "care time" which is dedicated to "reproduction, maintenance and repair" and so create possibilities for "alternative, livable relationalities."[22]

Hence, in addition to the more empirical enquiries previously outlined, we want to address the question of how the trisection of dumping, management and care might contribute to efforts to make sense of waste in the Anthropocene.

II. Previous Work on Radioactive Waste and Choice of Empirical Cases

Nuclear waste issues have attracted scholarly attention since the late 1970s. Social scientists, especially in the field of science and technology studies, have focused mostly on attempts to site high-level waste repositories, exploring such issues as risk perception, public trust, ethics, and local, national and international politics and conflicts.[23] It has been shown, for instance, that such siting processes are not mainly technical and scientific, but social and political.[24] There is a pronounced lack of research on this topic, though, with a

18 Beckett and Keeling, Rethinking Remediation, pp. 222 f.
19 Storm, Post-Industrial Landscape Scars.
20 Ureta, Caring for Waste, p. 1546.
21 Mary Douglas, Purity and Danger. An Analysis of Concepts of Pollution and Taboo, London 1966, p. 36; Maria Puig de la Bellacasa, Matters of Care in Technoscience. Assembling Neglected Things, in: Social Studies of Science 41. 2011, pp. 85 – 106, here p. 86; Martin, Politics of Care, p. 634.
22 Puig de la Bellacasa, Making Time for Soil. Technoscientific Futurity Pace of Care, in: Social Studies of Science 5. 2015, pp. 691 – 716, here p. 692 and p. 708 quoted in Martin, Politics of Care, p. 634.
23 Barry D. Solomon et al., Three Decades of Social Science Research on High-Level Nuclear Waste. Achievements and Future Challenges, in: Risk, Hazards & Crisis in Public Policy 1. 2010, no. 4, pp. 13 – 47.
24 See for example Yannick Barthe, Le pouvoir d'indécision. La mise en politique des déchets nucléaires, Paris 2006; Göran Sundqvist and Mark Elam, Public Involvement Designed to Circumvent Public Concern? The "Participatory Turn" in European Nuclear Activities, in: Risk, Hazards & Crisis in Public Policy 1. 2010, no. 4, pp. 203 – 229; Markku Lehtonen, Deliberative Decision-Making on Radioactive Waste Management in

geographical focus outside Western democracies.[25] In addition, as Karena Kalmbach points out, there are surprisingly few historians working on nuclear waste.[26] As one of these few historians, Gabrielle Hecht has recently conceptualized radioactive waste as one of many other toxic residues that are obvious manifestations of the Anthropocene and its unequal effects on different societies and geographical areas.[27] Among other historical works are Jacob Hamblin's study of international science and politics of radioactive waste disposal into the sea from the 1950s to the early 1970s, and Peter Galison and Robb Moss' documentary film "Containment."[28]

Inspired by these approaches, we want to scrutinize the history of attempts to make radioactive waste disappear through dumping or management, as it unfolded in Soviet and post-Soviet Russia and Sweden. Based on interviews with industry representatives and activists, historical and contemporary accounts and reports from nuclear organizations, NGOs and the media, site visits, participation in stakeholder meetings and a limited body of previous studies, we will extract practices and perspectives with bearing on technological choices, calculation of risks, distribution of responsibilities and voicing of temporalities.

The two countries can be described as contrasting cases with regard to how early and how thoroughly radioactive residue was addressed by their respective governments and industries. Soviet and post-Soviet Russia was late and superficial while Sweden was exemplary early in taking the issues seriously, although there are certainly nuances to this depiction.[29] Strong

Finland, France and the UK. Influence of Mixed Forms of Deliberation in the Macro Discursive Context, in: Journal of Integrative Environmental Sciences 7. 2010, pp. 175 – 196; Sophie Kuppler, From Government to Governance? (Non-) Effects of Deliberation on Decision-Making Structures for Nuclear Waste Management in Germany and Switzerland, in: Journal of Integrative Environmental Sciences 9. 2012, pp. 103 – 122; Anne Bergmans et al., The Participatory Turn in Radioactive Waste Management. Deliberation and the Social Technical Divide, in: Journal of Risk Research 18. 2015, pp. 347 – 363.

25 See though Achim Brunnengräber et al. (eds.), Nuclear Waste Governance. An International Comparison, Wiesbaden 2015; Achim Brunnengräber et al. (eds.), Challenges of Nuclear Waste Governance. An International Comparison, vol. 2, Wiesbaden 2018.

26 Karena Kalmbach, Revisiting the Nuclear Age. State of the Art Research in Nuclear History, in: Neue Politische Literatur 62. 2017, pp. 49 – 69, here pp. 65 f.

27 Hecht, Interscalar Vehicles; Gabrielle Hecht, Residue, in: Somatosphere, 8. 1. 2018, http://somatosphere.net/2018/residue.html/.

28 Jacob D. Hamblin, Poison in the Well. Radioactive Waste in the Oceans at the Dawn of the Nuclear Age, New Brunswick 2009; Peter Galison and Robb Moss (directors), Containment, USA 2015.

29 Kathleen M. Maloney-Dunn, Russia's Nuclear Waste Law. A Response to the Legacy of Environmental Abuse in the Former Soviet Union, in: Arizona Journal of International and Comparative Law 10. 1993, pp. 365 – 430; Felix Jaitner, A Profitable Business Strategy? Spent Nuclear Fuel and Radioactive Waste Management in Russia, in: Achim Brunnengräber et al. (eds.), Challenges of Nuclear Waste Governance. An International

differences in political and economic systems account for much of the variation in the approaches. In the authoritarian Russian system, civil society has, with a few exceptions, been either inexistent or weak, a condition that is further emphasized by the long-standing and tight interdependency between the state and the nuclear industry.[30] In the democratic Swedish system, environmental concerns were generally possible to voice, and translated into concrete policies and strengthened independent oversight of the industry.[31]

Our ambition, however, is not primarily to compare the two countries, but to explore more principally how key actors in different time periods have conceptualized and treated the leftovers from civil and military nuclear applications. Thus, the choice of Soviet and post-Soviet Russia and Sweden is rather motivated by their historically substantial involvement with nuclear matters, both materially and symbolically, as well as by their defining differences with regard to political system and geopolitical impact, providing us with a rich palette of waste handling practices and perspectives.

III. Soviet and Post-Soviet Russia – A Story of National-Military Primacy

1. Early Dumping and Uncontrolled Contamination

At the dawn of the nuclear age, the 1940s and 1950s, the focus of attention within the military-oriented Soviet nuclear industry was certainly not on the residue it produced, but on the scientific and industrial arms race. In general, unwanted leftovers were disposed of in simple waste dumps or discharged directly into water bodies. One relatively well-documented human and environmental disaster of this period centers on the first Soviet plutonium

Comparison, vol. 2, Wiesbaden 2018, pp. 51 – 72; Mark Elam and Göran Sundqvist, Meddling in Swedish Success in Nuclear Waste Management, in: Environmental Politics 20. 2011, pp. 246 – 263.

30 Maloney-Dunn, Russia's Nuclear Waste Law; Jane I. Dawson, Eco-Nationalism. Anti-Nuclear Activism and National Identity in Russia, Lithuania, and Ukraine, Durham, NC 1996, ch. 5: "Russia. The Demand for Local Self-Determination," pp. 99 – 123; Tatiana Kasperski, Nuclear Dreams and Realities in Contemporary Russia and Ukraine, in: History and Technology 31. 2015, pp. 55 – 80.

31 Herbert P. Kitschelt, Political Opportunity Structures and Political Protest. Anti-Nuclear Movements in Four Democracies, in: British Journal of Political Science 16. 1986, pp. 57 – 85; Rolf Lidskog, The Politics of Radwaste Management in Sweden. Civil Society, the Economy and the State, in: Acta Sociologica 37. 1994, pp. 55 – 73; Sören Holmberg and Per Hedberg, The Will of the People? Swedish Nuclear Power Policy, in: Wolfgang C. Müller and Paul W. Thurner (eds.), The Politics of Nuclear Energy in Western Europe, Oxford 2017, pp. 235 – 258.

production facility Mayak in the Southern Urals.[32] Between 1949 and 1956, an estimated 76 million cubic meters of liquid radioactive waste was let out into the nearby Techa River, causing severe irradiation of the population of dozens of villages downstream.[33]

After that, high-level waste at Mayak began to be stored in tanks. In 1957 a tank exploded and waste particles spread over 20,000 square kilometers, contaminating the land of more than a quarter of a million people.[34] Information about the non-sensible radioactive danger was not given to the affected population, nor to a wider public, but was kept as a military secret. Similar dumping and likely accidents also took place at other military facilities of the Soviet Union, for example in the regions of Krasnoyarsk, Tomsk and in the Arctic.[35]

Apart from military activities, radioactive waste was produced by research institutions, power plants and users of ionizing sources in medicine and agriculture. Many of these facilities were located in densely populated cities, like Moscow, and the residue was normally dumped in the closest neighborhood or in the outskirts of the cities, sometimes used as backfill with no information attached about its origin and composition.[36]

In the late 1950s, with a growing understanding of radioactivity being toxic to people and the environment, Soviet authorities created a specifically dedicated institution named Enterprise no. 808. It was later followed by 34 similar enterprises within the union, forming a system called Radon. The task of the Radon enterprises was to collect, transport, store and dispose of radioactive waste from medical and research institutions, but not, notably, the waste produced within the realms of energy production or the military. That is, the Radon organization covered the whole union, but did not address the by far largest bulk of radioactive waste produced.

In the international arena, Soviet officials and scientists at this time vigorously criticized the Western countries, especially Britain and the US, for polluting

32 Zhores Medvedev, Nuclear Disaster in the Urals, New York 1980; Kate Brown, Plutopia. Nuclear Families, Atomic Cities, and the Great Soviet and American Plutonium Disasters, Oxford 2012.

33 Thomas Cochran et al., Radioactive Contamination at Chelyabinsk-65, Russia, in: Annual Review of Energy Environment 18. 1993, pp. 507 – 528, here p. 511.

34 A. V. Akleyev et al., Consequences of the Radiation Accident at the Mayak Production Association in 1957 (the "Kyshtym Accident"), in: Journal of Radiological Protection 37. 2017, pp. R19 – R42.

35 Nikolai N. Egorov et al. (eds.), The Radiation Legacy of the Soviet Nuclear Complex. An Analytical Overview, London 2000.

36 Maria Nadezhkina, Therapy in Terms of Radioecology, in: Bezopasnost' iadernykh tekhnologii i okruzhaiushchei sredy / Nuclear and Environmental Safety 1. 2006, pp. 14 – 17, here pp. 14 f.; V. A. Salikov and V. G. Safronov, Cleaning Up the City, in: Bezopasnost' iadernykh tekhnologii i okruzhaiushchei sredy 1. 2006, pp. 18 – 23; Alena Iakovleva, Petr Neveikin, "New Law Will Herald the Beginning of a New Era in Radwaste Management," in: Bezopasnost' iadernykh tekhnologii i okruzhaiushchei sredy 2. 2011, pp. 80 – 82, here p. 81.

the oceans through their disposal of radioactive waste directly into the water. For example, at international meetings such as the International Conference on the Peaceful Uses of Atomic Energy in Geneva in 1958, Soviet delegates were unlikely allies of Western oceanographers and health physicists in their effort to demonstrate how environmental damage caused by the radioactive waste threatened all of humanity.[37] However, this did not prevent the Soviet nuclear industry, including some of those very actors, to approve and practice waste dumping into the Arctic Sea and the Pacific Ocean. In addition, a new chapter was before long written in the history of Mayak, this time at Lake Karachai, about twenty kilometers south of the plutonium facility, which had been used as an open-air waste storage. In 1967, the lake partially dried out and radioactive dust from its bed was blown into the air and spread, affecting numerous nearby villages.[38] Nor this time was any information revealed to the inhabitants or the general public.

2. Industrial Expansion and International Debate

The 1970s and 1980s were marked by the massive expansion of nuclear energy in many countries, including several Soviet republics. Towards the end of its existence, the Soviet Union housed close to fifty large electricity-producing reactors on its territory, with almost thirty of them in Russia.[39] The waste produced by these reactors was stored on-site at the nuclear power plants with little if any treatment to physically stabilize it or reduce its volume. Among the types of contaminated solid objects were, for example, process equipment, tools and clothing, while the liquid waste consisted of, for example, emulsions used in the reactor circuits and during decontamination of equipment.

International exchange of ideas on radioactive waste management continued in this environment of expansion of the industry. In 1972, the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, the so-called London Convention, was signed by more than eighty states, as one of the first international agreements that touched upon nuclear waste matters.[40] It was strongly supported by Soviet officials and scientists. However, only high-level radioactive waste was listed in the convention's register of materials that should not be disposed at sea. Moreover, it focused on deliberate

37 Hamblin, Poison in the Well, pp. 126 – 134, pp. 163 – 165 and pp. 172 f.
38 Cochran, Radioactive Contamination at Chelyabinsk-65, pp. 518 f.
39 B. A. Bezrukov et al., Nuclear Power Plants, in: Egorov, Radiation Legacy of the Soviet Nuclear Complex, pp. 51 – 84, here pp. 51 – 54.
40 Seventeen states began drafting the convention in May 1972 to report to the United Nations Conference on the Human Environment in June 1972 in Stockholm, leading to the London Convention at which 82 states of the International Maritime Organization were represented.

disposal from vessels and aircraft, and did not cover land-based sources of waste or accidental discharges.[41]

Soviet specialists also regularly participated in seminars and meetings, arranged among other institutions by the International Atomic Energy Agency (IAEA) and Euratom, and afterwards they reported about the discussions in Soviet scientific journals such as *Atomnaia Energiia*.[42] For example, in a report from a symposium in Paris 1972, US plans for waste disposal in space or into the Antarctic ice were heavily criticized and contrasted with the supposedly more reliable and much cheaper Soviet technology of vitrification, a method to cast waste into glass, in order to make it more stable and easy to handle.[43] Nevertheless, the impact on actual waste management practices at the more and more numerous nuclear power plants, military nuclear facilities, mining sites, enrichment and fuel fabrication facilities in the union was delayed. For instance, vitrification did not start at Mayak before the late 1980s. Instead, temporary storage in tanks was continuously used, along with a practice to inject liquid waste directly into the ground, three to four hundred meters below surface.[44]

3. Public and International Pressure Leading to Institutional Changes

The situation started to change dramatically in the late 1980s and early 1990s, due both to the Chernobyl disaster in 1986 and the liberalization of the Soviet political regime. For example, the Radon enterprise in Moscow started a geological exploration to map forgotten and abandoned radioactive waste dumps in the city, followed by the cleanup of more than a thousand of such contaminated sites.[45] However, many identified dumps remained, in spite of their proximity to sources for drinking water and other vital resources, as they were deemed too risky and expensive to clean.[46] Another important change was the 1988 establishment of the Nuclear Safety Institute (IBRAE) within the

41 Olav Schram Stokke, Beyond Dumping? The Effectiveness of the London Convention, in: Helge Ole Bergesen et al. (eds.), Yearbook of International Cooperation on Environment and Development 1998/99, London 1998, pp. 39–50.

42 We use the term "specialists" because Soviet delegations virtually always included a combination of scientists, government officials and even KGB agents to monitor the delegations.

43 N.V. Krylova and A.N. Kondrat'ev, Simposium po obrashcheniiu s otkhodami ot pererabotki obluchennogo iadergono goriuchego, in: Atomnaia Energiia 34. 1973, no. 4, pp. 316 f. The vitrification was not an exclusively Soviet technology, but developed and applied in the US and France as well. Ian L. Pegg, Turning Nuclear Waste into Glass, in: Physics Today 68. 2015, no. 2, pp. 33–39.

44 V.F. Peretroukhine and C.H. Delegard, Some Comparisons of Plutonium-Bearing Radwaste Management in the USA and Russia, in: Thomas E. Baca and Tadeusz Florkowski (eds.), The Environmental Challenges of Nuclear Disarmament, Boston 2000, pp. 13–23, here pp. 17 f.

45 Nadezhkina, Therapy in Terms of Radioecology, pp. 14 f.

46 Ibid.; Evan Gershkovich, Will a Road Through a Nuclear Dumping Ground Result in "Moscow's Chernobyl"?, in: The Moscow Times, 16.7.2019.

Soviet Academy of Sciences. Initially, the institute was dedicated to managing the consequences of the Chernobyl disaster, but later its mission broadened to include the inventorying and remediation of accumulated radioactive waste during Soviet time more generally.[47] From 1989, also the Mayak disasters were, finally, officially acknowledged.[48]

Overall, the weakening of censorship at this time allowed for greater publicity which in turn fueled a strong domestic anti-nuclear mobilization as well as international collaboration and international pressure.[49] Taken together, they pushed institutional changes. For example, in 1991, on the eve of the Soviet collapse, the newly elected Congress of People's Deputies of the Russian Soviet Republic adopted a resolution that required the development of a state program for the management of radioactive waste and to take "immediate measures for the improvement of the radio-ecological situation."[50] However, it took significant time before these ambitions materialized within a legal framework. As another example, it was revealed that Russia had been dumping highly radioactive waste in the Arctic. This provoked an international outcry as it was a violation of the abovementioned London Convention, and in response, Russia created a government commission that in 1993 made public an inventory of submarine reactors, spent fuel, and other radioactive waste dumped between 1959 and 1992.[51]

Overall, such disclosures triggered extensive international scrutiny across the Arctic and beyond, involving such international organizations as the IAEA and EU, NGOs, including Greenpeace and the Norwegian Bellona Foundation, as well as individual states. These organizations and states financially supported research and remediation projects focusing on waste dumps in the Arctic Ocean but also on contaminated areas and hazardous waste storage facilities around Mayak site.[52] From the early 2000s the Russian government itself began more actively to support, and, indeed, fund the work of scientists, industry organizations, and national and international NGOs dealing with radioactive

47 L. A. Bolshov et al., K 30-letiiu IBRAE RAN. Osnovnye itogi deiatel'nosti v oblasti obrashcheniia s RAO, in: Radioaktivye otkhody 2. 2018, pp. 7 – 15.

48 B. V. Nikipelov et al., Ob avarii na Iuzhnom Urale 29 sentiabria 1957 g., in: Informatsionnyi biulleten' TsNII Atominform, 30. 6. 1989, pp. 1 – 11.

49 See for example A. A. Iskra et al., The Evolution and Perfection of the "Radleg-Radinfo" Radioecological Information System, in: International Symposium INSINUME. In Situ Nuclear Metrology as a Tool of Radioecology. Radioprotection of the Environment, Albena, Bulgaria, 27. – 30. 9. 2004.

50 Bolshov, K 30-letiiu IBRAE, in: International Nuclear Information System (INIS), no. 35106149, p. 8. Unless stated otherwise all translations by TK and AS.

51 Spent fuel was not officially considered as waste but sometimes still treated as such. Aleksei Yablokov, Radioactive Waste Disposal in Seas adjacent to the Territory of the Russian Federation, in: Marine Pollution Bulletin 43. 2001, no. 1 – 6, pp. 8 – 18.

52 Tatiana Kasperski, From Legacy to Heritage. The Changing Political and Symbolic Status of Military Nuclear Waste in Russia, in: Cahiers du Monde Russe 60. 2019, pp. 517 – 538.

waste, which lead to three state programs on nuclear and radiation safety, the third of which is still ongoing.[53]

4. Emerging New Understandings of Radioactive Residue

Parallel to these endeavors, nuclear waste began to be reframed in two main ways, which significantly changed its symbolic and political status. First, starting from the 2000s, the waste was transformed from an unwanted radiation "legacy" whose disclosure tarnished the national image, into a "heritage" from the glorious Soviet history of atomic weapons production.[54] For example, in a volume on "Nuclear Legacy and the Ways of Its Remediation" published by the IBRAE Institute, the reader is reminded of the atmosphere of urgency and of the expectation of an imminent nuclear attack from the US:

> The elimination of the US monopoly on the possession of nuclear weapons, and then the achievement of nuclear parity became the main objective of the thousands of scientists, engineers and organizers of domestic production. The priority of achieving this goal overshadowed other conditions, including those related to safety.[55]

The waste thus became more positively loaded because it was connected to the nation's scientific and military achievements which in turn were seen to justify past practices of mismanagement.[56]

Second, what had been characterized previously as "simplified schemes for the management of radioactive waste" in the context of "an acute shortage of resources and time" was now replaced by legal frameworks and new institutional actors.[57] Based on a 2011 law, a new National Operator for Radioactive Waste Management begun a national inventory of radioactive waste sites, including the energy and military sectors. It also initiated

53 The official names of the programs were: Federal'naia tselevaia programma "Iadernaia i radiatsionnaia bezopasnost' Rossii na 2000 – 2006 gody" (Federal target program "Nuclear and radiation safety of Russia for 2000 – 2006"); Federal'naia tselevaia programma "Obespechenie iadernoi i radiatsionnoi bezopasnosti na 2008 god i na period do 2015 goda" (Federal Target Program "Ensuring Nuclear and Radiation Safety for 2008 and for the Period until 2015"); Federal'naia tselevaia programma "Obespechenie iadernoi i radiatsionnoi bezopasnosti na 2016 – 2020 gody i na period do 2030 goda" (Federal Target Program "Ensuring Nuclear and Radiation Safety for 2016 – 2020 and for the Period until 2030"). See the website of the last and still ongoing program: http://xn--2030-bwe0hj7au5h.xn–p1ai/.

54 Kasperski, From Legacy th Heritage, pp. 517 – 538.

55 E. V. Evstratov et al., Problemy iadernogo naslediia i puti ikh resheniia, vol. 1, Moscow 2012, ch. 2: "Posledstviia realizatsii nachal'nykh etapov iadernykh oboronnykh programm", pp. 78 – 191, here p. 79.

56 Anna Storm et al., Urban Nuclear Reactors and the Security Theatre. The Making of Atomic Heritage in Chicago, Moscow and Stockholm, in: Heike Oevermann and Eszter Gantner (eds.), Securing Urban Heritage. Agents, Access, and Securitization, New York 2019, pp. 111 – 129.

57 Evstratov, Problemy iadernogo naslediia, p. 96.

processes of siting for new storage facilities, where "final isolation" *(okonchatelnaia isoliatsiia)* was envisaged.[58] In an interview, its director confided how difficult it was to carry out a licensing process for a repository designed to last for 300 years: "This is a great responsibility for the regulator: we are talking about centuries, and they have never issued licenses for such terms. It is a very serious decision for them."[59] Thus, by the 2010s, the understandings of waste as a positive heritage in the present was complemented by views of the waste as having an impact also on the long-term future.

In this reorientation, nuclear residue was divided into new categories of "special" *(osobye othody)* and "removable" *(udaliaemye othody)* waste, where the first signified waste that was too difficult and too costly to be removed safely, while the latter was obviously movable.[60] Counterintuitively, however, the special waste amounted to more than 82 percent by volume of the solid radioactive waste and more than 99.9 percent of all accumulated liquid radioactive waste.[61] This implies that a vast majority of the radioactive waste management in today's Russia is focused on adaptation of already existing places of storage. It is also important to note that neither in Soviet time, nor in post-Soviet Russia was spent nuclear fuel considered as waste but instead as a reserve of raw materials for new types of nuclear reactors.[62] Spent fuel therefore does not exist as a category of nuclear waste in Russia.

Furthermore, existing storage places of what counts as special waste have lately begun to be transformed from sites of so-called "placement" *(razmeshenie)* into sites of "conservation" *(konservatsia)* and, if deemed sufficiently stable for the entire period of the waste toxicity, they can become "disposal facilities" *(punkt zakhoronenia)*.[63] In this process, reliance on "natural" repositories is key. For example, the previously established practice to inject liquid radioactive waste into deep underground geological formations continues (currently in three places in Russia) and is approved by the new national legal framework.[64] It is clearly articulated that this practice is supposed to mimic the depositions of natural resources:

58 State Duma of the Russian Federation, Federal law no. 190-FZ: Ob obrashchenii s radioaktivnymi otkhodami i o vnesenii izmeneniy v otdel'nyye zakonodatel'nyye akty Rossiyskoy Federatsii, 11.7.2011.

59 In comparison, interim storages were expected to last about thirty years. Ekaterina Tripoten', Planiruem na sto let i bol'she, in: Atomnyi Expert 6. 2015, pp. 38–45, here p. 41.

60 Public Council of the State Corporation Rosatom, Radioaktivnye otkhody. Ot obrazovaniia do izoliatsii, Moscow 2013, p. 23.

61 I.I. Linge (ed.), Osobyye radioaktivnyye otkhody, Moscow 2015, p. 3.

62 Per Högselius, The Decay of Communism. Managing Spent Nuclear Fuel in the Soviet Union, 1937–1991, in: Risk, Hazards & Crisis in Public Policy 1. 2010, no. 4, pp. 83–109.

63 State Duma of the Russian Federation, Federal law no. 190-FZ, art. 3.

64 The practice is not approved, however, by the IAEA. Jaap Hoek, Deep-Well Injection of Radioactive Waste in Russia, in: Michael J. Stenhouse and Vladimir I. Kirko (eds.),

> The main idea behind the storage or burial of waste in the geological environment is to create man-made objects in the ground that are similar to mineral deposits in terms of their isolation […] in the ground for long periods of time. Creating such objects, we try to repeat the natural processes of formation of accumulations of substances in the geological environment.[65]

The "returning to nature" vision of radioactive waste disposal is also prominent in the public discussions about two final repositories one of which is currently under construction and the other being discussed. In one of the largest mainstream weeklies in Russia, *Argumenty i Fakty*, a journalist commented:

> What to do with wastes of different hazard classes accumulated in enormous amounts? The answer is obvious: to return them to nature from which they were taken. Not just to throw them in the landfill however, but to hide them safely for hundreds of years.[66]

Thus, at the turn of the 2020s, responsibility for taking care of waste for a protracted period into the future was finally publicly articulated.[67]

IV. Sweden – A Story of Industrial-Environmental Politics

1. From Non-Waste to Dangerous Matter

Despite being a small country, Sweden's activities in research and development of both civil and military nuclear applications after World War II were notably ambitious.[68] This early period was marked by enthusiasm and confidence, and nuclear residues were not considered a problem – if considered at all.[69] In spite of a general awareness of radiation being dangerous, no one discussed half-lives of radioactive substances, that is, for how long these materials and substances would stay toxic to living biota. Among the few ideas articulated about how to treat the unwanted leftovers that nevertheless materialized were,

Defence Nuclear Waste Disposal in Russia. International Perspective, Dordrecht 1996, pp. 219 – 230; A. N. Dorofeev et al., Evolyutsiia obosnovaniia dolgovremennoy bezopasnosti PGZ ZhRO, in: Radioaktivye otkhody 1. 2017, pp. 54 – 63.

65 P. M. Vereshchagin et al., Ideologiia, prakticheskie i nauchnye rezul'taty 50-letnego opyta glubinnogo zakhoroneniia zhidkikh radioaktivnykh otkhodov i neradioaktivnykh promstokov predpriiatii atomnoi promyshlennosti, in: Vestnik Rossiiskoi akademii estestvennykh nauk 2. 2017, pp. 12 – 23, here p. 12.

66 Tatiana Forsova, Izoliatsiia RAO na sotni let. V Rossii nakopilos' 500 mln kubometrov otkhodov, in: Argymenty i Fakty, 24. 12. 2018.

67 Nikolai Trokhov, "Takikh ob'ektov bol'she net." Vse o stroitel'stve podzemnoi issledovatel'skoi laboratorii pod Zheleznogorskom, in: Newslab, 12. 12. 2018.

68 Arne Kaijser, From Tile Stoves to Nuclear Plants. The Historical Development of Swedish Energy Systems, in: Semida Silveira (ed.), Building Sustainable Energy Systems. Swedish Experiences, Stockholm 2001, pp. 57 – 93.

69 Jonas Anshelm and Vasilis Galis, The Politics of High-Level Nuclear Waste Management in Sweden. Confined Research versus Research in the Wild, in: Environmental Policy and Governance 19. 2009, pp. 269 – 280, here p. 273.

for example, to cast them in concrete and sink them into the ocean or put them in abandoned mines.[70]

At the beginning of the 1960s, however, the time horizon for how long nuclear waste needed safe storage changed drastically. Initial estimations of twenty, thirty years were replaced, first by hundreds of years, then by thousands of years, and then – with regard to plutonium – to hundreds of thousands of years.[71] Yet, none of these drastic changes triggered any notable public debates and when the large-scale expansion of commercial nuclear power took off towards the end of the 1960s, the waste issue was principally non-existing to the politicians involved in the decisions.[72] Instead, the question was how to get hold of enough spent fuel from the first generation of nuclear reactors to be used for the expected next generation.[73] Obviously, this meant that spent fuel was not regarded as waste but as a valuable resource.[74]

Yet some radioactive waste began to be acknowledged and talked about as, for example, "atomic garbage" *(atomsopor)* and "atomic ashes" *(atomaska)*. With the new understanding of much longer time horizons, storage possibilities that were discussed at this time included vitrification, followed by storage in steel capsules in the bedrock, in old oil drilling holes or in closed salt mines. Swedish bedrock was also said to be geologically stable and therefore most suitable for waste storage. Other more spectacular suggestions were to bury the waste in the polar ice or send it into space by rocket.[75]

During the 1970s, as the anti-nuclear movement along with the general environmental movement grew in Sweden, as in many other countries, the management of nuclear waste turned into the most debated environmental question of all.[76] The debate did not concern whether radioactive waste was dangerous or not – everyone agreed that it was dangerous indeed – but rather if it could be stored safely. The physicist and Nobel Prize winner Hannes Alfvén, for example, expressed serious concerns and envisioned that radioactive waste could "poison the earth and jeopardize the future of humanity."[77] Similar worries were articulated by other leading critics using expressions such as

70 Jonas Anshelm, Från energiresurs till kvittblivningsproblem. Frågan om kärnavfallets hantering i det offentliga samtalet i Sverige, 1950 – 2002, SKB Rapport R-06–113, Stockholm 2006, pp. 15 – 19.
71 Ibid., p. 17.
72 Göran Sundqvist, The Bedrock of Opinion. Science, Technology and Society in the Siting of High-Level Nuclear Waste, Dordrecht 2002, pp. 57 f.
73 Anshelm, Från energiresurs till kvittblivningsproblem, p. 20.
74 Sundqvist, Bedrock of Opinion, pp. 57 f.
75 Anshelm, Från energiresurs till kvittblivningsproblem, p. 34 and p. 17.
76 Jonas Anshelm and Vasilis Galis, (Re-) Constructing Nuclear Waste Management in Sweden. The Involvement of Concerned Groups, 1970 – 2010, in: Linköping Studies in Technology and Social Change. Socio-Technical Perspectives on Sustainable Energy Systems 241. 2015, pp. 401 – 430, here p. 408.
77 Cited in Anshelm and Galis, Politics of High-Level Nuclear Waste Management in Sweden, p. 273.

"playing Russian roulette" or "colonizing" the future, which was seen as profoundly unethical.[78] Through the anti-nuclear push, the question of waste storage thereby moved from a technical to a moral issue with regard to future human generations and the environment. The nuclear industry objected that the problem was all about misunderstandings and lack of knowledge, as nuclear power in fact was the most environmentally friendly of all energy sources. Furthermore, its representatives stated the branch was better prepared to take care of its waste than other industries, whose waste would cause much bigger environmental damage for future generations, especially fossil fuel-based energy production.[79]

In 1972, a state-sponsored investigation was initiated, which after four years concluded that Sweden should build reprocessing plants for spent nuclear fuel, and in connection with this, engineer rock caverns for final disposal of high-level waste.[80] The critics, including physicists and geologists, questioned the results and asserted that cracks in the bedrock and especially flowing ground water made bedrock storage unsafe, which sparked a vivid public discussion among geologists. In this debate, the proponents of bedrock storage referred to Sweden's long experience in mining, while the critics referred to the bedrock as "a living body" whose movements and reactions could not be predicted.[81] The critical geologists also emphasized that geological models were not at all suitable to predict the future, and by implication not capable of guaranteeing safe waste storage for long time periods ahead.[82]

2. KBS – A Nuclear Fuel Safety Research Project

In 1976, at the same time as the government investigation presented its results, the nuclear industry initiated a financially massive research project called Nuclear Fuel Safety (Kärnbränslesäkerhet, KBS), a project given to the Swedish Nuclear Fuel Supply Company (Svensk Kärnbränsleförsörjning, SKBF). Its mission was to prove to politicians and the general public that the proposed storage solutions were feasible.[83] This mission became even more crucial to the

78 Anshelm, Från energiresurs till kvittblivningsproblem, pp. 30 f.

79 Ibid., p. 24 and p. 37.

80 Reprocessing is undertaken to recover valuable materials like uranium 235 and plutonium for reuse as fuel, and to reduce the volume of the waste. See Steve Fetter and Frank N. von Hippel, Is US Reprocessing Worth the Risk?, in: Arms Control Today 35. 2005, pp. 6–12; on the Swedish plans for a "plutonium factory" see Evert Vedung, Det högaktiva kärnavfallets väg till den rikspolitiska dagordningen, in: Mats Andrén and Urban Strandberg (eds.), Kärnavfallets politiska utmaningar, Hedemora 2005, pp. 33–56; Sundqvist, Bedrock of Opinion, pp. 67 f.

81 Anshelm, Från energiresurs till kvittblivningsproblem, pp. 40–42 and pp. 56 f.

82 See Sabine Höhler and Andrea Westermann's introduction to this special issue on geologists beginning to make future predictions in relation to discussions on the Anthropocene.

83 Lena Andersson-Skog, Från ren energi till farligt avfall – kärnkraftsfrågans reglering i det svenska välfärdsbyggandet. En ekonomisk-historisk översikt, in: Andrén and

industry in 1977, when the Swedish parliament approved the so-called "Nuclear Power Stipulation Act," which implied that the industry had to prove that it could take care of the waste in a completely safe way before any new reactors were allowed to start operating. The government decided to stay out of the debate, leading to a situation where the industry in some respects became its own reviewer. Consequently, radioactive waste retreated from its moral conceptualization into a task for juridical, technical and natural science argumentation around specific storage choices.[84]

The KBS project soon advanced a general storage principle which could be adapted either reprocessing and thereafter storage (called KBS-1), or to direct storage (called KBS-2). The principle stipulated that the waste was to be surrounded by different technological and natural barriers that should prevent leakage such as glass, stainless steel, bentonite clay, storage space deep into the ground, and the surrounding bedrock itself.[85] Soon, direct storage became favored as the US decided to say no to all reprocessing of spent nuclear fuel based on uranium exported from the US, in order to prevent an increase of plutonium proliferation. From this moment on, all spent fuel in Sweden was to be considered as waste that needed final storage.[86] The industry however described the total waste quantities as negligibly small, comparable to what could be stored in an ordinary villa, office building or oil cistern, for example.[87]

In 1978 the government approved the KBS barrier principle as fully safe. The engineers behind KBS also emphasized that some referral bodies had found it even "overly safe" *(översäker)*.[88] The only missing part to fulfil the "Nuclear Power Stipulation Act" was to show that there was a geologically suitable place within the country, which was not even a vital requirement according to the State Nuclear Energy Inspectorate (Statens kärnkraftsinspektion, SKI).[89] At this point, in 1979, the Three Mile Island accident occurred in the US and the Swedish debate decisively changed focus from the waste problem to the risks from reactor accidents. This was also the situation when Sweden carried out a referendum the following year about the future of nuclear energy – the question of radioactive waste management had suddenly been moved to the margins of the public debate. Out of the three alternatives for voting in the referendum, only one even mentioned radioactive waste.

Strandberg, Kärnavfallets politiska utmaningar, pp. 16 – 32, here p. 23; Sundqvist, Bedrock of Opinion, pp. 77 f.

84 Anshelm, Från energiresurs till kvittblivningsproblem, pp. 47 – 54.

85 For a description of the technical principles of the refined version KBS-3, see Gunnar Gustafson, De tekniska principerna bakom det svenska slutförvaret för använt kärnbränsle – KBS 3, in: Andrén and Strandberg, Kärnavfallets politiska utmaningar, pp. 57 – 71.

86 Sundqvist, Bedrock of Opinion, p. 111.

87 Anshelm, Från energiresurs till kvittblivningsproblem, p. 36.

88 Ibid., p. 58.

89 Ibid., p. 60.

Regardless of this change in public focus, the Swedish government increased its control by establishing a special fund intended to cover the expected costs of radioactive waste management and storage.[90] Following the polluter pays principle, the industry was still accountable for the costs, but from now on it had to pay a certain rate per kilowatt-hour of nuclear electricity produced into this nuclear waste fund.[91] The rate was continuously revised based on the industry's own estimates; the regulator's review of these estimates resulted in a recommendation to the government which made the final decision. The levels have been steadily increasing as cost estimates have risen along with diminishing contributions from interest on accumulated funds.[92]

3. Local Siting Conflicts and Changing Rationales

Detached from the most heated national debates, SKBF, which was later renamed the Swedish Nuclear Fuel and Waste Management Company, SKB, began the process to find a suitable geographical location for a storage, especially for the high-level radioactive waste including the spent fuel. Following the result of the referendum and subsequent parliament decision to phase out nuclear power to 2010, it was calculated that the nuclear program in Sweden would produce about 8,000 tons of such waste.[93] When test drillings started, however, they were met with intense local resistance. Local communities guarded what they considered their mountain, and spectacular conflicts arose.[94] Test drilling was thereafter done at some places without informing the concerned communities beforehand, which led to even more intense local

90 A model for financing the handling of radioactive waste was proposed by a state investigation already in 1972, but it was another model that was later implemented in 1981. Kärnavfallsrådet, Kunskapsläget på kärnavfallsområdet 2014. Forskningsdebatt, alternativ och beslutsfattande, Rapport, Statens Offentliga Utredningar SOU 2014:11, Stockholm 2014, pp. 96 – 101; Andersson-Skog, Från ren energi till farligt avfall, pp. 27 – 28.

91 The polluter pays principle was first spelled out in 1972 in a recommendations of OECD of which Sweden was and is a member. It later also became part of the sustainable development principles contained in the 1992 United Nations "Rio Declaration on Environment and Development." In 1987, with the coming into effect of the Single European Act it became legally binding for the members of the European Union, which Sweden joined in 1995. By that time however, the principle was already reflected in Swedish legal norms, such as the "Environmental Protection Act" of 1969 that stated that any operator *(verksamhetsutövare)* take all precautionary measures reasonably required to prevent or remedy the environmental harm. The same principle is also part of the "Swedish Environmental Code" that entered into force in 1999. Jonna Carlson, Principen att förorenaren betalar och den svenska miljöbalken, Master thesis Linköpings University 2000. See also Andersson-Skog, Från ren energi till farligt avfall, p. 22.

92 Tomas Kåberger and Johan Swahn, Model or Muddle? Governance and Management of Radioactive Waste in Sweden, in: Brunnengräber, Nuclear Waste Governance, pp. 203 – 225, here pp. 220 – 222.

93 Anshelm, Från energiresurs till kvittblivningsproblem, p. 69.

94 On the importance of laypeople in this conflict, see Anshelm and Galis, (Re-) Constructing Nuclear Waste Management in Sweden, pp. 401 – 430.

resistance, finally involving the police to remove and arrest protesters, and resulting in court appearances and fines.[95] A number of different communities began to cooperate in their resistance and managed to stop test drilling at more than a dozen places in the country.

In parallel, the water basins storing spent fuel at the nuclear power plants were nearly filled, which led to numerous new radioactive waste infrastructures taking shape during the 1980s. The world's first interim storage for spent nuclear fuel in the world, Clab, was built close to the Oskarshamn nuclear plant along with a deep underground laboratory; the aforementioned final repository for low and medium level waste, SFR, was blasted into the bedrock under the sea outside the Forsmark nuclear plant; and a specially built ship started to transport the waste between the plants and the storage facilities.[96] Public critique was limited and focused mostly on SFR and especially whether the ground water could be affected, but some people were also worried that the bay at Forsmark, due to the continuous ground uplifting, over time would be transformed into a radioactive lake. The industry representatives certainly rejected this view and emphasized how international experts had found SFR to have remarkably big safety margins, and claimed that it in fact was a "Rolls Royce solution."[97] In 1984, a third version of KBS, KBS-3, which involved storage in 4,400 copper capsules, embedded into bentonite clay and bedrock 500 meters underground, was presented as an "overly strong system."[98]

However, as the test drillings had been met with such fierce local resistance, SKB now reoriented their position not to find the best geological site for a final storage, but a willing hosting community.[99] The rationale was that the task for the bedrock was actually to protect the capsules from people, not the other way around.[100] In 1992, SKB sent a letter to all 286 municipalities in Sweden about "deep storage," as it was called, and asked if they were interested to take part in this process. Good local employment opportunities were emphasized: a deep

95 Sundqvist, Bedrock of Opinion, p. 109; Olov Holmstrand (ed.), Kärnkraftavfall: Avfallskedjans syn på den svenska hanteringen, Solna 2001.

96 Anshelm, Från energiresurs till kvittblivningsproblem, p. 73; Göran Sundqvist and Mark Elam, The Swedish KBS Project. A Last Word in Nuclear Fuel Safety Prepares to Conquer the World?, in: Journal of Risk Research 12. 2009, pp. 969 – 988, here p. 980; Mark Elam and Göran Sundqvist, Stakeholder Involvement in Swedish Nuclear Waste Management, in: SKI Report 2007. 2, pp. 3 – 68, here pp. 22 f.; Kåberger and Swahn, Model or Muddle, pp. 213 f.; Rolf Lidskog and Göran Sundqvist, On the Right Track? Technology, Geology and Society in Swedish Nuclear Waste Management, in: Journal of Risk Research 7. 2004, pp. 251 – 268, here p. 256.

97 Anshelm, Från energiresurs till kvittblivningsproblem, pp. 75 f.

98 Ibid., p. 78.

99 Sundqvist, Bedrock of Opinion, ch. 5: "No Particular Place to Go," pp. 109 – 1142, and ch. 7: "The Myth of Democracy," pp. 175 – 219.

100 Anshelm and Galis, Politics of High-Level Nuclear Waste Management in Sweden, p. 277.

storage facility was expected to generate about 350 new jobs for a period of fifty years.[101]

Politicians in Sweden's northern municipalities, with tough unemployment situations, first showed interest, but later withdrew due to protests from the local populations. Critics on the national level also argued that the northern parts of the country already had been sacrificed enough to help Sweden modernize, and that the idea to dump nuclear waste on poor municipalities was a new form of colonialism.[102] Instead, SKB turned to municipalities that already had nuclear facilities, and where people were expected to be more used to and also more positive about nuclear facilities. To this, critics ironically stated that the criteria for a safe storage site had become "high unemployment, sparsely populated and willing politicians."[103] On the contrary, SKB argued that it was "everybody's responsibility" to contribute to the care for the nuclear waste in order to avoid a situation when the next generation had to inherit the problems. The SKB representatives phrased it as "the duty of our generation."[104]

In the early 2000s, two coastal municipalities in southern Sweden that already housed nuclear facilities remained on the list of possible sites for final storage of high-level radioactive waste.[105] As test drilling started, the two municipalities intensively competed to win the storage localization, in remarkable contrast to previous local resistance elsewhere. At the same time, meteorologists and hydrologists argued that a coastal location was the absolute worst choice with regard to ground water flows.[106] Yet, in 2009, the municipality housing the Forsmark plant turned out as the winner.[107] As of 2020, the decision to build a final storage for high-level waste based on the KBS-3 barrier principle has not yet been taken, but has become a subject for a protracted environmental court case. The focus of the deliberations is on the potential corrosion of the copper capsules and on the different views on building a storage which could work as a walk-away solution, or as an installation that would need continuous human oversight.[108]

101 Anshelm, Från energiresurs till kvittblivningsproblem, p. 87.
102 Ibid., p. 87 and p. 90.
103 Ibid., p. 89 and p. 91.
104 Ibid., p. 89; Anshelm and Galis, Politics of High-Level Nuclear Waste Management in Sweden, p. 275.
105 Sundqvist and Elam, The Swedish KBS Project, pp. 982 f.
106 Elam and Sundqvist, Stakeholder involvement, pp. 57 f.
107 Kåberger and Swahn, Model or Muddle, p. 209.
108 Hannes Lagerlöf et al., Monitoring the Underground. What Role for Repository Monitoring in the Governance of Geological Disposal for Nuclear Waste?, Modern 2020 Deliverable n°5.1, 27.3.2018, on the Swedish case pp. 22 f; for a discussion on a "final solution" vs retrievability, see Yannick Barthe et al., Technological Fix or Divisible Object of Collective Concern? Histories of Conflict over the Geological Disposal of Nuclear Waste in Sweden and France, in: Science as Culture 29. 2020, pp. 196–218.

V. Temporalities and Responsibilities towards Eternal Care

As our cases demonstrate, the most notable temporality in the history of radioactive waste is that of linear progress. Despite the critical differences in political systems, and in the possibilities for the public and non-state actors to criticize and influence nuclear waste management, in both Russia and Sweden there was a widely shared belief that, based on more and more advanced technologies, human society will improve, and all possible side effects will be efficiently dealt with. The practices of haphazard dumping in the Soviet Russian context and the non-acknowledgement of waste as a problem in the Swedish context are both early expressions of this confidence in continuous progress. When radioactive residue was identified as toxic matter – often triggered by public critique, but at different times in the two countries –, the confidence of industrial and partly also state actors was unshaken, and instead redirected to finding solutions for waste management. As we have seen, the suggested geographies for isolating radioactive matters from humans closely followed the idea of the ultimate sink, for example, to let the waste seemingly disappear into the sea, into space or into the deep underground. In this temporal understanding the nuclear industry stands out as the accountable actor, both in terms of technological development and in terms of financing. The state is however visible in the background, with direct owner interests in the nuclear industry, and also as regulator, and gradually by increasing its control over the funding of waste management and storage. At the same time, local protesters, especially in Sweden, persistently reminded the state, the industry and the general public that the potential radioactive waste storages would affect particular communities and places, no matter the technology used.

The way of relying on natural elements to safely contain waste furthermore connects to a certain idea of a cyclic temporality, namely, to return to nature what was once extracted through uranium mining. This was perhaps most clearly expressed in the Russian case where it was explicitly articulated as a technology of mimicking geological deposits by injections of liquid waste into the underground; the Swedish reliance on stable granite bedrock and bentonite clay as a container for very old water next to toxic residue resembles this view.[109] The Swedish focus changed over time, though, from primarily viewing the bedrock as a container of waste protecting the surroundings from toxicity, to the bedrock as isolating the waste from human interventions. The

109 Anna Storm, When We Have Left the Nuclear Territories. Nonhuman Entanglements with Radioactive Remains, in: Colin Sterling and Rodney Harrison (eds.), Deterritorializing the Future. Heritage in, of and after the Anthropocene, London 2020, pp. 318 – 343, here pp. 334 f.; see also Anshelm and Galis, Politics of High-Level Nuclear Waste Management in Sweden, p. 276.

responsibility in this cyclic view was, although often implicitly, associated with abiotic elements like bedrock and clay, in combination or not with human technologies and oversight.

Another variant of a cyclic temporality was expressed through different understandings of spent nuclear fuel as a resource. While this understanding fluctuated over time and between actors in the Swedish case, the Russian view always favored the cyclic resource perspective. As a resource, spent nuclear fuel would provide potential new generations of nuclear reactors with valuable fuel, and thus imaginatively close the nuclear cycle by using much more of the energy content of the uranium and, in principle and according to the proponents, leave no waste behind.[110] One consequence of this variant of a cyclic view is the resistance of some actors towards intended final isolation of spent nuclear fuel, who instead favor options of retrievable storage in order to let this resource remain accessible to future human generations.[111]

A third significant temporality in the history of nuclear waste centers on the impacts of the past in the present. The Russian case here offers the most striking contrasts. On the one hand, the toxic legacies of numerous events of unintended or just haphazard dumping in the past continue to expose humans to radiation and contaminate the environment in the present, and this is an example of slow violence which is gradually also becoming publicly known and acknowledged. On the other hand, the recent efforts to acknowledge and handle the toxic legacies are carried out in parallel to a reframing of nuclear waste as a sign of past national glory, for example by labelling it as "heritage" with positive connotations. The framing of the leftovers as a sign of necessary sacrifices in the past implies a justification of the hazardous situation in the present as something unavoidable and morally respectable. The responsibility here is therefore certainly linked to the nuclear industry, but foremost to the state leadership promoting Russia as a powerful nation.

Fourth and finally, we want to highlight a temporality focusing on future prospects, expectations and even fantasies. If past glory was prominent in the Russian case, future control dominated much of the Swedish deliberations. Whether more short-term, such as in the perspective of one's grandchildren, or more long-term, such as in the potentialities of movements in the bedrock, the linear progress vision was in many ways extrapolated into the future. This future vision encompassed a proposed shared responsibility: While the nuclear industry remained centrally accountable for developing "Rolls Royce" waste storages, it also asked the general public to take responsibility by

110 For a description of the principles of transmutation, that is, the change of one substance into another, see Janne Wallenius, Nyttiggörande eller kvittblivning – transmutation eller bara förvaring?, in: Andrén and Strandberg, Kärnavfallets politiska utmaningar, pp. 101 – 115.

111 See for example Jonas Anshelm and Vasilis Galis, (Re-) Constructing Nuclear Waste Management in Sweden, p. 420.

supporting the implementation of the suggested storage technologies. The move from searching for a geologically optimal site to searching for a socially acceptable site is perhaps the most notable expression of this widening view of accountability in the Swedish case.

While considering these temporalities, we have to remember that they are not abstract visions. As other scholars have pointed out, such temporal categories are closely connected to concrete material and historical conditions, and produced by specific actors using different tools and technologies in order to describe, control and shape the present and the future.[112] The characteristics of nuclear waste make it an unescapable legacy from the past at the same time as it evokes imaginations of eternity. Lately, nuclear heritage initiatives are growing somewhat in numbers and scope, while artistic work exploring radioactive waste themes abounds, for example under such headings as "Perpetual Uncertainty."[113] Furthermore, international nuclear industry organizations have carried out work to create a toolbox for transferring critical knowledge to those for whom radioactive waste will be of concern in the future.[114] As Jennifer Gabrys points out, waste "creeps into the future" as "stores for unforeseen […] effects," and local communities living close to waste repositories ask how they should tell coming generations "that this monster underground is dangerous."[115]

Thus, it is becoming clear that existing waste management practices do not suffice, that we must move beyond managerial fantasies of total control, and instead engage with more wide-ranging practices. To care about waste is to be willing to respond to its constant moving and transformative character, which requires us to live with it rather than imagining its disappearance. In this living with, or, in the words of Donna Haraway, in this "staying with the trouble," the intricate entanglements of humans, animals and abiotic elements entail practices that take into account different ways of being, while acknowledging the political nature of care.[116]

112 See for example reflections on the "history of the future" approach: Jenny Andersson and Eglė Rindzevičiūtė, Introduction. Toward a New History of the Future, in: Andersson and Rindzevičiūtė (eds.), The Struggle for the Long-Term in Transnational Science and Politics. Forging the Future, New York 2015, pp. 1 – 15.

113 Storm, Urban Nuclear Reactors and the Security Theatre; the travelling exhibition "Perpetual Uncertainty" was curated by Ele Carpenter and shown, for example, at Bildmuseet in Umeå, Sweden 2017.

114 See the final report of the project "Preservation of Records, Knowledge and Memory across Generations" launched in 2011 by the OECD Nuclear Energy Agency's Radioactive Waste Management Committee: OECD Nuclear Energy Agency, Preservation of Records, Knowledge and Memory (RK&M) Across Generations: Final Report of the RK&M Initiative, Paris 2019.

115 Gabrys, Sink, p. 667 and p. 677; Sandlos and Keeling, Toxic Legacies, p. 17.

116 Donna J. Haraway, Staying with the Trouble. Making Kin in the Chthulucene, Durham 2016, pp. 1 – 4.

Granted, if we want care to become more than an intellectual or ethical perspective, we need to develop institutions and practices that support local communities to live with the waste. Such institutions and practices would have to go beyond participation in decisions about site selection, as is currently often the case. On a deeper level, care practices should guarantee broader and more democratic engagement of all concerned actors and communities that enables continuously evolving understandings of the risks and responsibilities that long-term living with toxic waste entails.[117]

We hope to have shown that the palette of historical temporalities at work in dealing with radioactive residue has not become obsolete in relation to geologically imagined futures. Instead, we suggest that care is a practice that resides in the historical time of living beings, and to merge it with a view towards eternity – that is, to propose the perspective of eternal care – is to accentuate an ongoing interdependence of historical and geological temporalities. To insist on caring for waste as a political practice, a manifold of temporal understandings and their implications are key. Nuclear waste is simultaneously toxic legacy and future fantasy, claiming present power relations and uneven geographies, as well as pointing to the generations and species that will inherit this anthropogenic wound or scar on their bodies and landscapes – whether or not through a sip of possibly very old water in an underground waste storage cavern.

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117 Tatiana Kasperski and Olga Kuchinskaya, Energy Democracy, Nuclear Power, and Participatory Knowledge Production about Radiation Risks, in: Leah Sprain et al. (eds.), Routledge Handbook of Energy Democracy, New York [2021].