Material Infrastructures of Transition: The Silmet Plant

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Abstract

This paper traces the post-Soviet transition of the Silmet rare metal and rare earth element plant, situated in the north-eastern Estonian town of Sillamäe. Initially developed as a secret Soviet enterprise for uranium processing, its current material focus has been pursued continuously since the 1970s. I situate the plant in terms of its material infrastructures, broader forces of economic reorientation, and the horizon of digital transformation its output is strategic in sustaining. The account is contextualised within Silmet's wider material geographies, in particular long-standing ties to loparite reserves on Russia's Kola Peninsula, and its former affiliation to the bastnäsite-rich Mountain Pass Mine, California. Approached with close attention to Karen Barad's call for a 'sedimenting historiality', this is a challenge to readings of infrastructure as an economic instrument, or an informational medium, at the expense of its material specificity.

Keywords: post-Soviet, Estonia, rare earths, infrastructure, territory, materiality.

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Introduction

In August 2011, then Estonian President Toomas Hendrik Ilves met with representatives of the rare earth and rare metals processing plant Molycorp Silmet, situated to the country's north-east in the coastal town of Sillamäe. The occasion was, presumably, the purchase that same month of a ninety percent controlling stake by US firm Molycorp Minerals LLC in the plant formerly known as AS Silmet.[1] It was a merger that offered both parties much needed vertical integration within the fickle industry to which they variously belonged. To clarify, each handled rare earth elements (REEs) the name currently applied to the fifteen lanthanides, scandium, and yttrium, usually subdivided into 'heavy' and 'light' groupings dependent upon atomic weight. Silmet's focus was on the 'light' class as well as the metals niobium and tantalum – materials essential to a diverse and expanding array of advanced technologies. Recently decoupled from financial ties to strategic Russian partners[2] Silmet was looking for long-term import stability.[3] Molycorp, the owner of the bastnäsite-rich Mountain Pass mine in San Bernardino, California, offered access to plentiful resources, and, in return, was able to expand the higher value-added end of its production – which the merger effectively doubled.[4] Underpinning all of which, were the deeper tectonics of geo-political and techno-economic transition, threaded with an acute sense of historical inversion.

The Estonian plant had been developed in 1946 upon what was then Soviet-occupied territory, established as a secret site for uranium mining and processing amidst the nuclear arms race. By 1952 it had entirely transitioned to ore imports from across the USSR, with its current material focus integrated during the 1970s. Mountain Pass' rare earth deposits were discovered by uranium prospectors in 1949 during the same drive for atomic ascendancy. From the 1960s through to the mid-1990s it stood as the largest REE extraction site in the world, an important tributary to post-war American military and technical expansion. However, throughout the

[1] President Ilves met with the heads of Molycorp Silmet – Office of the President, Public Relations Department, 4 August, 2011, https://vp2006-2016.president.ee/en/media/press-releases/6361-president-ilves-met-with-heads-of-molycorp-silmet/index.html (accessed 12 April, 2020).
[2] This included the Solikamsk Magnesium Works (Perm Region) and Revda loparite mines (Kola Peninsula). See: NPM Silmet OÜ - http://www.silmet.ee/ (accessed 12 April 2020).
[3] C.Ecclestone, Molycorp (MCP) – Hallgarten & Company, Corporate Actions Coverage, 20 July2011, http://www.mining.com/wp-content/uploads/2011/07/MCP_silmet_july111.pdf (accessed 14 November, 2019), p.3.
[4] C.Ecclestone, Molycorp (MCP), p.4.

1990s, as Silmet negotiated transition from command to market conditions – Estonia regained national independence in 1991 – the rare earth industry's centre of geo-strategic gravity was similarly in flux. China rapidly supplanted the US as the global market leader, and by 2002 operations at Mountain Pass had folded[5] – with the original 'Molycorp' dissolving into Chevron Mining Inc. in 2007.[6] The revival of the mine, corporate identity, and subsequent Silmet merger, were facilitated by a dramatic rise in REE prices triggered by the tightening of Chinese exports – the continuation of which, Molycorp was essentially banking on.[7] Thus, the investment of US dollars in Estonian industry was less a case of confident American expansion, than a mutual twinning of market hopes underpinned by fundamental uncertainties.

According to the press release, Ilves referred to Silmet as 'an excellent example of an Estonian high-tech company that is capable of exporting all of its production to foreign countries'.[8] He continued by underlining the plant's leading European position and regional employment of some 500 people. It is between the prehistories of the merger – essentially the precursor to the plant's current status – and the implications of the President's endorsements, returned to below, that I aim at situating this thesis. My objectives in doing so are threefold. Here listed separately, they are worked towards in dialogue.

First, I trace the history of the plant itself from the Soviet development of its technical base to privatization under domestic control and the run-up to North American integration. Second, I attempt to contextualise that account within a wider body of revisionary literature concerning Estonia's post-Soviet transition. Thus, if the paper reads east to west, the point is to problematize that geographic sweep, or rather, the reductive binary formations that adhere to it. In doing so, I indicate both the contributions and limits of existing literature in terms of accounting for Silmet. Finally, I expand this lens to a wider body of related criticism. Cautiously affirming the need for an infrastructural approach to the issues as stake and the futures they underpin, I nonetheless indicate what I consider the limits both to architect-theorist

[5] T. Heffernan, Why Rare-Earth Mining in the West is a Bust – High Country News, June 16 2015, https://www.hcn.org/issues/47.11/why-rare-earth-mining-in-the-west-is-a-bust (accessed 18 April 2020).
[6] Annual Report: Molycorp – United States Securities and Exchange Commission, EDGAR archives, for the fiscal year ended December 31, 2011, form 10-K, https://www.sec.gov/Archives/edgar/data/1489137/000104746912001655/a2207459z10-k.htm (accessed 1 May, 2020), p.3.
[7] T. Heffernan, Why Rare-Earth Mining in the West is a Bust.
[8] President Ilves met with the heads of Molycorp Silmet - Office of the President.

Keller Easterling's influential discussion of '*infrastructure space*',[9] as well as the cybernetic inflection to historian Aro Velmet's timely call for a 'more expansive concept of "infrastructure"'.[10] Instead, I turn to that which feminist theorist Karen Barad has articulated as the need for a 'sedimenting historiality'[11] in our accounts of techno-material realities. To clarify which, in terms of the given case, it is worth returning to Ilves' praise.

The President spoke to the specific qualities of the plant but, in doing so, effectively enfolded them within the official rhetoric of the Estonian state – where issues of technological and entrepreneurial competitiveness figure prominently. Granted, 'high tech' and 'enterprising' are hardly a unique rhetorical duo, yet within the Estonian context they have a distinct inflection that should not be overlooked. Namely they implicate the country's primary international reputations established post-1991: a radical neoliberal reformer and a digital pioneer.[12] Viewed from afar, Silmet fits tidily within either characterisation, however, upon closer inspection it registers as somewhat estranged on both counts. For, the 'neoliberal state' and 'digital state', whilst not one and the same thing, have equally been defined by leave-taking of the country's Soviet heritage, with perhaps particular emphasis on its industrial base. In pursuit of which, advocates of each agenda have deployed a degree of *tabula rasa*, or, to cite Velmet, 'blank slate'[13] rhetoric. That which revisionary theorists have questioned in terms of both its generative and reductive powers.

Conversely, up until Estonian independence, Silmet and the town of Sillamäe formed a closed urban-industrial enclave from which ethnic Estonians were actively excluded. An exaggerated example of the Soviet application of 'blank slate' tactics as a tool of territorial dominance and cultural negation. It was also representative of the substantial ethnic recomposition of Estonian society during the Soviet era, whereby migrant labour from across the USSR helped construct and operate particular industries, generative of new cultural realities. The President in question is not renowned for the warmth of his relations with this segment of Estonian society – most

[9] K. Easterling, Extrastatecraft: The Power of Infrastructure Space. London, New York: Verso, 2016, p.11.
[10] A.Velmet, The Blank Slate e-State: Estonian Information Society and the Politics of Novelty in the 1990s – Engaging Science, Technology, and Society, 2020, vol.6., p. 164.
[11] K. Barad, Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning. Durham, London: Duke University Press, 2007, p.391.
[12] See: R. Kattel, I. Mergel, Estonia's Digital Transformation: Mission Mystique and the Hiding Hand. – UCL, Institute for Innovation and Public Policy Working Paper Series (IIPP WP 2018-09), 2018, https://www.ucl.ac.uk/bartlett/public-purpose/wp2-18-09 (accessed 10 January 2020).
[13] A.Velmet, The Blank Slate.

of whom were not offered automatic rights to Estonian citizenship upon the reestablishment of national independence.[14] Nonetheless, his words tacitly moved through those layered ground zeros. A gesture that this paper attempts to think through.

I suggest this engages the third, broader objective, given that to study Silmet's post-Soviet transition inevitably implicates the technologically advanced horizons its output is critical in sustaining. Materially underpinning ambitious digital agendas, inclusive, within the urban arena, of an advancing 'smart city' discourse. Regionally, the latter has been most persuasively articulated as a 'Finest' horizon[15] shared between Tallinn and the Finnish capital Helsinki, and the recent recipient of substantial government and EU funding.[16] The increasing ascendency of a 'smart' discourse poses the question of how to meet such projections without simply feeding to and from their own self-promotional terms, which, by design, are mutable and evovling. I understand this paper to function as a complement to studies that tackle such issues head on. Instead, I am interested to examine certain digital and enterprising 'ground states' with emphasis on a region that is often figured as somewhat distant from the main techno-economic thrust of the Estonian state.

I propose that approaching techno-economic transition through the case of Silmet, its material practices, and wider geographies, certainly demands a 'more expansive' infrastructural understanding, but also a move beyond feedback to and from information-based tropes and their respective effects.[17] Instead – which is what I understand Barad's 'sedimenting historiality'[18] to mean – it requires close attention to how one term is naturalised through another in materially non-separable ways. A statement which, I argue, cuts to heart of what we actually mean by 'digital economies', for whom. The point of this paper is to not to 'add' Silmet to what it appears 'absent' from, but rather to reconsider the parameters of related discussions,

[14] See: V. Kiisler. lves - omadele võõras, võõrastele oma [Ilves – A Stranger to Strangers] – Äripäev, 7 October 2016, https://www.aripaev.ee/uudised/2016/10/07/ilves-omadele-vooras-voorastele-oma (accessed April 25, 2020).
[15] R-M. Soe, FINEST Twins: Platform for Cross-Border Smart City Solutions - Proceedings of the 18th Annual International Conference on Digital Government Research, 2017, pp. 352-357.
[16] H.Goncalves, Finest Twins - €32 Million European Funding for the Creation of a Smart City Research & Innovation Centre of Excellence – Forum Virium Helsinki, 5 March 2019, https://forumvirium.fi/en/finest-smart-city/ (accessed 4 April 2020).
[17] K. Easterling, Extrastatecraft, p. 235.
[18] K. Barad, Meeting the Universe Halfway, p.391.

challenging that which Barad would likely term the centre of 'material-discursive'[19] gravity.

[19] K. Barad, Meeting the Universe Halfway, p.390.

1981, Material Correlations

In 1981 Garry Wells, a journalist for Douglas County News-Press paid a visit to the headquarters of Molycorp Inc. in Louviers, Colorado, then the 'foremost United States supplier of ... separated rare earths'.[20] He reports bemusedly on the wide array of technical applications for Molycorp's much used, yet little-known, chemical output – notably colour television – and an abundant local rabbit population. Whilst the rabbits 'sit placidly among the clangor and hiss of operating machinery ... [and] quietly partake of the sparse verdure, big business goes on'[21] Wells relates – which, for Louviers at the time equated to 'an estimated 200,000 pounds of pure yttrium, lanthanum, praseodymium and neodymium'.[22] The latter three elements, we are told, were sourced from Molycorp's Mountain Pass Mine in California. To be precise, they were extracted from bastnäsite, the primary ore mineral present at that particular section of the Mojave Desert, San Bernardino County. Geologically, Mountain Pass is characterised by pre-Cambrian metamorphic rock cut by potash-rich igneous, and constitutes a unique terrain whose rich metallic properties have long been a focus of mining activity.[23]

Rare earths were officially identified at the site in 1949 by Herbert Woodward, Clarence Watkins, and P.A. Simon, uranium prospectors trailing the region with a Geiger counter during the post-war rush to find radioactive deposits.[24] Mountain Pass proved disappointing. However, at a carbonatite dike, some 900m northwest of the mine's present location, they discovered significant concentrations of REEs.[25] The Molybdenum Corporation of America (later Molycorp), purchased the Birthday

[20] G. Wells, Molycorp specialised chemical firm few understand – *Douglas County News-Press*, July 17, 1981, Vol 89 (165), p.1.
[21] G. Wells, Molycorp specialised chemical, p.1.
[22] G. Wells, Molycorp specialised chemical, p.1.
[23] See: D.F. Hewett, Forward: History of Discovery at Mountain Pass, California – J.C. Olson, D.R. Shawe, L.C. Pray, W. N. Sharp, Rare-Earth Mineral Deposits of the Mountain Pass District San Bernardino County, Geological Survey Professional Paper 261, United States Government Printing Office, Washington, 1954, pp.III-VI.
[24] D.F. Hewett, Forward: History of Discovery at Mountain Pass, p. IV.
[25] S. B. Castor, G. W. Nason, Mountain Pass Rare Earth Deposit, California. – Betting on Industrial Minerals: Proceedings of the 39th Forum on the Geology of Industrial Minerals, Reno-Sparks, Nevada. Eds. S.B. Castor, K. G. Papke, R. O. Meeuwig. May 18-23, 2003. Nevada Bureau of Mines and Geology, Special Publication 33, 2004, p. 69.

claims in 1950[26] and open-pit operations commenced in 1951.[27] The mine itself was not fully exploited until the 1960s, but from 1966 to 1984 the U.S. would dominate commercial REE production, primarily due to Mountain Pass's reserves – the mine would remain the industry's most productive extraction site until the mid-1990s.[28]

Meanwhile, the Sillamäe Metallurgical Plant (later Silmet), was handling the same combination of metals Wells describes as being transferred from California to Colorado. These were elements it extracted from chemical concentrates processed via a method of solid-phase sulfation, resulting in a mixed light rare earth (LREE) product.[29] The origin of the loparite was the Lovozero alkaline massif on Russia's Kola Peninsula, whose rare earth mineralization, although less concentrated, bares many similarities to that of the bastnäsite found in San Bernardino.[30] At this time Estonia was still a Soviet-occupied territory – annexed under the name of the Estonian Soviet Socialist Republic (ESSR) in 1944. The Sillamäe Metallurgical Plant, or Factory No.7 – its name shifted in step with its classified status[31] – had been developed as a closed urban-industrial enclave originally for the mining and processing of uranium, and stood as an important component within the Soviet nuclear-industrial and military complex.

As explained by geographer Julie Michelle Klinger REEs emerged as critical to the nuclear sector, 'both inputs and outputs of the nuclear war effort.'[32] From the 1950s onwards they were also integral to the development of superalloys, facilitating lighter and more resistant metals that underpinned advances in aviation but also military weapons design.[33] The term itself, Klinger emphasises, has acted as a shifting

[26] S.B. Castor, G.W. Nason, Mountain Pass Rare Earth Deposit, p.69.
[27] E.C. Nystrom, From Neglected Space to Protected Place: An Administrative History of Mojave National Preserve, Prepared for: U.S. Department of the Interior, National Park Service, Mojave National Preserve, Great Basin CESU, March 2003, p.197.
[28] S.B. Castor, G.W. Nason, Mountain Pass Rare Earth Deposit, p.68-69.
[29] V.D. Kosynkin, V.J. Nikonov, Rare Earth Production at the Sillamäe Plant, 1961-1991 and the Possibility of Scandium Extraction from Loparite – Turning a Problem into a Resource: Remediation and Waste Management at the Sillamäe Site. Eds. T. Kaasik; C.K. Rofer. Estonia Series: Nato Science Partnership Subseries: 1, 2000, Vol. 28, p.57.
[30] A.G.Bulakh; N.B. Abukamova, Entry: 63677 – Artic Bibliography. Ed. M.Tremaine, The Artic Institute of North America, 1963, vol.11, p.153.
[31] E.Maremäe, Uranium Production Research at Sillamäe, Estonia, in 1946-1989. - Historical Survey of Nuclear Non-Proliferation in Estonia, 1946-1995. Ed. I.Maalmann. Estonian Radiation Protection Centre, December 2003, p.14.
[32] J. M. Klinger, A Historical Geography of Rare Earth Elements: From Discovery to the Atomic Age. – The Extractive Industries and Society, 2015, vol.2, p. 576.
[33] J. M. Klinger, A Historical Geography..., p.577.

and somewhat misleading signifier. [34] Its application tending to indicate a twinning of strategic value with limited access, whereby limited does not indicate – as 'rare' would seem to imply – a lack of abundance within the earth's crust, but rather the complicated nature of their extraction, both chemically and politically.

REEs occur closely intermingled in mineral deposits, often in low concentrations and together with radioactive materials. Separation is a lengthy and delicate process during which more strategic elements cannot be targeted discretely. Thus their real economic value is generated not at pit-side but only after separation is complete, incentivising the vertical integration which drove the Silmet-Molycorp merger. Almost all stages of production demand expensive radioactive licensing, thereby giving significant economic advantage to ventures who exploit territories with lax regulations and poor protection for the rights of local inhabitants and workers. Loparite processing also enables access to its rare metal content of niobium and tantalum.[35] These are elements that similarly tend to occur alongside radioactive materials, implicating the same array of ethical questions.[36] They also form the basis of important alloys and are valued within the nuclear sector due to their largely inert character, high melting points, and high thermal conductivity. Tantalum, integral to the electronics industry for its ability to store electric charge – the basis of capacitors – was in critically short supply throughout the USSR.[37]

Lovozero itself is a horseshoe-shaped mountain range, forming the world's second largest layered igneous complex,[38] and situated at the centre of the Kola region – a territory jutting out between the White Sea and the Barents Sea, almost entirely above the Arctic Circle. From 1938 Kola was administratively referred to as Murmansk Oblast, at roughly the same time as a heavily polluting nickel smelting industry was established at Monchegorsk – 100km west from Lovozero. Its name

[34] Klinger points out that during WWII 'Thorium, uranium, tungsten, platinum and vanadium were grouped with rare earth elements because of their geological coincidence and complementary applications'. See: J. M. Klinger, A Historical Geography..., p.575.

[35] Considered chemical twins, Nb and Ta elements usually occur together within the earth's crust, and were long mistaken for the same element 'Columbite'. See: K. Schulz, J. Papp, Niobium and Tantalum – Indispensable Twins: U.S. Geological Suvey Fact Sheet 2014, 3054, https://dx.doi.org/10.3133/fs20143054, (accessed 2 March 2020).

[36] Tantalum is officially classed as a 'conflict mineral' due to its presence within Coltan – notorious for its role in funding the colonially rooted conflicts of the Democratic Republic of Congo. Since 2013, Silmet has been a full member of the International Tin Association (now ITSCI), an initiative for monitoring and promoting responsible mineral sourcing. See: NPM Silmet OÜ. – http://www.silmet.ee/ (accessed 12 April 2020).

[37] Y. Freeman, Tantalum and Niobium-based Capacitors. Cham: Springer, 2018, p. xviii.

[38] G.Y. Ivanyuk, A. Kalashnikov, N.G. Konopleva, Y. A. Pakhomovsky, Rare Earth Deposits of the Murmansk Region, Russia: a Review. – Economic Geology, 2016, vol. v, no. 111, (November), p.1538.

refers not only to the alkaline rock formation, but also to a neighbouring lake and village settlement considered the cultural and demographic centre of the Russian Saami population.[39] A partly nomadic Finno-Ugric people, the Saami suffered forced-collectivization concurrent with Kola's early Soviet industrial transformation. However, the strength of their ties to the surrounding territory is evident from the rock itself – etymologically loparite derives from the Russian for Saami, *лопар* ('lopar').[40] Interest in extraction of these ores began seriously in 1951 at the Karnasurtsk mine.[41] By 1971 the Solikamsk Magnesium works in Perm Oblast, at the foot of the Ural Mountains, started to handle the first stages of loparite beneficiation, extracting concentrates from raw inputs through a process of chlorination[42] which resulted in a semi-finished product transported elsewhere for further refinement, including to Sillamäe. Between 1970 and 1991, the plant would handle a total of 152 379 metric tons of this concentrate,[43] and whereas its uranium operations were liquidated in 1989 – seemingly in recognition of the Baltic States' growing independence – its rare metal and LREE production have continued, with ties to Solikamsk a fluctuating but ongoing part of its material transition.[44]

Evidently, in 1981 these were correlations between industrial complexes functioning within fundamentally different economies. However, as already noted, by 2011 those same points of material tangency formed the basis of a concrete merger between Molycorp Minerals LLC and AS Silmet. In both cases titles referring to new corporate entities, yet comprising many of the same assets relevant to production in 1981. Klinger is careful to point out that to refer to the REE market is, in fact, to indicate 'multiple markets'[45] based on the elements' 'widely divergent availabilities

[39] The origins of the Lovozero settlement are not known, but the first records indicate a community dependent on fishing in the local lake – the Saami name for Lovozero is *Lujavrsyit*, 'the community by the great lake.' The Saami's traditional territory encompasses northern Norway, Sweeden, Finland (collectively referred to as Sámpi). See: Encyclopedia of the Artic: Volume 1, 2 and 3, A-Z. Ed. M. Nuttall. New York, London: Routledge, 2005, p.1209.
[40] Loparite-(Ce), Handbook of Minerology, Mineralogical Society of America, Mineral Data Publishing, 2001-2005, version 1, https://rruff.info/doclib/hom/loparitece.pdf (accessed 1 March, 2020).
[41] J. B. Hedrick , V. D. Kosynkin, S. P. Sinha, Loparite, a rare-earth ore (Ce, Na, Sr, Ca)(Ti, Nb, Ta, Fe^{+3})O_3 – Journal of Alloys and Compounds, 1997, no.250, p.468.
[42] Loparite-(Ce), Handbook of Minerology.
[43] E.Lippmaa, E.Maremäe, A.Rummel, A.Trummal, Tantalum, Niobium and Thorium Cake Production at the Sillamäe Oil Shale Processing Plant – Oil Shale, 2006, vol. 23, no.3, pp.281.
[44] E.Maremäe, Uranium Production Research at Sillamäe, Estonia, in 1946-1989. – Historical Survey of Nuclear Non-Proliferation in Estonia, 1946-1995. Ed. I.Maalmann. Estonian Radiation Protection Centre, December 2003, p.35.
[45] J. M. Klinger, A Historical Geography..., p, 573.

and applications'[46]. In the given case it was the element neodymium, which forms the basis of neodymium-iron-boron (NdFeB) magnets – the strongest commercially availabe[47] – that was most valued. That said, Klinger nonetheless provides several broad outlines.

By the time of the Molycorp merger, global REE production was no longer anchored to the resources of Mountain Pass[48] nor framed by atomic expansion. Rather, it was Chinese-led, both in terms of mining and processing, with the Bayan Obo mine in Baotou, Inner Mongolia, standing as the leading extraction site – in 2011 China accounted for a total 95 percent of global mine production.[49] As for the industry's commercial incentives, these were now closely aligned to expanding digital economies. Indeed, as Klinger notes, it was precisely 'The acceleration of innovations in information technology ... through the 1970s and 1980s'[50] that led to the lanthanides being 'conceptually decoupled ... from radioactive elements such as uranium and thorium'[51] thereby transforming 'the politics of prospecting and production.'[52]

She emphasises how this coincided with reorientation of interest from their chemical to their physical characteristics, with particular focus in 'their exceptional magnetic and conductive properties that enabled an impressive miniaturization of computing devices.'[53] Without them, we would still have 'global political, economic, social, and information networks'[54] but their form and feel would be vastly different. They often constitute little more than a trace within the technologies and materials they sustain, yet that presence is decisive as to global physical composition.[55] To qualify which, Klinger cites the changing tone of US government analysts between two documents dated 1974 and 2013.

Initially the official opinion is that if access to REEs were threatened, then 'the effect on our present standard of living would not be catastrophic'.[56] However, by

[46] J. M. Klinger, A Historical Geography..., p, 573.
[47] The strongest magnet commercially available, they are present in everything from hard disk drives and smart phone, wind turbines and hybrid cars.
[48] The Mountain Pass mine was out of action by the late 1990s, the original company name dissolved into Chevron Mining Inc. and the Louviers is no longer operational.
[49] J. Gambogi, Rare Earths – U.S. Geological Minerals Yearbook, 2011, https://www.usgs.gov/centers/nmic/rare-earths-statistics-and-information (accessed 1 March, 2020), p.60.3.
[50] J. M. Klinger, A Historical Geography..., p, 578.
[51] J. M. Klinger, A Historical Geography..., p, 578.
[52] J. M. Klinger, A Historical Geography..., p, 578.
[53] J. M. Klinger, A Historical Geography..., p, 578.
[54] J. M. Klinger, A Historical Geography..., p, 578.
[55] J. M. Klinger, A Historical Geography..., p, 578.
[56] J. M. Klinger, A Historical Geography..., p, 578.

2013 their status had shifted to 'essential'.[57] Illustrating, Klinger expands, that they have transitioned from a niche concern for select industries to an important material thread throughout the fabric of technologically enhanced existence, implicating everything from 'the rise of digital economies, [and] the increasing importance of satellite communications to the daily functions of global political economy, security, and scientific progress'.[58] In the EU's current list of 'critical raw materials' LREEs, but also niobium and tantalum are all listed.[59] Importantly, in her own work, Klinger challenges over-emphasis on this latter phase of their industrial history, especially the tendency to see their recent politicisation – triggered first by the introduction of Chinese trade quotas in 2010, now a faultline within ongoing US-Chinese tensions – as something novel.

Instead, she situates recent tension within deeper histories and broader geographies of territorial conflict and control. If the chronological framing of this paper sticks to the standard lens, then it affirms the need for an expansion of geographical scope. Or rather, an approach to well-trodden ground from other angles. In doing so, I understand 'territories' to encompass the materials themselves as *part of* the discursive terrain. Where Klinger moves from 'an international historical geography'[60] to the assertion that 'Now, rare earths matter for everybody',[61] I aim at addressing one particular aspects of these broader geographies, approaching 'everybody' through the particulars of the Estonian context. A territory that has not only been dramatically shaped by Cold War politics, but has emerged as an important voice in advancing the REE-laced horizons Klinger threads back from. It has also been an active player in negotiating and inflecting the amorphous meaning of the term 'neoliberal' whose increasing prominence partly aligns and certainly intersects with that of the equally expansive referent, 'the digital'. The point of which is to emphasise that 'digital economies' are just as variegated and contestable as the geology underpinning them.

[57] J. M. Klinger, A Historical Geography..., p, 578.
[58] J. M. Klinger, A Historical Geography..., p, 578.
[59] European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: on the 2017 List of Critical Raw Materials for the EU. – Register of Commission Documents, 13 September 2017, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017DC0490&from=EN (access 2 March 2020), pp.6-7.
[60] J. M. Klinger, A Historical Geography..., p, 573.
[61] J. M. Klinger, A Historical Geography..., p, 578.

In the following chapter I aim at contextualising these material correlations more thoroughly within Silmet's industrial prehistories. Given that most of the plant's current infrastructure and technical know-how dates from the Soviet era, that history is an ongoing account of its material and technical composition, worked through two of the 'blank slates' to be negotiated: Sillamäe's exceptional urban status, and Velmet's call for an 'expanded' approach to digital infrastructures.

Chapter I: Territories of Techno-Material Production

If you study the current status of Silmet's market's linkages, what becomes strikingly apparent is both the vast span of its material relations yet somewhat peculiar geographical situation. Accepting its strategic access to major transport arteries – including both the E20 Tallinn-St Petersburg highway, or, more recently, the neighbouring port development AS Sillamäe Port (Silport) – it is nonetheless adrift from any major potential source of raw material. Visit the local town website and you find a whole page devoted to the plant, a leading local employer, promoted as a global venture with import and export figures both totalling ninety-nine percent.[62] In direct contrast, the site's industrial roots are intimately related to the geology upon which it stands. However, in detailing these beginnings, I suggest that there is more than one way to think that material rootedness.

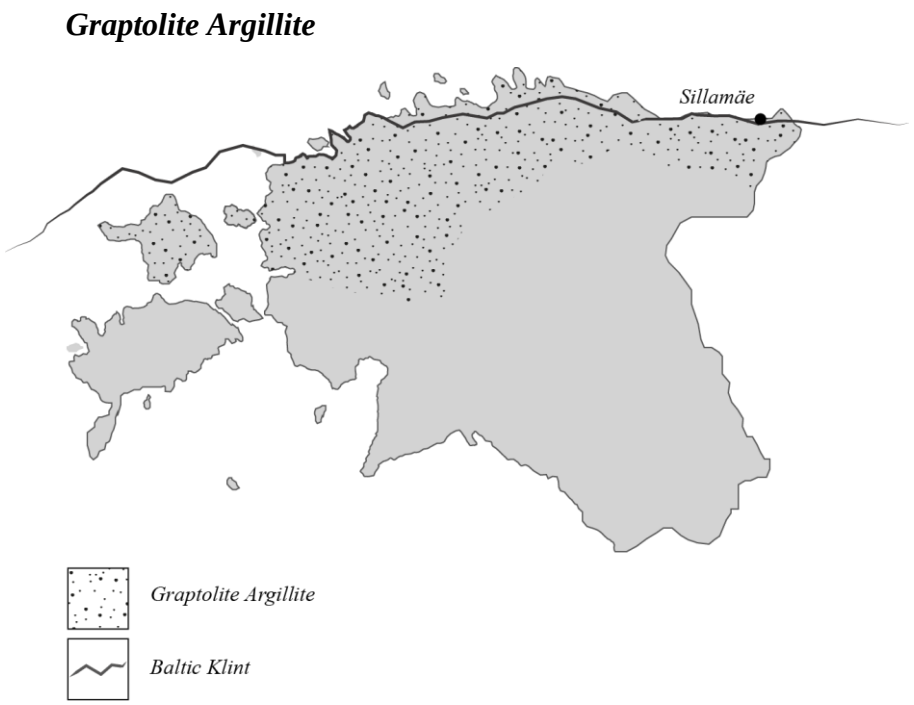

Fig. 1. *Estonian geological features relevant to Sillamäe's early industrialisation. (Source: Author).*

[62] NPM Silmet – Sillamäe Linn, http://www.sillamae.ee/silmet (accessed 1 March 2020).

The northern Estonian coast lies along the Baltic Klint, a limestone escarpment of whose total 1200km – spanning from the Swedish island of Öland to Russia's lake Ladoga – Estonia traces some 300km.[63] Commonly referred to in Estonian as *paekallas* (limestone coast), in fact it is a distinctly composite formation. For our purposes, it is the presence within its many-coloured rock strata of graptolite argillite, otherwise known as dictyonema or black alum shale that proves critical to the early industrialisation of Sillamäe. This darkish mudstone is identifiable within certain sections of the escarpments' coastal cliff face, or else as eroded black slate along the beaches bellow.[64] Shoreline traces that are merely the tip of shale beds totalling an estimated 65 billion tons and covering roughly a quarter of the Estonian land mass.[65] Graptolite argillite contains a wide array of metal compounds of potential commercial interest including uranium, and has been studied for such purposes since the nineteenth century.[66] However, it was not until 1928 that active exploitation of these resources began regionally. This took the form of a Swedish-financed oil shale venture, the *Estonian Oil Consortium AS,*[67] established at Türsamäe – then the site of

[63] North Estonian Klint: A Symbol of Estonian Nature, 2008 – KIK Environmental Investment Centre, GEOTRAIL, https://www.looduskalender.ee/klint/eng/index.html (accessed 2 February 2020).

[64] Dictyonema shales are technically not a shale (metamorphosed clay) but hardened clay. Part of the family of Cambrian-Ordovican black shales, they are carbon-rich sedimentary rocks formed largely of clay minerals. The name dictyonema is also somewhat misleading, derived largely from the Soviet-era it refers to what were thought to be Dictyonema flabelliforme fossils found within its sedimentary layers – later research has proved them to be examples of Rhabdinopora graptolites. See: R. Aguraiuja, E. Lippmaa, E. Maremäe, A.T. Pihlak, Estonian Graptolitic Argillites: Ancient Ores of Future Fuels? – Oil Shale, 2009, vol.26, no.4, p. 531.

[65] It should be clarified that these shale beds are distinct from the brown kurkesite shales, also abundant across the northern Estonian territory, which form the basis of its large oil shale energy industry.
See: S. Kulli, Estonian Argillite – Biota Tec, http://biotatec.com/technology-1/estonian-argillite (accessed 2 February 2020).

[66] Research on its radioactive properties started in the St Petersburg region. Early observations within the Estonian context were focused its potential agricultural application as a fertilizer. However interest was also triggered by its unstable properties when in the form of weathered slate – liable to self-ignite. Apparently this triggered suspicions amongst Paldiski locals that the spontaneous fires along their beaches were signs of volcanic activity. During the 1920s more detailed surveys were conducted by Estonian geographer August Tammekann who focused on its potential for oil shale production. He suggested various promising sites for industrial development, the most viable including: Paldiski, Keila-Joa, and Iru. See: H. Tankler, General Background. – Historical Survey of Nuclear Non-Proliferation in Estonia, 1946-1995, Ed. I.Maalmann, Estonian Radiation Protection Centre, December 2003, p.8.

[67] This was the first, and last, venture to mine both Estonia's dictyonema and kukersite shales. Financed by Swedish capital a decade after Estonia first established independent statehood, the factory should be contextualised within an era marked by large inflows of foreign direct investment, predominantly British and German. See: E.Lippmaa, J.Lippmaa, E.Maremäe, A. Rummel, A. Trummal, 2006. Enriched Uranium Technology at the Sillamäe Oil Shale Processing Plant. – Oil Shale, vol.23, no.3, p.275.
Also: K.Liuhto, 1995. Entrepreneurial Transition in Estonia – Turku School of Economics and Business Administration Business Research and Development Center and Institute for East-West Trade, Series C Discussion 3/95, p.8.

a manor house, small fishing village, and still a distinct settlement from its neighbour Sillamäe.[68]

Throughout World War II, the oil shale factory passed between Estonia's various occupying forces – by 1944, as the Republic was annexed for the second time under Soviet control, it appears to have been largely destroyed. Besides territorial expansion, the USSR was focused on the atomic arms race, at which point competition was based less on access to technical know-how than to sufficient resources of uranium. The northern Estonian reserves of graptolite argillite and the site of the former factory were identified as easily accessible and effective cover for what was to be an entirely secret operation.[69]

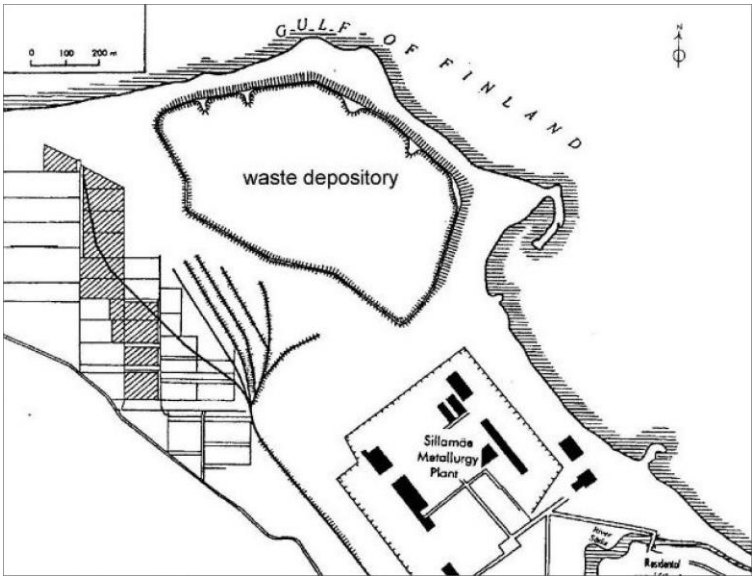

Fig.2. *Map of the Sillamäe Metallurgical Plant, mine (striped area), and tailings pond (labelled waste depository). Source: See list of figures.*

As early as July 1946 a classified decree was issued 'to establish a diversified enterprise "Combine No.7" at Sillamäe ... for the mining and industrial processing of the Baltic Dictyonema shale'[70] – initially the largest post-war industrial development on Estonian territory.[71] It was planned to include two mines (the second was never

[68] H. Tankler, General Background. – Historical Survey of Nuclear Non-Proliferation in Estonia, 1946-1995, Ed. I.Maalmann, Estonian Radiation Protection Centre, December 2003, p.8.
[69] H. Tankler, General Background, p.9.
[70] E. Maremäe, Uranium Production Research..., p.13.
[71] H. Tankler, General Background, p.9.

developed) and Plant No.1 at Sillamäe,[72] as well as a pilot plant in the nearby town of Narva.[73] Labour for establishing the combine was vast, reportedly including some '16,000 prisoners and convicts, and a 10,000 man forced labour unit.'[74] Mining activity commenced in December 1946, and the conditions were, according to the research of chemical engineer Ello Maremäe, 'near ideal – a dry 1.15m thick seam of shale with 13 to 20m of overlay.'[75] However, she continues, initial mining targets of 400 tons per day were never met – from a planned 1.5 tons the first year's output totalled all of 99kg.[76] Underpinning the project's industrial overreach was the poor health of its labour force,[77] technological limitations, but also the limits imposed by the shales themselves. Extensive testing across leading Soviet research institutes revealed that Estonia's graptolite argillite was 'a rather non-uniform ore with unpredictable properties'[78], essentially a poor choice of raw material. By 1952, the decision was made to terminate processing of local shales for anything other than research purposes.[79] From that date the plant transitioned entirely to the handling of ore imports from across the USSR, including: Poland, Czechoslovakia, Romania, Hungary, East Germany, and Bulgaria.[80]

[72] E. Maremäe, Uranium Production Research..., p.16.
[73] E. Maremäe, Uranium Production Research..., p.16.
[74] E. Maremäe, Uranium Production Research..., p.17.
[75] E. Maremäe, Uranium Production Research..., p.17
[76] E.Maremäe, Uranium Production Research..., p.19.
[77] Maremäe recounts that forced labour mainly constituted 'Baltic conscripts who had served in the German army' and that 'The workforce actually used in the mine ... consisted of prisoners of war and criminal convicts (79%) and soldiers serving various kinds of punishment (19%) with only 2% of free labour. Out of all these, 30% were in normal health, 60% weak, and 10% very weak.' See: E.Maremäe, Uranium Production Research..., p.17.
[78] E.Maremäe, Uranium Production Research..., p.20.
[79] E.Maremäe, Uranium Production Research..., p.17.
[80] E.Maremäe, Uranium Production Research..., p.26.

***Fig.*3.** *Detailed Plan of the town of Sillamäe (1947-48). The plant is situated within the territory left blank to the western edge of the town, where the central road can be seen crossing the Sõtke river as it curves out to sea. Source: See list of figures.*

However, if this marked the beginning of Silmet's infrastructural drift, then the impression of disconnect from the territory upon which it stands is perhaps more fundamentally associated with its history as a closed urban-industrial environment. Developed in step with the plant, Sillamäe gained the status of a town in 1957,[81] together they formed an administrative enclave officially instructed to exclude ethnic Estonians. Instead, the site was to be populated by migrant labour, and remained a zone of restricted access up until national independence was regained.[82] In recent communication for this paper, Maremäe – whose doctoral research in the 1970s was uranium-based but still did not facilitate access to Sillamäe[83] – explained that these conditions initially remained post-1991:

[81] H. Tankler, General Background, p.9.
[82] H. Tankler, General Background, pp. 10-11.
[83] Maremäe explained to me that: 'Before defending my uranium-themed secret dissertation in Moscow in 1975, there was one reviewer of my study who was appointed from Sillamäe. I was very interested in going from Tallinn to Sillamäe to conduct the review process in person, but I was not allowed access. Therefore, my meeting with the reviewer took place on the eve of the dissertation defence on the Moscow subway. I was given my review without a word other than in Russian for "hello" and "goodbye".' – E. Maremäe, email correspondence with the author, 24 April, 2020.

> Working in KBFI (NICPB)[84], we wanted to visit the Sillamäe facility during the first days of our independence. Despite a mountain of documents that we had with us for granting us access, we were not let in, and had to return 180km back to Tallinn. The trip was in vain. Some time later, we were allowed in to take some water samples from the waste depository of the plant, but were followed around by several militia cars. Following the replacement of the facility's management, the plant later became an ordinary institution.[85]

As such, its status was radically split. On the one hand, an aggressive insertion upon occupied territory, of material extraction and cultural negation. On the other, for its inhabitants – who by 1950 already totalled some 10,000 people[86] – the factory and town were a pragmatic site of everyday work and residence, based upon shared cultural construction and an elevated industrial narrative – the plant being considered an 'elite' Soviet industry.

In the 1988 film by Estonian director Roman Baskin, *Vernanda*, we arrive by train in Sillamäe, which stood in for the fictional town of the film's title.[87] Perhaps best characterised as feeding to and from the façades of the town's Stalinist-era architecture, Baskin slowly lures us into a surreal house of ideological mirrors within which the protagonist, an unnamed young man, accidently stumbles. Burdened by a loaf of bread which, upon purchasing, he discovers also happens to be ticking bomb – an object Vernanda locals appear to find unremarkable and that he can't quite seem to rid himself of – the man's relation to his urban environs, intended to symbolise life within a totalitarian regime, descends from subtly comic to increasingly hysterical. Adrift in a place that gradually reveals itself as no place.

[84] *Keemilise ja Bioloogilise Füüsika Instituut* (National Institue of Chemical Physics and Biophysics).
[85] E. Maremäe, email correspondence with the author, 24 April, 2020.
[86] H. Tankler, General Background, p.10.
[87] The film is based on the short story *Vernanda leib* [Vernanda's Bread] by Arvo Valton. permits were still necessary to gain access to the town. See: Vernanda (1988) – Eesti Filmi Andmebaas, https://www.efis.ee/et/filmiliigid/film/id/490 (accessed 18 March, 2020).

Fig.3-4. *Stills from Vernanda, 1988. Director: Roman Baskin. 'Man': Sulev Luik. Sources: see list of figures.*

There is something of Vernada that lingers in Sillamäe's wider reputation, captured in a 2011 interview conducted by Estonian broadcaster *Eesti Rahvusringhääling* (ERR) with then Molycorp Silmet CEO David O'Brock[88]. The interviewer quizzes O'Brock – a US expat, whose affiliation with the plant long-predates the Molycorp merger – on the ethnic integration of the town, stating that: 'To most Estonians, when the name Sillamäe is mentioned, it conjures up thoughts of a closed city of Russian speakers that came late in removing its Lenin statue.'[89] O'Brock's response – precisely the same I encountered in a recent interview conducted for this paper[90] – was gently correcting on the 'Russian' tag: 'Silmet has a very diverse workforce which originally came from all parts of the Soviet Union. We have 32 cultures represented in our workforce.'[91]

Such comments should be contextualised within the broader politics of the region. Political scientist David J. Smith has explained that by the time independence was reinstated only '18 per cent'[92] of the inhabitants of Ida-Virumaa – the county to which Sillamäe belongs – were ethnic Estonians. Most of this substantial migrant population did not automatically receive Estonian citizenship upon regained national independence triggering substantial insecurity for ethnic minorities. Tensions were heightened by rising levels of unemployment connected to the collapse of Soviet

[88] M. Huang, Silmet CEO on Metals, Investment and his Company's Future – ERR, 24 March 2011, https://news.err.ee/99575/silmet-ceo-on-metals-investment-and-his-company-s-future (accessed 12 April 2020).
[89] M. Huang, Silmet CEO on Metals.
[90] D.O'Brock, conversation with the author, 15 April 2020, author's notes.
[91] M. Huang, Silmet CEO on Metals.
[92] This compares to the national percentage of non-titular groups which Smith details has rising 'from 12% to 39% during 1940–1989.' See: D. J. Smith, Narva Region within the Estonian Republic: From Autonomism to Accommodation? – Regional & Federal Studies, 2002, vol.12 (2), p.107.

industries, but also further alienating legislation.[93] This gave weight local political figures advocating for regional autonomy, often upon markedly aggressive terms – Davies notes that they 'frequently invoked the spectre of possible inter-ethnic violence'.[94] All of which culminated in referenda on the issue in Narva and Sillamäe in 1993.

What is interesting about Smith's account is the sense of a strained geo-political backdrop – the status of the Estonian-Russian border was still legally undetermined – dramatized by the posturing of certain key actors at both local and national levels, yet the largely ambiguous position of the majority of regional inhabitants. For example, as early as July 1991, he notes that 'Tallinn was warned that the option of forming a breakaway 'Transnarovan SSR' was becoming increasingly popular amongst the inhabitants of north-eastern Estonia.'[95] Yet this contrasted markedly with surveys of a similar date which indicate that 87 percent of the region's population were opposed to secession.[96] He also stresses that 'much emphasis has been given to the transient nature of post-war immigration'[97] but that in reality '69 per cent of Narva's population during the early 1990s had either been born in Estonia or had lived there for over 30 years'[98] – a statement that holds true for Sillamäe. Finally, he underlines that the referenda, which seemed to strongly support secession, took place amongst relatively weak voter turnouts and suspicions of vote-rigging.[99]

Returning to the ERR interview, O'Brock, prefers to stay clear of the overtly political.[100] Instead, he focuses on the skills and loyalty of Silmet's workforce, and his admiration for the town. In response to a noted mismatch between Estonia's pride in its high-tech achievements and 'the general lack of information and knowledge about one of the country's largest privately-held companies'[101] he explains that the plant's shareholders have encouraged a 'lack of public attention'.[102] He continues by stressing

[93] Namely the proposed 'Law on Aliens' by the 1993 government headed by Mart Laar, who, 'In June ... introduced new legislation stipulating that holders of Soviet passports must apply for new residence and work permits within a year or else face the status of illegal immigrant and the possibility of deportation from the country.' See: D. J. Smith, Narva Region..., p.96.
[94] D. J. Smith, Narva Region..., p. 94.
[95] D. J. Smith, Narva Region..., p.95.
[96] D. J. Smith, Narva Region..., p.95.
[97] D. J. Smith, Narva Region..., p.91.
[98] D. J. Smith, Narva Region..., p.91.
[99] D. J. Smith, Narva Region..., pp. 98-99.
[100] M. Huang, Silmet CEO on Metals.
[101] M. Huang, Silmet CEO on Metals.
[102] M. Huang, Silmet CEO on Metals.

– and again this matches our recent conversation – that 'The people working at Silmet are its greatest asset and I cannot emphasize this point enough. In the world there are two places with advanced, concentrated 'know-how' in the practical handling of lanthanides and how to effectively extract these elements from minerals: China and Estonia.'[103]

In my own communication with O'Brock, no longer affiliated with the plant but evidently still interested in the community's future, he explained how one of his main concerns had been to maintain the next generation of workers, which requires substantial training and countering a tendency for families to encourage out-migration based not upon a lack of local pride but rather concerns as to long-term futures – the region is still marked by high levels of unemployment.[104] He also made a point of noting how staff nearing retirement often stay on to ensure work runs smoothly and assist with mentoring trainees, demonstrating a great deal of loyalty to the company and care over its output. Silmet's material rootedness remains, yet this has transitioned from a question of the immediate geology, to that constructed about careful material practices and evolving chemical know-how. By extension, without denying the hard facts of its closed past, we might emphasise the performative rather than 'natural' aspect to territorial belonging.

[103] M. Huang, Silmet CEO on Metals.
[104] D.O'Brock, conversation with the author, 15 April 2020, author's notes.

Beyond the Blank Slate?

The Estonian state's 'digital' identity, for all it oft-used promotional imagery of regional nature, is similarly a construct whose territorial specificity is reliant upon infrastructural advances and shared societal practices. In relation to which, the revisionary criticism of historian Aro Velmet is particularly instructive. He stresses the historically composite, and conceptually diverse character of what he refers to as Estonia's evolving 'information society'.[105] In doing so, he picks apart that which he dubs the 'blank slate e-state', an immaculate e-conception that naturalises a truncated history. On the one hand, this has served commercial interests, on the other, it has provided a spring board for the projection, of 'a bright future, a founding myth'.[106] However, on both counts it serves to mask more complex and deep-rooted foundations.

As to what is actually meant by Estonia's digital reputation, then, if concretely pinned to an array of digital governance infrastructures, perhaps it is best framed in broader terms as a certain developmental disposition. Increasingly, this takes the form of prioritising a supportive base for high tech investment, research, and entrepreneurship – the so-called 'digital ecosystem'.[107] As explained by political scientists Rainer Kattel and Ines Mergel, fundamental to the foundations of this reputation has been an early commitment to the principle of 'transition as replacement'.[108] Namely a strategic refusal of international 'assistance' in the form of complex digital legacy systems, in tandem with the political drive 'to 'leapfrog' the West's technology'[109] – the generative blank slate.

They also emphasise that the decision 'not to upgrade the inherited economy'[110] despite being at the technological and economic forefront of the Soviet Union, was intimately related to protests sparked by plans for industrial expansion, wherein environmental and ethnic tensions intersected – the so-called Phosphorite War of 1987. A response, they explain, both to 'Plans for even more investment into resource-intensive heavy industry and mining – and fears of new waves of immigration'.[111] The

[105] A.Velmet, The Blank Slate e-State, p.164.
[106] A.Velmet, The Blank Slate e-State, p.164.
[107] e-Estonia.com, https://e-estonia.com/ (accessed 11 April, 2020).
[108] R. Kattel, I. Mergel, Estonia's Digital Transformation, p.4.
[109] R. Kattel, I. Mergel, Estonia's Digital Transformation, p.4.
[110] R. Kattel, I. Mergel, Estonia's Digital Transformation, p.5.
[111] R. Kattel, I. Mergel, Estonia's Digital Transformation, p.5.

protests proved a pivotal force within the independence movements of the late 1980s, but also, we are told, sparked commitment by elites to an economic future based upon 'something completely different'[112]. They underline that 'The digital' thus came to express Estonia's – or more precisely, its elite's – ambitions and explains why, to this day, the 'digital elite', with some rare exceptions, is almost all ethnically Estonian.'[113] Foremost, within their account the digital state emerges as an ambitious alternative to industrial integration within 'Scandinavia's global value chains',[114] distinct from, even at odds with, the country's neoliberal credentials, 'a paradigm next to, and competing with, electronics and industry in general'[115].

On the website 'e-Estonia' – the state's official presentation of its digital achievements – the start date reads tidily 1994, marking 'the first draft of "Principles of Estonian Information Policy"'[116]. A timeline threads from here through early innovations such as a nationwide computing education and access programme 'Tiger's Leap' (1996), and transition to online tax declaration (2000). Projects that both combined widespread public engagement with the skills, funding, and interests of private actors – notably from within the domestic banking sector.[117] Further down we find bolder infrastructural advances, notably the x-road data exchange layer (2001) spanning all government agencies. Achievements that were complimented in 2004 by Estonia's accession to both the European Union and Nato, facilitating a more assertive digital leadership role within international arenas – notably on the issue of cybersecurity. In 2014 this status was both advanced and leveraged with the launch of its 'e-residency' programme, a service enabling global entrepreneurs to register their business activities remotely in Estonia, benefiting from its digital services, low corporate taxation, and European credentials. Since 2016, this increasingly expansive digital identity has also become a more curated and media-savvy projection under the direction of Brand Estonia, a government affiliated organisation responsible for coordinating the state's official multi-platform profile, via which we now encounter 'e-Estonia' home to a 'digital society'.[118]

[112] R. Kattel, I. Mergel, Estonia's Digital Transformation, p.5.
[113] R. Kattel, I. Mergel, Estonia's Digital Transformation, p.5.
[114] R. Kattel, I. Mergel, 2018. Estonia's Digital Transformation, p.4.
[115] R. Kattel, I. Mergel, Estonia's Digital Transformation, p.4.
[116] e-Estonia.com, https://e-estonia.com/ (accessed 11 April, 2020).
[117] See: K.Kerem, Internet Banking in Estonia – PRAXIS Working Paper No.7, 2003, pp. 20-26.
[118] e-Estonia – https://e-estonia.com/ (accessed 11 April, 2020).

Velmet has challenged the standard narrative's linear progression in terms of its chronological framing, the degree of its implicit east-to-west axis, and related subjective supports. In doing so he substantially expands upon that which Kattel and Mergel refer to as the Soviet inheritance of 'a wealth of R&D talent',[119] calling for a 'more expansive concept of "infrastructure"'.[120] Namely one capable of incorporating 'the expertise of sociologists and cyberneticians educated within the Soviet system',[121] yet pivotal to translating the adoption of Western hardware into a broad and sustained societal programme. Critically, this includes acknowledging their role in expanding the digital discourse beyond a narrow focus on 'on hardware purchasing and telecoms liberalization' [122] or 'STEM-education' [123] to such issues as 'regional inequality, national culture, and poverty'[124].

In doing so, Velmet helpfully interweaves discourse as part of the infrastructural matrix, and productively looks not 'to establish a "correct" history of continuity to replace narratives of rupture'[125] but rather to draw forth 'a more tightly interwoven'[126] one. This threads between geographic and temporal polarities, treating infrastructural orientation as an ongoing practice between partners, rather than a story of one info-ideological camp trumping another. Moreover, he is careful to draw out the more relational aspects of digital transition, foregrounding 'Tiger's Leap' as a key example whereby a complex and multi-directional debate emerged about what was initially a rather hardware-centric initiative. This was capable of bridging the centre-periphery divides that hard-line neoliberal economic policies had accentuated.

He is careful to note that Ida-Virumaa was something of a watershed for progressive agendas, with limited involvement in Tiger's Leap initiatives. However, if, as he states, 'ethnic disparities demonstrates the limits of [its] expansive discourse'[127] then ultimately the trope of the 'information society' itself, the deeper premise to the Tiger's Leap project, and much of the wider digital governance discourse, emerges from his text as an optimistic site for a 'new language',[128] a means

[119] R. Kattel, I. Mergel, Estonia's Digital Transformation, p.12.
[120] A.Velmet, The Blank Slate e-State, p.164.
[121] A.Velmet, The Blank Slate e-State, p.164.
[122] A.Velmet, The Blank Slate e-State, p.164.
[123] A.Velmet, The Blank Slate e-State, p. 178.
[124] A.Velmet, The Blank Slate e-State, p.164.
[125] A.Velmet, The Blank Slate e-State, p.165.
[126] A.Velmet, The Blank Slate e-State, p.164.
[127] A.Velmet, The Blank Slate e-State, p. 178.
[128] A.Velmet, The Blank Slate e-State, p.178.

of tackling issues that 'might otherwise have been dismissed as too "Soviet" or "unrealistic"[129] and thus an important counterweight to the neoliberal-led public sphere that characterised the 1990s.

The broader scope of such a study, Velmet tentatively indicates, is 'a more cybernetic approach'[130] to a more international history. However, it is precisely here, I would argue, that another blank slate is quietly sustained. Namely the establishment of an atomised base which a cybernetic discourse ultimately necessitates. This has been clearly articulated by media theorist and philosopher Alexander R. Galloway as underpinning that which he dubs *The Cybernetic Hypothesis*. Galloway situates this phenomena by a return to the 1920s and English mathematician Lewis Richardson's production of a 'crystalline space'[131] or, more precisely, a '*latticework of parallel calculation*'.[132] It was the result of Richardson's scheme for an international grid of meteorological sensors for weather prediction, and was striking, we are told, for its elaborate grasp of the grid's logic, its depth, and structural inequalities. Essentially, Galloway elaborates, having fixed 'the lower bounds of the grid's granularity'[133] then the cells themselves become a ground-zero, a 'black box', or 'an atom: uncuttable, impenetrable, and invisible. Its functionality ... purely an outward relation to the lattice as a whole, never inward toward any kind of microcosm of interiority.'[134]

This is merely one striking example of the various geneses of an increasingly ascendant computational rational. One whose networks and systems combining 'both human and nonhuman agents in mutual communication and command'[135] is more than a technical adjunct for a particular group of tasks – as Velmet's call for a more global reading fully acknowledges. Rather, Galloway continues, it forms the basis of a vast and expanding algorithmic reality, which, in the terms established by Michel Foucault, constitutes 'a general regime of knowledge'.[136] It is precisely this ground state, inflecting what is perceptible and conceivable, that I understand the 'the digital' to refer to. As such, when encountering its standard promotion, as an inherently innovative and future-facing terrain, perennially 'pioneering', it is important to treat

[129] A.Velmet, The Blank Slate e-State, p.178.
[130] A.Velmet, The Blank Slate e-State, p.179.
[131] A. Galloway, The Cybernetic Hypothesis, p.118.
[132] A. Galloway, The Cybernetic Hypothesis – differences, 2014, vol.25 (1), p.118.
[133] A. Galloway, The Cybernetic Hypothesis, p.118.
[134] A. Galloway, The Cybernetic Hypothesis, p.118.
[135] A. Galloway, The Cybernetic Hypothesis, p.111.
[136] A. Galloway, The Cybernetic Hypothesis, p.125.

this with a degree of caution. Just as Klinger situates rare earths within their wider and deeper territorial reach, Galloway underlines that today's digital futures are merely 'a final period at the end of a very long sentence.'[137] If we are to take seriously that sentence, which structurally underpins so much of contemporary knowledge production, then embracing its futures means to question thoroughly attendant scripts. The more the digital advances the more imperative, and yet apparently overwhelming, that task becomes.

In sum, if we accept the 'information society' as our touchstone, our discussions of the digital transact across the territories formed by its own algorithmic operations. Whether that be perceived as purely a technocratic concern, or else muddied within the wider politics of socio-economic, and cultural debates. It means to naturalise its atomised kernel, to internalise a blank slate, which, as Velmet's work eloquently demonstrates, does not foreclose diverse experience and nuanced agential relations. Nonetheless, without undermining the importance of recounting that variety, and the progressive role it has played at given moments for given groups, surely we must also view critically what adopting and perpetuating that logic – for example, by hitching history up to a cybernetic creed – is ultimately generative of. Which, as Galloway points out, necessitates accounting for the hegemony of computing, and determining whether we understand the function of criticism to be a symmetrical or asymmetrical structural practice in relation to that power. I propose that one important response is simply to persist in paying attention to that which is integral to sustaining digital futures, but tends not to figure in its dominant projections.

This includes its industrial base, and its materiality-in-the-making. Here to talk of a 'more expansive infrastructure' starts out in step with that which I understand Velmet to have achieved, namely an unthreading of key aspects of what an infrastructural discourse actually constitutes. However, I propose it also means to go further, namely to the externality, command, and control, that the grid however progressively cushioned, inserts. This is a move towards Barad' material-discursive practices which, worked out towards through the third 'blank slate', the neoliberal, in dialogue with the specifics of Silmet's material practices.

[137] A. Galloway, The Cybernetic Hypothesis, p.125.

Chapter II: Territories of Material-Economic Transition

1981 is likely not remembered by many for the rabbit-favoured terrain of the world's leading rare earth producer, nor for the secretive processing of loparite imports along the northern Baltic coast. By contrast, the contemporaneous political-economic reorientation of the US towards a neoliberal agenda is widely understood as a pivotal transition of powerful and ongoing effect. Signalled by the presidential inauguration of Ronald Reagan and appointment of Milton Friedman to the *Economic Policy Advisory Board*, achieved was the translation of a radical belief in unfettered free-markets into simple and actionable policy. Specifically, a four-pillar strategy of cuts to: government spending, income and capital gains tax, business regulation, and monetary supply. Concrete shifts in policy formation and governance practice that were preached as an expression of liberation slung, somewhat paradoxically, between Freidman's televised edict *Free to Choose* and (across the Atlantic) British Prime Minister Margaret Thatcher's repeated campaign mantra 'there is no alternative'.[138] Jamie Peck and Adam Tickell have characterized this period as 'roll-back neoliberalism'[139], a negatively formulated conception of freedom premised upon the 'active *destruction* and *discreditation* of Keynesian-welfarist and social-collectivist institutions'.[140] In the promotion of which, both Friedman and Thatcher thrived upon forms of economic machismo underpinned by a polarizing rhetoric that pitted old against new. Elevating the 'entrepreneur' as a universally applicable subjective form, ideally suited for negotiating the vistas of persistent novelty promised – the neoliberal 'blank slate'.

Within that combative rhetorical arena, more gradated forms of change or anomalous detail are easily overlooked, or else reductively held to the dominant narrative upon terms that remain those dictated by its leading proponents. One means of critical response is thus to pay careful attention to forms of persistence threading through declarations of 'rupture'. Transitioning to Estonia's uptake of similar economic principles a decade later, this methodology remains relevant although upon terms irreducible to its Anglo-American application. Indeed, it is precisely the radicalness of Estonia's neoliberal embrace that belies its specificity. Migratory ideas

[138] J.Peck, A.Tickell, Neoliberalising Space – Antipode, 2002, vol. 34 (3), p.381.
[139] J.Peck; A.Tickell, Neoliberalising Space, p.384.
[140] J.Peck; A.Tickell, Neoliberalising Space, p.384.

were not simply transposed, expanding their territorial reach whilst remaining discursively intact. Instead, they disassembled within forces of political reorientation, national expression, and ongoing entrepreneurial exchange. Establishing all of which is well-beyond the scope of this paper. I aim at drawing forth several prominent revisionary features through which not only the term 'rupture', but equally the retort 'continuity' must be problematized. In doing so, I move towards foregrounding Silmet's own composite addition to existing accounts, intimately related to its careful material practices and practitioners.

Enterprise and Exception

A quite typical account of Estonia's pre-independence economic interaction with the west is that provided by political scientists Magnus Feldmann and Razeen Sally in their 2001 paper on Estonian trade policy from independence to anticipated EU integration. Estonia's later reform action is referred to as 'the swiftest, most comprehensive transformation of a national economy in modern times'[141] leading '*to almost complete free trade*'.[142] Contextualised with reference to the closing years of Soviet occupation, they underline the 'puzzle'[143] as to why Estonia surpassed Latvia and Lithuania in the depth and pace of its liberal transition, despite what they characterise as essentially the same starting point. As such, they refer to all three Baltic States as 'fully integrated into Soviet central planning'[144] with external economic relations entirely 'managed via all-Union foreign trade associations'[145] – failing to note that by 1987 Estonia had, in fact, established the first independent foreign trade association of the Soviet Union, *Estimpeks*,[146]

In contrast, Finnish economist Kari Liuhto, in his summary of the 'Perestroika' years of liberalisation initiated throughout the USSR by Mikhail Gorbachev in 1985, notes that this was not, in fact, an entirely even project. Referring to Estonia as 'the

[141] M.Feldmann, R. Sally, From the Soviet Union to the European Union: the Political Economy of Estonian Trade Policy Reforms, 1991-2000 – *Bank of Finland Institute for Economies in Transition* (BOFIT), 2001, No 1, p.5.
[142] M.Feldmann, R. Sally, From the Soviet Union to the European Union, p.5.
[143] M.Feldmann, R. Sally, From the Soviet Union to the European Union, p.12.
[144] M.Feldmann, R. Sally, From the Soviet Union to the European Union, p.6.
[145] M.Feldmann, R. Sally, From the Soviet Union to the European Union, p.6.
[146] This allowed independent negotiation of imports and exports within certain sectors.
See L.F.Stöcker, Paths of Economic "Westernization", p.454.

cradle of private entrepreneurship in the Soviet Union'[147] he explains that it had been selected to spearhead sanctioned economic freedoms. Moreover, that this was simply an amplification of Moscow's long-standing approach to the northernmost Baltic State, which since the 1950s had been treated as the USSR's 'economic laboratory'[148]. What Perestroika facilitated was a far more forthright expression of that longstanding experimentalism, including expanded Western linkages and the establishment of quasi-private ventures.

Liuhto foregrounds officially condoned methods including the number of private cooperatives established and the concentration of foreign-owned companies – in both cases Estonia outpaced all other Soviet states.[149] However, he is also careful to stress that the degree to which this entrepreneurial turn penetrated the economy was relatively restricted, impacting mainly larger enterprises and elite actors. He makes a sharp distinction between the 'real entrepreneurship'[150] of the West and the '*shadow entrepreneurship*'[151] of the Soviet occupied territory – the summer of 1990 is located as the date when '*Estonian entrepreneurship*'[152] becomes a meaningful phrase.[153]

More recently, historian Lars Fredrik Stöcker has similarly revisited the years preceding independence. In doing so he offers a yet bolder assessment, focussed primarily on networks of cooperation emerging 'between economic decision-makers in the Estonian SSR and investors and economic experts in capitalist countries'[154] – especially neutral Sweden and Finland. He claims that between these territories there was established a substantial base of entrepreneurial exchange and education that has been either underplayed or outright absent from accounts of transition due to the largely informal and undocumented nature of its interactions. Instead, he continues, explanations for Estonia's later economic boldness have tended to cite: strong

[147] K. Liuhto, Entrepreneurial Transition in Post-Soviet Republics: The Estonian Path. – *Europe-Asia Studies*, 1996, vol.48, no.1, p.121.
[148] K. Liuhto, Entrepreneurial Transition..., p.121.
[149] Liuhto describes how in April 1989 Soviet Estonia had 26 registered foreign-owned companies, which equated to one company per 60 000 Estonian citizens, whereas the Soviet Union average was one per 800 000 people. Figures were similar for the establishment of cooperatives (following the Law on Cooperatives enacted in 1988). Whereas the standard figures were one cooperative per 80 000, for Estonia there were a total of one per 20 000 already by 1987. See: K. Liuhto, Entrepreneurial Transition..., p.122.
[150] K. Liuhto, 1992. Developing Estonian Entrepreneurship in Economic Transition – *Turku School of Economics and Business Administration Business Research Centre and Institute for East-West Trade*, Series C Discussion, 4/92, p. 1.
[151] (Italics as in original text) K. Liuhto, 1992. Developing Estonian Entrepreneurship..., p.1.
[152] (Italics as in original text) K. Liuhto, 1992. Developing Estonian Entrepreneurship..., p. 2.
[153] K. Liuhto, 1992. Developing Estonian Entrepreneurship..., p.1.
[154] L.F.Stöcker, 2016. Paths of Economic "Westernization", p.450.

attachment to the republic's pre-Soviet values, then still within living memory; vague Weberian assertions as to an inherent protestant ethic; and proto-entrepreneurial training via the pervasive Soviet black-market. The omission is striking, he continues, given that when combined with the degree of independence instigated by IME – the so-called 'Four Man Proposal' of 1987, a call for economic autonomy – then by 1991 Estonia was 'close to an economic revolution.'[155]

In sum, it was a somewhat schizophrenic condition, whereby the structural fundamentals of a planned economy continued to circumscribe action, yet 'the majority of the laws and decrees'[156] necessary for wholesale transition to market conditions were already in place. Both in terms of the scope of market linkages and the degree of autonomy advocated, Perestroika freedoms were not simply adopted, but rather restated on subversive, if not yet politically independent, terms. With relevant actors referred to – with strong parallels to Velmet – as pioneering partners, rather than simply developmental recipients. This subjective framing is accentuated by Stöcker's closing remarks, where he underlines that post-1991 reforms signalled not only a decisive westward transition but assertiveness vis-à-vis international advisory bodies, notably the International Monetary Fund (IMF).[157] As such, 'rupture' retains its political value, but in terms of Estonia's neoliberal credentials, this appears less a 'break' from the past, than a radical inflection of ideas substantially in motion. Nor is it a one-way relationship of increased intimacy with Western institutions and paradigms by those 'catching up'. The sharpness of Estonia's economic turn simultaneously enacted proximity and distance, integral to the expression of independence.

However, whilst Stöcker's account nuances in important ways the primary developmental thrust of the Estonian economy, it touches little on what is implicitly left behind. At issue here is not his emphasis on the Nordic axis itself, but rather the stark contrast between his careful differentiation of entrepreneurial actors and a single lumped reference to the those beyond the 'autochthonous'[158] fold. After the broad statement that market liberalisation triggered renewed 'anti-capitalist sentiments'[159]

[155] L.F.Stöcker, 2016. Paths of Economic "Westernization", p.471.
[156] L.F.Stöcker, 2016. Paths of Economic "Westernization", p.471.
[157] L.F.Stöcker, 2016. Paths of Economic "Westernization", p.474.
[158] L.F.Stöcker, 2016. Paths of Economic "Westernization", p.454.
[159] L.F.Stöcker, 2016. Paths of Economic "Westernization", p.454.

especially within 'the Russian SFSR and parts of the Ukranian SSR'[160] he adds that such reservations similarly held sway amongst 'the masses of Estonia and Latvia's Russian-speaking industrial workers and leading managers at state enterprises'[161]. Certainly, Silmet, as a secretive, exclusionary, and quasi-military venture, stands in stark contrast to the increasingly autonomous free-market cultures detailed. As noted, there were also undoubtedly regional actors advocating against aligning the fates of the region with those of the nation. Yet, that framing also masks how, in practice, transition relied upon a more composite collective of actors and interests. Accounting for whom demands a cautious application of 'rupture', but perhaps foremost a more careful formulation of 'continuity'.

In detailing the ideological polestars of Estonia's economic reorientation post-1991, attention inevitably gravitates towards the figure of two-time Prime Minister Mart Laar. Referred to by Kattel and Mergel as 'openly radically neoliberal, citing Milton Freidman and counting Margaret Thatcher among his friends',[162] Laar's own wording of events is worth pausing on. The rhetorical field he has been pivotal in constructing, at home and abroad, registers as an acute expression of neoliberal 'rupture', yet it does so upon specific terms. Exemplifying, that which Velmet – applying the terminology of historian Gabrielle Hecht – has described as, 'rupture-talk'[163]. Essentially, an exaggerated rhetorical device that may be reductive to historical complexity, but should not be underestimated as a generative force in its own right.

For example, in 1994 Laar gave a speech for the UK conservative think tank *The Centre for Policy Studies*, where he was introduced by Thatcher herself. She recalls how: 'I noted with amusement that some thought Estonia's reforms were too radical. I understand, Prime Minister that you replied, in effect, that there was no alternative; if I may say so, a phrase I seem to have heard somewhere before.'[164] Setting a tone of comradery threaded with developmental patronage, she concludes by exclaiming '*Welcome!*'[165] to Estonia, as a nation aligned with European ideals. Laar's

[160] L.F.Stöcker, 2016. Paths of Economic "Westernization", p.454.
[161] L.F.Stöcker, 2016. Paths of Economic "Westernization", p.454.
[162] R. Kattel, I. Mergel, Estonia's Digital Transformation, p.5.
[163] A.Velmet, The Blank Slate e-State, p.165.
[164] M. Thatcher, Preface – M. Laar. The Challenge for Europe. *Centre for Policy Studies*, June. Bury St Edmunds: St Edmundsbury Press, 1994, p.4.
[165] M. Thatcher, Preface – M. Laar. The Challenge for Europe, p.4.

subsequent speech proves instructive. He confirms Estonia's position as a returning European 'lost son'[166], but not, as Thatcher had implied, through simply merging with the existing rhetorical repertoire. Rather Estonia is positioned as a bearer of 'values and principles which have been all but forgotten at home'[167]. He denounces a Europe that 'is still over-governed, over-taxed and over-manned'[168], sculpting a shared ground upon which post-Soviet states and the European 'establishment' are equal partners in pursuit of economic liberalism.

Over a decade later, he applied a similar rhetorical device in accepting the *Milton Freidman Prize for Advancing Liberty,* awarded by American conservative think tank the Cato Institute, Laar claims that to follow Freidman's teachings meant not only freeing Estonia from the Soviet past, but also saving it from 'A lot of western countries, including the United States'[169] because, effectively, 'Communism is not dead in the West.'[170] If hyperbolic, then this territorial inversion of socialist otherness serves to underline the Anglo-American bent of the theory with which we started.

Peck and Tickell, attempt to break the amorphous label 'neoliberal' into several broad chronological progressions. They start with the 'proto-' neoliberalism of the 1970s, an era of 'abstract intellectualism'[171] focused on resuscitating and reinventing libertarian convictions within academic circles. Followed in the 1980s by the 'roll-back' neoliberalism, already cited, of Thatcher and Reagan.[172] Finally, 'roll-out'[173] neoliberalism, characterising the Third-Way politics of Clinton and Blair, which, they claim, ironically entrenched a more pervasive market rational whilst rebuilding state apparatuses. According to such a chronology, Estonia is effectively a decade behind the macro curve. Yet, if so, that is not a position passively held. Estonia's radical adherence to the theories of the 1970s, over and above the example of the 1980s, and staged against the apparent softening of the 1990s, projected an *unfulfilled abstraction* back into the neoliberal homelands. In doing so it helped sharpen, and revive the rhetoric of the think tanks themselves. Certainly, as Peck and Tickell claim,

[166] M. Laar. The Challenge for Europe, p.14.
[167] M. Laar. The Challenge for Europe, p.14.
[168] M. Laar. The Challenge for Europe, p.15.
[169] M.Laar - Mart Laar Receives Milton Friedman Prize, *Cato Policy Report*, July/August 2006, p.4.
[170] M.Laar - Mart Laar Receives Milton Friedman Prize, p.7.
[171] J.Peck, A.Tickell, Neoliberalising Space, p.388.
[172] J.Peck, A.Tickell, Neoliberalising Space, p.388.
[173] J.Peck, A.Tickell, Neoliberalising Space, p.389.

neoliberalism is 'more than the sum of its (local institutional) parts'[174] but if we start out mapping its abstract spaces about the same old political personae, then we not only obscure local detail, but miss the shifting inclination of the abstraction itself.

Crucially the exceptional state Laar constructs counter to the dominant 'neoliberal space', had specific domestic implications, whose details matter for situating Silmet. Here we might turn to his 2007 essay 'The Estonian Eonomic Miracle', published by *The Heritage Foundation*, whose 'miraculous' exceptionalism is mirrored by its opening geographical account of Estonia as 'a small country in Northern Europe on the Baltic Sea, at the crossroads of East and West, South and North.'[175] To be at a crossroads is simultaneously to be central but effectively no place, thus neatly aligns with the paper's vision of national reconstruction as 'making the nation a free-trade zone'. [176] These floating cardinal points are, however, immediately anchored about the same axes far more subtly implicated by Stöcker: North, towards Finland, lies the axis of comparison and competition; east, towards Russia, lies 'a border where civilizations clash.' [177] If the first incentivises the construction of a frictionless economised plane, then the second generates its own form of negatively conceived exceptionalism, circumscribing Estonia's Soviet legacy.

In making this assertion, Laar refers to American Political Scientist Samuel Huntington, citing his reference to the Estonian-Russian border as 'a border of Western civilization'[178]. Political Geographer Merje Kuus has noted how pervasive references to Huntington's thesis emerged within domestic discourse during the 'fluid conceptual space and geopolitical vertigo of the early to mid 1990s, in which Estonia's identity and geopolitical location was being rethought and rewritten'.[179] She refers to its uptake as *Banal Huntingtonianism,* which, she claims, is a form of 'civilisational and geopolitical narrative' [180] that 'bundles up geopolitics and culture, casting geopolitics in terms of essential identities and framing culture as a geopolitical

[174] J.Peck, A.Tickell, Neoliberalising Space, p.401.
[175] M. Laar, The Estonian Economic Miracle – Backgrounder, The Heritage Foundation, 2007, No.2060, August7, https://www.heritage.org/report/the-estonian-economic-miracle (accessed 25 November 2019), p.1.
[176] M. Laar, The Estonian Economic Miracle, p.6.
[177] M. Laar, The Estonian Economic Miracle, p.6.
[178] M. Laar, The Estonian Economic Miracle, p.6.
[179] M. Kuus, Banal Huntingtonianism: Civilizational Geopolitics in Estonia. – The Return of Geopolitics in Europe?: Social Mechanisms and Foreign Policy Identity Crisis. Ed. Stefano Guzzini, Cambridge: Cambridge University Press, 2012, pp.178-9.
[180] M. Kuus, Banal Huntingtonianism, p.174.

matter'[181]. Kuus' interest is in tracing how such a conception emerged, not as a natural point of common understanding, but the result of rhetorical repetition and gradual re-reinforcement. Which, it is important to underline, relates to certain a concrete political realities. As established within the Estonian constitution Soviet occupation was deemed officially illegal and its legacy effectively void, with a geographic return to Europe equated with a temporal return to the interwar republic. That which Kattel and Mergel refer to as 'the new republic's double-ambition: to be the state and society that it wsa in the interwar period *and* to leapfrog the West in development.'[182] As such, the neoliberal blank slate within the Estonian context is a very specific blending of 'rupture' *and* 'continuity', wherein associative repetition, and distancing exaggeration transact on the economic plane, and yet cannot be wholly reduced to an economic script. 'Return' evidently had widely different resonances, to which, within the context of Sillamäe there was little concrete meaning for its inhabitants.

In terms of Silmet, working through various archival newspaper reports and parliamentary debates of the 1990s what emerges is a strikingly composite intermingling of 'belonging' and 'otherness' in relation to dominant transitional narratives. Initially the plant was converted into a State-owned joint-stock company. Registered as RAS Silmet on 4 May 1992, falling within the category of large-scale enterprises awaiting privatization. Economist Alari Purju has provided a detailed overview of Estonia's initial experience of privatization, which was based on the principles of 'restitution and compensation'[183] to pre-Soviet ownership, and thereby formed an integral pillar for instituting the illegality of Soviet occupation. In the case of Silmet, where there was no clear pre-war ownership, the plant was transferred to the State. Purju details the differing methods applied to various categories of property, explaining that for largescale infrastructure the process was relatively slow. A 'pilot'[184] scheme of seven enterprises took place between 1991 and 1992. However, only after the stabilisation of monetary reform did this become a more widespread endeavour.

[181] M. Kuus, Banal Huntingtonianism, p.174.
[182] R. Kattel, I. Mergel, Estonia's Digital Transformation, p.5.
[183] A.Purju, The Political Economy of Privatisation in Estonia – CERT Discussion Papers, 1996, no. 9602, January, The Centre for Economic Reform and Transformation, Herriot-Watt University, p. 10.
[184] A.Purju, The Political Economy of Privatisation in Estonia, p.20.

In 1992 there was organised the Estonian Privatisation Enterprise, based upon, and supported by, the German *Treuhand* model.[185] As such, before Silmet's eventual privatisation in 1997, the plant remained under the control of the Ministry of the Economy. Under the first freely elected Estonian government of 1992 to 1995, a coalition led by Mart Laar, there was a strong emphasis on 'the rapid privatisation of infrastructure'.[186] Although in practice less swift than promised, certainly by 1993 it appears that Silmet had begun selling off various assets.[187] In 1995 a new government was elected under the leadership of Tiit Vähi – Silmet's later, and most significant, owner – who curbed the pace of privatization for large infrastructure.[188] Silmet was removed from the 'privatisation list' in October 1995, due to its apparent lack of preparation and misleading accounting.[189] It would not be deemed ready for re-entry until June of the following year.[190]

The start-stop nature of these procedures are mirrored by its unstable management patterns,[191] as well as its precarious import and export linkages. The degree of uncertainty for its, at this time, roughly 1500 workers is perhaps most neatly encapsulated by a report in the business newspaper *Äripäev* from November 1995, which describes how the plant's tantalum and niobium line had been out of action for a year and a half, only just restarted after securing imports from its former supplier, Solikamsk. However, nor did this signal a simple resumption of the former status quo. Negotiations now took place via an intermediary company Raznoimpex[192] who levied a two percent commission, and demanded advance payments. [193] The prices

[185] The Treuhand model meant that the State retained ultimate control over the organisation of sales. See: A.Purju, The Political Economy of Privatisation in Estonia, p.9.
[186] A.Purju, The Political Economy of Privatisation in Estonia, p.15.
[187] Silmet jäetakse erastamisnimekirjast välja [Silmet to be removed from the privatization list]. – Eesti Päevaleht, 24 October 1995, (as archived by: ärileht.delfi.ee), https://arileht.delfi.ee/news/uudised/silmet-jaetakse-erastamisnimekirjast-valja?id=50720381 (accessed 15 April, 2020).
[188] A.Purju, 1996. The Political Economy of Privatisation, p.15.
[189] S. Niitra, Silmeti erastamine oli ettevalmistamata [Privatisation of Silmet Unprepared]. – Ärileht, 9 January 1996, https://arileht.delfi.ee/news/uudised/silmeti-erastamine-oli-ettevalmistamata?id=50722565 (accessed 20 March 2020).
[190] S. Niitra, Silmet on erastamiseks koras [Silmet in order for privatization]. – Ärileht, 28 June 1996, https://arileht.delfi.ee/news/uudised/silmet-on-erastamiseks-korras?id=50728020 (accessed 20 March, 2020).
[191] The plant had four different managers between June 1992 and April 1997: Vladimir Antonov (June 1992 - June 1994) Walter-August Terav (June 1994 - September 1995) Enn Rohula (September 1995 - October 1995) Priit Saksing (October 1995 - April 1997).
See: V. Rozental, Vana koore all uus sisu [Old cover, new content]. – Äripäev, 1 December 2012, https://www.aripaev.ee/uudised/2012/12/01/vana-koore-all-uus-sisu (accessed April 16, 2020).
[192] Raznoimpex was then a subsidiary of the Russian joint stock company Techsnabexport.
[193] Silmet saab tooret Solikamskist [Silmet obtains raw materials from Solikamsk]. – Äripäev, 29 November 1995, https://www.aripaev.ee/uudised/1995/11/28/silmet-saab-tooret-solikamskist (accessed 6 April, 2020).

negotiated required the plant to resort to major bank loans[194], slipping into greater debt and thereby further complicating its chances of private purchase.[195] Negotiations were referred to by Raznoimpex's deputy director as having been 'difficult'[196].

As for Silmet, the amounts of raw materials secured frustratingly did not meet its full operational capacity.[197] Its manager acknowledges that suspension of operations had cost the plant market linkages, but confirmed potential Norwegian interest was being pursued – he is also reported as engaged in talks with the Chinese ambassador.[198] A report in the paper *Postimees* from March of the following year claims that the plant had been exporting largely to France, the USA, Belgium, and Russia, striking a major deal with Japan.[199] It is also described as having supplemented imports from Solikamsk with feedstocks from the USA, Germany and the Netherlands.[200] A report from the same paper in July describes Silmet, by then hosting prospective investors, as having received largely domestic interest, but that several foreign parties had also viewed the plant considering it a potential competitor.[201]

As such, the narrative fluctuates between a sense of deepening financial brittleness, and internationally recognised strategic value. Affirmations of the plant's importance as a national asset, are followed by concerns over potential Russian influence – either through a direct buyout by Russian capital, or else managerial ties and material dependencies, as evident from contemporary parliamentary debates.[202]

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[194] The Ministry of Economic Affairs agreed to the plant's request to enter into a five million kroon loan agreement with the bank Hoiupank to secure working capital. It further agreed that Silmet could enter negotiations for future financing with banks: Tallinna Pank, Hansapank, Virumaa Kommertspank and Ühispank. See: Silmet taotleb lähiajal kuni 60 miljonit krooni laenu [Silmet soon to apply for a loan of up to 60 million kroons]. – Äripäev, 22 December 1995, https://www.aripaev.ee/uudised/1995/12/21/silmet-taotleb-lahiajal-kuni-60-miljonit-krooni-laenu (accessed April 25, 2020).

[195] Raw materials totalled seven million US dollars for rare earths one and a half million for niobium and tantalum. See: Silmet saab tooret Solikamskist.

[196] Silmet saab tooret Solikamskist.

[197] Silmet saab tooret Solikamskist.

[198] Silmet saab tooret Solikamskist.

[199] Silmet saab tooret Solikamskist.

[200] T.Tomak, Eesti keemiatööstuse selle aasta toodang ulatub 2,9 miljardi kroonini, ... [Estonian Chemical Industry Production Reaches 2.9 Billion Kroons, ...]. – Postimees, 1 March 1996, https://www.postimees.ee/2471281/eesti-keemiatoostuse-selle-aasta-toodang-ulatub-2-9-miljardi-kroonini-keemiatoostus-toodab-valisturule-uutel-tehastel-on-raskusi-kaivitumisega-suurtootjad-on-positsioone-parandanud-tulevik-naib-lootusrikas (accessed April 5).

[201] U. Tooming, Silmet läheb esimese ettevõttena kaheetapilisele erastamisele [The First Company to go to the Second Stage of Privatization]. – Postimees, 13 July 1996, https://www.postimees.ee/2481301/silmet-laheb-esimese-ettevottena-kaheetapilisele-erastamisele-lapsendamise-vaevad-halastusest-hoolimiseni-keda-voib-usaldada-kasuvanemate-ja-laste-suhted-eesti-puuetega-laps-voib-leida-kodu-rootsis-muutuste-hind-laste-kannatused-totaalne-ebavord (accessed 16 April, 2020).

[202] See: VIII Riigikogu stenogramm II Istungjärk, [Transcript of the VIII Riigikogu, Session II]. – Wednesday, 20 September 1995 (14:00) - http://stenogrammid.riigikogu.ee/et/199509201400 (accessed April 15, 2020).

So that a neoliberal emphasis on the necessity of privatisation as a means of resolving Silmet's problems, converges with protectionist controls over the origins and ends of investment. Anticipated and actual expansion of western networks largely do not follow the dominant Nordic pattern, rather Silmet globalises in step with the rational of the industry to which it belongs, and that includes continued dependency upon Russian trade.

Silmet criss-crosses in dominant neoliberal rhetoric concerning national transition. However tentatively, it attracts precisely the sorts of globalised trade networks Laar envisions, but in doing so it does not establish what could be characterised as a strictly European identity. Ultimately, the plant was privatized in 1997 under domestic capital, with the slightly later entry of former Prime Minister Tiit Vähi proving critical to its long term governance. Vähi steered the plant from the late 1990s through to the 2011 Molycorp merger – working alongside O'Brock at key junctures. Molycorp was merely the third of two attempts at greater integration with complementary market actors. Including the sale of a 25 per cent stake to Austrian REE processor Triebacher AG in in 2002, and a fifty per cent sale to the Swiss group Zimal S.A. in 2006 – a holding company for Russian capital, which also owned both Solikamsk and the Kola loparite mines.[203] As such, between 2006 and 2009 the plant was in a midway state between its original axis of vertical integration, stronger European affiliations, and domestic control.

Whilst the Molycorp merger itself only lasted as long as 2015 – China relaxed its tariffs in 2014 under the ruling of the WTO, and Molycorp was unable to ride the precipitous drop in REE prices.[204] The company was refinanced by Oaktree Capital Management, ad emerged in 2016 as a reorganised and Canadian-based entity Neo Performance Materials Inc. (Neo).[205] As part of Neo, Silmet (now NPM Silmet) belongs to a global corporation, significantly the only non-Chinese REE processor licenced to operate within the country.[206]

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[203] C.Ecclestone, Neo Performance Materials (TSX:NEO, OTC:NOPMF): Risen from Molycorp's Ashes. – Hallgarten & Company, Coverage Update, 9 July 2019, http://hallgartenco.com/pdf/RareEarths/NEO_July2019.pdf (accessed 14 November, 2019), p.8.

[204] Annual Information Form: For the Year Ended December 31, 2018. – Neo Performance Materials Inc., 10 March, 2019, https://www.neomaterials.com/wp-content/uploads/2019/03/Neo_AIF_2018_AIF_FINAL.pdf (accessed 21 January 2020), p.4.

[205] Annual Information Form, p.4.

[206] F. Bastion, F. Frederick, Neo Performance Materials Inc.: Rev Up Your Investment Engine – Canada Research, Company Report: Initiation of Coverage Report, Raymond James Ltd., 2 October, 2018, https://www.raymondjames.ca/-/media/rj/dotcom-canada/files/corporations-and-institutions/neo100218.pdf (accessed 5 September 2019), p.1.

Critically, sustaining that vision of global expansion are the workers and their specific metallurgical skills. Precisely what must *not* rupture if the related market negotiations are to achieve the sorts of free-flowing competitiveness envisioned. This is highlighted in the July 1996 *Postimees* report which explained how difficulties with adapting to a change of import source had complicated the plant's move away from Solikamsk's loparite concentrates. It was also corroborated in my discussion with O'Brock concerning the plant's switch to US mixed rare earth carbonates in 2011. Such actors tend not to be written into the narratives of market paths and pioneers, however that does not mean that their work was not integral to transition. As such, I will now sketch these skills in more detail.

Loparite, Columbite, Bästnasite

It is important to note that the high grade of Silmet's technical competence extends well beyond current operations. Despite initial failures, its subsequent industrial record was one of almost constant technical innovation, often to a notably high standard. By 1951 uranium operations had been upgraded resulting in the production of U_3O_8, commonly referred to as 'yellow cake' – this remained the plants' primary output for the next three decades.[207] During this time the plant witnessed constant improvements of ore grade and technical capacity, culminating during the 1980s when the plant incorporated activities of an increased radioactive level.[208] Including the recycling of rejected fuel elements from such sites as Elektrostal, Ust-Kamenogorsk, and Novosibirsk, enhancing the level of low-enriched uranium dioxide ($^{235}UO_2$) – the grade necessary for nuclear reactor fuel.[209] It also played a significant role in the research and development of advanced pebble bed reactor technology.[210]

As for the processing of loparite concentrate, between 1972 and 1988 a total of 612.32 tons of tantalum, 9638.2 tons of niobium pentoxide, and 48676 tons of light rare earth trioxide mixtures were handled.[211] V.D. Kosynkin and V.J. Nikonov have

This is due to another Neo corporate genealogy, namely the Canadian firm formerly known as AMR technologies. See: Annual Information Form, p.4.

[207] E.Maremäe, Uranium Production Research..., p.24.

[208] E.Maremäe, Uranium Production Research..., pp.24-34.

[209] E.Maremäe, Uranium Production Research..., pp.29-34.

[210] E.Lippmaa, J.Lippmaa, E.Maremäe, A. Rummel, A. Trummal, Enriched Uranium Technology..., p.279-280.

[211] E.Lippmaa, E.Maremäe, A.Rummel, A.Trummal, Tantalum, Niobium and Thorium..., p.281.

noted that REE production was similarly a gradually upgraded process. In 1984 the plant transitioned from a method of solid- to liquid-phase sulphation, and in 1987 more than three hundred extraction cascades units were introduced – which remain the backbone of its REE production to date.[212] Here LREEs were suspended in nitric acid solutions and tributyl phosphate added as an extractant. Then, through a mixer-settler method lanthanum, cerium, and neodymium could be individually retrieved to a purity of roughly 99.5 percent.[213] It is important to underline that these activities, although unrelated to the plant's uranium production, similarly require handling of radioactive waste, which, as previously noted, is almost always a by-product of handling REEs or niobium-tantalum. Sillamäe's loparite operations resulted in some 800 tons of thorium being added its tailings pond.[214] The pond itself, situated on a coastal outcrop just beyond the plant, is one of the most serious instances of industrial waste on the Estonian territory. By 1991 it included, in addition to thorium, an estimated 1200 tons of uranium.[215] This radioactive waste was not only a Soviet 'legacy', but rather an active part of continued production.

A more animated account of the specifics of Silmet's operations has been provided by former industry trader and US government advisor David S. Abraham, who visited Silmet in 2013.[216] Starting with its handling of REEs, he underlines the degree of complexity involved in related extraction processes, whereby precise chemistry meets a craftsman like understanding of the materials themselves. Silmet is involved in the very last stages of the REE production cycle, whereby concentrates are separated into distinct element powders. He describes his entry into the building housing Silmet's Soviet-era extractor units as follows:

[212] V.D. Kosynkin, V.J. Nikonov, Rare Earth Production..., p.59.
[213] V.D. Kosynkin, V.J. Nikonov, Rare Earth Production..., p.59.
This is still rather low, high-purity grades – Silmet's current output – being measured in degrees above 99.9 percent.
[214] Mixed with shale ash this now forms the top layer of the plant's waste depository. See: V.D. Kosynkin, V.J. Nikonov, Rare Earth Production..., p.283.
[215] E. Lippmaa; E. Maremäe, Uranium Processing at Sillamäe and Decommissioning of the Tailings. – Turning a Problem into a Resource: Remediation and Waste Management at the Sillamäe Site. Eds. T. Kaasik, C.K. Rofer. Estonia Series: Nato Science Partnership Subseries: 1, 2000, vol. 28, p.10.
[216] Unfortunately I was not able to get access to the plant for this study, which explains the reliance on second-hand sources throughout.

> Sitting in front of me is a maze of large steel pipes that rises and falls above rows and rows of stainless steel rectangular containers the size of oversized garbage cans sitting several feet off the cement floor on metal scaffolding. Each one of the three hundred containers has a red number emblazoned on it and protruding thick welded-metal tubes that connect one box with the next.[217]

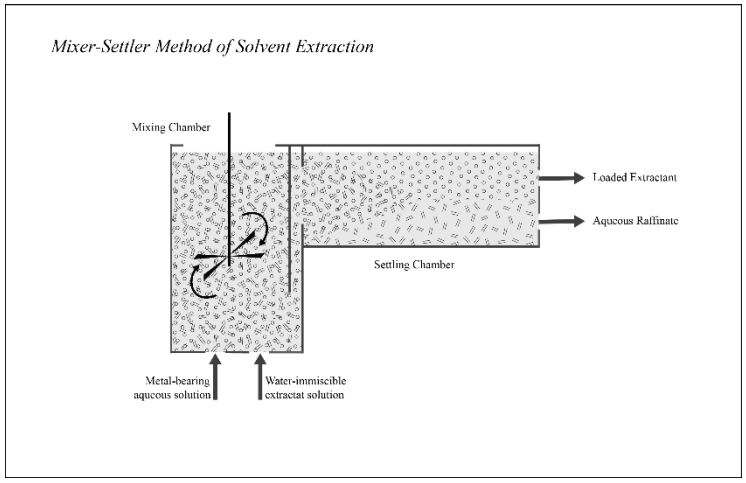

Fig. 5. *Source: Author's interpretation of illustration from the Royal Society of Chemistry – see list of figures.*

Within these containers takes place an extremely delicate chemical process, one that requires understanding the different atomic weights of each element, and thus the depth inside the extractor unit at which it will be possible to remove one element from the rest of the chemical mix. For Silmet to retrieve the most commonplace of its REE products, cerium and lanthanum, that process must be repeated 300 times. To retrieve the more valuable praseodymium and neodymium around another 300 repetitions are required. In total, Silmet's extraction process is cited as taking 'about two weeks'[218]. O'Brock likened the task to me as akin to mixing together a whole array of oils, then demanding their individual retrieval, a metaphor effective in illustrating the degree to which a desired product cannot singled out discretely, rendering management of supply and demand itself a case of careful fine tuning and experience. [219]

As for niobium – which predominates over Silmet's Tantalum line, but for which processing is relatively similar – the plant has carved out a niche in an industry dominated by Brazil and primarily focused on the application of niobium as an alloy

[217] D. S. Abraham, The Elements of Power: Gadget, Guns, and the Struggle for a Sustainable Future in the Rare Metal Age. New Haven, London: Yale University Press, 2015, p.74.
[218] D. S. Abraham, The Elements of Power, p.75.
[219] D.O'Brock, conversation with the author, 15 April 2020, author's notes.

for high-strength low-alloy steels. Instead, Silmet concentrates on a high-purity grade that is expensive and complicated to achieve.[220] It appears to have sourced its niobium and tantalum on and off from concetrates extracted from columbite, sourced from the Pitinga mine, Brazil. Abraham describes how 'The Estonian refiner sells small amounts of specialized high-grade niobium metal to universities and small manufacturers, rather than to giant multinational companies.'[221] Through which channels its output finds its way into such technologies as 'magnetic resonance imaging machines, televisions, and even the electromagnets that steer streams of protons around CERN's Large Hadron Collider.'[222] The first stage of separation of these metals is highly dangerous due to the volatile nature of its metallic dust.[223] As such, not allowed into the building housing the initial stages of niobium and tantalum extraction, this remains something of a blank in Abraham's account. Instead, he skips to the later stages of niobium metallurgy where '94 percent niobium powder'[224] is mixed 'with 6 percent aluminium to help convert the niobium to metal.'[225] This purification process takes place in an electron beam furnace:

[220] D. S. Abraham, The Elements of Power, p.81.
[221] D. S. Abraham, The Elements of Power, p.81.
[222] D. S. Abraham, The Elements of Power, p.81.
[223] In 2015 Silmet's suffered a major fire that destroyed its rare metals leaching building – it did not return to full capacity production until 2017. See: C.Ecclestone, Neo Performance Materials (TSX:NEO, OTC:NOPMF): Risen from Molycorp's Ashes – Hallgarten & Company, Coverage Update, 9 July 2019, http://hallgartenco.com/pdf/RareEarths/NEO_July2019.pdf (accessed 14 November, 2019), p.13.
[224] D. S. Abraham, The Elements of Power, p.81.
[225] D. S. Abraham, The Elements of Power, p.81.

> Workers slide the niobium-aluminium ingots into a long blue tube of a furnace that shoots a white electron beam at the metal, heating it to 2,300 degrees Celsius ... That temperature vaporizes nearly everything except the niobium, which turns into a liquid and collects at the bottom furnace.[226]

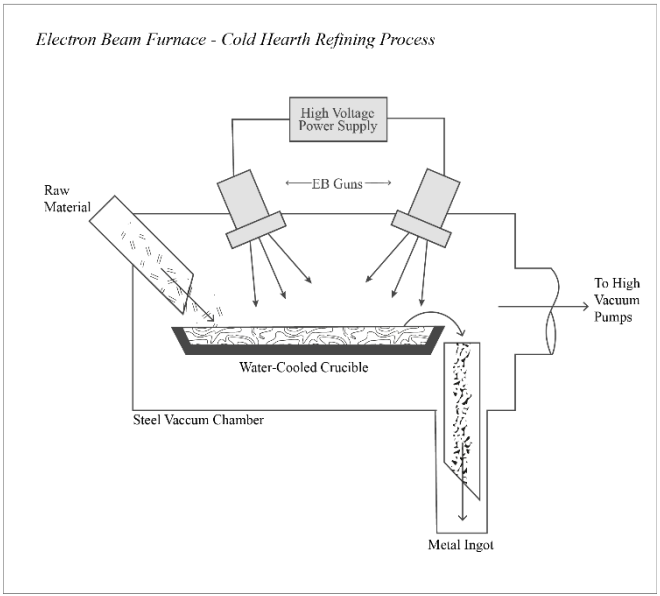

Fig.6. *Source: Author's interpretation of illustration from: F.J. Zanner, Vacuum Melting. - see list of figures.*

If this is a strikingly different process to long lines of methodical extraction cascades, then it similarly requires considerable fine-tuning, constituting a 'long process of alternating a mix of high temperature and acids'.[227] With temperatures reaching over 3000 degrees Celsius for tantalum production[228], rendering it a particularly costly element of Silmet's production. Essentially these are the sorts of infrastructure that have aided the plant's transition from command to market conditions. Considering that any change of raw material requires careful retuning of the intricate chemical and thermal balancing of the plant's work, that infrastructure cannot be disassociated from its practices and practitioners.

[226] D. S. Abraham, The Elements of Power, p.81.
[227] D. S. Abraham, The Elements of Power, pp.81-2.
[228] M.S. Fulp, REEs Up Close and Personal: A Visit to the Silmet Plant, Estonia, 6 June 2011 – MercenaryGeologist.com, http://www.goldgeologist.com/mercenary_musings/musing-110606-REEs-Up-Close-and-Personal-A-Visit-to-Silmet-Estonia.pdf, (accessed 1 April 2020).

1997, Digital Transformations

'To many Southern Californians, the East Mojave is that bleak, interminable stretch of desert to be crossed as quickly as possible while driving Interstate 15 from Barstow to Las Vegas'[229] wrote Los Angeles Times reporter cum desert enthusiast John Mckinney in 1995. He is quick to amend this perception of the Mojave Desert, which in October of the preceding year had attained the status of a national preserve. The Mountain Pass mine itself sits just beyond the northern edge of the park's boundaries, but in 1980 it had established a 14 mile underground waste-water pipe, connecting its separation facilities and the Ivanpah Dry Lake evaporation ponds.[230] Roughly five miles of which now lay within the Mojave reserve's boundaries, for a while, a largely unremarked piece of infrastructural information.[231]

In 1981, as Wells reported on the company's facilities in Colorado, and US politics decisively reoriented, Molycorp claimed to the Lahontan Regional Water Board that the contents of the pipe were not hazardous but a highly saline water solution, a benign by-product of its milling processes. What it failed to mention was it also contained various heavy metals and low-level radioactive waste.[232] Thus, when between 1984 and 1993 the mine reported 40 spillages totalling 727 000 gallons of escaped water, this raised little regulatory concern.[233] In 1996, plans to expand the mine's facilities required increasing the capacity of the pipe.[234] Molycorp engaged in an overdue cleaning of its scaled interior, but apparently forgot about its uneven diameter. Combined with high water pressure it resulted in seven major ruptures in the subterranean structure.[235] Within a fortnight 350 000 gallons of waste water had leaked into the desert.[236]

In April of 1997, Marla Cone, also reporting for the Los Angeles Times, detailed the Mojave spills. Citing the Bureau of Land Management, she describes the ruptures as having sprayed 'water and hazardous materials into the soil ... leaving a

[229] J. Mckinney, 1995. New Life for the Lonesome Desert : The East Mojave Was Recently Designated A National Presserve, But Even So, Few People Have Discovered Its Subtle, Silent Pleasures : Destination: California. – Los Angeles Times, March 26, https://www.latimes.com/archives/la-xpm-1995-03-26-tr-47201-story.html (accessed 18 March, 2020).
[230] E.C. Nystrom. *From Neglected Space to Protected Place*, p.195.
[231] E.C. Nystrom. *From Neglected Space to Protected Place*, p.195.
[232] E.C. Nystrom. *From Neglected Space to Protected Place*, p.195.
[233] E.C. Nystrom. *From Neglected Space to Protected Place*, p.195.
[234] E.C. Nystrom. *From Neglected Space to Protected Place*, p.195.
[235] E.C. Nystrom. *From Neglected Space to Protected Place*, p. 198.
[236] E.C. Nystrom. *From Neglected Space to Protected Place*, p.198.

white crystalline scale on desert vegetation.'[237] Worse, she relates, disputes between Molycorp and the government as to the terms of clean-up obligations had left the hazardous liquid to stagnate for months. This time it was not rabbits, but rather San Bernadino's population of Mojave Desert tortoises, who burrow in the Ivampah Valley, which held the interest of the reporter. The levels of radioactivity were not considered particularly high, but overall effects remained uncertain. Citing the local Water Board, she notes that the harmful substances deposited included: 'lead in toxic concentrations as well as radioactive uranium, barium, thorium and radium above background levels'.[238] That the pollution now crossed national reserve territory leveraged the power of local authorities, and in 1998 San Bernardino County prosecutors filed a civil suit against Molycorp, who suspended operations at the plant in September of the same year. Faced with fierce Chinese competition, as well as Ivampah remediation costs, by 2002 the mine had folded.

Meanwhile, Cheryl Rofer, a chemist at Los Alamos National laboratory was reminded of a brochure in Russian and English she had been handed in 1992, 'about a production plant for rare earth metals and oxides in Estonia'[239]. As she and her colleagues leafed through they noted its mention of 'a "waste depository."[240] None of us could figure out what that "waste depository" was'[241] she relates. Nor was anybody at the laboratory sure what the Soviet plant had actually constituted, with a site of uranium enrichment, or potentially plutonium weapon parts manufacture speculated upon. Uncertainties aside, Rofer penned a proposal to help with the site's clean-up, filed the brochure, and heard nothing. Late in 1997, due to a chance encounter between a Los Alamos manager and then Estonian Minister of the Environment Tõnis Kaasik – also CEO of Ökosil AS, the public-private company responsible for handling Silmet's radioactive waste – at a meeting in Vilnius, Lithuania, Rofer was encouraged to draw up another proposal. This time addressing NATO interest in a post-Soviet site to host its Advanced Research Workshop. Rofer relates: 'I wrote up a couple of paragraphs proposing a workshop on Sillamäe. Estonia was not as wired as it is now,

[237] M. Cone, Desert Lands Contaminated by Toxic Spills – Los Angeles Times, 24 April 1997, https://www.latimes.com/archives/la-xpm-1997-04-24-mn-51903-story.html (accessed 5 April 2020).
[238] M. Cone, Desert Lands Contaminated by Toxic Spills.
[239] C.Rofer, Averting a Baltic Sea Disaster – *Doomed to Cooperate: US-Russian Lab-to-Lab Cooperation Story*, https://lab2lab.stanford.edu/e-archive/welcome-e-archive/beyond-lab-lab/cheryl-rofer/averting-baltic-sea-disaster (accessed 18 March, 2020).
[240] C.Rofer, Averting a Baltic Sea Disaster.
[241] C.Rofer, Averting a Baltic Sea Disaster.

and emails were erratic. We faxed the proposal with a cover letter ... just before Christmas break.'[242] By January she was in Sillamäe.

Rofer describes her encounter with the 'the "waste depository" that had puzzled us in 1992'[243] continuing, 'Later, as I learned Estonian, I realized that the word they use for it, *jäätmehoidla*, could reasonably be translated that way.'[244] The conditions of the visit were 'dark and sleety'[245], the pond itself 'immense'[246]. Situated within a wider dam 'maybe fifty meters from the sea'[247] built on soft Cambrian blue clay 'a poor foundation for a tailings pond that contained thousands of tons',[248] thus threatening complete collapse into the Gulf of Finland beyond. In total it stood 'a kilometre long and half a kilometre wide.'[249] The tailings from the plant's production continued to feed into the unstable structure through a single pipe, 'Water ... leaked through the soil below into the sea. Rain washed through the tailings, taking metals with it.'[250]

Nonetheless, the conference proved productive. By 2009 the site had been stabilized. This was achieved via 'pilings that anchor into solid rock 70 meters below the Cambrian blue clay.'[251] No longer left open, 'the area was covered with layers of oil shale ash, soil, sand, rubble from waste concrete at the site, and a layer of clay to shed water.'[252] She visited again in 2011 the site of, what was by then, Molycorp Silmet. 'I saw brown hawks circling for rodents in the grass'[253] she notes, as she investigates the transformed site, and its expanding industry, including the adjacent port development, and free trade zone.

To which we might add that Silmet's tailings are now transported to the White Mesa Mill, Blanding, Utah, apparently planned to be recycled for use in nuclear fuel rods.[254] White Mesa is the last US uranium mill, and handles radioactive waste from

[242] C.Rofer, Averting a Baltic Sea Disaster.
[243] C.Rofer, Averting a Baltic Sea Disaster.
[244] C.Rofer, Averting a Baltic Sea Disaster.
[245] C.Rofer, Averting a Baltic Sea Disaster.
[246] C.Rofer, Averting a Baltic Sea Disaster.
[247] C.Rofer, Averting a Baltic Sea Disaster.
[248] C.Rofer, Averting a Baltic Sea Disaster.
[249] C.Rofer, Averting a Baltic Sea Disaster.
[250] C.Rofer, Averting a Baltic Sea Disaster.
[251] C.Rofer, Averting a Baltic Sea Disaster.
[252] C.Rofer, Averting a Baltic Sea Disaster.
[253] C.Rofer, Averting a Baltic Sea Disaster.
[254] See: USA firma plaanib Silmeti tootmisjäägist tuumakütust toota [USA firm proposed nuclear fuel production from Silmet's production residue]. – Baltic News Service (as published in Postimees, Majundus) 2 July 2019, https://majandus24.postimees.ee/6721017/usa-firma-plaanib-silmeti-tootmisjaagist-tuumakutust-toota (accessed 20 January 2020).

across the country. The Silmet deal coincides with a plan to expand its own aging tailings ponds which lie on the sacred burial grounds of the Ute Mountain Ute Indian community, who have long protested against the mill's operations. In 2019 they marched against the planned expansion and its threats to their local community's water safety and air quality.[255]

Fig. 11-13. *(Left to right) 'Bureau of land management environmental officials John Key, left, and Alan Stein inspect one of the sites where Molycorp's waste water pipeline leaked', San Bernardino Sun, (1997); 'Pipe delivers waste to the tailings pond', C. K. Rofer, Silmet (1998); 'Indigenous members of the White Mesa Concerned Community organization gathered at the White Mesa Community Center during the 2018 protest and walk', Moab Sun News (2019).Sources: See list of figures.*

'Sedimenting historiality'

Observing that 'Atoms aren't what they used to be'[256], which is to say, that 'They aren't invisible, indivisible, immutable, impenetrable corpuscles running aimlessly in the void'[257] – the trope that, in myriad hues, recurs throughout the cannon of Western thought – feminist theorist Karen Barad has articulated an important and radical counterweight to blanks slates and the atomistic realities they necessitate. She calls for instead an approach to futures as a 'sedimenting historiality'[258] which, she makes clear, is a fundamentally material concern. One that emerges form 'particular practices that we have a role in shaping and through which we are shaped'.[259] If that

[255] See: White Mesa Uranium Mill. – Grand Canyon Trust, 2020, https://www.grandcanyontrust.org/white-mesa- uranium-mill (accessed 14 January 2020).
[256] K. Barad, Meeting the Universe Halfway, p.391.
[257] K. Barad, Meeting the Universe Halfway, p.391.
[258] K. Barad, Meeting the Universe Halfway, p.391.
[259] K. Barad, Meeting the Universe Halfway, p.391.

sounds like feedback then, thick, textural, tactile, Barad does more than slow informational flows by adding a touch of material friction. Instead it is a complete reworking of causality 'beyond its classical conception'[260] but also that of 'complex systems theory'[261]. Emergence, she continues, 'is dependent not merely on the non-linearity of relations'[262] but on how things are made through each other in non-separable and non-trivial ways. We are within that which we try to describe, but not as a networked node in the system, a conveyor or purveyor of information. Rather we are thick and fast with the world, which as her 'sedimentinary' choice of adjective implies, is a far denser and ultimately intimate matter than a crystalline space is capable of allowing for – however intricate the relations that can be spun from it.

Critically, it is a historiality that rejects an invite back into the humanist 'fold of knowers'[263] for those manifold 'others' long excluded: 'females, slaves, children, animals, and other dispossessed.'[264] Rather it demands careful accounting of ground states, premised on practices of *difference*. Barad is careful to elaborate this point, emphasising that 'there is no absolute inside or absolute outside. There is only exteriority within',[265] wherein accountability lies. It is not, she continues, about staking out a 'position', but rather finding ways to be with the 'dynamic specificity'[266] that is already at work. To clarify, that is not about reneging on responsibility or accountability, rather, it is what we might think of as a call for a posthuman pragmatics. A means of engaging with what is at stake in, say, digital transformation, without simply translating everything into a system-savvy representation, nor retreating into old fortresses of epistemic exclusion.

Within the urban field, emphasis on information has twinned with the increasing primacy of infrastructure. This has been perhaps most influentially theorised by architect-theorist Keller Easterling, who claims that instead of the 'hidden substrate'[267], infrastructure is rapidly becoming nothing less than 'the overt point of contact and access between us all'.[268] Demanding a rethink of spatial practice, and a rewriting of related histories. In doing so, she recasts architecture from an object form

[260] K. Barad, Meeting the Universe Halfway, p.393.
[261] K. Barad, Meeting the Universe Halfway, p.393.
[262] K. Barad, Meeting the Universe Halfway, p.393.
[263] K. Barad, Meeting the Universe Halfway, p.378.
[264] K. Barad, Meeting the Universe Halfway, p.378.
[265] K. Barad, Meeting the Universe Halfway, p.377.
[266] K. Barad, Meeting the Universe Halfway, p.377.
[267] K.Easterling. Extrastatecraft: The Power of Infrastructure Space. London, New York: Verso, 2016,p.11.
[268] K. Easterling, *Extrastatecraft,* p.11.

to 'a medium of information'[269] one that bears a scalar relation to the city-as-operating system, or '*infrastructure space*' [270] . Once again, we 'earth' the digital, the infrastructural, the spatial, by looking to their informational ends. Eloquent in terms of mimicking the flows and incentives of financial capitalism, and broken down carefully to its particulars, nonetheless Easterling's wager is a game of mimicking and mirroring.

To the sly spatial tactician, she asserts, it is a means to game the globalising Goliath that is infrastructure operating at a scale of 'extrastatecraft'. Infrastructure as 'the very parameters of global urbanism.'[271] One has the sense that if Easterling were to visit Sillamäe it would be the zone and not the tailings pond that caught her infrastructural eye. Indeed, there is a whole vocabulary absent from Easterling's 'space'. Namely that which spews, slicks, spills, stains, or stays (for the next thousand plus years). Which is to say, that the work at Sillamäe, and the sorts of digital, infrastructural negotiations encountered are an integral and important part of our understanding of what 'the digital' is. They are also a meeting of material transitions that tell other narratives of digital transformation than those that prevail.

Essentially, that is what I understand Barad's 'sedimenting historiality' to mean. An opening to 'other' materially entangled relations that constitute techno-material production and material-economic transition. Infrastructure is part of this material process, a locus where questions of nature-culture binaries become powerfully realised. An expanded infrastructural understanding is an ongoing process of questioning how to open to such questions, a search for a posthuman pragmatics.

[269] K. Easterling, *Extrastatecraft*, p.13.
[270] K. Easterling, *Extrastatecraft*, p.11.
[271] K. Easterling, *Extrastatecraft*, p.12.

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S. B. Castor, G. W. Nason, Mountain Pass Rare Earth Deposit, California. – Betting on Industrial Minerals: Proceedings of the 39th Forum on the Geology of Industrial Minerals, Reno-Sparks, Nevada. Eds. S.B. Castor, K. G. Papke, R. O. Meeuwig. May 18-23, 2003. Nevada Bureau of Mines and Geology, Special Publication 33, 2004, pp.68-81.

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