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Three Lavas

A field guide to new grounds

Karl Kullmann

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When it rains, water flows downhill. Rivulets merge into streams, streams into creeks, creeks into rivers, picking up sediments along the way, and as the water converges and gathers force, it etches gullies, gulches, valleys, and canyons across the land, before finally slowing up and diverging again into distributaries that deposit their load on coastal deltas. We intuitively understand this process because it describes the landscapes where most of us live, in cities sited on the floodplains of major waterways, which have grown to encompass tributary rivers whose imprint still registers in urban form and syntax, even after the waters were diverted into drains or canals. [1] Thus, Barcelona's La Rambla recalls the ancient stream that runs beneath the boulevard, and the atypical curve of Minetta Street in New York's Greenwich Village traces the course of a long-buried creek. Raindrops shape not only our cities, but also our cognitive maps. We rely on visible and invisible creeks and valleys to find our way around and construct a sense of place. [2]



People who grew up in cities shaped by converging water lines can have a hard time reading other landscapes. We may be baffled by Florida, where runoff vanishes through sinkholes in the Karst limestone before it has a chance to shape the terrain; or sand dunes, where wind is the dominant force. Lava fields are even more uncanny — alien yet familiar — shaped by flows of molten rock that cool into a highly porous stone which resists water and wind alike. Those flows are embedded in the word itself, from the Latin *lavare*, meaning to wash. In Italian, lava referred first to the rivulets of water that formed after heavy rains, and only later to the glowing rivers that poured forth from Mount Vesuvius. [3]

One measure of our difficulty in reading this ground is that we use the same word for molten lava, in its viscous sliding form, and solid lava, the hard black igneous rock also known as basalt. Seemingly frozen in time, basalt landforms are unstructured and irregular, full of lobes and cracks, crevasses and voids. Traversing this terrain is an exercise in mental misdirection and physical exhaustion. [4] Without any creeks to follow, it's hard to track progress and nearly impossible to draw a cognitive map. Even compasses are confounded by magnetic interference from iron in the rock. Of course, those characteristics can be useful for people who want to get lost, or to avoid persecution, like the band of Modocs who escaped the U.S. Army in 1872 by retreating to a lava bed in northern California, where they held out for five months until they ran out of water. [5]

We might then see lava fields as the ultimate badlands: otherworldly landscapes, lacking basic resources for sustenance, impenetrable, unstable. And where lava has flowed before, it will again; cities built on volcanoes don't tend to survive. Yet lava activates the sublime imagination. There is an evocative strangeness about this liquid landscape set in stone, which literally connects us to the Earth's underbelly. And the new ground of lava presents an opportunity to start over, to build anew. For those driven to persevere, it is possible to inhabit lava, and to forge a sense of place.

So it's worth thinking about lava from a design perspective. Here I present a survey of three lava fields that have catalyzed creative interventions: on the Big Island of Hawai'i, where lavatics re-inhabited a residential tract buried by an eruption; on the Icelandic island of Heimaey, where townspeople engineered a lava flow to save their harbor, then cultivated a garden on the basalt; and in Mexico City, where urban encroachment on the Pedregal lava fields has been inscribed in a megalithic sculptural work.

Inhabitation (Kalapana)

From seafloor to summit, the island of Hawai'i is the tallest mountain on Earth, formed by the accumulation of lava over one million years. That's a blink of an eye in geologic time, but as rock climbers know, geologic time includes now. In other words: watch out for falling rocks. [6] If we join the climber's perspective to the erosive and seismic processes surmised by geologists, we can gain some measure of how landscapes change, though the incremental progression of many observable events over a very long timeframe.

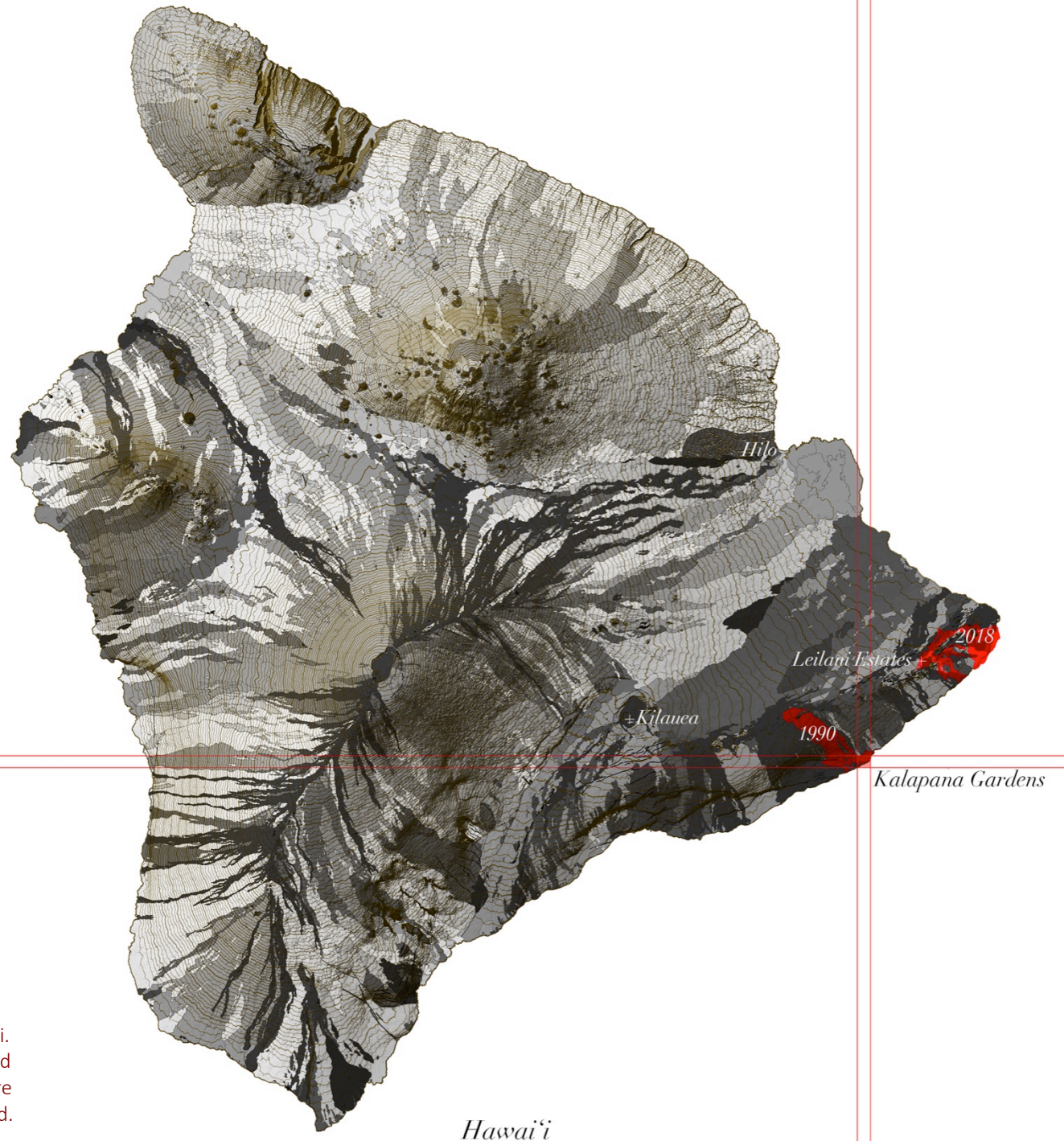
We might also comprehend the story of Hawai'i as a series of biological events. In the time that has passed since the first land in the island chain emerged from the sea, only fifteen species of bird have found this isolated archipelago and made it their home. And those pioneers didn't arrive feather-by-feather or bone-by-bone. They landed as whole birds, with really big gaps in between arrivals. On average, one gravid female (or, less likely, a breeding pair) made landfall about every one million years. [7]

Imagine that one evening in the mid-Pleistocene, a disheveled finch rode in on an atmospheric river to nest. For an entire geological age there were no other avian castaways. As the islands changed shape and the bird's descendants evolved into new species, the horizon was silent, dispensing only occasional seeds, insects, and 365 million sunrises. Then, one morning in the late Holocene, the easterly trade winds subsided and a rare breeze arrived from the west. The birds witnessed a twin-hulled voyaging canoe heaving into view, conveying Polynesian explorers and their cargo of sweet potato and taro tubers.

Half a million sunrises later — with the island now five feet taller — a pair of His Majesty’s barks dropped anchor in a sacred cove, and soon mongooses, coffee trees, and fire ants made landfall.

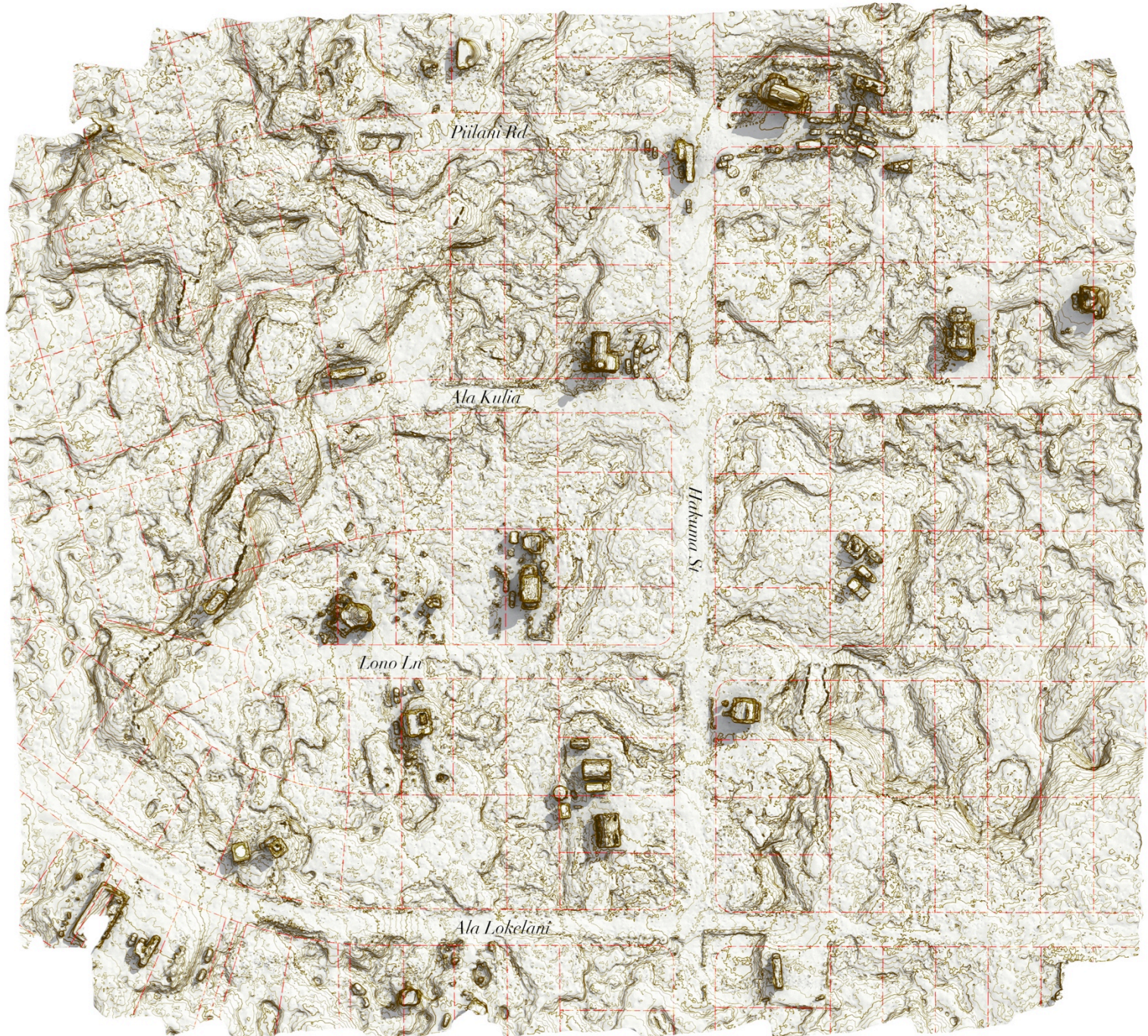
As biological and geological events converged toward the present, the Big Island was being created in real time. Viscous lava pushed new routes down the mountain, thickening the ground. Humans yielded to those veins, retreating when the flow changed course, and then gradually re-inhabiting the new ground after it cooled and hardened. Indeed, lava has been so integral to life in Hawaii that its geomorphology is expressed in the language. Italian gives us lava in the most general sense, but Hawaiian supplies the nuanced forms: pāhoehoe, a solid sheet with a billowy glassy surface that often twists into ropy forms; ‘a’ā, a jumble of broken basaltic blocks creating a rough rubbly surface; kīpuka, a remnant oasis of green between converging lava streams. The last of these words also means island, so the oases are essentially little islands within a big one.

Historic lava flow map of the Big Island of Hawai’i. The 1990 flow that covered Kalapana Gardens, and the 2018 flow that erupted from Leilani Estates, are highlighted in red.



After Hawaii became a U.S. state, real-estate speculation spurred the sale of 80,000 lots on the Big Island in just over a decade. The land rush clustered on and around Mt. Kilauea's volcanically active East Rift Zone, which was no obstacle to mainland investors who bought property sight unseen. The first subdivision on the southern flank was called Kalapana Gardens, after a nearby village named for a priest of Pele, the volcano deity. The developer platted 740 lots from a 160-acre 'ili (a traditional division of land) in an idyllic seaside setting, and by the early 1980s about a fifth of those lots were built out into homes. [8]

Then, in 1983, began the largest and longest eruption of the rift zone in five hundred years. Lava streaked downhill to the ocean until a shift in direction trapped flows behind a horst, or fault ridge, running parallel to the coast. With the outflow blocked, the lava pooled laterally, burying houses, gardens, and streets underneath 50 feet of solid rock, eliminating the black sand beach, and pushing the coastline out by nearly a quarter mile. [9]



Kalapana Gardens

Detailed topographic map of Kalapana Gardens, with original streets and parcels
overlay onto new landform and dwellings

By 1990, Kalapana Gardens was physically erased, and every landmark that held the community's collective memory had been destroyed. And yet the subdivision parcels were legally intact. Thus it was not — as the saying goes — wiped off the map.

Here the traditional Hawaiian ways of inhabiting a fluid landscape are confounded by the intransience of modern land title. Under the old system of land division, large wedge-shaped territories called ahupua'a ran from the coast to the highlands, providing access to a diversity of resources and room to relocate after a lava flow. When the coastline shifted, so did the territory. [10] But now the land has been converted to real estate. Ownership projects vertically to the newly thickened surface, from survey pegs buried deep beneath the basalt.

So while the lava flowed, Kalapana Gardens was a virtual holding on the map, but when it cooled again, the neighborhood was inscribed back onto the ground. And because the plan existed before the eruption, it paid no heed to the contours of the new terrain. The result was a radically crumpled projection of parcels and rights-of-way onto a wildly amorphous lavascape. Where a straight street once ran, a rough track now squirmed within the confines of a road easement, before dissolving at the foot of an impassable lava shelf.

The re-inhabitation of this subdivision began with simple shacks that touched the ground lightly. With a watchful eye on Pele, owners brought in shipping containers, old buses, tiny homes, flat-pack pole huts, and prefabricated greenhouses. Each human pod was like a life raft: self-sufficient because there were no utilities, self-funded because it would be easy to overcapitalize in an uninsurable risk zone. The pāhoehoe cracked and settled around them.

It's one thing to subsist in a lifeboat on a black sea of stone, and quite another to build a home. How do you put down roots in a place with no soil? By terraforming. Some of these pioneers identified as lavatics (playing off lunatic, or moon-madness). Stepping down from the landing pod, they contemplated the lay of the new land and looked for niches, and they began to adapt the terrain. Here, one bolstered a

small kīpuka with a windward stone fence, so that hardy vegetables such as sweet potatoes might germinate. There, another scraped channels in the rock to funnel rainwater to a gravity-fed cistern. And everywhere, they forged paths that followed topographic desire lines, not rigid road easements from another time.

There are now about 60 off-grid dwellings on the lava bed, and it's not hard to imagine a permanent settlement here. The residents of Kalapana Gardens Mark II may have set out with intentions to live lightly, like astronauts on the moon, but the pull of ground's gravity is compelling. A weekend escape becomes a homestead, and then more roots are planted. Yet there is the gnawing recognition that Pele will one day return to this side of the mountain, which gives pause for thought. Lava is still disgorging into the ocean two miles from Kalapana, so close that you can see the orange glow at night, and in 2018 residents of nearby Leilani Estates lost their homes to a fresh eruption. [12]

You might argue that the subdivision of an active volcanic rift zone represents a scandal of one kind or another — an object lesson in failed regional planning, or unethical behavior by local officials, or paper-thin speculation and short-term greed. If balanced land suitability analytics were applied to this part of Hawai'i, no one would live there at all, despite the fact that Hawaiians did so for more than a thousand years. Yet if sensible planning were applied universally, some of the most seductive settlements on Earth would not exist. Venice, Santorini, and New Orleans are all severely compromised. Even San Francisco's radical pact between grids, hills, and fault lines defies sense. Humans settle imperfect places for various reasons, but ultimately because they have resolved that the rewards outweigh the risks. [13] They are willing to gamble that the tick of geologic time does not include now. And all things considered, Hawai'i's slow-moving, non-explosive lava is a manageable risk; unlike tornados, floods, tsunamis, and wildfires, it rarely claims lives.



Eclectic assortment of structures on the lava.
The flat-pack greenhouse in the foreground is
probably not used for growing tomatoes.



The beginnings of more elaborate dwellings on the lava at Kalapana Gardens.



Bird's-eye view of scattered structures rebuilt onto the lava at Kalapana Gardens.

The remaking of Kalapana is a story of frontier exceptionalism, but there are lessons that can be applied in less dramatic settings, too. We might start by questioning the historical relation between the building of cities and the processes of clearing and leveling ground. A flat ground plane lets us build settlements with well-ordered streets full of similar homes connected to efficient infrastructure. At the same time, the leveling out of urban environments often leads to a smoothed sameness that is hard to connect to, be inspired by, or be invested in. The tiny homes of Kalapana show what is possible when unruly topographies are incorporated into the design of communities, rather than leveled out.

Cultivation (Heimaey)

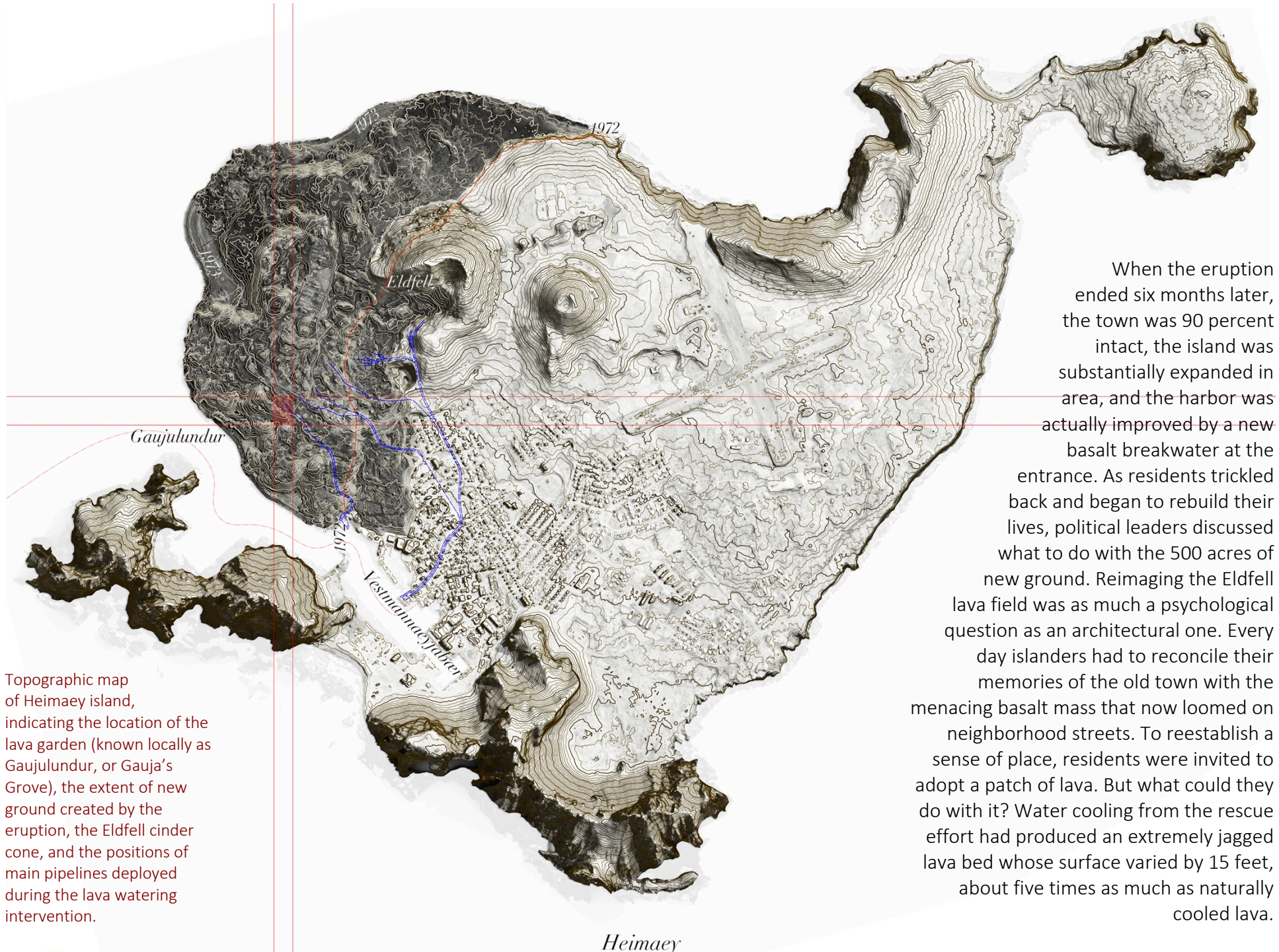
Following the Age of Discovery (the European one, not the earlier Polynesian one), the idea of paradise was transposed onto the luxuriant atolls of the Pacific. This marked a profound inversion, since for millennia paradise had been conceived as a walled oasis cultivated from a sea of sand, while islands were spaces of exile, incarceration, or refuge. Even today, our disposition toward islands depends on our ability to come and go. When movement is restricted, a single event can disrupt the island's delicate social and ecological balance. An ecology that has evolved in isolation can be wiped out by a mainland predator, like mongooses or pathogens. More insidiously, disruption can come from within, as when a crop failure triggers social collapse. A safe harbor is thus essential to island living. It facilitates fishing and trade, and the renewal of people and the genes and memes they carry.

Defending the harbor — whether from pirates in the 17th century or lava in the 20th — is a defining motif for the Icelandic island of Heimaey. Its name means Home Island, and it is the only permanently inhabited ground in the Vestmannaeyjar archipelago, six miles off Iceland's rugged southern coast. Formed over the last 10,000 years, the chain of volcanic islands straddles the Mid-Atlantic Ridge, which also bisects the mainland. Diverging at a rate of about one inch per year, this continental rift cradles some of Iceland's most storied landscapes. [13]

To understand why humans would risk making a home on this tiny, volcanically active island, we have to acknowledge the value of the harbor. Heimaey's superb, all-weather fishing port is a fluke of nature, with high cliffs on two sides offering shelter from arctic storms, whereas the nearby stretch of mainland coast offers no such haven, only hundreds of miles of exposed volcanic beach. Although there is now a ferry port cut into that coast, its operation lies at the mercy of the rolling North Atlantic swells, which compel breathtaking acts of seamanship even in the best circumstances. The nearest all-weather mainland port is three hours away.

The community and economy built around that harbor was nearly lost overnight in the winter of 1973, when a lava fissure one mile long opened on the eastern edge of Heimaey's main settlement. Five hours later nearly all of the island's 5,000 inhabitants had been evacuated on the trawler fleet, and within days a cinder cone later named Eldfell, or fire-mountain, grew 500 feet high. As the eruption progressed, lava flowing twenty feet per day threatened to inundate the town and block the entrance to the harbor. [14]

Instead of sailing away for good, a hastily assembled team of Icelanders dared to stand their ground and defend the port. On paper, their plan would fit among the most deluded visions from the golden age of civil engineering, like detonating nukes in the Sahara to create an inland sea, or damming the Strait of Gibraltar to lower the Mediterranean. On the advice of geologists and geophysicists, the government-backed team resolved to hose down a volcanic eruption and divert the 300-foot-deep lava flows away from critical infrastructure. The operation began within weeks, and at peak intervention the rescue crews had four dozen pumps feeding seawater through 20 miles of piping laid out across the lava. [15] While the tactics changed as the fight progressed, the general strategy was to solidify the lava into dams that would redirect flows away from the town and harbor. Astonishingly, it worked. It took 1.5 billion gallons of water, and it remains the only recorded instance of humans successfully engineering a landscape with molten lava.



Topographic map of Heimaey island, indicating the location of the lava garden (known locally as Gaujulundur, or Gauja's Grove), the extent of new ground created by the eruption, the Eldfell cinder cone, and the positions of main pipelines deployed during the lava watering intervention.

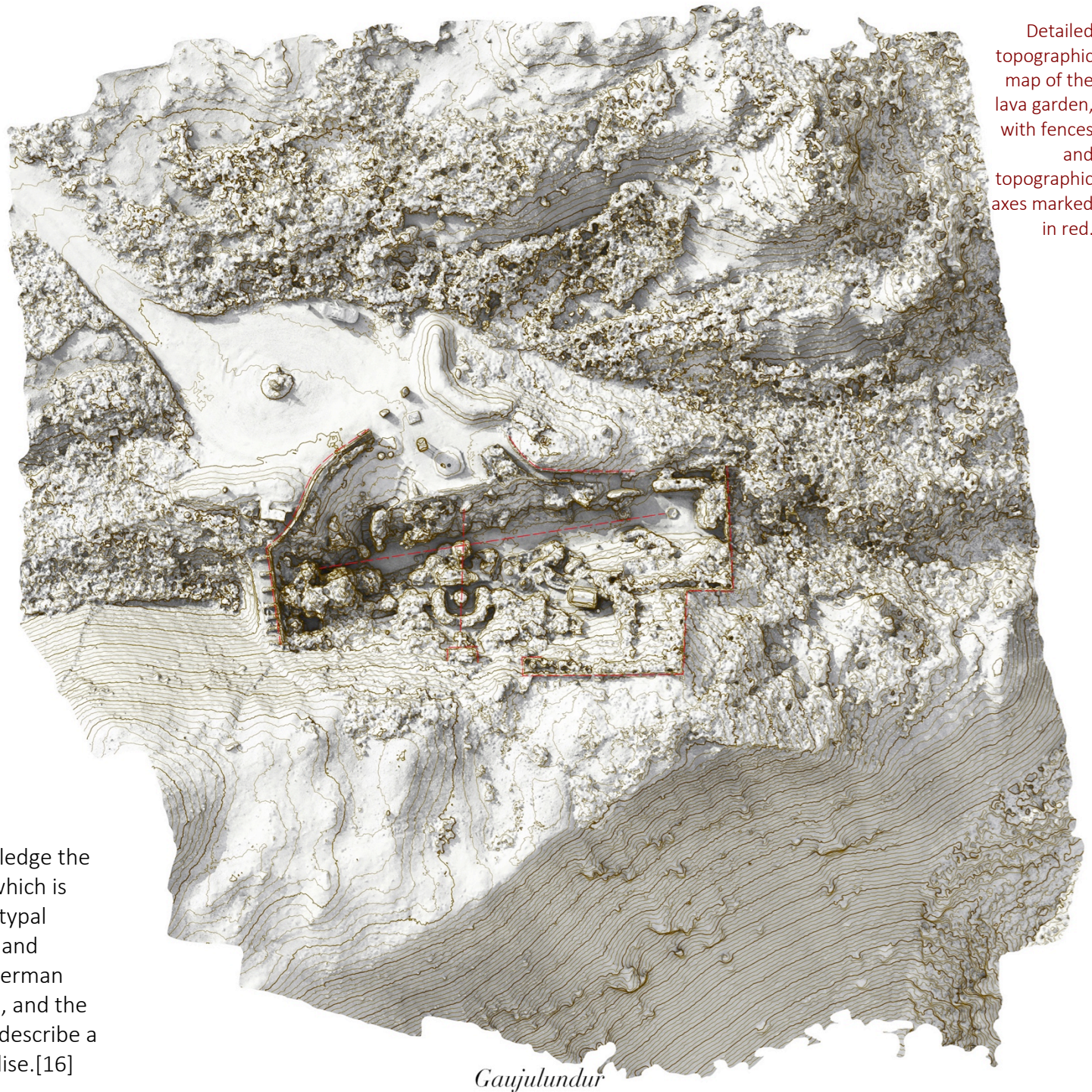
When the eruption ended six months later, the town was 90 percent intact, the island was substantially expanded in area, and the harbor was actually improved by a new basalt breakwater at the entrance. As residents trickled back and began to rebuild their lives, political leaders discussed what to do with the 500 acres of new ground. Reimagining the Eldfell lava field was as much a psychological question as an architectural one. Every day islanders had to reconcile their memories of the old town with the menacing basalt mass that now loomed on neighborhood streets. To reestablish a sense of place, residents were invited to adopt a patch of lava. But what could they do with it? Water cooling from the rescue effort had produced an extremely jagged lava bed whose surface varied by 15 feet, about five times as much as naturally cooled lava.



Excavated residential structure from the area of the Heimaey settlement covered by the lava flow.

A married couple, Erlendur (Elli) Stefánsson and Guðfinna (Gauja) Ólafsdóttir, decided to turn that design limitation to an advantage. Out on the lava field, about a half mile from the edge of town, they discovered a protruding rock whose silhouette appeared animistic from certain angles. Around that basalt talisman, which they named The Dragon, they planned a lava garden. A deep dell offered some shelter from the incessant gales, and the ground, slightly warmed by trapped geothermal energy, nurtured more exotic botanica than would otherwise grow at this frigid latitude. Under Elli and Gauja's stewardship, some 100 species of plants would be cultivated there. First, though, they had to keep the wind from stripping away the topsoil that they laboriously carted in by hand. They needed to build a wall.

It's worth pausing briefly to acknowledge the long history of the perimeter wall, which is such a defining feature of the archetypal garden that the concepts of garden and enclosure are entwined. The High German *garto* refers to land that is fenced in, and the Persian *pairi* and *daeza* combine to describe a walled garden, *pairi-daeza*, or paradise.[16]



Detailed topographic map of the lava garden, with fences and topographic axes marked in red.

Gaujulundur



Inside the of the lava garden dell, with The Dragon rock silhouetted in the background



Bird's-eye view of the lava garden, with the entrance to the harbor in the middle ground, and the Icelandic mainland visible in the distant background.

A perimeter wall offers protection from weather, pests, and trespassers, and it helps to distinguish the cultivated from the wild, demarcating the line between the garden's fragile representation of nature and nature itself. As humanity's horizons expanded outward, the garden wall was progressively deconstructed, opened up, and ultimately transcended. We leapt the wall and came to see ourselves as part of nature, and all of nature as a garden. [17]

The Eldfell lava field, formed by an extraordinary act of landscape engineering, represented a total dissolution of the human/nature divide. It also violated the notion of private property; the tragedy belonged to the community as a whole and so did its monuments. How could Elli and Gauja build a wall around something so deeply personal and yet widely shared, on a field that had no bounds? They built a hybrid frame that was both open and enclosed. To the east and west, they installed six-foot-tall windbreaks, but on the other two sides, the dell was protected by landforms whose crests did not clearly mark the garden's beginning or end. Over time, they added a gnome, a fishpond, a gabled wooden shed, several follies, picket fences, and paths to welcome visitors to the garden, which extended about 180 feet along the dell.

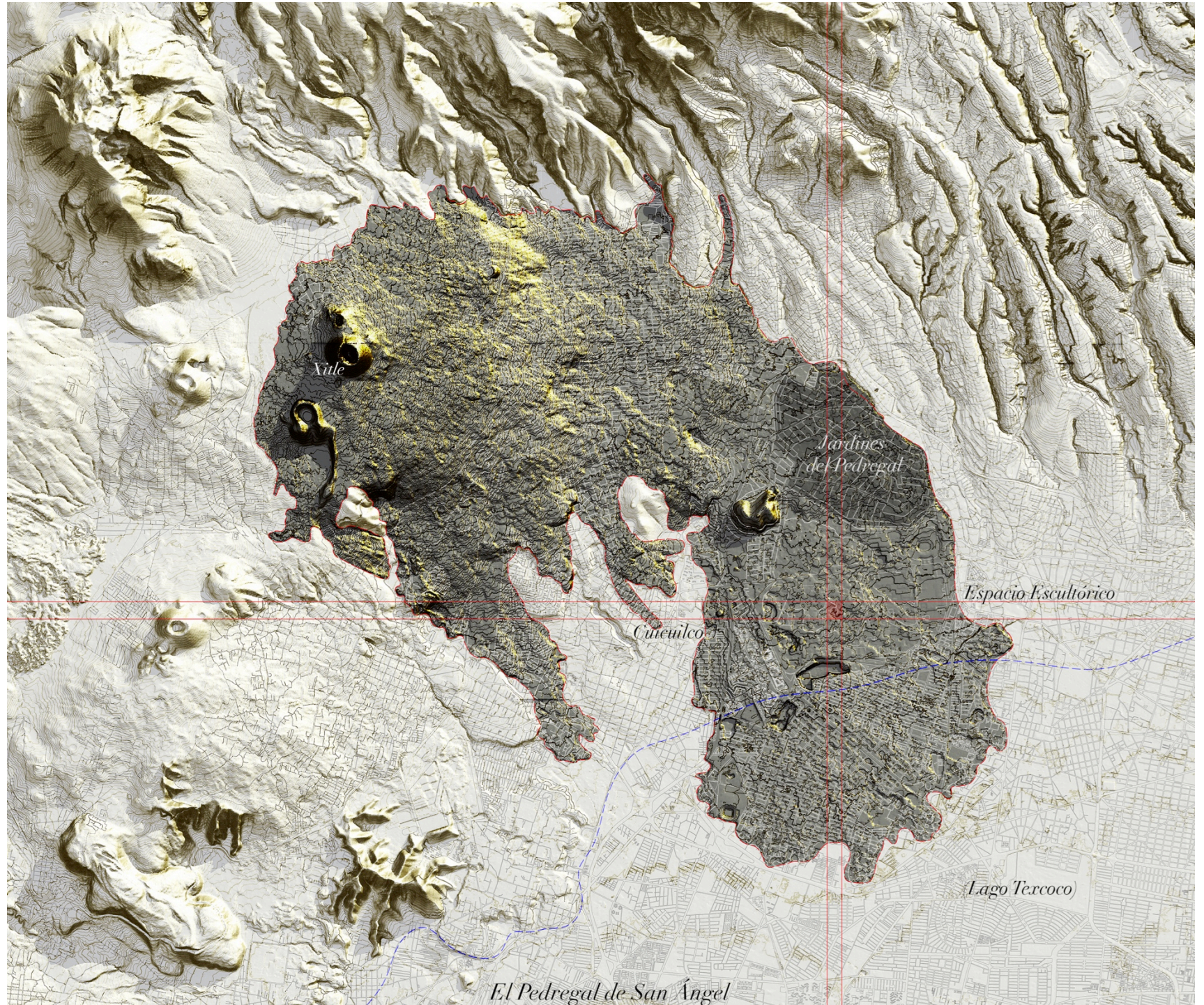
Today, this is a place for reflection and contemplation. Heimaey residents may not venture often to the isolated location, but they derive meaning from knowing that a living refuge has taken root in this often-bleak environment. The lava garden is also a place of discovery for the island visitors who arrive on day trips in the short summer season, before the weather turns. Like locals who ride out the winter, a garden confirms commitment to place. Gardeners must stick around to tend what they've planted, yet even as they bend nature to their will, it twists free again. [18] And somewhat wonderfully, things never go according to plan. As Elli and Gauja tended to their dell for 20 years, it took on a life of its own. A garden that began as a way to remember a difficult event grew its own happier memories, and after the founders passed on a new couple began to care for the plants. To this day, it remains the only cultivation of the Eldfell lava field.

Revelation (El Pedregal)

The Aztec metropolis of Tenochtitlan, which underlies modern Mexico City, was situated on a vast body of water in an endorheic basin, with no natural outlet to the sea. That's an extremely challenging environment in which to build a large city — indeed, Mexico City is unique — since water levels fluctuate with the balance of inflow to evaporation. Variation in climate cycles and human practices can cause the shoreline to shift dramatically. The Aztecs, and later the Spanish, engaged in hydraulic engineering on an immense scale, building dykes and community irrigation canals (acequias), filling wetlands, and excavating discharge channels. Over centuries, the expanding metropolis pursued the retreating water line until there was almost no water left. Lake Texcoco was reduced to a salt marsh, with only a few remnant waterways. Yet Mexico City never stopped growing. Overdrawing of the aquifers beneath the metropolis of 21 million people has caused some districts to sink below the water table, negating centuries of flood mitigation.

As the city spreads across the subsiding valley floor, it also surges up into the surrounding foothills. Eight miles southwest of the historic center, urban growth has been constrained by el Pedregal de San Ángel — a 20,000-acre lava field formed by the Xitle volcanic cluster, which erupted about 1,700 years ago. Desolate and revered, the malpaís was a formidable barrier for most of that time. Few ventured onto its surface, although villages ringed the lower edge, near springs fed by rainwater that filtered through the porous stone. Over centuries, lichens etched away at the rock, creating tiny basalt particles that accumulated in cracks and hollows to form a thin layer of soil. Moisture in shaded crevasses supported mosses and ferns and nourished the roots of the palo loco (crazy-stick) trees, with their thick stems and erratic floral displays. Scattered amid localized blooms of marigolds, dahlias, and begonias, the large stinging leaves of the pica-pica shrub tracked the sun's rays. In this unique environment, bats, butterflies, dragonflies, vipers, and scorpions thrived. [19]

Topographic map of el Pedregal de San Ángel lava field, indicating the location of Espacio Escultórico, Jardines del Pedregal, Cuicuilco pyramid, Xitle volcanic cone, and the former shoreline of Lake Texcoco.



In the late 1930s, Armando Salas Portugal, a young chemist, amateur photographer, and avid alpinist, was drawn in to the strangeness of the Pedregal. Unperturbed by its reputation for harboring bandits and sorcerers, he hauled a wooden tripod and rudimentary folding camera across the malpaís. The camera had only a small sighting hole and no light meter, but the lens was exceptional, as was its operator's mastery of light-filtering techniques. With infrared as his medium and the crazy-stick tree as his muse, Salas Portugal illuminated a shadow landscape that lay just beyond the visible spectrum. [20]

His revelation of the lava field's poetic forms drew the attention of the celebrated architect Luis Barragán. Recognizing in the Pedregal's unique landscapes the potential for informing a distinctly Mexican adaptation of Modern architecture, Barragán acquired cheap ranchlands and laid out the low-density neighborhood of Jardines del Pedregal, or Gardens of the Stony Place. Incorporating about 1,200 lots across 1,250 acres of the lava field, the development featured roads and walls aligned to the contour, a material palette matching the local stone, and gardens and buildings configured to incorporate lava outcroppings. In the houses Barragán designed himself, the garden served as a private retreat from the city, connected to the home interior and enclosed with freestone walls. [21]

At least, that's how it was seen by Salas Portugal in promotional photos taken in the mid-1950s. As the neighborhood was gradually enveloped by greater Mexico City, the connection between garden and stone was lost. The large lava lots were subdivided into denser parcels. The freestone boundary walls were armored into elaborate fortifications. And Barragán's public lava park at the heart of the development was neglected to a state of dereliction. Elsewhere on the Pedregal, formal and informal settlements advanced across the lava until most of the malpaís that had so captivated Salas Portugal and Barragán was built out.

Today, the largest remnant of lavascape is sequestered behind a ten-foot fence in an ecological reserve on the UNAM campus. [22] It is a refuge for over 300 species of native vascular plants and an important

pore for aquifer recharge. Peering through the locked gates of the reserve, we might wonder: is nature the prisoner or are we? [23] That riddle is left unanswered when the gates are unlocked at 7:45 on weekday mornings, and we are allowed to enter — or escape to — the ecological reserve. A single path leads down and around to Espacio Escultórico, or Sculptural Space, a megalithic work created in the late 1970s through the collaboration of six artists. On the lava bed sits a large plinth, 330 feet in diameter, constructed of two concentric freestone basalt walls, 45 feet apart, which are surfaced in red volcanic gravel. This pedestal is crowned with 64 identical concrete wedges, each twelve feet high, set in a circle with larger openings at the cardinal points.

In its size, Espacio Escultórico pays homage to the lone pyramidal mound that survived the volcano's destruction of Cuicuilco, a Meso-American city-state one mile south. But whereas that pyramid stands as a manmade kīpuka rising above the lava like a lost island, Espacio Escultórico evokes an archaeological excavation site. Within the circular frame, the dense vegetation and topsoil have been removed to reveal the bedrock lava. In defining a perimeter and peeling back the organic layer, the artwork recalls the history of human clearing, from forest campsites built around fires, to early agrarian settlements built around granaries. And, of course, the history of clearing is also a history of enclosure, as removed stones were stacked to create a perimeter wall, and cut timber used to build a fence. [24]

Preparing level ground is the fullest manifestation of the clearing's utility. Humans rake the ground, dig out rootstocks, and fill holes and divots. Yet if we apply that standard to the distinctly un-level bedrock at the center of Espacio Escultórico, the work appears unfinished and unusable. No one inhabits this space, and with the topsoil gone it cannot be cultivated. Although it is sometimes described as an amphitheater, it accommodates no performances, at least none with a conventional audience or cast of performers. What purpose, then, does this clearing serve?

It serves the revelation of the clearing itself. Here, lava is the original



Detailed topographic map of Espacio Escultórico, indicating the circular arrangement of the 64 concrete wedges, and the surface of the exposed lava placed in contrast to the surrounding vegetated lava.



Bird's-eye view of Espacio Escultórico, looking south over part of the UNAM campus at dawn.

clearing, the force that erased an ancient landscape and leveled a civilization, now cleared and leveled in turn by urbanization. Thus situated, Espacio Escultórico can be understood as a clearing of clearings. Martin Heidegger connects the German verb *leeren* (to empty) with an original definition of *Lesen* (collecting in place) to express the idea that a clearing releases a place for gathering. [25] And gather we do. Visitors come alone, in pairs, in larger groups, approaching the Espacio as though exploring an island. In an unprompted ritual, they circumnavigate the stony “shoreline,” tracing the edge of the plinth, before climbing one of the concrete wedges, from whose peak the whole ensemble resembles a cog in an undisclosed machine. Perhaps it is a cosmological wayfinding device, operating in some kind of telekinetic triangulation with James Turrell’s celestial Roden Crater project (a reshaped extinct volcano in Arizona, 1,000 miles northwest) and the Arecibo Observatory (an enormous radio dish nestled into the Karst terrain of Puerto Rico, 2,000 miles east). Most visitors then strike out across the naked lava, but since there is no campfire or survey peg to mark the geometric center, they tend to drift, like a compass needle deflected by the iron rich basalt. They get turned around and return to a different point on the circle, and so the work begins to seem less like a wayfinding device and more like a disorientation machine.

Late in his career, Salas Portugal came to the ecological refuge to photograph this artwork — a bittersweet moment for the chief documenter of the Pedregal. He poignantly did not use the infrared filter that had revealed the sculptural shapes of the lava field half a century earlier. Perhaps there were practical reasons for that choice, owing to the model of camera he now carried or the brief of UNAM, which commissioned the photographs. But perhaps, too, he shot in the visible spectrum because the artwork needed no extra filtration. The shape of the stony place was in plain sight. We might imagine that after returning from his lifelong travels through jungles and ruins, deserts and volcanoes (he summited over one hundred), the seer of the malpaís found in the Ecological Reserve a garden with a clearing at its heart. [26] It was a clearing designed to be cleared and re-cleared, lest it be re-wilded. At its center smoldered an invisible fire of

missingness, or what the Portuguese call *saudade*, a profound melancholic yearning for something lost. Notwithstanding its preservation at the refuge, the Pedregal lives on mainly in the silver halide crystals of Salas Portugal’s photographs.

Epilogue: Tabula Lava

Lava registers a negotiation between the forces of nature and culture in which nature absolutely holds the upper hand. As such, it compels a psychological reckoning that is often avoided in cities where the natural topography and hydrology have been engineered out. (Geologically commanding metropolises like Sydney, Hong Kong, and Rio de Janeiro are the exception.) Yet though we may not build our cities on lava, we do work with new ground. We use sand, dirt, clay, cement, rock, rubble, and garbage, poetically known as land fill, to create space for development — to level a clearing — and to push the city into rivers, deltas, and seas. [27] The stratigraphy of this new ground is heterogeneous and unstable, but unlike lava it can be engineered with walls and other armaments. Those defensive strategies work until they don’t. As climates shift, the low-lying zones of our city built on fill are most likely to flood, or to suffer catastrophic failure.

Understanding how humans have responded to lava flows can prompt discussion about how we prepare for and respond to radical change in our own environments. In the years to come, we will need a new language to grapple with processes of adaptation, retreat, and re-inhabitation. Like a landscape laboratory, lava teaches powerful lessons about the meaning of home, about survival under compromised conditions, and about the psychogeography of denial. It reveals the human bias toward optimism and turns it back in our face. Lava teaches us about creativity, cooperation, self-sufficiency, and versatility in the face of scarce resources and limited engineering solutions. And because lava is almost certain to flow again, it encourages us to value the present moment in geologic time. The lava field is not a *tabula rasa*, but a palimpsest overwritten with each new scripture. [28] We are drawn here, in both senses of the word, to rebuild, re-cultivate, and reveal.





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Notes

1. The interaction between water flow and culture is explored in Matt Edgeworth, *Fluid Pasts: Archeology of Flow* (Bristol Classical Press, 2011).
2. See Yi-Fu Tuan, *Space and Place: the Perspective of Experience* (University of Minnesota Press, 1977); and Kevin Lynch, *The Image of the City* (MIT Press, 1960).
3. In Middle English, we have laven (to pour or stream out). An alternate Latin derivation is labes (to slide or fall).
4. For more on disorienting landscape experiences, see Karl Kullmann, "Dis/orientation Machines: Journeys Into Labyrinthine Landscapes," *Studies in the History of Gardens and Designed Landscapes* 38:1 (2017), 1–23, <https://doi.org/10.1080/14601176.2017.1386422>.
5. Martin A. Peacock, "The Modoc Lava Field, Northern California," *Geographical Review* 21:2 (1931), 259–75, <https://doi.org/10.2307/209279>.
6. While pinned down by a boulder in a Utah canyon, Aron Ralston famously etched "Geologic Time Includes Now" into the sandstone. Days later, he cut his own arm off to escape. Aron Ralston, *Between a Rock and a Hard Place* (Atria Books, 2004).
7. Sherwin Carlquist, "The First Arrivals: Hawaii's First Plant and Animal Colonizers Traveled Great Distances across the Sea, Carried by Water, Wind, and Birds," *Natural History* 91:12 (1982), 20–30.
8. Charles Langlas, *Under The Volcano: The People of Kalapana, 1823 to 2010* (Pili Productions, 2016).
9. Tari N. Mattox, Christina Heliker, Jim Kauahikaua, and Ken Hon, "Development of the 1990 Kalapana Flow Field, Kilauea Volcano, Hawaii," *Bulletin of Volcanology* 55:6 (1993), 407–13, <https://10.1007/bf00302000>.
10. Today, in contrast, new ground created in the ocean is annexed by the state, rather than the local landowner.
11. This eruption and the associated earthquakes occurred while I was in the midst of fieldwork in Kalapana.
12. Muncel Chang, "Human Decisions and Natural Hazards: A Case of the East Rift Zone of Kilauea Volcano on the Island of Hawaii," in Shyamal K. Majumdar, et al., Eds., *Natural and Technological Disasters: Causes, Effects and Preventive Measures* (Pennsylvania Academy of Science, 1992).
13. See Karl Kullmann, "The Shape of Things: Re-imagining Landscape Parliaments in the Anthropocene," *Forty-Five: Journal of Outside Research* 190 (2018).
14. Richard S. Williams, Jr. and James G. Moore, *Man Against Volcano: The Eruption on Heimaey, Vestmannaeyjar, Iceland* (United State Department of the Interior Geological Survey, 1976); and Alan V. Morgan, "The Eldfell Eruption Heimaey, Iceland: A 25-Year Retrospective," *Geoscience Canada* 27:1 (2000), 11–18. A dedicated museum on the island commemorates the eruption, evacuation, intervention and aftermath. The events were also popularized by John McPhee in a pair of articles in *The New Yorker*, which are reproduced in *John McPhee, The Control of Nature* (Farrar, Straus and Giroux, 1989).
15. Richard S. Williams, Jr., Ed., *Lava-Cooling Operations During The 1973 Eruption Of Eldfell Volcano, Heimaey, Vestmannaeyjar, Iceland* (U.S. Geological Survey Open-File Report 97-724, 1997).
16. For more on garden framing, see Karl Kullmann, "Concave Worlds, Artificial Horizons: Reframing the Urban Public Garden," *Studies in the History of Gardens and Designed Landscapes* 37:1 (2016), 15–32, <https://doi.org/10.1080/14601176.2016.1181939>. See also Alessandro Scafi, "Mapping Eden: Cartographies of the Earthly Paradise," in Denis Cosgrove, Ed., *Mappings* (Reaktion Books, 1999), 50–70.
17. I am paraphrasing a famous quote in Horace Walpole, *History of the Modern Taste in Gardening* (Ursus Press, 1782, c1995).

18. See Robert Harbison, *Eccentric Spaces* (Knopf, 1977).
19. César Carrillo Trueba, *El Pedregal de San Ángel* (Universidad Nacional Autónoma de México, 1995).
20. This description of Salas Portugal's camera is based on a portrait of him in action on the Pedregal. In homage to his mastery of the infrared format, my photographs accompanying this essay are reproduced in (post processed) infrared. For more on Salas Portugal's work and career, see Armando Salas Portugal, *Morada de Lava: las colecciones fotográficas del Pedregal de San Ángel y la Ciudad Universitaria* (Universidad Nacional Autónoma de México, 2006); Armando Salas Portugal, *Armando Salas Portugal* (Lunwerg Editores, 2005); and Aurelio Asiain, Ed., *Los Pueblos de antes / fotografías de Armando Salas Portugal* (Chrysler México, 1991).
21. Keith Eggener, *Luis Barragán's Gardens of el Pedregal* (Princeton Architectural Press, 2001). And in this journal, see Keith Eggener, "Regionalism Revisited: The Case of Francisco Artigas," *Places Journal*, January 2015, <https://doi.org/10.22269/150120>.
22. José Luis Palacio Prieto and Marie-Noëlle Guilbaud, "Patrimonio natural de la Reserva Ecológica del Pedregal de San Ángel y áreas cercanas: sitios de interés geológico y geomorfológico al sur de la Cuenca de México," *Boletín de la Sociedad Geológica Mexicana* 67:2 (2015), 227–44, <https://doi.org/10.18268/BSGM2015v67n2a7>.
23. Here I am drawing on Gerhard Auer, "The Desiring Gaze and the Ruses of the Veil," *Daidalos* 33 (1989), 36–53.
24. Joseph Rykwert, *The Idea of a Town: The Anthropology of Urban Form in Rome, Italy and the Ancient World* (Faber and Faber, 1976). For more on levelness and utility, see Karl Kullmann, "The Usefulness of Uselessness: Towards a Landscape Framework for Un-activated Urban Public Space," *Architectural Theory Review* 19:2 (2015), 154–73, <https://doi.org/10.1080/13264826.2014.967330>.
25. Martin Heidegger, Trans. Charles H. Seibert, "Art and Space," *Man and World* 6:1 (1973), 3–8, <https://doi.org/10.1007/BF01252779>.
26. I am paraphrasing Salas Portugal's own reflections in Armando Salas Portugal, *El Pedregal de San Ángel* (Universidad Nacional Autónoma de México, 2000).
27. See Stephen Graham, "City Ground," *Places Journal*, November 2016, <https://doi.org/10.22269/161107>, an adaption from his book *Vertical: The City from Satellites to Bunkers* (Verso, 2016).
28. This reading of lava as a manuscript is etymologically supported, with *lava/lave/labe* related to *label*, which in its original usage referred to a slip of paper.