Introduction
Liminal Responsive Architecture

PHILIP BEESLEY

"Words and tones, since they can hurt, are no doubt made of material stuff"
Titus Lucretius Carus, *De Rerum Natura*

When Lucretius watched motes of dust quivering and darting within the sunbeams of his Roman window, he saw atoms play. Rivers of motion took the particles in laminar flows, bringing degrees of certainty into the sight of barely tangible things. Darting and wavering, the dust spoke of decay and loss; possibility; specious circumstance in flux: corrupted, damaged, and dying swerves. And a vague, shaded shift of life arising too—the rising semiquaver of living seeds. This quickening leads into the earth.

The Hylozoic project seeks abject fertility. In the footsteps of Lucretius, it imagines new layers of hylozoic soil. Hylozoism is the ancient perception of life arising out of material. Lucretius followed earlier, Grecian thinkers in seeing life arising from the chaos-borne quickening of air, water, and stone.

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1 Detail of breathing column. Hylozoic Soil, "(in)posición dinámica," Festival de Mexico, Laboratorio Arte Alameda/ Ars Electronica México, Mexico City, 2010

Hylozoic Ground is an immersive, interactive sculpture environment organized as a textile matrix supporting responsive actions, dynamic material exchanges, and 'living' technologies—conceived as the first stages of self-renewing functions that might take root within this architecture. The Hylozoic Ground environment can be described as a suspended geotextile,[2] gradually accumulating hybrid soil from ingredients drawn from its surroundings.

Akin to the functions of a living system, embedded machine intelligence allows human interaction to trigger breathing, caressing, and swallowing motions and hybrid metabolic exchanges.[3] These empathic motions ripple out from hives of kinetic valves and pores in peristaltic waves, creating a diffuse pumping that pulls air, moisture, and stray organic matter through the filtering Hylozoic membranes.

2 A civil engineering material which provides temporary earthen support for landscapes that will eventually be taken over by organic growth.

3 Lucretius dwelt also on measurement of this flux. His writing speaks of an approximate geometry within curves shearing away from lines, calibrated within the infinitesimally small angle called clinamen. A clinamen is the angle that occurs when a straight line meets the tangent of an arc. Hylozoic Ground employs the conceptual terrain of the clinamen as a launch into the realm of hyperbolic forms.

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4 Immersive environment. Hylozoic Soil, "e-art: Communication Vessels," Montreal Museum of Fine Arts, Montreal, 2007.

A distributed array of proximity sensors activates these primitive responsive devices, stirring the air in thickened areas of the matrix. Dense groves of frond-like 'breathing' pores, tongues, and thickets of twitching whiskers are organized in spiralling rows that curl in and around its mesh surfaces. A trickling water source connects the matrix to the Venice lagoon.

The structural core of the Hylozoic environment is a flexible meshwork skeleton of transparent, lily-shaped ribbed vaults and basket-like columns. The meshwork stretches and billows, creating a hyperbolic grid-shell topology that surrounds occupants in the space. It is assembled from small acrylic chevron-shaped tiles that clip together to form a pleated diagrid textile structure. Columnar elements extend out from this membrane, reaching upward and downward to create tapered suspension and mounting points.

Tension rods support the scaffold with toothed clamps that bite into the ceiling and floor surfaces.

Pure, distilled spheres and pyramids from Plato's cosmology might hover as ghosts that inform this environment, but that family of reductive crystal forms does not govern. Far from transcendent perfection, the formwork that organizes the space boils out of local circumstance. As with the fabric that emerges from the steady cadence of knitting or crocheting, the chevron links are combined in repeating rows, and their numbers tend to drift and bifurcate. Adding links within linked rows crowds the surface, producing warped and reticulated surfaces that expand outwards in three dimensions.

Similarly, the linking systems that form scaffolds for the filtering systems use a tessellated geometry of self-healing hexagonal and rhombic arrays that readily accommodate tears and breaks within their fabrics. In opposition to design principles of the past century that favoured optimal equations where maximum volume might be enclosed by the minimum possible surface, the structures in Hylozoic Ground prefer diffuse, deeply reticulated skins.[5] These forms turn away from the minimum surface exposures of pure spheres and cubes as they seek to increase their exposure and interchange with the atmosphere.[6]

Although the surface topologies of these forms are generous, their material consumption is reduced to a minimum by employing form-finding design methods, textile systems, and tensile forces. Strategies include the use of thin tensile component arrays with floating compression elements within interlinked fields of tension fibres. Three-dimensional forms are derived from thin, two-dimensional sheets of material, organized in nested tessellations to nearly eliminate waste during digital fabrication. In pursuit of resonant, vulnerable physical presence, components use materials stretched near to the point of individual collapse. The space formed from these materials expands a thousand-fold, filling the volume of the containing building.[7]

The responsive devices fitted into the expanded Hylozoic topology function similarly to pores and hair follicles within the epithelial skin layers of an organism. Breathing pores are composed of thin sheets shaped into outward-branching serrated membranes, each containing flexible acrylic tongue stiffeners fitted with monofilament tendons. The tendons pull along

5 The geometries of this system are 'quasiperiodic,' combining rigid repetition with corrupted inclusions and drift. A tiling system invented by the contemporary British physicist Roger Penrose, based on multiple angles following the ten-way division of a circle, alternates with close-packed regular hexagonal geometry.

6 Such lavish exfoliation has borne disapproval in twentieth-century design education. Perhaps inflected by mid-century cold war preoccupations, North American design has tended to equate energy conservation with heat retention and has prioritized resistance and inert barriers. Reticulated surfaces, despite their inherent ability to foster free cooling and heating through increased energy exchanges with their surroundings, have often been judged excessive and wasteful. The American engineer Buckminster Fuller's 1975 opus Synergetics: Explorations in the Geometry of Thinking exemplifies this view.

7 Some twenty cubic feet of acrylic and elastic polymers, two hundred pounds of copper wire and glass, aluminum sheeting, and handfuls of specialized alloys were expended in the Venice installation.

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8 View of hyperbolic meshwork canopy. Hylozoic Soil, "VIDA 11.0," Matadero, Madrid, 2009.

the surface of each tongue, producing upward curling motions that sweep through the surrounding air. Sensor lashes, carried by the lower tips of meshwork columns, are cousins of the breathing pore. These are fitted with a fleshy latex membrane and offer cupping, pulling motions.

A further kind of swallowing actuator is fitted inside the meshwork columns. Its chained air muscles are organized in a segmented radial system to produce expanding and contracting movements, causing convulsive waves in their surrounding halo of hooked whiskers, while at the same time delivering an incremental siphoning transport of lagoon water within their cores. Wound-wire pendant whiskers are supported by acrylic outriggers with rotating bearings. Tensile mounts for these tendrils encourage cascades of rippling and spinning movements that amplify swelling waves of motion within the mesh structure.

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9 Sensor lash assemblies. Hylozoic Soil, "e-art: Communication Vessels," Montreal Museum of Fine Arts, Montreal, 2007.

Dozens of sensors that detect the presence of visitors through changes in space, light, and touch are spread throughout the Hylozoic environment. They function like the space-reading sonar employed by dolphins and bats and feed impulses into an embedded network of microcontrollers, working in concert with and guiding device movements.

Interactive processing is based on the open-source Arduino microcontroller system. This palm-sized board can read sensors, make simple decisions, and control devices. The boards used in Hylozoic Ground carry extensions that provide communication, power outputs, and mode switches, together supporting the emergence of different behaviours. Levels of behaviour organized by local clusters, neighbourhood groups, and global systems are programmed into the sculpture in order to encourage coordinated spatial

behaviour. Each processor produces its own response to local sensor activity and listens for messages from neighbours. Background behaviours akin to pre-conscious muscular reflexes are produced in the environment using these encoded responses. Controllers hold information about sensor activity from individual boards and catalyze 'global' behaviour with this information.

Alongside mechanized component systems, a wet system has been introduced into the environment, with bladder clusters surrounded by thickened vapours. The system supports simple chemical exchanges that share some of the properties of life-giving blood in living organisms. Thousands of primitive glands containing synthetic digestive liquids and salts are clustered throughout the system, located at the base of each breathing pore and within suspended colonies of whiskers and trapping burrs. The salt derivatives serve a hygroscopic function, pulling fluids out of the surrounding environment.

The adaptive chemistries within the wet system capture traces of carbon from the vaporous surroundings and build delicate structural scaffolds. Engineered *protocells* and *chells*—liquid-supported artificial cells that share some of the characteristics of natural living cells—are arranged in a series of embedded incubator flasks. Bursts of light and vibration, created by the responses of visitors standing within the work, influence the growth of the protocells, catalyzing the formation of vesicles and inducing secondary deposits of benign materials. Sensors monitor the health of the growing flasks and give feedback that governs the behaviour of the interactive system surrounding the viewer. The flux of viscous, humid atmospheres creates a hybrid expanded protoplasm with constantly changing boundaries.

soil and protoplasm

Can soil be constructed? Work in previous decades began in this pursuit of the chthonian, the deep underground. The recent geotextile forms that prevail in Hylozoic Ground extend this pursuit, making synthetic earth.

Design paradigms for shelter built upon the solid, eternal ground of a Canadian wilderness render the task for architecture relatively simple.[10] Springing from foundations secured by the cardinal powers of the earth, one of the primary tasks of a building envelope might be rendering the outer world as vividly as possible, consuming the environment and serving my outward-seeking gaze in acute encounter. A functional definition of this architecture could describe

10 A compelling example is the lattice-work shelter that supports St. Francis in Giovanni Bellini's 1480–85 St. Francis in Ecstasy, amongst countless other 'primitive huts' that speak to the origins of architecture in cultural history.

building envelopes as filters that enclose human bodies and draw the environment inward and outward, sheltering the interior and amplifying the experience of the surrounding world.

The great extinction that occupies current human culture has swept away celebration of such transcendent, eternal qualities.[11] If I stand on the floating piers of the Venice lagoon, amidst a withering biosphere, my posture shifts. The ground is yawning, viscous, inducing queasy vertigo. My legs unconsciously tense themselves, reptile brain–inflected posture tensed by the elastic meniscus underfoot. The shift of my own posture inverts a confident gaze, sending it outward. The enclosing function of architecture shifts from consuming the surroundings. A renewed task appears: constructing synthetic ground.

Geotextile systems seen in installations such as *Haystack Veil* at Deer Isle, 1997, and *Erratics Net*, Peggy's Cove, 1998, pursued methodical expansion of landscape surfaces, building hybrid layers of artificial soil.[12] Earlier built projects, such as contributions to A. J. Diamond and Donald Schmitt's York University Student Centre,[13] also speak of nascent versions of this synthesis, folding and layering relatively thin planes of material, constructing hybrid depth. Recent buildings such as the Niagara Credit Union in Virgil, Ontario, and interior layers at the French River Visitor Centre[14] show a movement towards increasingly porous open space. In those buildings, hovering latticeworks of interlinking timber vaulting and dense constellations of material components offer expanded boundaries. Most recently, contributions to the North House project[15] include design of filtering active shades which work in distributed arrays. These design systems provide an expanded physiology akin to the layered envelopes created by nightdresses and bedclothes surrounding a sleeping body.

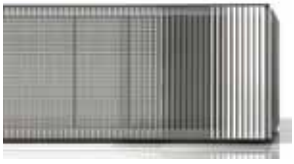
What ground, what soil, might support involved dwelling? Within Hylozoic Ground in Venice there lies a diffuse matrix, riddled with the ground. If, quickened by the humid Venetian microclimate and organic atmospheres blooming around human occupation, the vesicles and primitive glands crowding the Hylozoic Ground surface spoke, they might call and lure, voicing abject hunger. This matrix offers a map of a dissociated body moving to and fro across junctures of conception, disarticulating. This soil is pulling. Its environment seeks human presence as elemental food.

11 "Global Biodiversity Outlook 3," published by the United Nations Secretariat of the Convention on Biodiversity (2010), is a recent report identifying logarithmic acceleration of biodiversity erosion in the twentieth century, marking a third phase within the Holocene or Sixth great extinction.

12 Haystack Veil, Philip Beesley, Warren Seelig, and Haystack Mountain School for Craft students, Deer Isle, Maine, 1997. Erratics Net, Philip Beesley and Dalhousie University students with Caroline Munk, Peggy's Cove, Nova Scotia, 1998.

13 York University Student Centre, A. J. Diamond, Donald Schmitt & Co., Toronto, 1989.

14 Interior French River Visitor Centre Gallery, Philip Beesley Architect Inc. and Baird Sampson Neuert Architects, French River, 2004.



15 Responsive Envelope Prototype System, North House, Team North, Washington, 2009.

journal

The journal entries that follow correspond to various stages of development of the Hylozoic series. They loop in a series of wide aerial paths, tangent to Venice. The notes seek an orienting lexicon for the practical craft of working with protoplasmic space. These visualizations navigate weather-like formations of the atmosphere, layers of earth before condensation. The entries offer common threads that form a language rooted in generative formation and dissipation—a flux of dissemblance and figuration.[16]

16 Scholar Sarah Bonnemaison led me to George Didi-Huberman's Fra Angelico: Dissemblance & Figuration (Chicago 1995), which offers a nuanced bridge between materiality and transubstantiation.

The constructed fertility of the Hylozoic series claims material lying within the dark layers of soil that cloak the world, coming before the light-filled events of measured geography, and again before boundaries coalesced into smooth-skinned spheres of bounded territory. Interlinking pools of vortices play within Pacific and Atlantic currents, forming surging necklaces that encircle the granite-bound landscape of the Canadian shield. The spiral pools are scored by glacial ice that cleared febrile soils, and even the salt-encrusted limestones that traced earlier lives in the Cambrian explosion. Barred, wrinkled hazes of cumulus and nimbus clouds hover in diffuse octaves that echo this liquid skin. Starved of metered focus, tinges of delirium blur these sightings. Pathways stretch through ripples, coalescing into bundled, gaseous rivers. I grasp faintly quivering traces, flame-licking tendrils projecting within the diffuse, slipping currents. What patterns am I printing within this field?

melt

Homogenous silence, marked by blurs and flecks. The dimension so vast as to measure time: an aeon of girth. Elephant-skin wrinkles, emerging from the smoothly ruffled surface of the massive depth of ice. At the edge, soaking in a million pits, the mass opening, revealing pitted subcutane, and then felted, porous liquid tendrils. At the edge, catastrophes: frozen tumbling fragments, continuous collapse. A minor sea collects in a shallow; accordioned shards of the sheet above, intermixing anew. Then failing: the phase yields into river. Cascade: infinitesimally slow torrent, rime of shards above the fresh water discharging to the ocean.

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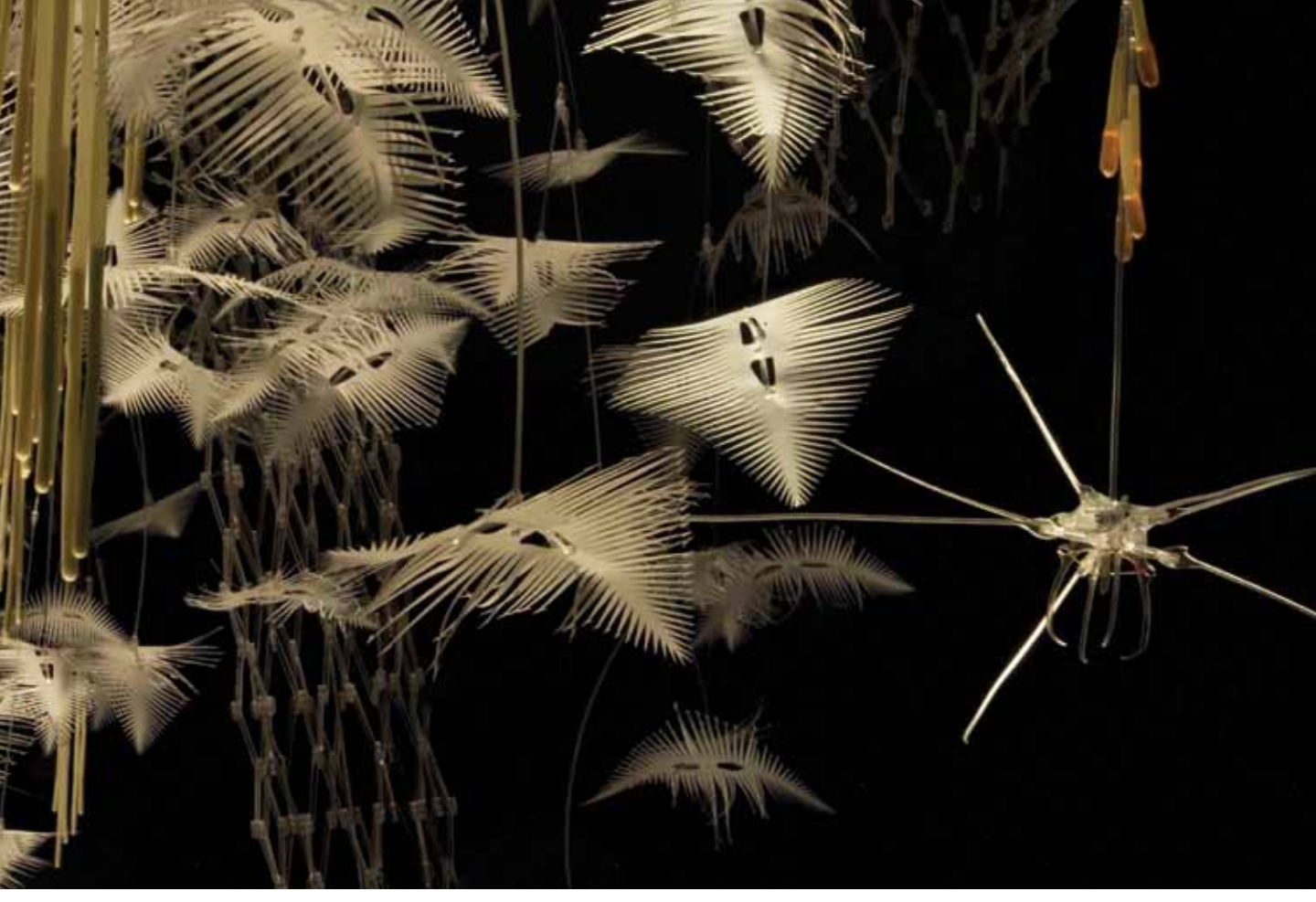
17 Filter layer detail. Hylozoic Soil, "(in)posición dinámica," Festival de Mexico, Mexico City, 2010

This is a landmass in reverse: not the fundament eroded by the shore, but a proto-ocean above as an upper land, turning like a sun into the open

water outside. The land here seems like residue, effluent incident of the melt. Ocean salt receives the freshwater: bright fissures of current, overlapping arcs of wrinkled pressures from the tide slowly pulsing toward the land in counter-current to the melting. Then the sea begins, homogenous: a miasma of swells, fissured by the transverse wind and second transverse of rebounding coastal current. Cumulus drifts hover above, clustering into a stratum that stands offshore, making a counter-coast, long dissolved fingers casting shadow on the rippled water.

A new shore: a vast floating edge ends, revealing the preceding world as a tableau. Trailing carcasses of thinning haze stream downward and stretch off into entrails. A plunging gorge, edged by lapping swells that converge, and marrow to heal the foot, bleeding into lower depths. This catastrophe is



18 Hylozoic Soil lower layer detail. Hylozoic Soil, "VIDA 11.0," Matadero, Madrid, 2009.

quickly cloaked by upper haze, engulfing me. Except for a string of plumes that orient me wide to my left, the field shifts to a single, hovering sphere reaching the pure horizon, sky against stratosphere, pronouncing the lensing flux of light at its furthest spherical tangent. Almost nothing, a suspension that plays me by deflection. That parsimony is stretched toward primal vagueness. Not lost, but delayed past recognition. Corrosion cloaked as leavened temperance: the quietest death.

Like finger-print wrinkles, clumping in repeated rolls, barrel-vault wrinkle oriented in a single meandering spread that shifts every few diameters, then reasserts itself. Cutting across, a twill chevron of cross-wrinkles searing across the whole, a ridge that grows in height, reverse fissures, becoming more turbulent as it merges, then collapsing upward into cumulus bursts

with entrail-quilted spicules and hydra-vortices shedding beside and behind. This thermal plumage is tiny, not the thunderhead I already know but instead tufts, follicles. Where is the *next*? Just ahead, one valley's length and then another. And another—skipping-stones' lengths, decelerating.

landfall

Similar wrinkles, but sharper and with tighter folds—like tulle or gauze, compared to the canvas lower down. Tufts here only singular, but marked by great outward swaths of rebound and counter-current that furrow the surface. Nipple and navel arrays, but then the reverse—ahead, a pitted skin with sinks and gentle whirlpool creases converging around, upholstered. Pigskin and orange peel alternating.

The drift coheres at landfall, resolving to corrugated cover and sheltered base. The fabric nap covers, approximately—gradient stretched between flickering surface of sea and quilted shore. Free-soldier trenchant barges plough up the middle of the strait. Tended cells arrayed along tight-lipped seams, tidied by the tightening cluster of attention at water's edge. Reaching inward, the cloud cover tightens its grain, first shifting to a dense stranded screen punctuated by fissures, then to wide banded rivers moving south-east, thrown into relief by the dawn light.

As the spread thickens further, the distinction of the warp-oriented main vectors blurs, fusing into broad ribbons interspersed with valleys. Slight shivers appear in the perpendicular axis, an oscillation recapitulating the chop of the dispersed veil that preceded it, now two hundred miles passed. Fusing again, toward an evenly spread, delicately wrinkled miasma of swells. One hundred miles more, and strains shadow the surface, reaching south and then south-west, arcing across the bias in a shuddering series of braided cross-currents. The seams reach deeper and suddenly cleave the surface, sending wide fjord-furrows out in repeating chatters of cross and parry. The breaks extend, each arcing back toward itself in a lagoon form, broken by its opposite arcing course reaching out and slowly dying in intensity, a string of vortices shed from the first cleavage.

Tidal river delta cut and banked, saturated with industry: mineral salts, ores, graded systems, riddled with access and irrigation and inventory controls.

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19 Filter layer from above. Hylozoic Soil:Meduse Field, "Mois-Multi Festival," Meduse, Quebec City, 2010.

Beside the transport, a tidal marsh, racing outward fissure-like and then bounded again, beachheads running striated arms out into the ocean, long shallow subsidence fissured below by undersea valleys, and above by streaking sooty contrails. Dust layers above, rising into miasma at midlevel, rising to peacock blue in the atmosphere—a distinct, luminous lens, before I raise up again and lose myself in the lapis void above. The lighter blue, though—it gathers, thickened by light fluctuations in the mist that coalesce into the stuttering grain of cumuli, before hardening into the crystalline dewy grain of field and soil. Is this how gelatines are made? The colour is faint, gathering from hazy tan and gray-green field-webs. Gradually, shifting from soil to air: there is a middle zone that I pass over at first, racing into the brilliant blue in long horizon's reach. The furthest reach of all holds peacock blue glistening with clouded veils. Behind it again: only the 'further' of parallax, of beyond, of my birth. It whispers emerald green, more potent for its restraint, basest tincture amidst horizon blue.

tracking

Somewhat like this, I looked into the woods, standing on snow-crusted tracks that lead a mile in from washed-out bridge abutments. Alder saplings rising all around made a dense thicket, saturating the middle ground. Dotted in between are pines and cedar bushes, planted by the family a decade ago. In the snow just in front of mine, I saw rabbit and deer tracks clustered into a dense path, crossing and winding through the alder deep into the thicket on my right. I turned and looked, following the staccato clumps of rabbit paw racing, and deer hoof at measured pace. Folding out deeper, I saw the path lengthen and run past one alder clump, then another and another, overlapping tangles layering. Like tripping arpeggios, flittering in dashing ribbons threading down and in. It is that lengthening, darting further and further in a staccato rush, that I now wonder on: is it my skill in seeing the diminishing tracks, darting and reaching deeper? I see a tightly focused set of dashing stripes within a densely embroidered field: this mask includes, and excludes. The photograph of that scene shows only a clotted morass, path buried after only the immediate foreground, but I see; I am disposed to see. The springy trill of magnetic meniscus clumps lensing my named field: Track. Track. Track-track-track-track. Marionette, of my own ingrained rigging.

"Anima here is not a projection, but the projector. And our consciousness is the result of its prior psychic life. Anima thus becomes the primordial carrier of psyche, or the archetype of psyche itself." James Hillman, Anima: An Anatomy of a Personified Notion, Spring Publications (Dallas, 1985) p. 69.

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20 Hylozoic Soil filter layer. Hylozoic Soil, "(in)posición dinámica," Festival de Mexico, Mexico City, 2010

Reprogramming animal, limbic feeling-fountains with construction and optimism, the quickening of spring leavening the death embedded in present feelings. The lee housed the material that would carry the charge. Reprogrammable matrix, lemming-infants acting unhesitatingly. The habit of thinking positively, not as a leaden mask but as a buffered encapsulating sheath for the surging core. More directly, an interpretation gate: this means that we can make something of this, and that this thing is possible, and that the path that leads through there and there will not cause extinction, but salved opening. With emotional compass, seeking solution. With growth medium, where the pattern can hold.

"The construction of the painting is replaced by construction of the preconditions for the act of painting in the determinant of the action-field (of the space around the actor—the real objects present in his surroundings). The actual act of painting is freed from the compulsion of needing and having relics." Rudolf Schwarzkogler, Panorama Manifesto (1965), in Brus, Muehl, Nitsch, and Schwarzkogler, Writings of the Vienna Actionists, trans. Green, (London, 1999), p. 432.

Interrupted by upper-layer haze, thickening into the next skin. A circular rainbow accompanies my view. Centre: warm gold-pink, then blushing into rose, and cooling to violet and fading to pure blue indistinguishable from the surrounding bright sky above. Yet I see it as a shadow, marking the cloud field outward to green emerald, moving into yellow hue, and then into pink-orange in the centre. Again to red, and to violet, and outward into sky-blue. Yet again, elusively—the faint glow of green tinting the orb, moving toward yellow. When I see it, the arc asserts, streaming around. I turn around the whole and survey, answered by hints of hue—yellow, red-orange, violet outward in its condensing zone—outward again, octave-wise, measured from the cadence, and breath-whisper signal of hue in one zone, there at upper left, rippling outward with its accompanying inner tinges and echoed at sixty degrees to the right; four, five, six rings.

lagoon

Toward the Adriatic, I sweep over the field of clouds, furrowed in local and regional and national octaves, ocean swells enfolding molecular ripples and soviet clusters, sheared and torn by the strain of cross-current into shatters, gore hanging in thread. Shifting ahead into frozen crystal breaks whose cracking pattern marches for half the horizon and then softens into elastic rolls again, white meringue alternating. Drifting down my own membranes, darkened fragments of microorganisms float. My glasses fog slightly as the vessel turns into the light, carving the field with relief and searing through with prism shards, radian. Seeing the meniscus, blinded in pink and white, turning inward. Slow-shifting caustics and acids corroding soft-tissue wells; muscle sheath, cleavage-fissure working into cores running alongside bones,

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21 Protocell detail. Hylozoic Soil, "(in)posición dinámica," Festival de Mexico, Mexico City, 2010

the relaxed eddies created by spaces in between sinews just before they intersect and plan—pools, cruelly, where collagen and might otherwise relax, recovering. In the lee of the joint. Not resolved for work like the resilient inner and outer pad layers between my vertebrae. Not resolved for birth, like the enriched ready-to-boil plasma of stem cell marrow. Taken unawares, dewy-saucer-eyed-cuddling-infant-throng-jelly-bubble matrix first irrigated with a tease of delight, then pulled void. Not resolved, but waiting interregnum.

The space that lies in the sheltered lee quietly rebounding just short of the pinching joint of two converging vectors, hollows where I might have paused to rest had I been a soldier. What am I seeing, and what am I projecting? Where do I look, and what is found? Pre-history tracks await in limbic brains, fissured to receive my gaze. Cutting and lurching to the front, in proud social *cognitium*: freezing, holding the view firm. Mine.

In those places lie dark pools. Out from the Lido, away from the sinking island. Reaching toward fertility.

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22 Hygroscopic islands and filter layer. Hylozoic Soil, "(in)posición dinámica," Festival de Mexico, Mexico City, 2010

overleaf

23, 25 Hylozoic Soil:Meduse Field, "Mois-Multi Festival," Meduse, Quebec City, 2010.

24 Hylozoic Soil, "(in)posición dinámica," Festival de Mexico, Mexico City, 2010.