

# The House Of Matter

by

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#### **AUTHOR'S DECLARATION**

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.



Everything falls apart, but some materials do it with a specific panache, and once design leaves paper to be built, no project is complete until it falls. As creatures subject to time, we identify with things in which we see ourselves, we identify with our mortal buildings.

Alchemy used material transformation as an active metaphor for human betterment. This thesis will search for ways that the inevitable indexing of time on the built environment can be used to catalyze a broader understanding of time and our place in it. Sympathetic engagement with our environments can form rich internal narratives while also fostering collective memory.

Four materials form the basis of these investigations: Cedar, Copper, Iron and Marble. For each material, chemical properties, history and mythology are invoked to describe their particular temporal nature, an understanding of how they come together and fall apart. The four material chapters of this thesis mean to return a sense of cognitive depth to our relationship with materials without resorting to symbolism.

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Dedication:

This indulgence is dedicated to Toby, for making this a stepping stone instead of a finish line.



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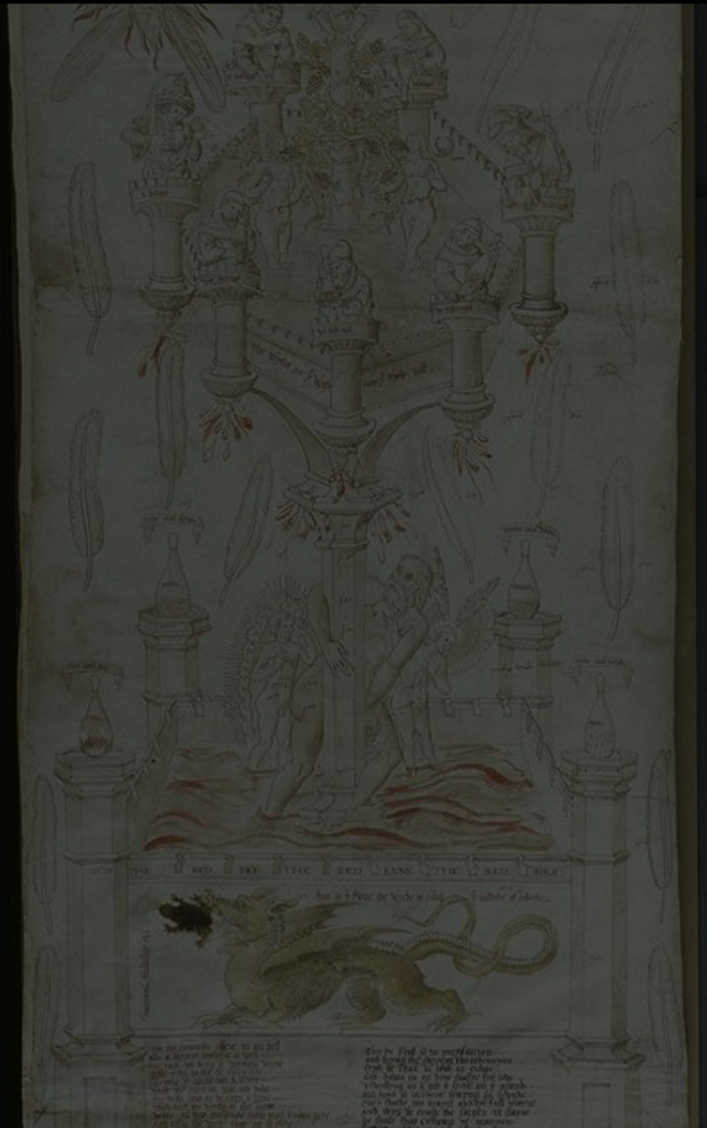
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**Conclusion**





# Architecture, Alchemy and the Archive





Ozymandias

I met a traveler from an antique land  
Who said: two vast and trunkless legs of stone  
Stand in the desert. Near them, on the sand,  
Half sunk, a shattered visage lies, whose frown  
And wrinkled lip, and sneer of cold command  
Tell that its sculptor well those passions read  
Which yet survive, stamped on these lifeless things,  
The hand that mocked them and the heart that fed.  
And on the pedestal these words appear:  
“My name is Ozymandias, king of kings:  
Look on my works, ye Mighty, and despair!”  
Nothing beside remains. Round the decay  
Of that colossal wreck, boundless and bare  
The lone and level sands stretch far away.<sup>i</sup>

-Percy Bysshe Shelley, January, 1818







There is a schizophrenia nestled in the heart of contemporary architecture, a contradiction that was expressed to its fullest in the Modern movement, and which continues to problematize design. It has to do with our relationship with matter. Modernism put forward its best effort to make an architecture that was 'progress'. Post-modernism tried to craft symbolic architecture that was a metaphor, while Deconstructivism attempted an architecture that was a metaphor for non-architectural ideas. Architecture, however, is made of matter. While symbols and metaphors are static, matter changes. While much of architecture, from the Modern movement on, tries to deny architecture's mortal relationship with time, streams of thought can be found espousing a more dynamic engagement with the fourth dimension. Writers like Tanizaki and Aldo Rossi describe time as a key element in thoughtful design: a position that casts the architect in the role of the modern alchemist. Zumthor's phenomenological architecture agrees in spirit with the architect operating as alchemist. His writing advances the opinion that designing with time is both responsible design practice, and possibly a way to capture one of the few

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the Archive**



remaining common experiences in a globalized world. Using time to create relatable instances of architectural mortality may be one of the remaining paths to universal beauty available to the alchemist / architect.

#### Architecture/Archive

Modern Architecture's dysfunctional relationship to time is exemplified in its problematic relationship with the archive. The architects of medieval cathedrals, the Master-Builders, were craftsmen who guided construction that held to the spirit of a design but adapted to changing technologies and priorities as the project continued through their lifetimes. It was never the goal to reproduce in reality the premonition of a cathedral realized on paper. As building science and construction techniques complicated themselves, the idea of the complete set of drawings needing only to be reified became industry standard. Freed from the quotidian requirements of construction's realities, the relationships expressed in the documentation of a design became the focus of the architect. This separation of architecture and its archival counterpart left the physical reality of the building in the role of the imperfect corporeal brother to the charged forms on the page. In his article, "Archiving/Architecture", Kent Kleinman writes that "... seeing the weathering of a work by Carlo Scarpa one learns to read his cryptic drawings. But expecting the built and the drawn to be alike is an expectation born of ideology rather than of nature."<sup>1</sup> The relationship of a building and its archival design drawings is complicated in two senses: the first is the probability of constructing exactly the design as imagined, the second is the new building's inevitable relationship with time.

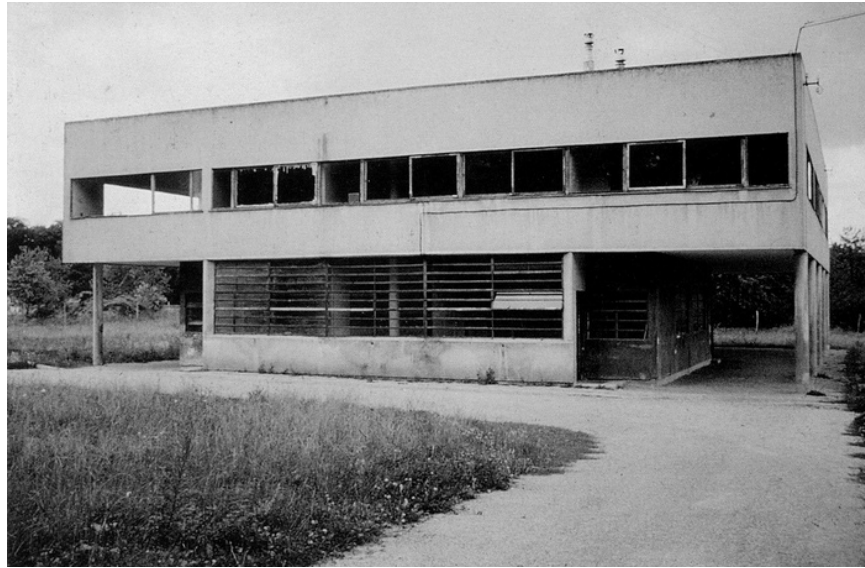
The Villa Müller, a project designed by Adolf Loos and built in Prague, was purchased by the Czech government in 1995 in an effort to protect it from faithless remodelling in the hands of a private owner. The government decided to restore the building to match the archival design drawings on record with the local building department.<sup>2</sup> They also drew on the *Albertina Graphische Sammlung's* Loos archives in Vienna. The restoration project immediately ran into difficulties. Comparisons of period photographs and original archival drawings showed discrepancies. Forensic investigation of the building revealed construction realities that differed from the



initial design drawings. The question became one of privilege: should the house be restored to match the initial construction, carried out under Loos' supervision or should the house be constructed to the archival specifications for the first time? Given that building technology had advanced since the original construction, was surface appearance what mattered or should building performance be sacrificed for authenticity? Ironically, the money and effort expended over several years, the closest possible concretization of the original design, ensured that the result was ontologically nothing like the original house. As Kleinman writes, "No longer is Loos' house architecture. We cannot get close to it now; it is presented as a work of art. It has been rendered distant, not with a gilded frame, but with equally effective velvet cords ...."<sup>3</sup> In removing the distinction between the architecture and the archive, the house as Loos intended it has vanished.

While Villa Müller's restoration highlights one complication in the relationship of Modern architecture to the archive, Modernism's indifferent relationship to temporal realities is exemplified by the case of Le Corbusier's Villa Savoye. Kleinman's apt description of architecture of the built environment is that it, "... ages and weathers, is subject to quotidian appropriation, is modified by changing needs, and is part of a dynamic that resists steady state descriptions."<sup>4</sup> This house was many things, fulfilling Le Corbusier's five points of architecture to produce a "machine for living." On paper, the free-plan allowing for the counterpoint of curve against plane, the roof garden and pilotis formed the epitome of the house as progress, but it had trouble also being architecture of the built environment. In their book, *On Weathering*, Mohsen Mostafavi and David Leatherbarrow describe why, Leatherbarrow writes: "Implied in Le Corbusier's understanding of the white building is a finality that manifests itself upon the completion of a construction ... accordingly the duration that is to follow the completion of the building - the life of the building - is conceived as a subtraction from the ideal condition of the project realized before inhabitation and weathering."<sup>5</sup> Given the ideals of "whiteness" and purity of form, and the underlying message of optimism and progress, any divergence from this 'finality' can only be seen as a flaw, as *On Weathering* states, "... for modern architects, stains ... were thought of as





*The Villa Savoye, before and after restoration.*

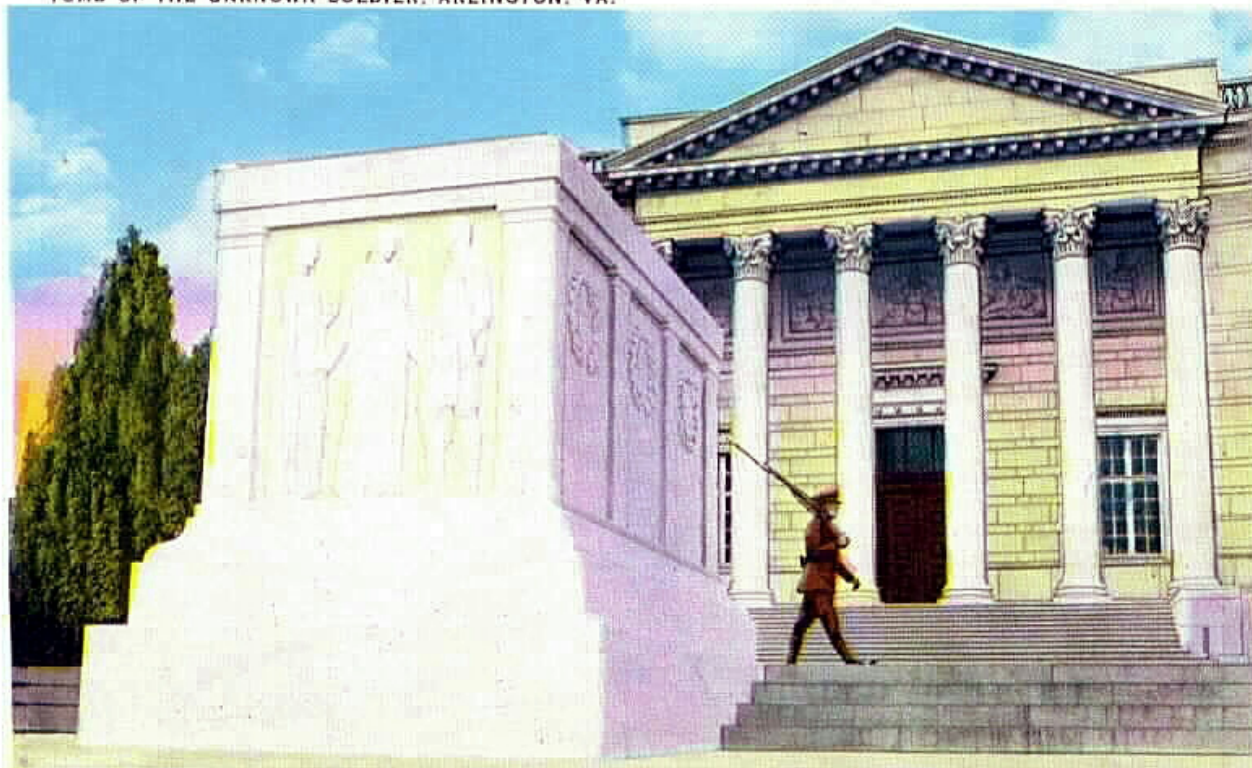


faults, to be suppressed technically and morally.”<sup>6</sup> After its construction between 1928 and 1931, the building immediately began to decay. By 1938 its owners had given up on inhabiting a machine for living. The house was occupied by both German and American soldiers during World War 2, and briefly enjoyed service as a barn around 1959. By 1960 the property had been appropriated by a youth center and modified accordingly. Restoration efforts began in 1962 and continued intermittently until 1985.<sup>7</sup> Constant restorative effort is required for the building to successfully fulfill its symbolic programme. The symbolic programme, or semiotic construct, is the matrix of symbolic instances that constitute the hermeneutic identity of a work. A piece’s intentional semiotic construct is dependant on the viewer’s ability to read the symbolic language being used if it is to be read as desired. While Modernism spoke a symbolic language of efficient speed and progress, these buildings were delusionally static in intention. This discrepancy between material reality and the fulfillment of a symbolic programme is not unique to Modernism. Any time the symbolic programme is privileged over material reality, potential problems arise.

The Tomb of the Unknown Soldier in Arlington National Cemetery consists of a memorial sculpture in the massive form of a white, marble, neo-classical sarcophagus placed over a tomb containing the body of the World War One Unknown Soldier. In front of the sculpture are three additional tombs, each one for another Unknown Soldier. One dug for the unknown dead of the Second World War, another for the Korean War, and the third for the Vietnam War. One of the tombs is empty. The sarcophagus, carved with epitaph, wreaths and the allegorical figures of Peace, Valour and Victory, is cracked. Lancing upward to the right, the fault line severs the arms of Peace and Valour at the elbow and splits Victory’s xiphoid process after neatly separating the hilt from the blade of his sheathed sword. Another crack cuts Victory’s legs out from under him. The cemetery had a thirty-ton block of marble cut from the same quarry as the original foisted on them by a zealous citizen, while President George W. Bush was signing the National Defence Authorization Bill that forbids them from touching the cracked original. Each plan for the sarcophagus’ future



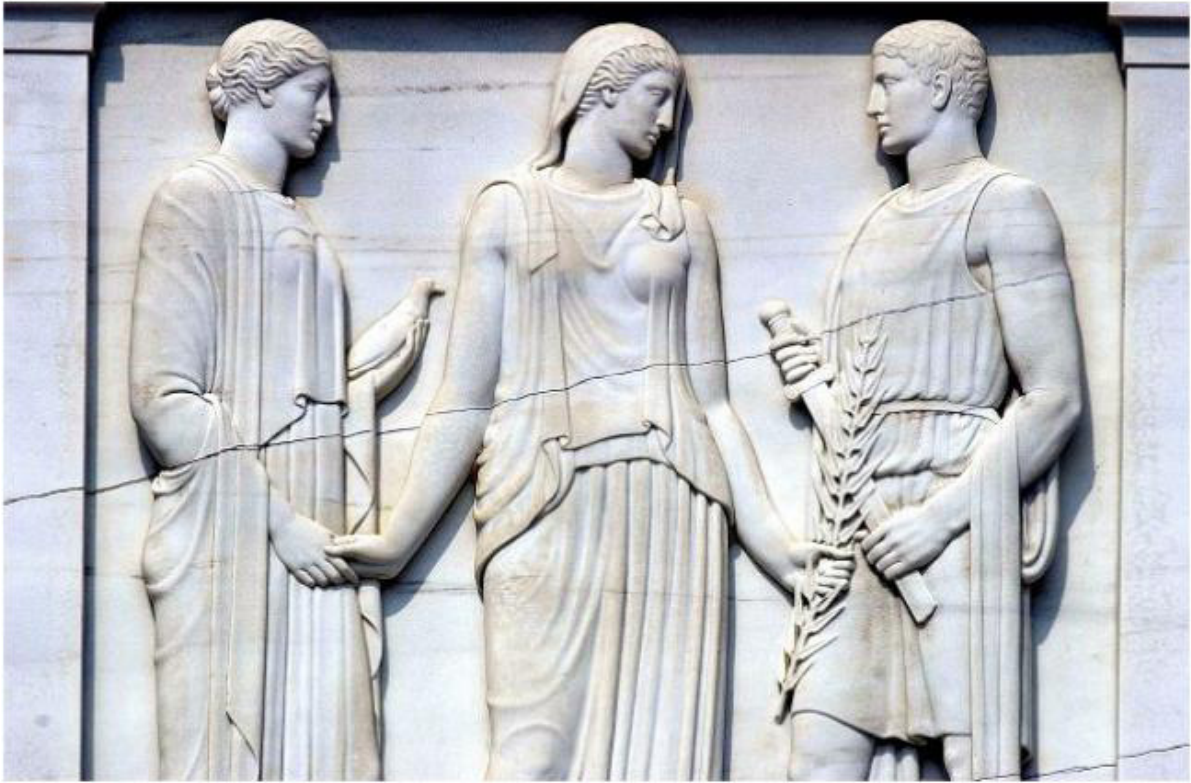
TOMB OF THE UNKNOWN SOLDIER, ARLINGTON, VA.



*Postcard of the guarded Tomb of the Unknown Soldier.*







*Crack in the sculpture on the face of the tomb.*



represents a claim on its purpose. With the memorial being pulled between the United States Army, Congress and the public, it's no wonder it's cracking.

The memorial sculpture of the original tomb consists of three pieces of gold-veined Colorado marble: the base, the die block and the cap. Overall the sarcophagus is eleven feet high, eight feet wide and fourteen feet long in solid stone. The die block is carved with four doric pilasters which divide each long face into three panels. Each panel is carved with an inverted wreath representing mourning. The six wreaths stand for six of the major battle campaigns of the First World War: Ardennes, Belleau Wood, Chateau-Thierry, Meuse-Argonne, Oise-Aisne and Somme. On the front panel, facing the Potomac, the figures of Peace, Valour and Victory are carved, bracketed by more Doric pilasters. On the panel facing the Memorial amphitheatre reads the epitaph originally approved by the Secretary of War in 1925 for all unidentified soldiers, "Here rests in honoured glory an American soldier, known but to God."

Memorials are storytelling devices. They attempt to communicate a specific cultural response to an event, a snapshot of collective memory. However, exactly what they communicate is a matter of public memory. In John Bodnar's essay on public memory, he describes it as the "... intersection of official and vernacular cultural expressions."<sup>8</sup> The way a monument like the Tomb of the Unknown Soldier is read will be a struggle. The official story it was originally constructed to convey will fight to be read, in contest with the readings that small-scale vernacular communities have assigned it. The official reading of the monument, as outlined in the Army's report on whether to replace or repair the Tomb, is one of nationalism and pride. In the short film, "America's Eternal Flame: The Tomb of the Unknown Soldier," the narrator explains that the Tomb, "... is a symbol of our eternally battle-ready youth."<sup>9</sup> The more weathered and cracked the tomb becomes, the less appropriate it is as a symbol of something immutable, young and potent. The material temporality of marble, outdoors near an urban centre, is completely at odds with the reification of rigidly immortal symbols; something that cannot help but change to represent something that cannot be allowed to change. The National Trust for Historic Preservation calls





the cracks in the marble, “purely cosmetic”, but they are only evaluating the monument for structural soundness, as an artifact of the past that represents the way a nation felt at the end of the Vietnam War towards its fallen soldiers. Some Veteran’s Legislative Coalition members support the National Trust for Historic Preservation’s efforts to protect the original Tomb, for them its primary purpose is as a marker in time of a past event. That piece of marble is theirs. The matter - not the symbol, is invested with collective mourning and memory and the pride and shame of a nation. This puts them in conflict with the Army and Arlington National Cemetery. The official semiotic construct of the Tomb, pride in eternally battle ready youth, means that weathering and cracking fundamentally affects the work’s intended reading. If the Tomb of the Unknown Soldier is a place to mourn the dead of the past, then it should age - sharp details should round into dull suggestions and immutable masses of frozen tensions should crack with release. That place to visit the past and mourn the unfound lost represents the vernacular cultural expression of the monument. The official story of the Tomb, however, is not of grief and mourning - the official cultural gesture of the Tomb is of pride, youth and battle-readiness : and the Army and Arlington National Cemetery have a vested interest in a monument that reminds every visitor of their country’s perfect, ageless pride in their fighting sons.

Public memory, collective memory, is the hybrid story of two narratives. Because of the matter to which the semiotic construct of the Tomb is bound, it can’t operate as a blending of the two expressions. Either it is allowed to bow to time, or it is not. With the official cultural expression so clearly in conflict with the vernacular, the debate over the tomb of the unknown soldier becomes a symbol of the distance between a government and its people.

Despite the antagonistic reaction to the realities of time and weathering evident in these examples and much of contemporary architecture, coming to terms with time’s role in construction simply requires a philosophical shift. After all, as *On Weathering* points out, “The mouth kisses, the mouth spits; no-one mistakes the saliva of the first for the second. Similarly, there is nothing necessarily impure about dirt.”<sup>10</sup> In 1967, Jun’ichirō Tanizaki published *In Praise of Shadows*, a work extolling the



unique aesthetic of the Japanese. In it he describes a deep-rooted appreciation for the character that time lends to a building. Specifically he waxes poetic on the beauty of tarnish, grime and aged wood. Wood, he claims, matures as it ages and darkens, acquiring an "... inexplicable power to calm and sooth."<sup>11</sup> Far from the Western obsession with objects static in time that remain new looking indefinitely, he recounts the Japanese love of the 'sheen of antiquity', saying, "Of course this 'sheen of antiquity' of which we hear so much is in fact the glow of grime. In both Chinese and Japanese the words denoting this glow describe a polish that comes of being touched over and over again, a sheen produced by the oils that naturally permeate an object over long years of handling - which is to say grime."<sup>12</sup> He describes the use of tin tableware and silver teapots, each of which is treasured for its slow evolution of a smoky patina. Tin flatware is allowed to age until the patina is sufficiently developed to etch lines of verse onto the rim, while aged silver is vigorously defended against the overzealous polishing of household staff.<sup>13</sup> In contrast to what he describes as a westerner's obsession with eliminating grime, he describes the Japanese as lovingly preserving it - out of the love for an object's history that grime is able to testify too. "We do love things that bear the marks of grime, soot and weather, and we love the colours and the sheen that call to mind the past that made them."<sup>14</sup>

Some Postmodern architects were concerned less about architecture's capacity to serve as a static vehicle for symbol and acknowledged time's integral role in architectural experience, notably Aldo Rossi. While his individual projects were not specifically temporally active, his philosophy of architecture as recorded in his *Scientific Autobiography* indicate his acknowledgement of architecture's temporal reality. "Perhaps this alone was what interested me in architecture: I knew that architecture was made possible by the confrontation of a precise form with time and the elements, a confrontation which lasted until the form was destroyed in the process of this combat. Its strength is potential."<sup>15</sup> While in his book, *The Architecture of the City* he gives a great deal of attention to the topic of permanences, he also emphasized architecture's role as an element that allows life to unfold, saying of the Abbey of San Galgano that "... abandonment is the beginning of design."<sup>16</sup> In Rossi, we see



an understanding of the temporal realities of architecture in the built environment at the core of understanding the nature of architecture and our relationship with it. Instead of architecture that attempts stasis in the name of an unchanging symbolic programme, we can understand architecture as Rossi saw it, as a, "... vehicle for an event we desire, whether or not it actually occurs ...."<sup>17</sup> Rossi returns the question of time to post-modern architecture.

In every work of architecture — built of matter and existing in time — alchemy is at work. All architects are alchemists, because we interfere with the natural time-driven cycles and relationships around us to produce material relationships that stimulate us. Alchemy is often thought of as chemistry's mad aunt, but while alchemical investigations did lead to the development of much of the equipment and insights of early chemistry, its goals were altogether distinct. In his book *The Forge and the Crucible*, Mircea Eliade distinguishes between them by writing that, "Alchemy posed as a sacred science, whereas chemistry came into its own when substances had shed their sacred attributes."<sup>18</sup> Alchemical operations were a dichotomy of esoteric and exoteric processes that allowed the practitioner to operate physically on material at the same time as he spiritually tempered himself. Alchemical operations guided material through a series of states from chaos to perfect order. They began by reducing the material in question to prima materia, hyle, while the alchemist must send himself spinning into a brooding melancholia. This chaotic mass was then rarified through a series of stages named for colours: The Nigredo (blackening); Albedo (whitening); and Rubedo (reddening). The Nigredo marked the change from chaos to the loosest possible organization, and was associated with the metal lead. Albedo represented form-giving light interacting with the matter, and was represented by white-silver. Finally, the Rubedo marked the infusion of vital energy, bringing about the ontological shift to gold.<sup>19</sup> Moving between these stages involved three agents of change, and the operations. The agents of change were Salt, Sulphur and Mercury. The feminine Salt was a grounding Earth-focused force; while Sulphur was associated

**Architecture/Alchemy**





with fire, energy and the masculine. Mercury, like the messenger god who shares its name, catalyzed change, and was thought of as androgynous.<sup>20</sup>

Alchemy was born when man started working with metals.<sup>21</sup> As Eliade states, “... the smelter, smith and alchemist have in common that all three ... work on matter which they hold to be at once alive and sacred, and in their labours they pursue the transformation of matter, its perfection and its transmutation.”<sup>22</sup> Smith-craft was a pseudo-religious occupation in many cultures. Among the Buriat of Mongolia, their god White Tangri was responsible for sending the Heavenly Smith to earth with his children, nine daughters and nine sons, to teach mankind to work metal.<sup>23</sup> African myths often feature the smith as a civilizing hero, while the individual craftsman was required to be sexually chaste, saving his potency for working transmutation.<sup>24</sup> Other cultures found other sources of vital energy for their alchemy. Chinese smiths effected the ‘marriage of metals’ using sacrifice to animate their operations, transferring a life to ensure union of the male and female principles.<sup>25</sup> Odin’s smith-priests were called the Forgers of Songs while Finnish hero Vainamoinen sang himself a boat of copper.<sup>26</sup> The earliest Greek smiths were part of mythic secret guilds, the priests of Cybele included both the Idean Dactyls and the Kuretes; who were said to have discovered iron smelting and bronze work, respectively.<sup>27</sup> In many of these traditions, metals were thought to grow in the earth, slowly ripening under the influence of the stars. Base metals were believed to be a less evolved, less mature form of the precious metals. Eliade describes this as an embryological perspective, “Mineral substances shared in the sacredness attached to the earth mother. Very early on we are confronted with the notion that ores ‘grow’ in the belly of the earth after the manner of embryos.”<sup>28</sup> The work of the alchemist-smith, then, was to intervene, to, “... jog and accelerate the rhythm of these slow cthonian maturations.”<sup>29</sup> Through his operations, man collaborated with nature, actively seeking to control the flow of time by first speeding the ripening of valuable metals from useless ore, and then freezing the process of natural degradation to hold the metal in its desired form. The famous goal of alchemy was the philosopher’s stone, sometimes interpreted to promise eternal life, the removal of the alchemist from the control of time.



Alchemy traditionally twinned two processes, the physical operations that involve the alchemist's efforts to assume the role of time: and the esoteric psychological evolution that accompanied them. Carl Jung, in the course of his work, began to discover remarkable parallels between the recorded dreams of his patients and alchemical symbolism. He describes the relationship of alchemists with matter as one in which alchemists "... were projecting part of their psyche into matter or inanimate objects ... a psychic content that they and their time had lost and abandoned."<sup>30</sup> For Jung, the 'philosophers stone' was the symbolic representation of the ultimate psychological goal, the integration of the self. Alchemical operations were inextricably linked to their psychological counterparts.

All architects are alchemists. When we select materials for our buildings we operate on them and expect them to operate on us. We accelerate or pace their natural cycles, pry, seduce, and fell them at their most appealing, and work on them to focus their attributes. Once in place, we expect them to communicate to us, thrill or calm us. We can deliberately work through alchemy to mirror and provoke psychological processes.

## Architecture

There is further reason to consciously design with time. In his book *Supermodernism*, Hans Ibelings describes the nature of thoughtful architecture after postmodernism:

... another essential difference between the architecture of a decade ago and of the present day, is the attitude towards symbolism. Symbolism was fundamental to both post-modernism and deconstructivism, whereby post-modernist architecture was usually a vehicle for symbolic messages and deconstructivist architecture a metaphor for non-architectural concepts ... in its place we now have a form of meaning that is derived directly from how the architecture looks, how it is used and, above all, how it is experienced.<sup>31</sup>

What he is describing, is called phenomenological architecture.

Try to pin down the message of a project like the Vals Therme, designed by architect Peter Zumthor, and you'll find yourself describing, not references or symbols, but emotions - resonances. In his book *Thinking Architecture*, Zumthor argues



that architecture is an instinctual, sensuous experience. Architecture shouldn't stand for anything but itself, or attempt to communicate anything outside the experience of architecture. Architectural precedent should be used as sets of phenomenological experience that you attempt to access, not shapes or details to copy. He writes that, "The world is full of signs and information, which stand for things that no-one fully understands because they too turn out to be mere signs for other things," but offers the solution - saying, "I am convinced that real things do exist, however endangered they may be."<sup>32</sup> His aspiration for his architecture is to have it be one of those things. Instead of standing in for something, or representing something, his architecture simply exists as a response to its programme, which includes its emotional climate. For Zumthor, "architecture is not a vehicle or a symbol for things that do not belong to its essence ... this means for me that power and multiplicity must be developed from the assigned task or, in other words, from the things that constitute it."<sup>33</sup> Key to this architectural integrity is Zumthor's attitude to materials. The Vals Therme was going to be made of local stone, stone whose nature was not known at the beginning of the project. The nature and behaviour of the stone under different finishing techniques drove the design of the project, a case of, as Zumthor puts it, "... things coming into their own, of finding themselves, because they have become the thing they actually set out to be."<sup>34</sup> Part of this material honesty is an acceptance and embracing of temporal realities. Zumthor's projects are not static metaphors to be circled by velvet ropes and constantly repainted. Conversely, he accepts and even prioritizes a building's ability to change with time - he writes, "I am convinced that a good building must be capable of absorbing the traces of human life and thus of taking on a specific richness."<sup>35</sup> Time in a building is both something understood viscerally and something we can learn to read.

In the Brion Cemetery, the chapel testifies to time passing in a setting where we traditionally try to make time stand still. Designed by Carlo Scarpa - the chapel features a ziggurat-stepped parapet across the top of a large blank wall. The parapet is interrupted by a gap allowing rainwater to drain down the face of the wall, slowly focusing a spreading black stain in the center of a wide blank plane. Deliberately







*Brion Cemetery Chapel, Carlo Scarpa*



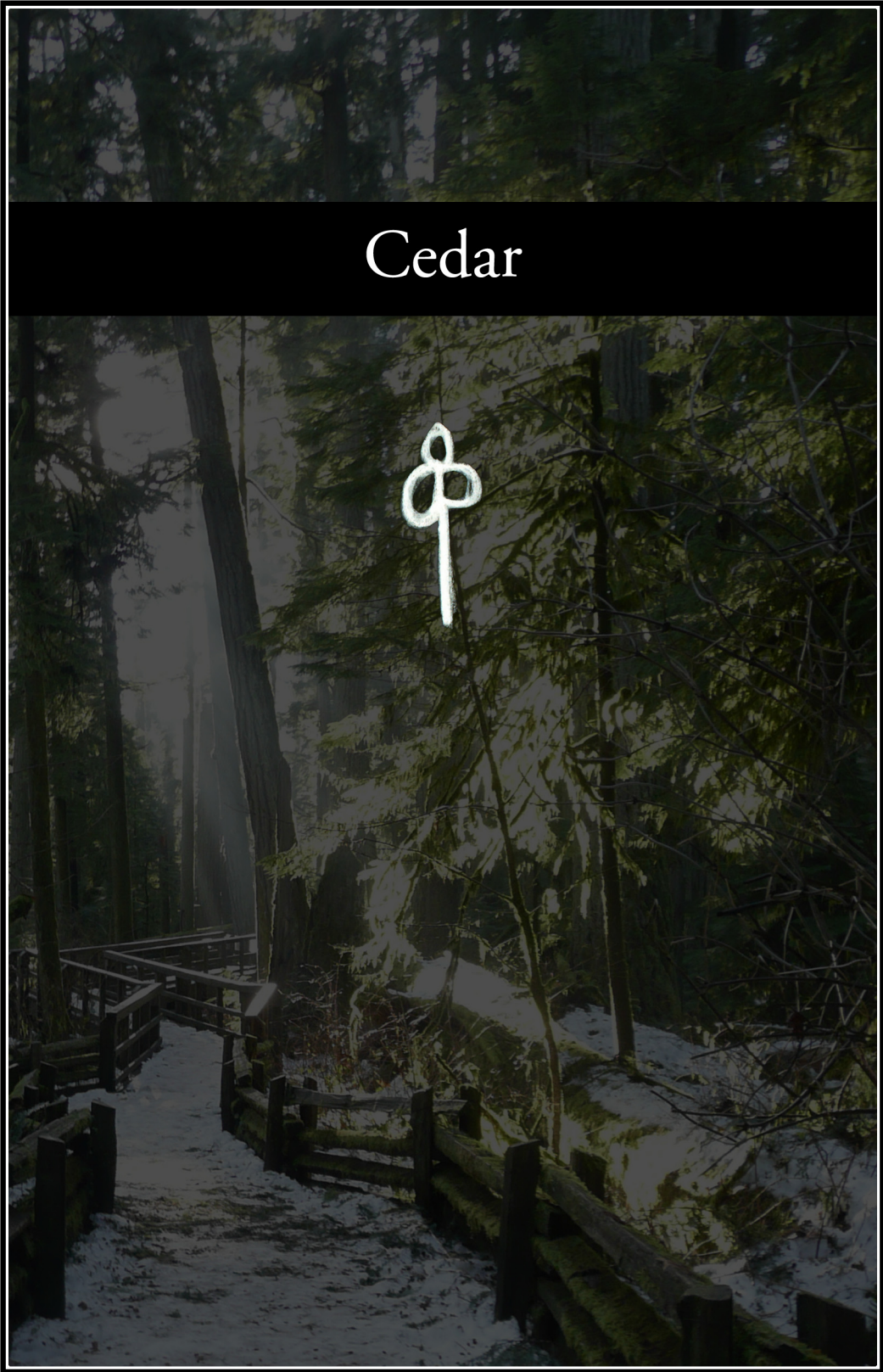


recording the passage of time using architecture indicates both an acceptance of time and renders the building sympathetically mortal, visibly subject to time. Mostafavi, in describing the wall, clarifies that, “This intended marking can be distinguished from other cases of sediments or tainting insofar as it has been singled out or framed as unique.”<sup>36</sup> Accepting, planning for, and capitalizing on a material’s temporal reality constitutes a deeper understanding of matter’s mercurial nature. The green-blue stain of precipitated copper salts, the red of rust, rather than something to be borne, could be celebrated. In writing about the importance of phenomenological architecture, Zumthor writes that, “Our times of change and transition do not permit big gestures. There are only a few remaining common values left upon which we can build and which we all share.”<sup>37</sup> Our existence as mortal beings, finite in the stream of time is one thing we all have in common, should our architecture not express its sympathetic condition?

Hans-Georg Gadamer, in writing *On the Relevance of the Beautiful*, examined the word beautiful and found it helpful to define it using a common phrase, “beautiful ethical life”. This well known description of the Greek ethico-political world does not refer to its visual appeal, but to the fact that it is communal, something enjoying universal recognition and assent.<sup>38</sup> Architecture, despite our best alchemy, remains constructed of matter trapped in the flow of time. Symbol and metaphor can’t be extended globally, or expressed indefinitely. If to be truly beautiful, something must strike a chord of universal recognition, the graceful expression of time passing may be one of the remaining common experiences on which architects can draw. The key to designing with time is a responsibility for understanding the materials we use that has been abdicated to the craftsmen. How commonly used materials come together, and fall apart. If a building is a poem, then material and form are our vocabulary and grammar. This then becomes an etymological study with the aim of reminding us of the rich origins and temporal realities of our lexicon.



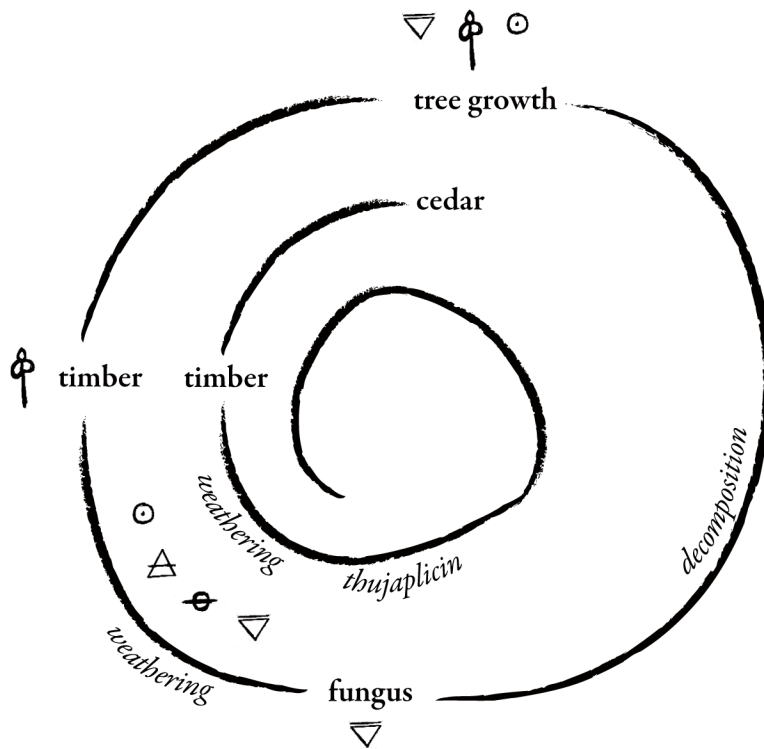




# Cedar









Wood is the most sympathetically human of all the materials in the architect's palette. In its range of colours and its capacity for tactile warmth, wood echoes our bodies. Unlike stone and metal, wood is a biologically ordered material, with its structures and idiosyncrasies determined by the same biological imperatives that shaped us. Like us, while it is alive, wood has the ability to resist and repair much of the damage it is subject to, its due for existing. But the wood we use is dead, and stripped of its living bulwarks. Light, water, salt and wind all contribute to wood's anthropomorphic aging, to its roughening and greying. In wood, our alchemy is the attempted interruption of its natural cycle of creative destruction. Wood's lot is to decay to support the growth of other life. Our attempts - through the banishment of water and the copper-sweet songs of fungicide - to pause this cycle after death, before decay, constitute an alchemical school that has shaped an industry. Wood's relationship with time is so flexible. It can live and grow, die and rot, or resist decay and index the light, salt, wind and rain of its environment. Aromatic woods like *arborvitae* grow so full of life that in their death, decay passes them by, allowing their full testimonial capacity to evolve in gleaming silver. Allowing for this recording is the second school of wooden alchemy, to teach graceful aging through time as wood changes with us.



Stone operates on a scale beyond us, both in terms of time and sheer size. Copper and iron find their form under our guiding hands, they are ontologically below us. Wood, however, is different. The growth of a tree is an observable phenomenon, operating at a comprehensible scale and in a time we can remain outside of. Wood is naturally anthropomorphic to the point where myth began to claim that trees may have had human provenance, as in the case of the sisters of blasted Phaëton as recorded in book two of Ovid's *Metamorphoses*, lines 148 - 168:

Lampetia, the fair one, tried to help her  
And could not move at all, suddenly rooted  
In earth; another sister, tearing her hair,  
Pulled leaves away, and another, and another,  
Found shins and ankles were wood, and arms were branches,  
And as they looked at these, in grief and wonder,  
Bark had closed around their loins, their breasts, their shoulders,  
Their hands, but still their lips kept calling Mother!  
What could Clymene do but follow impulse,  
Run every which way, try to kiss each daughter,  
Tear loose the bark, break off the little twigs  
At the fingers' ends? But the broken twigs were bleeding,  
And each one, wounded, cried, "Don't hurt me, mother!  
That is no tree you are tearing, but my body.  
Farewell, farewell!" And then the bark closed over  
The last words each one said, but still their tears  
Kept flowing down, till, hardened in the sunlight,  
They turned to amber, and the shining river  
Receives them, bears them on, to be the jewels  
Of Roman Brides, hereafter.<sup>1</sup>

We understand where wood comes from, and the form in which we use it in our constructions is recognizably linked to the processes that created it. Wood's combinations of organized bio-polymers form a strong lightweight substance as





complex as anything we've dreamed up in a lab.<sup>2</sup> The raw materials of wood consist of three polymers, cellulose, hemicellulose and lignin. Cellulose sheathes individual wood cells, providing them with a layer of fibrous strength. Hemicellulose, in turn, surrounds cellulose. Cellulose molecules are polysaccharides composed of a series of similar sugar molecules, forming long chains. Hydroxyl groups along these chains have the capacity to adsorb water, leading to a swelling of the cellulose chain perpendicular to its axis, causing the anisotropic behaviour of wood.<sup>3</sup> Lignin is a cement that bonds individual fibre strands together as well as bonding the fibres together. Insoluble in water and inert; lignin cannot be reduced to its constituent molecules in the manner that cellulose can be reduced to the sugars that make it up.<sup>4</sup> These three substances make up fibre bundles, whose axial orientation determines the specific grain of the wood, as well as vascular tissue that allows sap to move between the roots and leaves.<sup>5</sup> This sap movement is the difference between living and dead wood. Ideally we only make use of the parts of the tree where sap no longer circulates, portions that fulfill the role of structural support for the living crown and active sapwood.<sup>6</sup>

We use the forest as a source of raw material, harvesting wood as a natural, renewable and recyclable resource. Wood harvesting in developed countries is managed under a process called silviculture, a system of forest management that aims to find a balance between resource exploitation and eco-systemic equilibrium.<sup>7</sup> Once harvested and processed, stripped of its armour of bark and regenerative sapwood, wood begins to age.

Wood ages in reaction to processes that can be divided into five categories. The first three, mechanical, physical and chemical are considered weathering. The last two, microorganism and insect, are the processes that are structurally damaging, stealing strength from wood and requiring its replacement.<sup>8</sup> Weathering however, is different. Weathering is the indexing of site conditions onto the built environment, and allows wood to reflect the nature of its surroundings, its specific use patterns and the passing of time. The agents of change that act on wood include salt, water, light and wind. In salt-water environments, absorbed moisture can contain enough salt that during





*Well weathered wood showing lignin loss and subsequent corrugating.*



evaporation, salt crystals begin to precipitate out of solution, crystallizing between strands of cellulose. This crystallization pressure can fray and break wood fibres, roughening and loosening wood material.<sup>9</sup> Light, specifically ultraviolet radiation, attacks the insoluble lignin, breaking down the cement that holds the wood fibres together. As dark brown lignin is broken up by UV light, moisture moving in and out of the wood carries liberated lignin to the surface, darkening the surface of the wood. Evaporation deposits the colouring on the surface, where exposure to rain then cleans it away. This process results in a predictable evolution based on exposure to rain and sunlight, where exposed wood first darkens, and then washes out to a silvery grey.<sup>10</sup> The actions of salt and light, along with mechanical abrasion by wind-borne sand, weaken the fibre bonds of wood surfaces. Without lignin to hold the fibres in place, a wood surface can erode 1/4in. in 100 years. The porous spring growth, less dense than the later summer growth, erodes faster, causing the tactile corrugation effect of raised dense growth ridges between valleys of eroded spring wood.

The result of all these processes is an incredibly human aging process for wooden architecture. As time passes, fresh young wood matures, develops new textures and a bright silvery colour. Mechanical abrasion means that wood bears a record of its use, losing colour and developing grooves where it is sunlit and touched, pushed or walked on. The shift from honey yellow or brown to silver grey on unprotected exterior wood is usually effected within two years. The corrugation of differential erosion becomes apparent to the eye and to touch and continues to develop throughout the serviceable years of the wood. Or it would, if it were not for decay.

The processes of weathering are dependent on light, water, salt and wind. Exposure, however, also invites the more destructive processes of rot. Wood does not just fall apart. Wooden artifacts recovered from ancient tombs, historic wooden roof structures and piles that penetrate the water table all testify to wood's durability in the face of time. Yet, when burgeoning decay goes unnoticed, structural failure can occur in a few years.<sup>11</sup> While dampness and decay are tied, being wet does not cause wood to rot. Rotting is the result of fungal action, of a fungus disintegrating and



digesting wood components while growing in and on wood's cellular tissue. Fungi secrete ferments, enzymes that chemically decompose wood's cell structures, breaking cellulose walls down into their component sugars to fuel growth.<sup>12</sup> In wood, decay is so much the primary proponent of structural failure that the description of a wood's durability is not a measure of its hardness, but of its resistance to fungal attack.<sup>13</sup>

In order to reach its full expressive potential, silvering, corrugating and eroding to show use, wood must avoid the structurally destructive attacks of decay. Outside of insect and fungal predation, wood can remain sound for ages. In the book *Timber: Properties and Uses*, W. P. K. Findlay writes that, "Timber is a naturally durable material which does not change, or lose its nature, as a result of age. So long as it is protected from moisture and insect attack it can remain unchanged for centuries. Many materials become brittle and crumble after a certain number of years due to oxidation and other slow chemical alteration in their composition, but wood retains its strength indefinitely."<sup>14</sup> This depends on the hermetic protection of the wood in question, essentially removing it from the user contact, light, wind, salt and most importantly, water; silencing it for its own good. Yet Pliny writes about a wood that doesn't require such censorious defence. "Some persons give this tree the name of 'cedrelates'. The resin produced from it is very highly praised, and the wood of it lasts forever, for which reason it is that they have long been in the habit of using it for making statues of the Gods."<sup>15</sup> The tree to which he is referring is the cedar of Lebanon, *Cedrus libani*. Mentioned liberally in the Bible, this cedar from the Syrian mountains is one of the best and longest known trees in Judeo-Christian society. Trees known contemporarily as cedars, of which there are many, owe their name to a marked similarity in the fragrance of their wood to the aromatic timber of *Cedrus libani*.<sup>16</sup> In the words of W. Dallimore in his paper *Cedar Woods*, "There appears to be little doubt that the name was originally used in connection with the cedar of Lebanon, and that, by reason of its association with biblical history, is the most widely known cedar of the present day, although its wood is one of the least important of the many which now bear the name of cedar."<sup>17</sup> That same article identifies over fifty-eight species commonly called cedar, grouped into fifteen families. Two that have taken a



prominent place in the global timber market and Canadian history are *Thuja plicata* and *Thuja occidentalis*, north-western red cedar and white cedar. Algonquin legend holds that the hero Glooskap first made the cedars when three men came to him with three wishes. One wished to be tall, another wished he would never have to travel for he loved his land, and the third wished to live to an excessive old age in good health. To grant all of their wishes, he turned them into cedars, and when the wind blows through their branches you can hear them murmuring, pleased with themselves, “Oh, I am such a great man! Oh, I am such a great Algonquin.”<sup>18</sup> White cedar, as Algonquin myth would have been referring to, is also known as the Tree of Life, *arborvitae* in Latin. *Arborvitae* was used as a medicine to treat scurvy in the sixteenth century, provided by the Algonquin to hapless European explorers.<sup>19</sup> It is native to eastern Canada and the United States and can be differentiated from western red cedar, by its smaller size and lighter foliage. *Thuja plicata*, or giant *arborvitae*, is found in Alaska, British Columbia, Oregon, Washington and Northern California.<sup>20</sup> Both *Thuja plicata* and *Thuja occidentalis* are lightweight and easy to shape, as well as pleasantly fragrant. The sapwood of both is a warm yellow colour, while the heartwood of *Thuja plicata* tends towards reddish brown. The heartwood is traditionally known for its durability, earning it the name canoe cedar for its capacity to endure wet conditions. The same Haida tribes who named it canoe cedar used the inner bark to weave into textile products and baskets.<sup>21</sup> In a 1930 publication by the British Columbia Timber Commissioner, Western Red Cedar shingles are extolled as the white man’s realization of a traditional native truth. Citing their durability, they are proscribed as a premier roofing product guaranteeing roof lives of over forty years.<sup>22</sup> The specific mention of the heartwood of the tree as durable highlights a fascinating property of cedar, one that sets it apart from other timber in a relatively unique capacity for temporal expression.

North-American pioneers recognized and valued the natural durability of the heartwood of certain woods, using them in construction that has endured for centuries. Fenceposts and important structural elements were chosen from these long-lasting woods. Empirical evidence, experience, drove the pioneer’s choice of



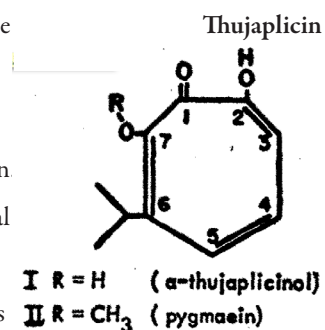


*Algonquin decoration on bark showing Glooskap creating the first cedar.*





cedar, black locust, chestnut, cypress, redwood and long leaf pine.<sup>23</sup> It would take the development of analytic organic chemistry to explain the rot resistance of the inner cores of these specific species. Many of the characteristics of a wood, like strength, flexibility and grain, depend on common wood components like cellulose and lignin. The varying proportions of these components in a single wood sample, across annual growth rings, and between species, make each wood unique to a certain extent. Characteristic colour, fragrance and durability, however, are determined by a wood's extractives. Extractives, so named because they can be extracted through the use of solvents, are chemicals present in wood in relatively small amounts.<sup>24</sup> The dramatic difference in colour between some heartwoods and their sapwoods results from the extractives stored in sapwood cells as they die and fill with air. H. Bynum published a paper in the journal *Mycologia*, examining the growth of the Polyporous amarus fungus on a medium of malt exposed to increasing concentrations of cedar extract. Fungal growth decreased as extract concentration rose.<sup>25</sup> Wood rot is a symptom of fungal attack, and the heartwoods of some species contain substances naturally toxic to fungi. In western red cedar, the extractives that deter attacking fungi are half water soluble, and half insoluble, while in incense cedar all extractives are insoluble.<sup>26</sup> In Cupressaceae, trees belonging to the cypress family, like *Thuja plicata* and *Thuja occidentalis*, tropolones are produced and stored in heartwood cells as extractives. One of them is called thujaplicin.<sup>27</sup> More specifically, alpha, beta and gamma-thujaplicin, alpha and beta thujaplicinol, and pygmaein form a set of tropolones with hydroxyl groups responsible for the fungicidal properties of cedar extractives. Each chemical deters specific fungal species.<sup>28</sup>



Wood durability is assigned in five classes, perishable through very durable, each tied to a maximum expected lifespan of a two by two stake of the wood set in the ground. Woods classed as perishable, if cut in the summer, should be extracted immediately before decay sets in, rendering winter harvesting preferable. Stakes of these woods, like beech and most sapwood, last less than five years in the ground. Non-durable woods, like scots pine, require preservative treatments to last five to ten years. Stakes of Douglas Fir, a moderately durable wood, can last ten to fifteen years.









*Thuja Plicata in Cathedral Grove on Vancouver Island*









*Thuja Occidentalis* growing in a typical cedar swamp





*Distinctively coloured fresh sawn red cedar lumber*



In exposed applications, it should be painted and not allowed to touch the ground. The class of durable timbers includes *Thuja plicata* and *Thuja occidentalis*. The heartwoods of these trees are expected to make stakes that will last up to twenty five years in the ground, rendering it suitable for boats, windows and gates. The class above cedar, very durable, includes dense heavy woods like teak.<sup>29</sup> Cedar has an earned reputation for durability - and yet builders depending on the resistance of cedar heartwood can be surprised when the timber they've left in contact with the ground proves to be as corruptible as some wayward sapwood. In the paper, "A Practical Look at Wood Decay", R.C. de Groot traces contemporary cedar's tendency for rot back to modern silvicultural practice. Heartwood supply was easily harvested in North America until the 1940's, when that available supply declined sharply until 1972, when it was rare to commercially harvest trees that had finished heartwood formation. Silvicultural practice exacerbates this issue, by focusing harvesting on fast growing, easily renewable resources. In a mature old-growth forest, a long-leaf pine with a flitch a foot in diameter could have potentially developed an eleven inch core of heartwood. In a fast-grown stand, a similar tree could potentially contain a heartwood core as little as two inches.<sup>30</sup> Newer heartwood also has a higher variability in its extract concentration, and the average is lower than extract concentrations in older trees. The reputation for decay resistance of these woods is based on the performance of these older trees.<sup>31</sup>

Taylor Smyth Architects made good use of cedar's reputation in designing the exterior cladding of their 'sunset cabin', a pre-fabricated sanctuary for a couple on their Lake Simcoe property in Ontario, Canada. Part of the cabin's programme was to disturb the serenity of the site as little as possible. To that end, the cabin is clad in a light filtering, view framing screen of untreated cedar. While the birch veneer plywood interior surfaces give a warm contemporary feel to the small space, the cedar outside is intended to evolve into a silvery grey with time.<sup>32</sup> Between the natively planted green roof and the eventual natural silver-grey of the screens, the cabin's presence is treated as an unfortunate disturbance, a scar that is intended to heal into the landscape. The decision increases enjoyment of the cabin, freeing the owners from annual staining and





*Sunset cabin, Taylor Smyth Architects, 2004*



painting to maintain the desired aesthetic. Allowing the colour to mature naturally further ties the cabin into the site, as its desaturation progresses along a recognizable timeline of establishment.

The quotidian behaviour of cedar harvested commercially will not always measure up to the stands of virgin cedar, some of which were mostly heartwood and replete with extractives. When we cannot depend on the alchemical efforts of young trees to ward off decay, we instead modify wood structure and cladding design in order to minimize moisture : often turning to fungicidal treatments when wood will remain damp. But hermetic isolation from moisture hides wood from the user, light, salt, wind and water that give wood its temporal voice; while soaking wood in creosote and copper-based poisons render its textural expression toxic and thus mute. Through rescue, windfall and selective harvesting, cedar heartwood is still one of our materials. The danger of letting other woods encounter moisture, incipient decay, is no reason to hide cedar from the world. The alchemy of poison and dry air is apt for sapwoods that will corrupt beneath our fingers and crumble to feed some creeping mycelium. Wood's sympathetic potential does not lie there. Filling wood with copper-poisons and painting it to look young denies wood's capacity to evolve with us. As Juhani Pallasmaa writes in his book *Eyes of the Skin*, "The detachment of construction from the realities of matter and craft further turns architecture into stage sets for the eye, into a scenography devoid of the authenticity of matter and construction."<sup>33</sup>

I can remember a balcony. I remember grey silver and rough texture beneath my fingers, and the smell of cedar. In one memory the smell is stronger, in another, the texture commands my attention. My grandparent's balcony in Eden Mills, Ontario, I remember. I have forgotten many balconies since. Cedar's raw beauty is built up through a lifetime of growth and biological imperative, while its sympathetic aging sees its constituent structures break apart to be washed and worn away. With the ability to age as we age, to grow silver and take on texture born of experience, cedar can produce moments of architecture we can track ourselves through. *Solve et coagula* — break apart and bring together.



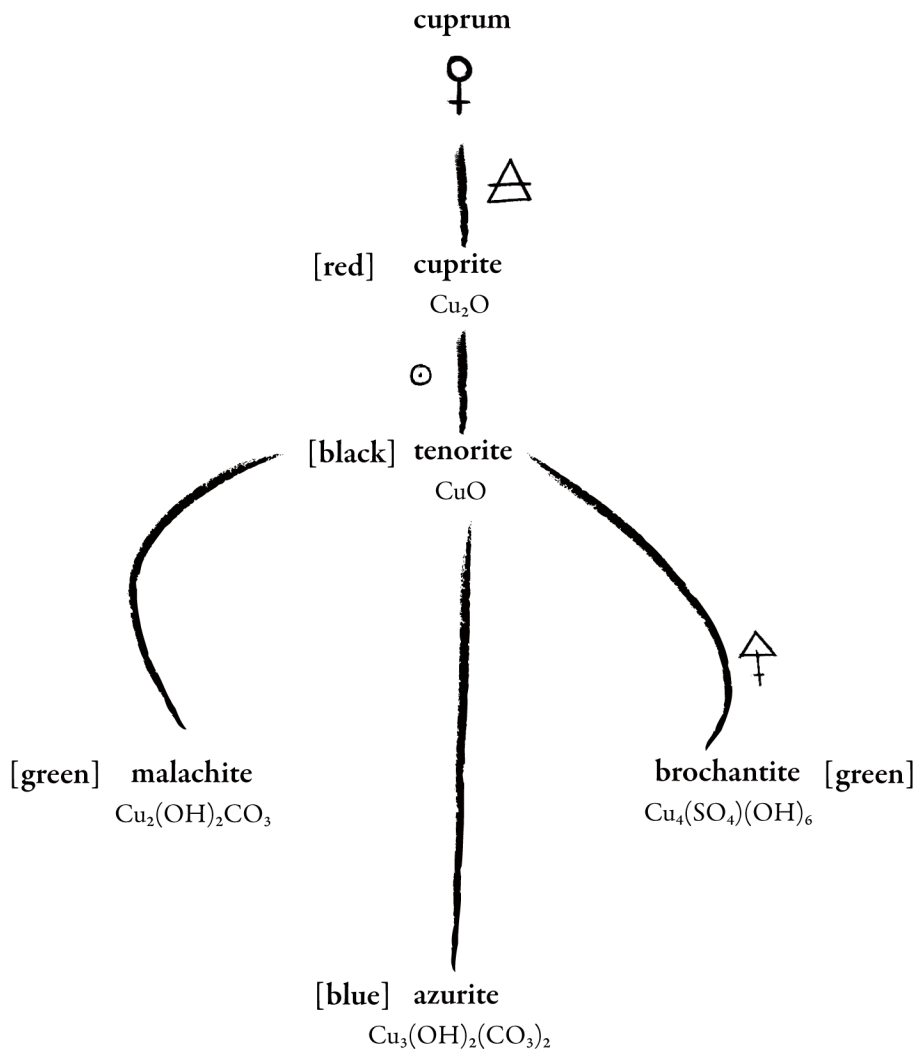




# Copper









What colour is copper? Textbooks will tell you copper is red-brown, but that would be like calling polished silver grey. Copper is red-brown becoming light. Copper is also dark brown, as much as it is also mottled green, or patchworked in blue. From mankind's first encounters with copper in its native state, to our efforts to bleed it from the earth with pick and flux, copper has been with us as long as civilization. Like its chromatic tranfigurations, copper's role in our lives has constantly evolved with us - and in us. Copper's changing face is the inevitable mirror of our efforts to purify it for use, fire and earth-mined flux give us the familiar fascinating metal - air and light help to take it away. *Solve et coagula.*

Our first experiences with copper pre-dated the development of the alchemy required to process ore. The native metal, periodically found at the earth's surface, would have been used along with prehistoric man's conventional rock and bone materials to make simple tools.<sup>1</sup> In a similar fashion, he would probably have encountered other metals that occur in their native state, like silver, iron or gold. Native copper would have been more abundant than these, and highly prized. Cold-worked using rocks and patience, copper would yield a fine sharp edge, without the heat required to work iron, or the characteristic softness of gold.<sup>2</sup> Copper generally occurs natively in small flakes at the





*Native Copper*







*Haida copper shield*



Earth's surface, but it can also form nuggets. Masses weighing up to 400 tons have been excavated in the Michigan cupriferous region.<sup>3</sup> In what would become British Columbia, the native peoples of the North Pacific Coast discovered and worked deposits of native copper on the Isle of Baranof, fashioning elaborate shields that would travel the coast on the arms of the Haida people to the Haida Gwaii, formerly the Queen Charlotte Islands.<sup>4</sup>

While our long story with copper began with discrete discoveries of true copper in its native state, the exploitation of telluric copper marked man's first advances into alchemy. In his book *Living metals*, Leendert Mees sets metals apart from other materials, says that, "All matter that people use for the manufacturing of objects is subjected to a certain amount of processing. Wood is cut, sawn, planed. Stone is quarried, cut, polished. Metals, however, with the exception of gold, are not present in nature in the form in which we use them. A great deal of energy is needed to free them from their 'enchantment.'"<sup>5</sup> Mankind has been using copper for 6000 years, its production and uses evolving as we learn more about its nature.<sup>6</sup> Before we learned to free copper from the earth, the mineral malachite — a natural carbonate of copper — served the pre-dynastic Egyptians as a green pigment.<sup>7</sup> While native copper formed the basis of our early metal use, the smelting of relatively copper rich ores was simple enough that some claim it happened by accident. Professor Elliot Smith attributes Egyptians with the discovery of copper smelting, a skill he theorized they taught to other civilizations they encountered.<sup>8</sup> The first metallurgy probably occurred in the campfire.<sup>9</sup> The heat of the fire was enough to draw metal from copper rich hearthstones, producing acceptably pure copper which could then be worked into a wide range of forms.<sup>10</sup> This process of smelting, isolating copper from stony copper ores, marked man's progress into the 'age of metals.'<sup>11</sup> Evidence of purposeful copper mining and smelting shows active Egyptian sites at Timna Valley, Israel, dating to 6000 years ago.<sup>12</sup>

Aside from native copper, much early copper was not the pure metal we see today. It was common for copper to be smelted as natural alloys, blending with the elements found in its surrounding material. Early copper in Hungary consisted of four





to five percent antimony, while the copper in Egypt was often four percent arsenic. German copper was usually two to four percent nickel, while Cornwall produced a natural bronze by smelting a copper-tin alloy. In Ireland and Cyprus - the greek island from which copper takes its name - mined and smelted copper was relatively pure.<sup>13</sup> While copper was readily available in Sumeria, Israel and Egypt by the fourth millennium BC, it was not until 1000 years later that we see evidence of smelting in Greek Cyprus. The ancient Greeks called the metal *chalkos*, lending their name for copper to the copper/stone age in the word 'chalcolithic'. The importance of the copper mines on Cyprus to the ancient world is immortalized in the Latin name for copper, *aes cyprium*, which gave us the later *cuprum*, a word that became our copper.<sup>14</sup> Pliny, in his *Natural History*, claims that copper was first discovered in Cyprus<sup>15</sup> and states that, "Indeed the Corinthian brass comes before silver, not to say almost before gold itself."<sup>16</sup> In the sixth century AD, Olympidorous the Younger, Neoplatonist philosopher and astrologer, linked the metal copper to its astrological counterpart Venus.<sup>17</sup> This association was tied to the myth of copper's flowering under the soil of Cyprus when Aphrodite, foam-born, first stepped ashore on that isle. Its association with the female archetype in astrology and alchemy finds its odd echo in the biochemical copper imbalance between men and women, with women typically having more copper in their blood serum.<sup>18</sup> The alchemical symbols for copper and Venus are one and the same.<sup>19</sup>

Investigation into the properties and methods of production of copper was spurred on by the electrical applications discovered by the mid nineteenth century researches of Michael Faraday.<sup>20</sup> About half of the global output of copper is used in electric and telecommunications applications, while the rest is used by the building industry, transportation and general engineering.<sup>21</sup> Copper's popularity outside of telecommunications and electrical applications is partially owed to its remarkable facility for joining other metals in alloys, combining strengths from both metals.<sup>22</sup> Copper's value is generally to impart to its alloys its own resistance to corrosion, rendering the resultant metals resistant to chemical attack.<sup>23</sup> Most ancient uses of copper were in alloyed form, by chance or design, including some remarkably arcane





*Gypsophila patrinii*, a species of baby's breath used as a biological copper indicator in Russia.

mixtures. The ancient's word for copper, *aes*, referred to a blend of copper and tin, and in Pliny's *Natural History* he describes the recipe for 'Egyptian silver' as being one part silver, two parts copper, and one part live sulphur.<sup>24</sup> \* Today, the principal alloy groups of copper are the brasses, bronzes and the low alloyed coppers. The brasses include coppers alloyed with up to 45% zinc. The bronzes contain up to 12% tin.<sup>26</sup> The low-alloyed coppers have copper's resistance to damaging corrosion but enjoy improved strength or easier machinability.<sup>27</sup> They can include three percent or less of beryllium, silicon, chromium, or zirconium, to name a few of many examples.<sup>28</sup>

As the ways we use copper evolves, so do the ways we find it. Early copper was found native in flakes or nuggets near the surface. Later, surface deposits guided copper miners, following the vein into the earth. Subterranean copper could also be found using an early form of empirical geology. Pliny reports that ancient silver mines would be considered tapped out when the vein ran to alum. The abandoned mines were quickly re-opened when it was discovered that beneath the alum often ran veins of copper.<sup>29</sup> Temporarily closing tapped out mines was a practice based on the idea that a mine needed time to regenerate its metallic bounty, part of the embryological conception of metals growing and ripening in the earth. In their book, *Copper: Its Geology and Economics*, authors Robert Bowen and Ananda Gunatilaka describe modern efforts at finding metals as being based on, "geology, sedimentology, petrology, oceanography, hydrogeology, structural geology, mathematics, physics, chemistry and biology."<sup>30</sup> Of these systems, the most poetic is the use of biological plant indicators. Certain flowers can only grow in copper rich soils, soils rich enough in copper that they reliably indicate an economically feasible site for exploitation. In Queensland, Australia, copper prospectors search for the flowers of the copper plant, *Polycarpaea spirostylis*. In Zambia, scent the air for the mint-family's *Beccium homblei*, or look for the blooms of *Gypsophilia patrini* in Russia - which will only grow in soils with 300-1000 ppm of copper.<sup>31</sup> The United States finds California poppies, *Eschscholtzia mexicana* growing on its copper-porphry deposits, while in Canada we look for copper moss, *Merceya ligulata*.<sup>32</sup> In 1977, it was estimated that there could be  $2 \times 10^{18}$  tons of copper

\*In the alchemical operation of calcination, materials were heated to the point of thermal decomposition without experiencing overall phase change, like roasting a vegetable. To engage elemental copper in calcination, where the application of heat will not effect change, the metal would be exposed to the alchemically symbolic fire of sulphur. Sulphur reacts aggressively with copper, its name is derived from *sulvari*, the enemy of copper.<sup>25</sup>



scattered throughout the earth's crust, exceeding annual global consumption half a billion times, but it's not necessarily available to us.<sup>33</sup> Ancient exploitation was limited to high grade ore, while native North-American excavations 5000 years old into ore that was fifteen percent copper have been found near Lake Superior. By 1540, in Northern Europe, eight percent copper ores were considered economically viable, and the copper content of our excavations has continued to decrease. By 1890 six percent copper ores were considered worthwhile for processing, and advances in ore processing brought us to 1906, where two percent porphyry copper was considered usable.<sup>34</sup>

Once found, copper must be freed from the ores it forms as a result of its propensity to seek chemical equilibrium with its environment. The relatively rich ores mined at Cyprus required little coaxing to produce copper. Pliny writes that copper was obtained by 'submitting to fire' the stones *cadmia*, *chalcitis*, or *aurichalum*,<sup>35</sup> and that the specifics of the process are similar to the method used for purifying silver. He describes the process as using lead as a flux to encourage the ore to melt, after which the metals of lighter density settle to the top of the liquid metal. "The earth in which it is found is sometimes red, sometimes of an ashy hue. It is impossible too, to melt it, except in combination with lead...when submitted to the action of fire, part of the ore precipitates itself in the form of lead, while the silver is left floating on the surface, like oil on water."<sup>36</sup> Like the ancient's method, 90% of global copper production today is pyrometallurgical<sup>37</sup>, but unlike the rich ores the Ancients were harvesting, we now exploit ores far less rich in copper, usually sulphide ores that result from copper's natural tendency to bond with sulphur. The early iterations of the industrial copper production processes we use today began in Europe at the end of the eighteenth century, when the majority of the world's copper was being produced in Wales. By 1698, smiths in Swansea were making use of a reverberatory furnace.<sup>38</sup> Their process of combining a charge of ore and flux to produce a matte of pure copper remains the initial step in producing copper today.<sup>39</sup> Producing the charge, however, from progressively lower grade ores, has changed considerably.



The method of producing a viable charge, the material to be submitted to the furnace, has evolved with the decline in copper concentrations in mined ore. Low-grade ore is processed in a series of crushers that reduce the rock to egg-sized fragments, and from there grind them to powder. This powder is then added to a bath of water, a frothing agent and a collecting reagent. The collecting reagent is carefully chosen depending on the chemical makeup of the particles to be concentrated. The reagent binds itself to the particles in question, and renders them hydrophobic. This causes them to seek out the air in the bubbles created by the frothing agent, which inevitably rise to the surface. A scum of bubbles containing the copper rich particles is created on the surface, which can be skimmed off and cleaned, producing a relatively rich concentrate to use in the charge.<sup>40</sup> This method works on copper sulphides, but the collecting reagents don't bond satisfactorily to copper oxides, carbonates or silicates. Sodium sulphide is added to the mixture first to bond with the less tractable particles, the sulphides then making the particle amenable to the collecting reagents.<sup>41</sup> After this process of concentration, an average charge would contain fifty percent copper, with sulphur, iron and silica composing the remainder, far preferable to the two percent copper some porphyry ore deposits yield initially.<sup>42</sup>

From here, the process for producing copper remains as described by Agricola in his sixteenth century treatise on metallurgy, *De Re Metallica*, a text dedicated to his aristocratic patrons, describing the value and current state of knowledge of the miner's art. Agricola's canonical text became the accepted authority on the subject for centuries after its publication. In his book, *Copper and its Alloys*, metallurgic consultant E. G. West summarizes Agricola's voluminous writing on the subject of copper smelting as stating that, "The basic principle of copper smelting... is based on the twin observations that copper has a greater affinity for sulphur than iron has and that iron has a greater affinity for oxygen than has copper."<sup>43</sup> The process follows four steps, roasting, smelting, converting to blister copper, and refining to ingots or anodes. Roasting, or calcination, is the application of heat to cause thermal decomposition without effecting a wholesale phase change. Heating the sulphur increases its tendency to bond with oxygen and form sulphur dioxide. At relatively







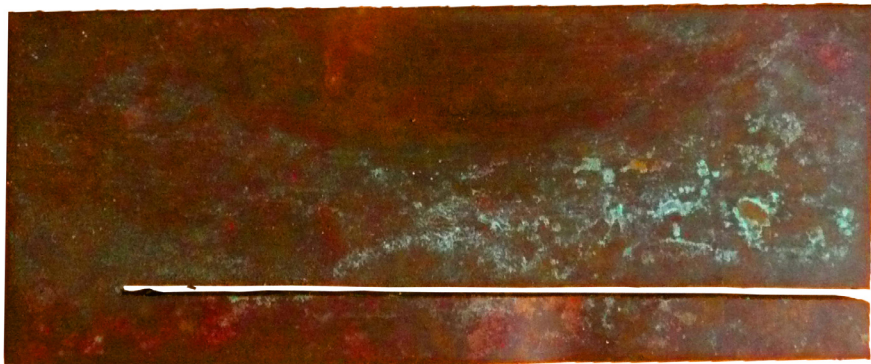
*Copper Mine, Bingham Canyon Mine, Utah.*



low temperatures, this can sublimate sulphurous components of the ore, causing sulphur to leave the concentrate in the form of a gas, which is collected and used in other industrial processes. Roasting takes place at temperatures between 500 - 750 degrees Celsius.<sup>44</sup> In smelting, the charge of concentrate, calcine, iron sulphide ore, flux and slag from earlier firings are introduced to the furnace. As the contents of the charge melt, reactions between the various chemical components produce a separable matte and slag. Copper's affinity for sulphur leads the copper oxides to become copper sulphides, while the iron sulphides become iron oxides. The matte will contain varying proportions of copper, iron, and sulphur. The slag will be made up of mostly ferrous oxide, up to two-fifths silica, and small amounts of lime, alumina, magnesia and waste copper. The matte will melt at 1000 degrees Celsius, forming a liquid with a greater density than the liquid slag, allowing the matte and slag to be tapped separately, like skimming cream off of milk.<sup>45</sup>

When the matte, called blue metal, is tapped it is taken directly to the converters. Conversion must eliminate the remaining iron and sulphur content of the matte, and this is done in two stages of oxidization. Tuyeres, openings along the base of the converter chamber, blow air through the liquid matte. The first introduction of air into the matte allows oxygen to react with the iron content, forming iron oxides that have a lower density than the remaining copper sulphides, or white metal. This iron oxide slag is skimmed off, and air is again introduced into the copper sulphides, allowing oxygen to react with the sulphur and form sulphur dioxide, a gas that escapes the surface of the metal, leaving characteristic blisters.<sup>46</sup> The copper content of the remaining blister copper is between 96-99.5% pure, it can still contain up to two percent sulphur and half a percent oxygen. This renders the copper too brittle for many applications, and makes further refining necessary.<sup>47</sup> Early refining methods centred around a practice known as poling. Tree trunks, often birch, would be thrust into the melt. Encountering molten copper, they would instantly burn beneath the surface, creating steam and a variety of carbonaceous gasses that would combine with the oxygen in the metal to create carbon monoxide and carbon dioxide, which leave the melt as hot gasses.<sup>48</sup> Modern methods will introduce a carbon-rich gas like





*Fresh copper. March 2010 / Weathered Copper. October 2010*







*Copper Sulphate Crystal*



propane or methane into the melt through the tuyeres.<sup>49</sup> When copper of perfect purity is required, the melt is formed into anodes, to be used in an electrolytic refining process that produces molecularly pure copper. The impure anode of refined blister copper is immersed in a copper sulphate solution. Up to one fifth of this solution will be composed of sulphuric acid. A pure copper cathode is also introduced into the solution. The impure anode will dissolve into the acidic solution. As the solution reaches copper saturation, dissolved copper will deposit out of solution onto the pure cathode. Any impurities, sometimes including other precious metals, will remain suspended in solution, or deposit at the base of the tank as a sludge.<sup>50</sup>

Pure copper as we know it is the result of a chemical matchmaking session run by a parent with abandonment issues, where we play the manipulative parent. Where copper wants to bond with iron, we first convince iron to leave copper for oxygen, and set copper up with sulphur instead. Now that copper is happy with sulphur, we parade oxygen in from of them until sulphur leaves copper alone, red-brown becoming light. *Solve et coagula* — break it apart and bring it together. Copper's most distinctive feature results from the fact that love wins out, despite our efforts. When copper is exposed to air, it immediately begins reacting with elements in the atmosphere. The oxides of copper develop in two heats of formation. Copper initially bonds with oxygen in a molecular ratio of one to two, forming a mineral called cuprite. Cuprite is formed of cuprous oxide, has a red colour, and is strongly adherent, meaning it is bonded firmly to the layer of copper below it. This adherent bond is the reason for copper's resistance to damage through corrosion. The initial formation of cuprite forms a thin layer of protection over the pure metal beneath. Having formed cuprite, the next reaction balances out the ratio of oxygen to copper, forming cupric oxide, a black mineral called tenorite. The formation of tenorite is dependant on the heating of cuprite in air, so the rate of formation can be affected by solar exposure. While the cuprite layer is strongly adherent, the tenorite layer is less so, meaning that constant wear can continually remove the tenorite layer as it forms, allowing red traces of use to stand out on a darkening field. After formation, tenorite begins reacting with the



surrounding environment to form complex basic salts, the carbonates and sulphates of copper. Three common minerals produced at this stage include the green sulphate brochantite, the green carbonate malachite, and the blue carbonate azurite. These minerals compose the familiar green patina seen on copper cladding in exterior applications. The makeup of the patina will vary depending on environmental conditions. Urban and industrial atmospheres generally have a higher sulphur content, changing the specific hue of the verdigris formed. Verdigris, from the Old French *verte de grez*, ‘green of Greece’, depends on exposure to air for its evolution, so coating copper with lacquer that prevents oxygen from reaching the copper can effectively prevent the heats of oxide formation that form the base for the patina.<sup>51</sup> Pliny provides several ways of preparing verdigris intentionally, including detaching it already formed from copper ores. He suggests suspending scales of copper over vinegar in a closed container, plunging copper vessels into earthen pots filled with vinegar for ten days, and various combinations of copper and grape husks.<sup>52</sup> The ancients also used it as a medicine, Pliny gives us a recipe for Hieracium, an eye salve containing ammonia, chalcantum, misy, saffron and verdigris.<sup>53</sup>

The Canadian War Museum, designed by Moriyama & Teshima Architects in joint venture with Rankin Cook Architects, and built in 2005 in Ottawa, Ontario, makes good use of the age and history that verdigris can imply. The themes the building aims to communicate affectively focus on the cycle of regeneration following destruction, to communicate the realities of war while also speaking to a hope for our ability to change and adapt in the face of history’s lessons. The copper cladding of the outside of the building, fresh and red-bright in the sun, is intended to slowly evolve to green as part of that narrative. At the same time, the building looks forward to that day by looking back. The lobby and foyer of the building feature a wall clad in copper, reclaimed during the re-roofing of the Library of Parliament. While the library roof is now penny-brown with a developing skin of tenorite, the lobby wall is a richly variegated green. Contextually this helps to tie the building to the ubiquitous green roofs of Parliament, but it also allows people an uncommonly intimate experience with copper exposed to the elements for 50 years.<sup>54</sup> The wall roots the building in





*Reclaimed copper wall of variegated verdigris abutting the distressed flyash concrete.*

*Foyer & lobby, Canadian War Museum*



history, and demonstrates an understanding of the building's future. The Canadian War Museum and Parliament turn Ottawa into a rich study in copper weathering and interrelated architectural histories. Beyond the material testimony, this particular installation carried more evidence of the touching value of human traces etched into material. In his book detailing the design and construction of the museum, architect Raymond Moriyama provides the following anecdote. "Working to install the recycled copper, this young man discovered his uncle's signature from about five decades ago on the back of one panel .... To continue or perhaps begin a tradition, the young man then signed his own name to the back of a new copper panel with the hope that, in another fifty years, a future relation might discover it in a similar way."<sup>55</sup>

Copper, as we use it, is a product of our alchemy. Beyond seizing something at a point in its natural cycles and freezing it in place, we ply our arts to seduce copper into a form it rarely finds on its own. Not surprisingly, the elements we pry it away from are the quickest to react with it again. We have always borrowed copper from the earth, after ten years on the surface most copper applications will be covered with a full blue-green patina as the element eagerly reacts with its surroundings. Copper's remarkable ability to trace use patterns in streaks of cuprite visible through tenorite gives it the capacity to remind us how we use our buildings. More importantly, it can remind us of others who have used our buildings before us. In *The Eyes of the Skin*, Pallasmaa writes that, "We have a mental need to grasp that we are rooted in the continuity of time, and in the man-made world it is the task of architecture to facilitate this experience. Architecture domesticates limitless space and enables us to inhabit it, but it should likewise domesticate endless time and enable us to inhabit the continuum of time."<sup>56</sup> Intimate knowledge of our materials can allow us to inhabit the continuum of time by connecting the visual changes of the matter before us to knowledge of the processes at work. Further, connecting the processes at work to the processes that first formed the matter we build with. Finally, seeing the bright lines that show where hands held railings before us, where doors were pushed. Mostly, reminding us we are not the first to pause at this window. Watching red-brown becoming light darken to black and flower into blue-green, *solve et coagula*.





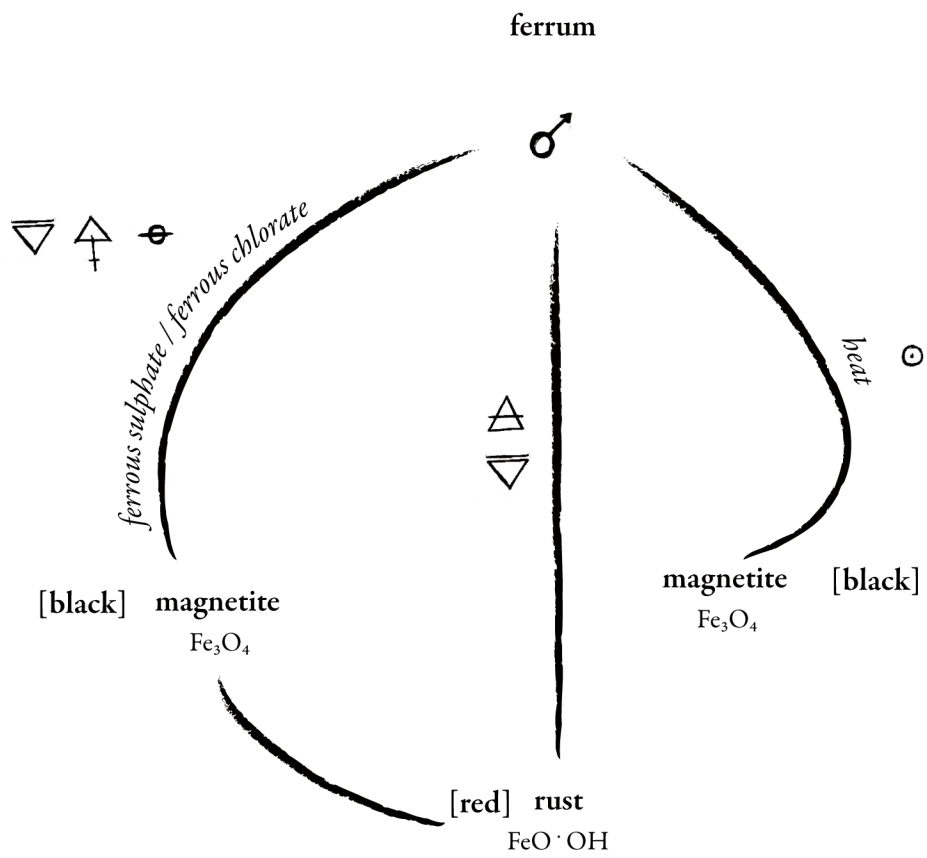


# Iron











The first iron came from the sky; little wonder the metal was thought to be god-sent. That association influenced our relationship with iron throughout the early chapters of its use by man, though we were hard-pressed to decide if it had been given to us as bane or blessing. The ancients were torn as far as their opinions on iron's moral qualities. In opening his description of it in his *Natural Histories*, Pliny says, "Next to copper we must give an account of the metal known as iron, at the same time the most useful and the most fatal instrument in the hand of man."<sup>1</sup> Smith-craft and alchemy were bound hand in hand as we discovered more about the properties and capabilities of iron, a distrust about this fickle and corrodible material evolving into an appreciation for the metal that spawned the industrial age. Iron's tenacious, predictable strength has always contrasted its susceptibility to rust; where malleable copper changes the colour of its skin, firm iron can vanish completely.



During excavations in a pre-dynastic cemetery in El-Gezereh, Egypt, archaeologists discovered a string of beads. Gold and carnelian hung on the string where they had lain since placed, and at a regular rhythm along the stretch of decorative metal and stone, were gaps punctuated by red marks on the stone below. The rusty gaps in this necklace confirmed that iron was known in Egypt c. 4000 BC.<sup>2</sup> One reason the metal was thought valuable enough to string with gold and semi-precious stones could be its provenance. The earliest evidence of iron deposits being exploited in Egypt points to the eighteenth dynasty, earlier instances of the metal's use would have been meteoric in origin.<sup>3</sup> According to *The Forge and The Crucible*, "While the use of meteoric iron lasted, the metal was rare and more precious than gold."<sup>4</sup> Meteorites are composed of matter that passes from the sky to the earth, that they would carry a charge of sympathetic sky-ness with them was a trope that found its expression in many cultural attitudes towards the metal. Eliade describes the Palladium of Troy as a meteorite worshipped as Athena, while in the South American jungle, only the Aztec chiefs carried iron knives. When asked by Cortez where they had obtained them they pointed to the sky.<sup>5</sup> In Mexico, the Descubridora meteorite, weighing 575 kilograms, was found with evidence of pieces painstakingly removed by human hands, including a cold-worked copper chisel wedged in a nine centimetre long gap.<sup>6</sup> The celestial origins of early iron in many cultures imbued the metal with an occult inscrutability that continued to haunt its reputation, even as the discovery of smelting allowed mankind to begin procuring large and steady amounts of iron plied from the earth, telluric iron.<sup>7</sup>

In a way, it was copper that led us to iron. The metallurgical prowess developed through the Bronze age prepared a generation of smiths to take advantage of iron anywhere its ores were found near the surface.<sup>8</sup> Iron was known in Homeric times, but military weapons were still commonly made of bronze. One reason for this could be that early iron was not the predictable product we know today, and militaries are traditionally conservative.<sup>9</sup> Early iron was not melted and purified, but was created as a spongy, slag-ridden and low-carbon mass that was then hammered into shape.



Iron that is made up of less than one tenth of a percent carbon is relatively soft.<sup>10</sup> The rough iron swords of Celtic warriors were expected to deliver one good blow before the blade needed to be straightened against the ground with a stamping foot.<sup>11</sup> Iron was trusted for tools before it became the standard material for weapons. As its strength became appreciated and methods of working it developed, iron slowly took the place of copper and bronze wherever iron's tenacity would benefit. Tools dating to 2900 BC and made of telluric iron were discovered wedged between the blocks of the great pyramids.<sup>12</sup> Iron is known to have been worked in India by 2000 BC, while in China evidence exists that it had become an accepted material for tools by 500 BC. The first evidence of industrial scale metallurgy in iron leads to the mountains of Armenia between 1200 and 1000 BC.<sup>13</sup> Once iron smelting had been discovered, iron was discovered to be a relatively plentiful resource, leading Pliny to comment that, "Of all metals, ores of iron are found in the greatest abundance."<sup>14</sup>

An excellent description of the smith's art comes to us in the form of Walenty Rożdżeński's *Officina Ferraria*. Written in the form of a poem, the work combines thoughts on the mythological genesis of iron-working, with descriptions of the physical processes of smelting and instructions on how best to staff an ironmongers in seventeenth century Poland. Written between 1599 and 1607, and printed in 1612 in Krakow, the book purports to detail, "Who first began to dig out the seeds of copper from the bowels of the earth, and when; and who, having constructed furnaces, smelted iron in strange ways with constantly raging fire; and how this craft, perfected by industry and art, may be of use to man..."<sup>15</sup> The celestial charge inherent to iron continues to inflect this work, and while the author's speculation on iron's origins runs to the mythological, his convictions ultimately place them squarely in Christian providence, "Iron is the foremost among all those metals which God Almighty created immediately in the first age of the world and provided for the use of man."<sup>16</sup> The *Officina Ferraria* describes by colour and texture the different ores that can be used to smelt iron, but cautions the first time prospector, "Iron ore is found in the bowels of the earth in various forms, but it is very difficult to recognize it. Nor will you make it out once when smelting it in a fire, but only when you have assayed it many





*Iron cobbler's tool showing scaling instead of rusting*



times.”<sup>17</sup> Through examination of this text, the smelting process in use in the historical region Silesia, now part of Poland, comes into focus. Their metallurgic alchemy used a bloomery furnace in a round pit. The furnace would be charged with alternating layers of charcoal and ore. The ore would sometimes be roasted in the open air in a preliminary calcination. Blowing air through the tuyeres with the aid of a bellows, the fire would be kept hot enough to encourage reactions between the carbon of the charcoal and the oxygen of the iron oxides that made up most ores. After several hours, the bottom of the furnace would be filled with an irregular spongy lump of reduced metal, mixed with slag. This was called a bloom. The bloom would be removed, and excess cinder knocked off the side with a hammer. The bloom would then be heated and cut into pieces to knock the slag off, when the remaining metal would be forged into bars.<sup>18</sup> The text also describes variations on the process used in nearby Bohemia, remarking that this decidedly inferior process takes up to three days to produce a bloom:

In our country the ore is smelted in low, round furnaces  
which produce iron rapidly, while there the  
furnaces are great and spacious, high like chimneys,  
and built square.

It is therefore hard to introduce a tuyere with a large  
hole through which the bellows can blow from above  
into the hearth. This causes much charcoal and iron  
to burn, so that it flows like mush through the slag notch.

Next there is one workman who is constantly busy  
breaking the slag in a stamp mill, and hence performs needless toil,  
picking the burned iron out of the slag  
which is again thrown into the furnace after being mixed with new ore.<sup>19</sup>

Ideally, these blooms of iron were of the remaining metal after impurities had reacted with oxygen and carbon, leaving iron behind. While it was raised to red-hot





A—FURNACES. B—FOREHEARTHS.

*Iron Bloomery : a woodcut from De Re Metallica*





A—HEARTH. B—HEAP. C—SLAG-VENT. D—IRON MASS. E—WOODEN MALLETS.  
F—HAMMER. G—ANVIL.

*Iron Bloomery: a woodcut from De Re Metallica*



*Dashuhua: peasant fireworks tradition from feudal Japan, where the performer hurls molten iron against a wall.*



temperatures, the iron did not typically undergo a phase shift to liquid, when it did it often got wasted as slag. The discovery of cast iron is thought to have resulted from overenthusiastic increases to the heat involved in the process of smelting in search of faster bloomeries. Bloomeries worked by directly reducing the ore to iron, and are thought to have evolved from those used to extract tin. As smith-craft advanced, larger more efficient furnace designs like the Swedish or Osmond furnace were developed. Ore smelted with charcoal in taller furnaces resulted in the metal reaching higher temperatures. When this resulted in phase change to a liquid, like in the Bohemian furnaces described above, iron flowed "...like mush through the slag notch."<sup>20</sup> It seems as though the Romans had also accidentally discovered cast iron, in Pliny's *Natural History* he notes that, "It is a remarkable fact, that when the ore is fused, the metal becomes liquefied like water, and afterwards acquires a spongy brittle texture."<sup>21</sup> Cast iron was known by the metallurgists of Sussex in 1350, and common by 1400, though the material's tendency for brittleness limited its applications. In 1740, the process of making cast steel was perfected by Huntsman, and in 1784 Henry Cort introduced the puddling process, a way to reduce the carbon content of the metal in a controlled way by stirring the liquid metal in an oxidizing environment. Later developments found that adding iron scale, chemically similar to rust, hastened the process, providing oxygen to react with the carbon and leaving iron behind. Cast iron was now also useful as the base material for the manufacturing of steel.<sup>22</sup>

Contemporary iron is found in a variety of material forms, each with ideal applications. Most commonly used in structural applications are the varieties of steel. Steels are metal alloys based on iron and carbon, with a carbon content below two percent. Increases to the carbon content increase hardness and mechanical strength, preventing the unreliable behaviour of a Celtic sword, but weakens the structure of the material, rendering it brittle.<sup>23</sup> At carbon contents above two percent, the material becomes cast iron. Cast iron can have a carbon content up to six percent. White cast iron is a hard fragile metal used for test pieces and artistic foundry, while grey cast iron is more common, easy to machine, and resistant to corrosion due to scaling.<sup>24</sup>



Iron's mythological backgrounds are a complicated mix of traditions, the *Officina Ferraria* puts forward some of the stories of its time, as well as indicating which one the author ascribed to. Diodorus claimed that a people called the *Idae Dactyli* first discovered the art of submitting metal to fire in Phrygia, while Pliny wrote that the Cyclopes first forged iron and taught the art to man. The past most reasonable according to the *Officina Ferraria* was that a descendant of Noah, Tubal, discovered and restored the forges of Tubal-Cain, the man who had discovered ore mines before the Flood. Greco-Roman mythology held that Vulcan taught men smith-craft, and was the patron of smiths in the pantheon, "He whom Saturnian Juno bore, pregnant with the seed of mighty Jupiter, and who revealed the use of iron to mortals: Mulciber the deformed one, who was hurled down from high heaven and taken in by Lemnos as he fell and shattered his knee."<sup>25</sup> And while Vulcan was the patron of those who forged the metal, the metal itself was alchemically linked to Mars, god of war, from Olympiodorus' association of metals with heavenly bodies in the sixth century AD.<sup>26</sup> Its association with the male archetype in astrology and alchemy finds its odd echo in the bio-chemical iron imbalance between men and women, with men typically having more iron in their blood serum.<sup>27</sup> The Greco-Roman classification of iron as the male opposite to the copper female was not universal. Among the African Kitara, specific types of iron ore were sexualized. Hard, black ores found on the surface were thought of as male while the soft, red, mined ores were female. Both ores were necessary to produce the varying degrees of hardness and flexibility that made a perfect union expressed as a strong supple blade.<sup>28</sup> Besides the casting of iron as male, female or both, iron's moral value was often called into question. In ancient Siberian tradition, the smith was said to learn iron-craft at the feet of K'Daai Maqsın, the master-smith of hell, in his house of iron surrounded by splinters of fire.<sup>29</sup> Herodotus wrote that, "Iron had been discovered to the hurt of man"<sup>30</sup>, while the *Qur'an* quotes Mahomet as saying that "We have sent down iron. Dire evil resideth in it, as well as advantage to mankind."<sup>31</sup>



Ovid, in his introduction to the *Metamorphoses*, is less optimistic about iron's advantages; his Iron Age described the arrival of mankind's penchant for self-destruction in book one, lines 127 - 145:

The Iron Age succeeded, whose base vein  
Let loose all evil: modesty and truth  
And righteousness fled earth, and in their place  
Came trickery and slyness, plotting, swindling,  
Violence and the damned desire of having.  
Men spread their sails to winds unknown to sailors,  
The pines came down their mountain-sides, to revel  
And leap in the deep waters, and the ground,  
Free, once, to everyone, like air and sunshine,  
Was stepped off by surveyors. The rich earth,  
Good giver of all the bounty of the harvest,  
Was asked for more; they dug into her vitals,  
Pried out the wealth a kinder lord had hidden  
In Stygian shadow, all that precious metal,  
The root of evil. They found the guilt of iron,  
And gold, more guilty still. And War came forth  
That uses both to fight with bloody hands  
Brandished the clashing weapons...<sup>32</sup>

Some iron was worse than others, legends surrounding 'live iron', iron that had developed magnetic properties as the result of coming in contact with lodestone, was reported by Pliny to cause more damaging wounds.<sup>33</sup> Terrible as iron may be, Pliny also saw in it a case of enantiodromia,\* saying that "Nature, in conformity with her usual benevolence, has limited the power of iron, by inflicting on it the punishment of rust; and has thus displayed her usual foresight in rendering nothing in existence more perishable, than the substance which brings the greatest dangers upon perishable mortality."<sup>34</sup>

\* Enantiodromia:  
The tendency of a thing to  
become its opposite.







*"Shipbreaking # 4", Chittagong, Bangladesh, 2000, Edward Burtynsky*



Iron's affinity for corrosion has always been a limiting factor in its use. The causes of corrosion and its prevention have been a topic of scrutiny throughout our relationship with iron. Pliny maintained that rust had a moral purpose, and that, "Human blood revenges itself upon iron; for if the metal has been touched once by this blood it is more apt to become rusty."<sup>35</sup> Iron that would resist rust was often the stuff of legends. In the *Laxdale Saga*, a thirteenth century Icelandic poem, Kjartan - a favourite warrior of the king - was killed by a legendary blade named Leg-biter. The providence of Leg-biter stretching back to its making is well recorded in the tales of generations of bearers of the blade. The reason for all the attention is made clear in the blade's description, "a great weapon and good; the brand was sharp, and no rust would stay thereon."<sup>36</sup> Further south, Alexander the Great was said to have constructed a bridge over the Euphrates whose original links would never rust, even as new links added fell out of place, outmatched by corrosion. One possible fount of such myths could be the period where meteoric and telluric artifacts were both in use. According to J.Friend, author of *Iron in Antiquity*, "In consequence of its nickel content, celestial iron has a much longer life than telluric iron..."<sup>37</sup> The comparison of the comparatively rare artifacts of meteoric iron and their telluric counterparts could well give credence to the myths of magically superior weaponry or tools from the sky. Iron's enantiodromia continued in the medical eyes of the Romans, as Pliny records a cornucopia of healing remedies derived from the rust of corroded iron. Rust was said to have the ability to heal wounds, pustules and itches anywhere, as well as granulations of the eyelid. Applied with lint it was said to heal hangnails, while applied as a pessary with wool it was a fix for all manner of female discharges.<sup>38</sup> Scales of iron, a different form of oxidized iron, were said to be especially helpful in stopping the bleeding of a wound that iron had caused. Iron scale was also supposed to be able to grow new flesh on 'denuded' bones, as well as cleanse all manner of wounds and sores.<sup>39</sup> Corrosion even had its place in Art, the bronze statue of Athamas Repentant was said by Pliny to have had iron blended into the metallic cheeks of the embarrassingly filicidal father, that the metal's rusting could bring ashamed colour to the cuprous face.<sup>40</sup>







*Iron Ore Mine at Tom Price, Western Australia*





*Zumthor: Therme Baths, 2009, Jonny Sage*



The oxidization of iron occurs in two ways, scaling or rusting. Scaling is the formation of an anhydrous oxide, and happens in the absence of water while the metal is exposed to oxygen under heat. With heat loosening the molecular bonds between iron molecules, available oxygen can bond to sets of three iron molecules to form a firmly bonded layer of black magnetite. As the thickness of the oxide scale increases, the rate of reaction falls off due to a lack of available iron. Rusting is a different story, in the presence of water, the hydrated oxide known as rust forms, and the rate of the reaction remains constant, with no protective layer of oxide forming over the exposed iron.<sup>41</sup> The key difference between the two types of oxidization, lies in the presence of water. Ulick Evans, in his book *The Rusting of Iron: Causes and Control* writes that, "At one time atmospheric rusting was regarded as a form of dry corrosion - comparable to direct oxidation. It is now believed to be more akin to drop corrosion...rusting only takes place at an appreciable rate under conditions of humidity consistent with the presence of a liquid phase, even though the trace of liquid causing the damage cannot generally be seen."<sup>42</sup> In scaling, the oxide is formed tightly bonded to the surface it evolved from, immediately shielding the raw metal underneath. In rusting however, the part of the iron that has oxidized passes into solution in the film of water covering it. Rust continues to evolve into solution from the iron surface, until the film reaches its saturation point. At this point solid rust begins to precipitate out of solution, and the red iron oxide deposits on the surface of the original iron. With no molecular or mechanical bond holding it in place, this oxide is easily washed or blown away, freeing new iron to take part in the oxidization reaction with the oxygen dissolved in the water.<sup>43</sup> Rust that does form while still in contact with the original body of metal occupies a greater volume than the iron that went into its creation. This gain in volume allows rust formations to push other particles of rust off the surface of the metal, resulting in additional loss of material.<sup>44</sup>

The presence of salt or sulphur both speed the formation of rust. They dissolve in water and bond with the iron to form ferrous sulphate or ferrous chloride. Rust near the sea is likely to contain molecules of ferrous chloride, while rust



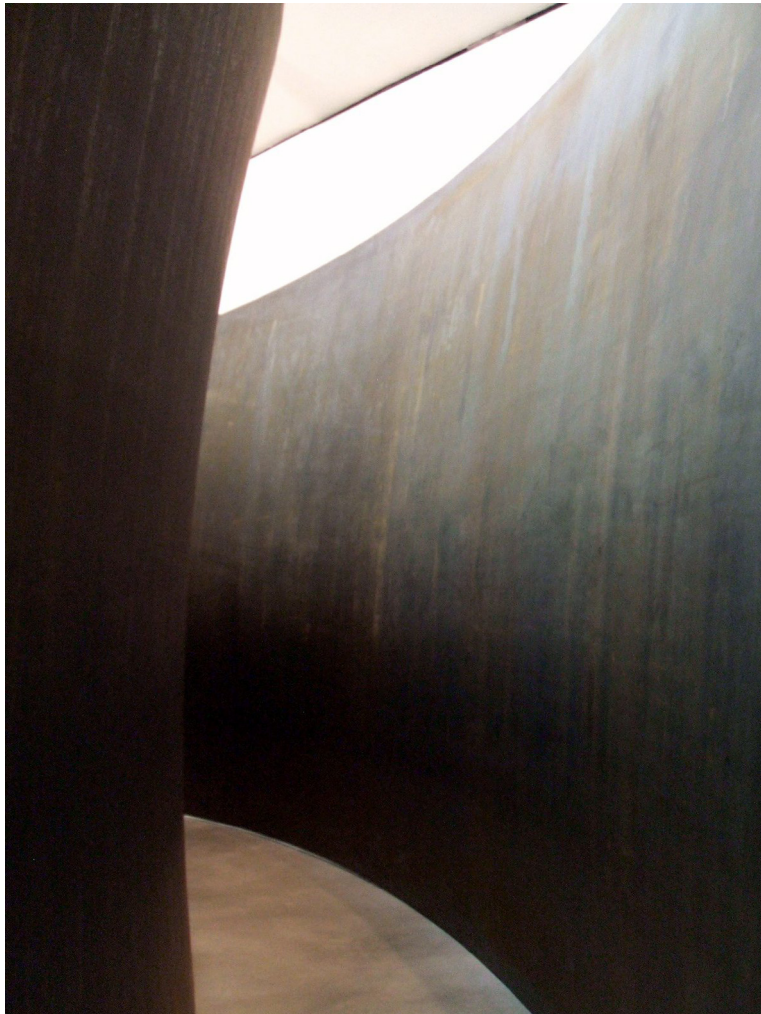


produced in an urban atmosphere is likely to contain ferrous sulphate. Either molecule acts as a catalyst in an electrochemical cycle that first causes the formation of magnetite in solution, which then evolves into rust when it contacts oxygen in solution.<sup>45</sup> The same substances iron is freed from in the smelting process are the chemicals that come to claim it again. Preventing the corrosion of iron requires more than a mechanical barrier against oxygen, and is most often accomplished with a coating of a non-ferrous metal.

Galvanizing, coating the metal with a sacrificial layer of zinc, will protect the iron underneath as long as the layer of protective metal lasts. Paint used to inhibit corrosion will often contain chemicals that encourage the evolution of a layer of iron compounds tightly bound to the metal beneath, forming a protective film beneath the mechanical protection of the paint. Weathering steels are a group of iron alloys that encourages the rapid evolution of a layer of rust under temperature fluctuations, without giving it the opportunity to dissolve in water, creating a tightly bound layer of protective iron oxide. This layer is similar to the patina on copper, which retards further corrosion of the material, and reforms in the event of its removal. The sculpture of Richard Serra makes good use of these properties in his work. In the essay “Practices of Eco-sensation: Opening Doors of Perception to the Nonhuman,” Anatoli Ignatov describes Serra’s work as sculpture that, “registers the affectivity and vitality of materiality.”<sup>46</sup> Part of his success stems from being able to forego painting his elemental sculptures in favour of allowing their finishes to develop in situ. Steel grey marred by stresses and joints moves through a seven year essay in orange and browns, before a decade passes leaving a uniform dark brown layer.<sup>47</sup>

We build with iron when we require strength. Iron forms structure, weapons and tools. Whether from the sky or deep within the earth, we find iron and draw it around us. Yet iron is a contradiction, of all our materials it is one of the most mortal. Maybe we can start to build with iron when we require perspective. In a human lifetime, unprotected iron can be drawn from the earth and returned to dust. In materials like weathering steel, iron’s active participation in the temporal can be illustrated plainly,





*Richard Serra: A Matter of Time, showing the continuing evolution of grey to brown.*





but where weathering steel attempts to persist, iron is at its most poetic when it is allowed to disintegrate. The characteristic red-orange of rust left where iron once was can be a beautiful and poignant reminder of the sweeping rush of time. Imagine specific iron elements, designed for their ability not to persist, but to vanish. Leaving only outlines in the stone below can create active, identifiable instances of change that we can use to register our own time. In *The Eyes of the Skin*, Pallasmaa writes that:

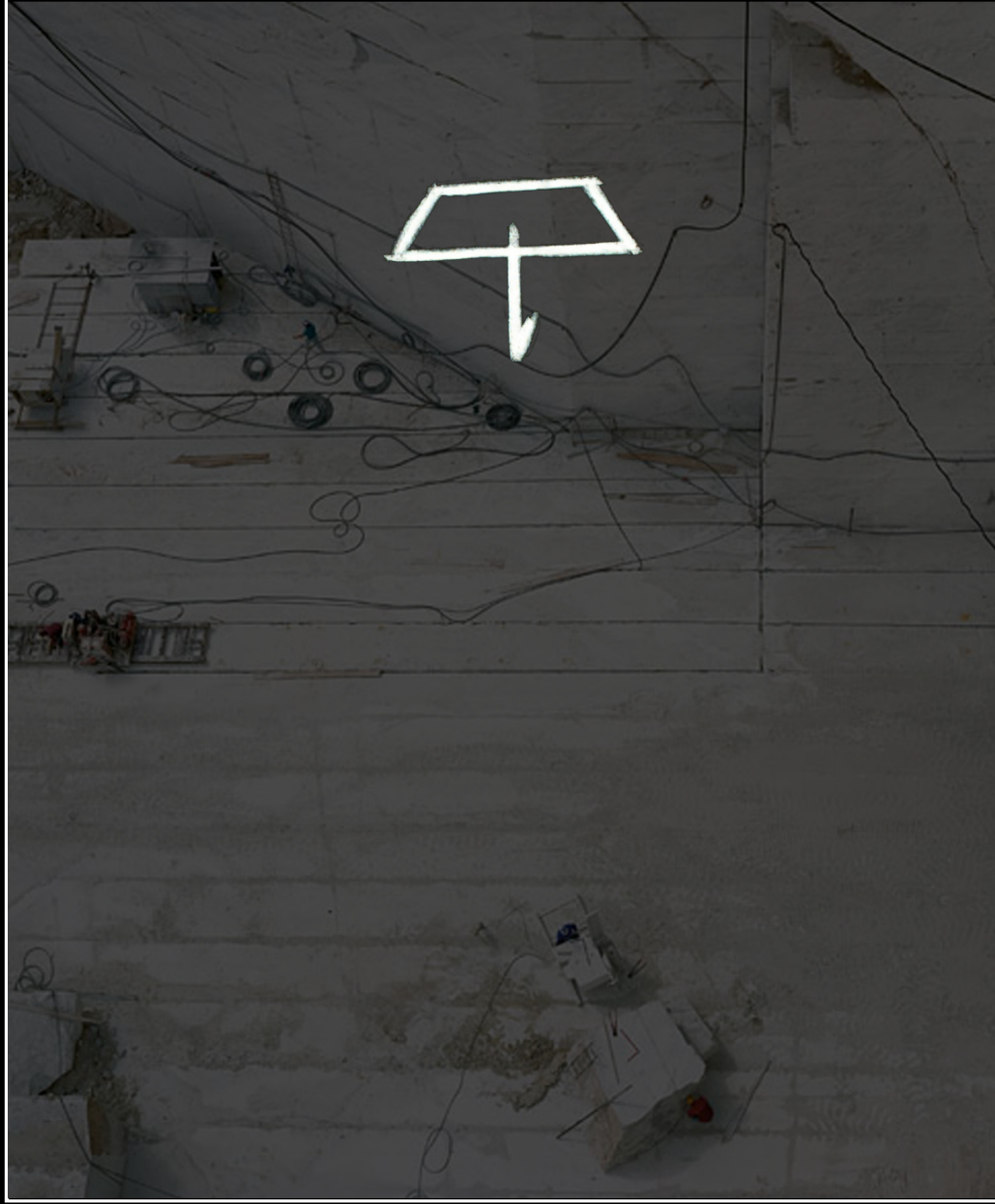
...the machine-made materials of today - scaleless sheets of glass, enamelled metals and synthetic plastics - tend to present their unyielding surfaces to the eye without conveying their material essence or age. Buildings of this technological age usually deliberately aim at ageless perfection, and they do not incorporate the dimension of time, or the unavoidable and mentally significant processes of aging. This fear of the traces of wear and age is related to our fear of death.<sup>48</sup>

While with effort and skill, our alchemy can almost - usually - freeze iron in our grasp, it is not a perfect binding. Rather than scrape and paint and pretend that nothing changes, what if we allowed some things to change. One alchemy to draw the iron from the earth, another to let it teach a sense of time passing gracefully. *Solve et coagula*.

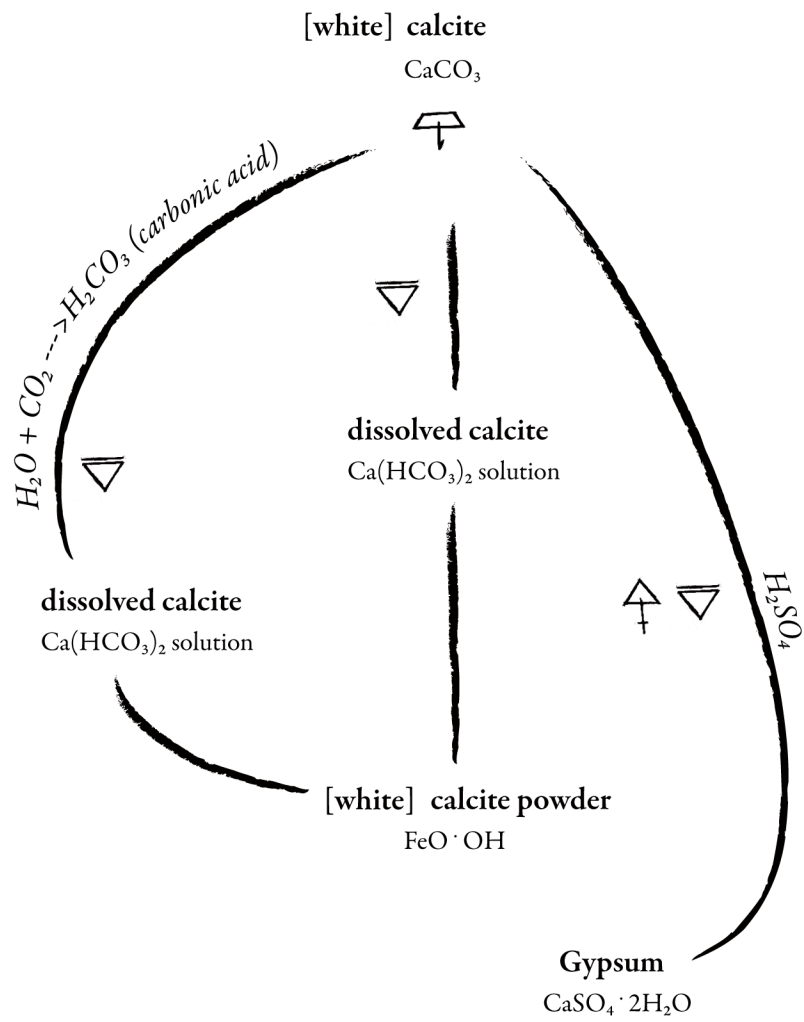




# Marble











Stone seems so permanent. Forming the lithospheric crust of the earth we walk on, it's difficult to think of stone in terms other than infinite. In their book *Materiology*, authors Daniel Kula and Elodie Ternaux describe stone as, "A material of memory - from a time of cathedrals and crazed constructions, heading for the skies - stone is the loyal side-kick of architectural megalomaniacs; it lasts and promises posterity."<sup>1</sup> Cultures the world over mythologized our own creation as a springing forth from the stony mass of the Earth. However, while it may move to a rhythm measured in human lifetimes, stone is anything but permanent. Its petrological cycles constantly transform disparate types of stone into each other and back again, *solve et coagula*. Our love affair with specific stones like marble has spanned the development of civilization, as we learn to seduce it from the ground more efficiently, shape it, and attempt to hold it. Far from the inert medium we often take it for, stone is alive with movement, tension, and eagerness to rejoin the cycles that created it. When we interrupt that cycle and attempt to freeze stone in time, we're often surprised that our alchemy is not perfect.



Understanding the millennia compressed into a block of marble, the human effort in freeing it from the earth, and its subsequent search for equilibrium, gives marble an inherent ability to fascinate that transcends its contemporary bourgeois associations.

Mankind's birth from earth and stone is the basis of myths from around the world. Incan, Mayan, Semitic, and cultures from Asia Minor to Oceania presage or share the theme of the Old Testament Adam's transmutation from clay. All look to stone to form the primary substance of which man is made. Greek mythology had its own account of the petrological origins of man immortalized in book eight of Ovid's *Metamorphoses*, lines 402 - 417 .

The stones — who would believe it, had we not  
The unimpeachable witness of Tradition? —  
Began to lose their hardness, to soften, slowly,  
To take on form, to grow in size, a little,  
Become less rough, to look like human beings,  
Or anyway as much like human beings  
As statues do, when the sculptor is only starting,  
Images half blocked out. The earthy portion,  
Damp with some moisture, turned to flesh, the solid  
Was bone, the veins were as they always had been.  
The stones the man had thrown turned into men,  
The stones the woman threw turned into women,  
Such being the will of God. Hence we derive  
The hardness that we have, and our endurance  
Gives proof of what we have come from.<sup>2</sup>

Having derived us from stone, myth also holds many instances of our sudden return to a mineralogical state. Lot's wife becomes a pillar of salt for her disobedience, while the Greek gods were famous for enacting lithomorphic punishments in response to hubris. The benefit of Medusa's transfigurative gaze and Niobe's marble prison is that the evidence of divine wrath would be around long enough for everyone to learn a

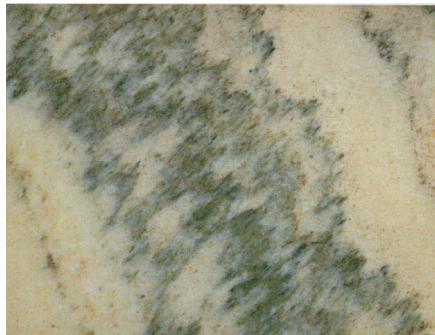
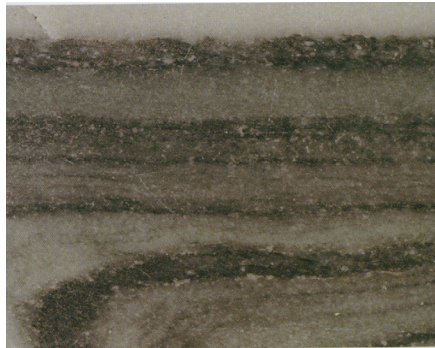


lesson. While everything we see changes around us, stone at least seems to offer some evidence of permanence, endurance; qualities we can desperately wish were more in abundance in a world of confusion and constant physical transmutation. Perhaps for this reason, in *The Forge and the Crucible*, Eliade states that, “Stone is an archetypal image expressing absolute reality ....”<sup>3</sup> However, while stone’s cycles are often beyond our temporal perspective, lending it the air of permanence, it’s anything but immutable.

The petrological cycle describes the series of states of transformation of stone, beginning from and returning to magma. The earth’s core is composed of magma, which becomes igneous rock when it cools, losing enough energy to undergo a phase change from liquid to solid. The type of igneous rock that it becomes depends on the conditions under which it makes that change. Magma leaves the earth’s core under volcanic action or through plate tectonics. Rock that cools slowly, while under great pressure and depth forms plutonic, intrusive rock like granites. Volcanic action leading to fast cooling on the earth’s surface under no tectonic pressure creates extrusive rock like basalt or tufa. Stones created by intermediate conditions, like porphyry, are referred to as dyke rock.

Exposed to the lack of pressure and erosion mechanisms of the surface, igneous stone is broken down into particles that collect in deposits of sediments like sand and mud, combining with organic waste. These sediments eventually become rock through a process called diagenesis. Sand and clay create clastic rocks like sandstone. Decomposed organisms form biochemical sedimentary rock like chalk or limestone, while salt precipitates form chemical precipitate sedimentary rock, like rock-salt.<sup>4</sup> This process of sedimentation is a key step in the formation of marble. As F. Wolfgang Tegethoff, author of *Calcium Carbonate: from the Cretaceous Period to the 21st century* writes, “sedimentation is the rock forming process from which all limestones originate ... marble, too, is ultimately only a sedimentary limestone which has undergone metamorphism through the influence of pressure and temperature.”<sup>5</sup> Limestone is primarily composed of calcium carbonate, also known as calcite. Calcite collects as sedimentation in three ways: chemical precipitation, biochemical processes





*From top to bottom, Parian, Carrara, Cipollino Verde and Cipollino Apuano*



and organogenic sedimentation. In chemical precipitation, calcite must be dissolved in water to a degree that chemical saturation is achieved, causing calcite to precipitate out of solution under changes in pressure or temperature. Stones like travertine form in this manner at the mouth of mineral-laden underground springs. This mechanism also introduces precipitated calcite into small cracks in other stones. Biochemical processes occur in algae that precipitate calcite, petrifying the algae bed into a stratified limestone, while organogenic sedimentation consists of the eroded inorganic invertebrate remains that collect on the seabed.<sup>6</sup>

All of these sediments are porous when they first collect, up to 90% water.<sup>7</sup> The porosity of a rock is generally less than a few percent. Diagenesis is a combination of compression and cementing that changes loose calcite sediment into solid limestone. As layers of sediment gather over one another, they eventually exert enough pressure on the layers below to begin compacting loose particles into stone. Water being forced out of the space between the particles is subject to increasing amounts of pressure, with the result that water being squeezed from the pores of the developing limestone begins to precipitate dissolved calcite into the passages it is escaping, closing them up and further decreasing the stone's porosity.<sup>8</sup>

When igneous or sedimentary rocks are buried through sedimentary accumulation or plate tectonics, they evolve again. Without entering a liquid phase, particles in the stone subject to compression and heat will adjust themselves to a more regularized, compact organization in a process called recrystallization. While the new minerals are chemically similar to the original material, they can have wildly different physical and mechanical properties, and are more stable under the increased heat and pressure.<sup>9</sup> Recrystallization occurs at pressures over 100 Bar, at temperatures between 200 - 500 degrees Celsius.<sup>10</sup> Clay will become schists, while sandstone will form quartzites.<sup>11</sup> When recrystallization occurs in limestones, it is called marmorisation, the specific reorganization of calcite into crystalline marble.<sup>12</sup> Since sediment beds are rarely pure calcite, a variety of mineral impurities can be formed into the parent limestones destined to become marbles. Under the action of marmorisation, a limestone of 98% calcite will form a pure white marble. Marble, a stone valued





*The worn steps of the Leaning Tower of Pisa*







*Carrara, Italy, 1993, carrara marble quarries # 24, Edward Burtynsky*



by sculptors for the vitality its crystalline translucence can bring to a sculpture is inexorably tied to life, as Tegethoff clearly states, “These rocks combine the carbon dioxide of the atmosphere and the calcium of the earth’s mantle rock ... to create a connection between a volatile gas and an inert rock, the support of living organisms was required, and therefore the formation of limestones on this planet has always been closely linked with biological activity.”<sup>13</sup> Any mineral impurities will be visible as other colours in the stone, iron oxides will create pink or cream coloured marbles while copper salts can introduce green or blue veins.<sup>14</sup> While the stone never enters a liquid phase in the course of this transformation, the heat and pressure can become sufficient to allow individual molecules to migrate between strata, gathering into bands that form veins of colour in the uniform crystal lattice.<sup>15</sup> The amount of heat and pressure in the environment of marmorisation has an effect on the nature of the marble that the limestone will become. Under conditions of very low metamorphism, at temperatures below 250 degrees Celsius, the calcite crystals produced will be measured in hundredths or tenths of millimetres; no new minerals will have formed as a result of reactions amongst the impurities. Strong metamorphism, above 500 degrees Celsius produces calcite crystals several centimetres long, producing a coarsely crystalline rock that is impossible to buff to a high polish. The marble we treasure is the result of a careful balancing act, low to medium metamorphism. Between 200 and 500 degrees Celsius at depths reaching five to fifteen kilometres below the Earth’s surface, impurities undergo reactions to produce stable new minerals, banding within a marked crystal structure that readily takes a polish.<sup>16</sup> Once formed, plate tectonics can shift metamorphic stone back to the upper lithosphere, where it can be pried from the earth and held by man under the sun - and begin natural erosion cycles once again. If a stone is heated past the plastic phase of strong metamorphism, it can melt and become magma, emerging eventually as new igneous stone.

Stones are distinguished by several characteristics that determine their behaviour and appearance. Structurally, a stone can be flaky, compact, granular, crystalline, granitoid, schistoid or sandy. Marble’s crystalline structure is what gives it a characteristic translucence and ability to take a polish. A stone’s porosity, from



impermeable to porous, can affect its behaviour in wetting-cycle environments, especially in cold environments, where it affects frost susceptibility. Clays are impermeable, while sandstones are porous. Marble falls somewhere in between.<sup>17</sup> In terms of hardness, stones can be measured according to the Mohs scale. This is an arbitrary scale of hardness based on common minerals, and can be tested in the field using a scratch test. Marble has a hardness of 3M, which can be tested in the field by scratching it with a piece of copper. Granite, at 8M, would ruin the copper implement.<sup>18</sup> In the building industry, the term marble is not reserved for metamorphic calcite, but instead follows a practice initiated by the Romans at the height of the marble industry, *The Sourcebook of Decorative Stone* clarifies, “Scientific names are the formal terms used by the international scientific community for minerals (quartz, turquoise, charoite, malachite, pectolite) and rocks (marble, gneiss, serpentinite). These terms do not indicate any place of origin, but they are fundamentally important for the petrographical descriptions used by geologists ... it should be remembered that when the stone trade uses the terms ‘marble,’ ‘limestone’ and ‘granite’ it uses the criteria of hardness and ability to take a polish ....”<sup>19</sup> Small wonder that some of our marbles sport a porosity and inclination to solvency better expected of a sedimentary rock.

Once the stone has been formed, and plate tectonics or erosion have brought it within reach, there is still the problematic issue of excising it from the earth’s crust. It is, after all, stone, and made of stern stuff. Marble was being quarried by the sixth century BC in Paros, the oldest Greek marble quarries.<sup>20</sup> The Greek name for marble was *marmareos*, a word that meant shimmering or shining.<sup>21</sup> But Pliny tells us in his *Natural History* that the marble from Paros was called *Lychmites*, lamplike, because of the lamp-lit mines from which it was quarried.<sup>22</sup> The earlier copper or iron saws used for sedimentary stones were insufficient for cutting the harder marble, prompting a leap forward in quarrying technology. Saws were made with no teeth, and sand that was harder than the marble was laid on the cut. Rubbing the harder grit across the surface of the softer stone cut without requiring constant reshaping of the tools.<sup>23</sup>





*Tomb of the Unknown Soldier, Arlington, Virginia*



Exactly how they decided to start digging for marble is a matter of some dispute. Vitruvius, in his *Ten Books On Architecture* maintains it was an accident. “When the inhabitants of Ephesos decided to build a shrine dedicated to Diana with marble from Paros, Proconneseus, Heraclea and Thasos, sheep had been put out to graze here by Pixodaros. Two fighting rams charged but missed each other with the result that one of them hit the rock with his horns with such force that it knocked off a fragment of dazzling white colour.”<sup>24</sup> While this serendipitous event isn’t impossible, it’s more likely that knowledge was passed down generationally between stone-masons regarding terrain features and rock veins that indicate the presence of desirable material.<sup>25</sup> Pliny named the inhabitants of Chios as the first builders in marble, digging it haphazardly from the hills they lived in to build their wall. He then claims it was adopted for use in temples because it was the hardest material they could process.

Classical use and later Neoclassical movements that started in the eighteenth century and carried on to reach their height in the 19th, maintained marble’s desirable status. The aspirations of Neoclassical authenticity carried right down to the Roman desire for specific and hard to find stone. These aspirations are expressed clearly in an anecdote from *The Handbook of Decorative Stone*. “When the new opera house in Paris was being built in the 1860’s, the architect Charles Garnier was obliged to compromise and use the modern Italian Cipollino Apuano instead of the famous Cipollino Verde of antiquity. This ... prompted sculptor and marble merchant William Brindley of the London firm Farmer & Brindley to seek out the ancient quarries and re-open them.”<sup>26</sup> Marble travelled to the new world as part of the neo-classical movement, the accepted material of authority and respectability - or bourgeois exuberance.

While stone is often thought of as a material of permanence, the petrological cycles that formed it do not halt simply because we’ve chosen to build with it. *Solve et coagula*, stone’s behaviour in buildings is the result of a dynamic play of systems seeking equilibrium. Stone looks static, eternal. But while it operates on an arc of time beyond us, stone is a dynamic expression of geological operas that have played out since the earth’s crust cooled. Limestone, under crushing pressure or intense heat,



undergoes a metamorphosis, its structure is energized into relative freedom while simultaneously being compressed and packed together, lining up into a crystalline solid that gives marble its particular sculptural qualities. This process traps intense forces into mountains of solid stone, held in stasis by the cold rock around it. Remove large pieces of marble from its anchoring context and you give these forces room to breathe, and a solid-seeming block of pure white Yule Marble can suddenly shudder with the release of millennia old burdens and fracture at its heart, like the Tomb of the Unknown Soldier. In E.M. Winkler's *Stone in Architecture*, he describes marble's animate nature, saying that, "The removal of confining stress during quarry operations gradually leads to expansion toward the original prestressed condition, like relaxing a squeezed spring."<sup>27</sup> Cracking occurs where mineral coherence is weakest, following crystalline fault planes. The time it takes to express these trapped stresses is variable, sometimes occurring at the quarry site itself. "An open pit quarry defies man's interference, often with violent reactions. It tends to re-establish equilibrium by the redistribution and reorganization of stresses. The response may take hundreds of years - or only minutes. For example, vertical cut by saw or by torch may close while cutting is still in progress."<sup>28</sup>

Some of the processes that make maintaining a level of polish difficult are also involved in stone's capacity to change - rendering stone a plastic material with indexical properties reacting to time, use and the environment. Thermal cycles are one of the primary facilitators of degradation in stone facades.<sup>29</sup> Marble is affected by thermal cycles in two ways: calcite's thermal behaviour and freeze-thaw damage. The individual crystals bound into marble's calcite crystal lattice are anisotropic. This means that, like wood fibres, changes in environmental conditions do not cause them to change size proportionally. Calcite crystals have three crystallographic axes, increases in temperature cause them to expand along two of the axes, and contract along the third, changing not only the crystal's size - but its shape. As each crystal alters its form during thermal cycles, cracks open up along the grain boundaries, increasing the porosity of the stone. Marble's structure, tightly packed owing to recrystallization, lends it a low porosity that increases its resistance to chemical attacks

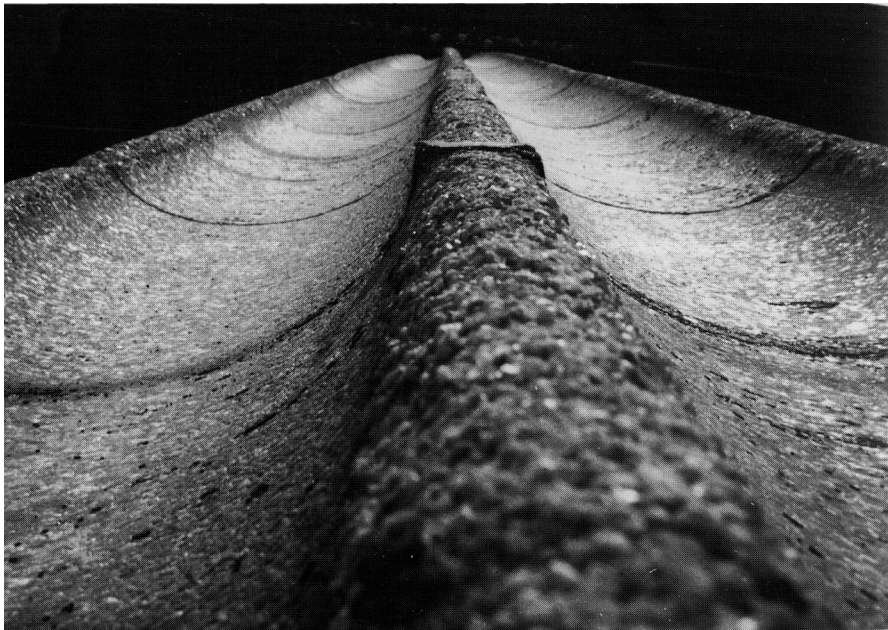




like acid rain. Increased porosity through thermal expansion increases the surface area available to attack by pollutants.<sup>30</sup> Increased porosity also allows greater moisture penetration - water can begin to saturate the stone's pores, damaging it through hydraulic pressure when low temperatures cause the nine percent increase in volume that water experiences upon freezing. Generally, freezing will only result in damage to the stone if saturation is above ninety-one percent, when neighbouring empty pores cannot accommodate the increased volume.<sup>31</sup> In that case, ice forming within the stone can cause a network of microcracking that can lead to disintegration.<sup>32</sup> Conversely, water that becomes trapped inside marble capillaries and is heated from ten to fifty degrees Celsius is capable of generating 200 atmospheres of tensile force against the crystalline walls.<sup>33</sup> Salt can play a role in marble's return to sediment as well. As moisture invades and evaporates from stone's pores, salt can precipitate out of solution within the marble. As salt re-crystallizes, crystallization pressure can exert force against the capillary walls, similar to the pressure of ice crystal formation.<sup>34</sup> Porosity aside, diurnal thermal cycles acting on stone can dilate marble within a few years of exposure, decreasing the material's mechanical coherence, and leading to crumbling.<sup>35</sup>

Beyond the mechanical processes related to heat and trapped stress, marble is chemically vulnerable in our surface atmosphere. Winkler writes that, "The process of weathering is an adjustment of the minerals and rocks to conditions prevailing at the earth's surface, the present site of building or monument."<sup>36</sup> The elements of our surface atmosphere that affect marble most are water, carbon dioxide, and sulphur dioxide.<sup>37</sup> Calcite is the primary component of marble, making it a carbonaceous stone. Carbonaceous stones have an interesting relationship with water. Water low in dissolved minerals can cause calcite to dissolve directly, but at a hardly noticeable rate, calcite is almost insoluble in pure water.<sup>38</sup> In the presence of dissolved carbon dioxide, however, it will readily form calcium bicarbonate, which is incredibly soluble in water. When the water evaporates, the calcite precipitates out again, but is no longer mechanically bonded to the original stone. When you introduce sulphur into the mix, things fall apart more quickly. Sulphur will dissolve into water, forming sulphuric acid. This acid can cause calcite to dissolve directly into it, or chemically react with the





*Inserts of hornblende, in a column in front of the south entrance of the Field Museum of Natural History, Chicago Illinois, persist while the marble surrounding it loses definition*





*Calcareous sandstone sculpture, showing damage attributed to industrial atmospheric damage.*





*Differential wear in the Chapter House stair of Wells Cathedral, stone witness to petitioners' preference for walking along the seats intended for witnesses called to testify.*





calcite to form hydrous calcium sulphate - gypsum. Gypsum will dissolve into solution 25 times more readily than calcite.<sup>39</sup> When gypsum precipitates out of solution, trapping dirt in its accretions, black stains of new matter evolve out of white stone.<sup>40</sup>

These processes make carbonaceous stones particularly susceptible to mechanical wear. While that sounds like an entry in the 'con' column of a stone dealer's catalogue, it's also the reason that limestones and marble can index the way an architecture is used over time. The contrast between the haptic experience of durability and the obvious signs of malleability in the face of use, invite speculation on the thousands of steps echoed by yours. The flowing stone steps of Wells Cathedral, built in 1306,<sup>41</sup> inspired the poem "Walking on Water" by poet John Spaulding, where he describes the affect of the exaggerated wear pattern running down the left-hand side of the stair:

A sea of steps flows down  
rising perhaps from the nearby springs  
as though the Cathedral at Wells  
were filling with water flooding  
through these porticos and doorways  
past pillars and columns  
taking us away floating  
into the space of something else  
like the music of a grand organ.

But what looks like water  
is only stone, perhaps granite. Steps worn away,  
ground down, or here and there chipped,  
by centuries of boots and shoes,  
thousands of worshippers  
turning stone to water.<sup>42</sup>

These processes can strip detail and definition from carved stone, and cause loss of material that can eventually lead to mechanical failure. It was because of marble's



soluble nature, in an urban atmosphere steadily increasing in carbon dioxide and sulphur, that its popularity as a grave-marker declined. Kenneth Jackson, in his book *Silent Cities: The Evolution of the American Cemetery* wrote that, “in 1989, more durable materials, granite and bronze were those most commonly used for funerary monuments. Granite is said to erode only one eighth of an inch every one hundred thousand years. But although granite can withstand the ravages of time, it is very expensive to carve or inscribe, and it lacks marble’s capacity to represent life-like forms and warm surface effects, both important in rendering the human figure.”<sup>43</sup>

Mankind operates alchemically on marble, by selecting it in the state of the petrological cycle where it is most lovely, and then by binding it into our buildings. As part of our alchemical arts, we have ways of preventing marble from seeking chemical equilibrium. Trapped sulphur in gypsum deposits readily dissolve back into water and continue changing calcite into gypsum when relative humidity levels rise. Removing deposits from the surface of the stone so relatively clean water can remove pollutants help to retard the process. Encrustations can be safely removed using low pressure water spray. Enriched with soluble salts like calcium sulphate, water is sprayed onto encrusted surfaces for days, requiring up to twenty hours to dissolve encrustations one to three millimetres thick. Approaches like sand-blasting remove the encrustations along with a thick layer of the stone substrate, leaving the surface porous and open to new attack. Newly cleaned stone requires reinforcement and protection, to restore cohesion of the stone surface and decrease porosity.

Marble is not, by nature, static in our atmosphere. Part of its nature is its chemical makeup, its dynamic response to temperature, its mercurial properties. What if, instead of wielding our alchemy to try to impose hopeless stasis on this matter, we use its potential for change as a property with which we can design? Thermal expansion triggering increased porosity and calcite’s vulnerable tendencies toward solubility are as much part of its nature as its crystalline luminosity. Instead of insisting on marble as the material of immortality, it could serve as a poetic architectural metaphor for memory. Details sharp and crisp when etched can fade with the event they recall.





Imagine a House of Marble, an architecture decorated by carving designed to celebrate wear. As nature takes its course, instead of lamenting the inevitable, the slow erosion of detail would be beautiful. Every stroke cut into the stone would be decided according to the laws of water, salt and calcite, tied irrevocably to the memory the stonecutter wants to create. Man's agency extends forward in time to the furthest reaches of the future they can manage to identify with. Controlled staining can bring contrast that develops like a photograph, creating architectural instances that evolve with the lives they shelter. Design marble to stain and weather. *Solve et coagula.*









My intention is to tell of bodies changed  
To different forms; the gods, who made the changes,  
Will help me- or i hope so- with a poem  
That runs from the world's beginning to our own days.<sup>i</sup>

- Ovid's *Metamorphoses*, book one, lines 1 - 4







There is a schizophrenia nestled in the heart of contemporary architecture. It arises from the conflict between the abstraction of design, and the reality of matter. After the exercise of agency in designing a building, willfully consigning it to decay seems defeatist; yet degradation is inevitable. The educational benefit of examining existing buildings seems to insist on retaining architecture's existence in its intended, built form; while the modern cult of ruins imparts value to buildings based on their departure from that form. Finally, people cannot be expected to continue using a building as it crumbles around them; while the evidence of time passing in our environment can address a real psychological need. I believe that careful attention to material temporality can mediate between these contradictions.



**Thesis: We need  
architecture to last**

Let us first acknowledge our ego. Contemporary architectural practice requires a confidence and surety of purpose that borders on the pathological. Except in the rare cases where architects design for themselves, it is the practice of convincing someone else that your idea, expensive and convoluted as it may be, is worth their time and money. That it will make their life better than anyone else's idea could. To overcome schedule, expense, stubborn clients and intractable crews to experience the *jouissance* of the architect as drawings reify on the site into the magic of 1:1, is a victorious moment. Given this, it becomes difficult to reconcile the idea that it should then begin to fall apart. Georg Simmel, in his essay "The Ruin," describes the relationship between human and natural agency, saying that architecture, "... uses and distributes the weight and carrying power of matter according to a plan conceivable only in the human soul .... This unique balance - between mechanical, inert matter which passively resists pressure, and informing spirituality which pushes upward - breaks, however, the instant a building crumbles."<sup>1</sup> He describes the ruin as no longer demonstrative of our art, but of nature's. "Nature has transformed the work of art into material for her own expression, as she had previously served as material for art."<sup>2</sup> From this perspective, allowing a building to decay is an act of active passivity privileging the agency of nature over the agency of man, relinquishing authorship.

Beyond the insult to artistic integrity, allowing buildings to age constitutes theft from history. Architectural education is largely focused on the examination of historical buildings, buildings that - still in service or not - serve as monuments to moments in architectural history. In his essay titled "The Modern Cult of the Ruin," Alois Riegl describes monuments as either intentional or unintentional. In neither case is history served by their ruined state. "Both intentional and unintentional monuments are characterized by commemorative value, and in both instances we are interested in their original, uncorrupted appearance as they emerged from the hands of their maker and to which we seek by whatever means to restore them."<sup>3</sup> The International Style building stock in Vancouver, British Columbia was allowed to fall into disrepair and was mostly demolished. This was due to contemporary tastes having



changed, its aesthetic was unappreciated. Its importance as architectural monument was almost realized too late. The Queen Elizabeth Theatre, quickly protected with a Heritage designation, constitutes one of the few remaining examples. The City of Vancouver has since had the theatre restored with careful integrity. If we don't know what will be historically significant to future generations, designing to fail decides for them that nothing of our time should persist.

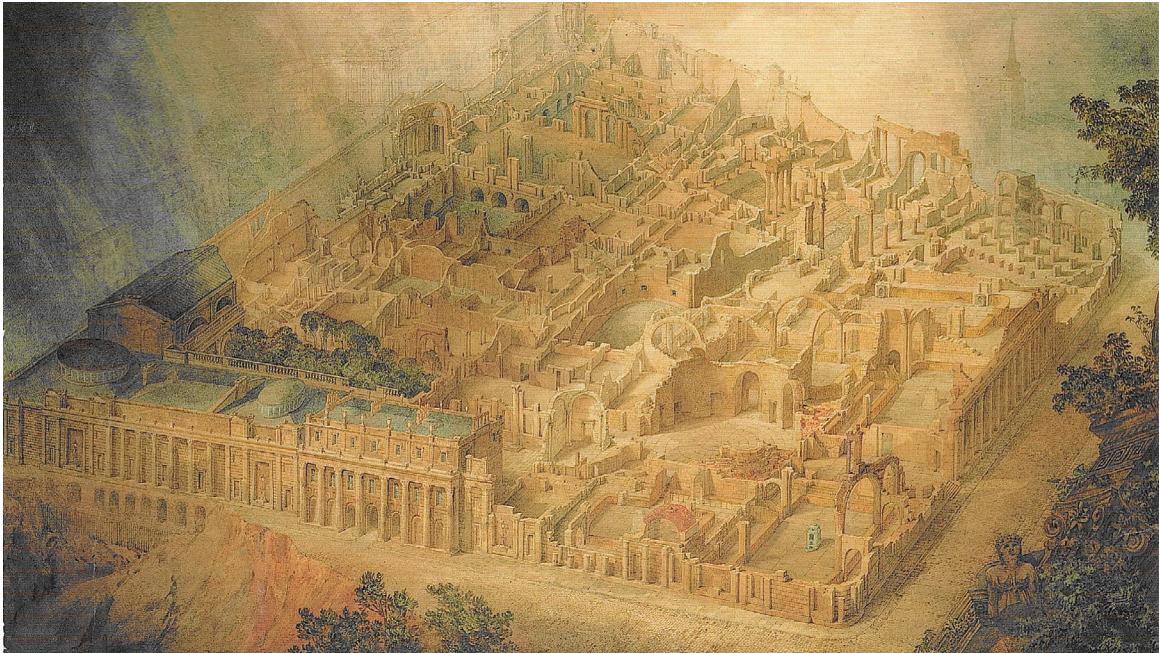
Finally, buildings have what Riegl describes as a use-value, which supersedes any poetically sympathetic mortality we may wish to ascribe to them. "Material life is a pre-requisite for psychic existence, and indeed is more important because there is no psychic life without a physiological basis. It follows then that an old building still in use must be maintained in such a condition that it can accommodate people without endangering life or health ...."<sup>4</sup> Deliberately introducing wear and age into a building is potentially unsafe, uneconomic and impractical. In our age we have material technology that allows our buildings to perform better. To deliberately ignore these advancements and encourage signs of aging is an irresponsible exercise in nostalgia.

In discussing the cult of age-value, the modern cult of the ruin, Riegl highlights one of the strongest arguments available for appreciating visible age in architecture, "... the advantage of age-value lies in the fact that it is easier to achieve - strictly speaking it is the only viable strategy."<sup>5</sup> No matter the ego involved, and no matter the material gymnastics we subject our architecture to, age is inevitable. All of our alchemy eventually falls short of the task of immortality, or as Riegl writes, "Permanent preservation is not possible because natural forces are ultimately more powerful than all the wit of man, and man himself is destined to inevitable decay."<sup>6</sup> When we build without acknowledging the eventual advance of time, without designing the building back into the ground, we are delusionally ascribing to our work an impossible immortality, approachable only with the twin alchemistries of preservation and repair.

In our modern context, we are heir to the aesthetic of the modern cult of the ruin, able to appreciate age-value. Riegl dates the beginning of the cult of ruins to fifteenth century Italy. Prior to that time, the intentional monuments of previous

**Anti-thesis: We need  
architecture to fail**





*John Soane's Bank of England, painted as a ruin by Joseph Michael Gandy (1830)*

generations were generally abandoned when the last living members of the groups responsible for their creation ceased to care for them. In the grip of the Italian Renaissance however, Romans found a way to channel their nostalgia for the glory of the Empire into more than disheartened lamenting for better days. Riegl describes this first revaluation of ruins as the result of an entire people who, "... began to regard the achievements of earlier generations as part and parcel of their own. Thus the past acquired a present-day value [*Gegenwartswert*] for modern life and work."<sup>7</sup> By the seventeenth century, the cult of ruins had become part of the Baroque movement, and adopted a new aesthetic and affect. For the Baroque, the painting of ruins contrasted past glory with current failing, with the specific theme of despairing the losses of the past. Riegl called that an, "... indulgence in pain which gave rise to the aesthetic value of Baroque pathos," and contrasts it with our modern appreciation of the ruin, "... nothing is more alien than this Baroque pathos: the traces of age strike us as testimony to natural law inevitably governing all artifacts."<sup>8</sup> Our modern appreciation of age-value has created a new way for architecture to serve us in its twilight. Unlike the gnostic play of intellectual complexity that gives rise to much of architecture, this value is universal and available to all. This mode of appreciation is described in "The Modern Cult of the Ruin" as an emotional effect that, "... depends on neither scholarly knowledge nor historical education for its satisfaction, since it is evoked by mere sensory perception. Hence it is not restricted to the educated ... but also touches the masses independent of their education."<sup>9</sup> With the emergence of the concept of age-value, architecture is given the opportunity to become more universally beautiful as it ages past its initial form. Allowing or promoting the aging of architecture equates to an increase in communal, accessible beauty. That the cult of age value's aesthetic is inextricably linked to the slow destruction of the objects of their appreciation is recognized by this modern cult of the ruin. Instead of focusing energy on the permanent preservation of existing monuments, society's efforts can go to producing new monuments to replace those we currently enjoy as they eventually degrade beyond recognition. The focus is shifted from the past to the 'cycle of creation.'<sup>10</sup>



For the users of individual buildings, materiality that encourages an indexical relationship with time and use is psychologically humane. In his book *What Time Is This Place?*, Kevin Lynch describes the relationship between an individual's personal conception of time and their psychological well-being. He focusses on how the built environment can play a role in creating and reflecting that internal image of time. In it, he describes what he calls a humane environment, one that, "... commemorates recent events quickly and allows people to mark out their own growth. It is more humane not only for the inhabitants but for the observer as well. He will sense its warmth and find in it a symbolic way of meeting its inhabitants."<sup>11</sup> Not only does an indexical environment allow its inhabitants to contextualize their time against that of their environment, it can also communicate with more transient presences. Evidence of use or its establishment on the site can all become stories a visitor can read in the architecture. Comparing the minute evidence of their passage against the more visible amalgamations of past traces can provide a sense of continuity and community.

## Synthesis

It is natural to regret seeing something you had a hand in creating begin to fail. Riegl describes this aversive reaction from the point of view of the cult of age value and the cult of new value. "From man we expect accomplished artifacts as symbols of a necessary process of human production; on the other hand, from nature acting over time, we expect their disintegration as the symbol of an equally necessary passing. We are as disturbed at the sight of decay in newly made artifacts (premature aging) as we are at the traces of fresh intervention into old artifacts (conspicuous restoration)."<sup>12</sup> I think the answer to this regret, however, lies in design. Riegl postulates a relationship between age, decay and age-value, using the examples of medieval castle ruins and baroque palace ruins. Castle ruins have more age-value, he argues, due to their historical distance. The baroque palace ruins are disturbing, rather than beautiful, due to their relative modernity. I agree with his relative valuation, but contest him on identifying the salient cause. This point of contention is why I believe design can mediate between the loss of agency caused by age and time's inevitability. I would introduce a third example, the ruins of old mill buildings found in many Ontario



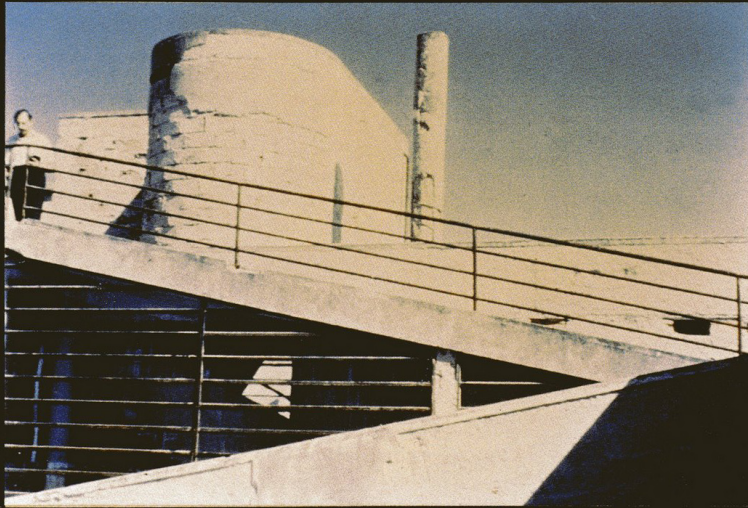
towns near rivers. Infinitely more picturesque than a ruin of a baroque palace - even if historically more recent. The difference lies in their materiality. Rounded stone and weathered oaken beams index time more subtly and beautifully than sagging mounds of rotting plaster. Time, aging, is inevitable, but we can extend our agency into time by designing the ways our buildings will age. Design the mill rather than the Baroque palace.

Designing buildings to age deliberately does not include purposefully shortening their lifespan. It does cause them to become conscious of their time, and participate more fully in the culture they exist to serve. In his book *The Eyes Of The Skin*, Pallasmaa describes architecture's potential, "If we desire architecture to have an emancipating or healing role, instead of reinforcing the erosion of existential meaning, we must reflect on the multitude of secret ways in which the art of architecture is tied to the mental and cultural reality of our time."<sup>13</sup> He describes contemporary architecture as being overly concerned with exploring the intellectual and technical limits of its art, rather than addressing the existential interaction between architecture and user. This withdrawal from experience and reality results in what he calls an "... architectural autism, an internalised and autonomous discourse that is not grounded in our existential reality."<sup>14</sup> The universal appeal described as age-value by Riegl constitutes an architectural acknowledgement of existential realities that hold true for all humanity. Introducing deliberate, beautiful instances of aging into our architecture can return to it the lost, "... physical, sensual and embodied essence ...."<sup>15</sup> that Pallasmaa mourns.

The idea of designing buildings to age should be vaguely uncomfortable. We sympathize with our architecture; its mortality reminds us of our own. In Lynch's *What Time Is This Place?* he describes open-ended change as equivalent to death, writing that we need to develop new rituals to approach traditionally unsettling phenomena. "Adaptation and conservation need psychological support as well as an ethical base. Open-ended change will continue to frighten us until we have the attitudes that make it seem natural and comfortable ... we need new rituals of death ... to complement the gift giving and bright wrappers associated with new things ...."<sup>16</sup> Architectural design



**The most architectural thing  
about this building is  
the state of decay in which it is.**



VILLA SAVOYE, 1929

Architecture only survives  
where it negates the form that  
society expects of it.  
Where it negates itself by  
transgressing the limits that  
history has set for it.

*Poster by Bernard Tschumi*



that consciously and deliberately integrates signs of aging can help to integrate agency within open-ended change. Watching the deliberate evolution of a building in time implies an awareness and acceptance of this phenomenon of mortality, ritualizing and normalizing it. As Lynch writes, "... there are novel temporal manipulations of environment that will not only delight us but also vivify our image of time - help us to heal the breach between the abstract intellectual concept and our emotional sense of it."<sup>17</sup>

Place strips of metals to capture wear patterns of cuprite through tenorite on hand-rails. Use woods inside and out to display the effect of salt, sun, light, and water. Run water over carbonaceous stones to create evolving grooves, or let a hidden iron clasp disintegrate to release a window-hiding panel in the distant future. I don't expect in my career to design houses that leave behind only artfully stained marble plinths. If I can create a house that ages with its inhabitants, records their lives, communicates them to the next owner, shifting and changing so that each decade brings new experiences in the same architecture, I will be happy.



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## Conclusion

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