Cosmographia Metallica

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.

Abstract

In his book *The Living Rock*, historian A.J. Wilson writes, "The history of metals is the history of civilization". From its beginnings in simple toolmaking, to modern-day machinery and weapons, the development of metallurgy ranks second only to agriculture in its impact on human society; to be sure, civilization as we know it would not exist without the discovery and use of metals. Modern man is familiar with dozens of metals, some common, some precious, some useful, some deadly. It is remarkable then to consider that, until the late Middle Ages, there were only seven metals known in their elemental form: gold, silver, copper, iron, lead, tin and mercury. For thousands of years, until isolated zinc was recognized in the fifteenth century, mankind would rely on what we now refer to as the seven classical metals.

Through a survey of their historical, scientific, cultural, utilitarian and mythological characteristics, the seven classical metals are investigated. From this research, common threads emerge that suggest a spirit or essence of each metal, expressed as the metal's *imperative*. The concept of the imperative embodies more than the metal's physical characteristics, symbolism and history; it suggests that each metal is compelled to be considered and used in a particular way. It is an idea that metals are not simply passive materials, but possessing of an active and influential force.

The metal imperatives, projected onto a barren site in the Sudbury area, are used as generators for the design of seven metal spaces. On this expansive landscape, the interventions communicate the nature of gold, silver, copper, iron, lead, tin and mercury against a backdrop of earth and sky.

Acknowledgements

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Dedication

to Henry Friesen, my high school chemistry teacher,
for a lifelong love of the periodic table.

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Introduction

the fable of the seven spirits

In the most ancient beginning, a time before men,
A time before gods, before separation of fire from air, earth, and water,
Spirits existed, disembodied, free-floating
Amid the cosmic dust.
Fragments congealed, spinning ferociously
Into orbs, then moons around a spark of light,
Planets to become.
The spirits settled these,
Finding places of warmth, cold, light and darkness
As befit their temperaments.
Many of these chose a still-molten earth, forming
Her masses of iron, mercury, tin,
Copper, gold, silver and lead into surfaces
One day to be traversed by men.

Seven spirits fell onto a chunk of rock,
Thick and heavy with iron, still soft
With the heat of a raging fire at its core.
The rock was hammered by these seven spirits, sifting the slag
From the purer metal. They made a smooth surface
Over which they could race with the winds,
Carved valleys in which to recline,
Stacked a promontory on which to stand
Closer to the heavens.

The seven spirits settled, contented,
In their home on the rock
And they waited, patiently,
For the day when the footfalls of men would draw closer,
Pulled to their presence here.

fig. 0.1- Jupiter. circa 2nd century BCE, bronze.

The Ages of Man

Homo Erectus, Upright Man	500 000 years ago
Homo Sapiens, Knowing Man	200 000 years ago
Stone Ages:	
Paleolithic (Old Stone Age)	30 000 - 2000 BCE
Mesolithic (Middle Stone Age)	
Neolithic (New Stone Age)	
Chalcolithic (Copper-Stone)	6000 - 3000 BCE
Copper Age	**from 3000 BCE**
Bronze Age	**from 2500 BCE**
Iron Age	**from 1000 BCE**
Coal Age	from 1600 CE
Industrial Revolution	1750 - 1850 CE
Oil Age	from 1850 CE
Electrical Age	from 1875 CE
Atomic Age	from 1945 CE

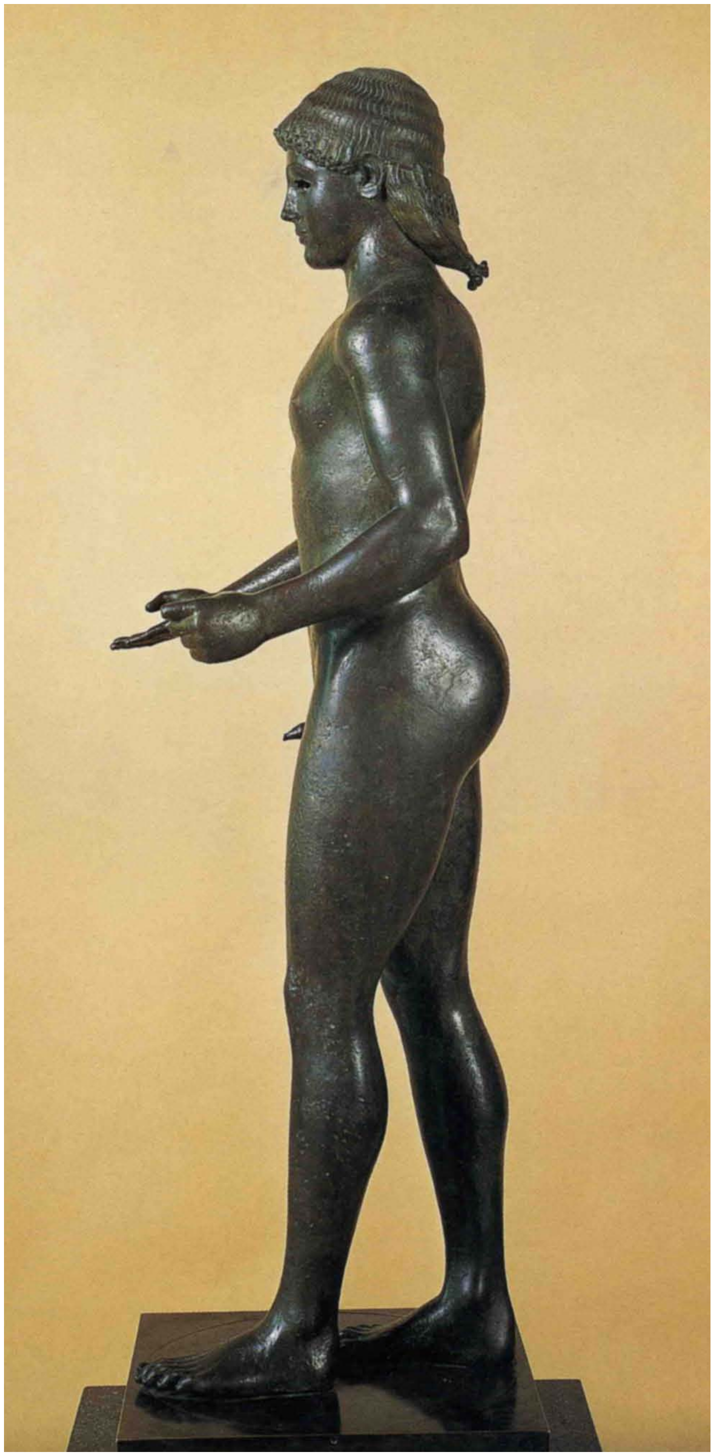

fig. 0.2- Apollo, circa 1st century BCE, bronze.

As written by the historian A.J. Wilson in his book *The Living Rock*, “The history of metals is the history of civilization.”[1] From its beginnings in simple toolmaking, to modern-day machinery and weapons, the development of metallurgy arguably ranks second only to agriculture in its impact on human society; to be sure, civilization as we know it would not exist without the discovery and use of metallic materials. Modern man is familiar with dozens of metals and their alloys, some common, some precious, some useful, some deadly. It is remarkable then to consider that, until the late Middle Ages, there were only seven metals known in their elemental form: gold, silver, copper, iron, lead, tin and mercury. For thousands of years, until isolated zinc was recognized in the fifteenth century,[2] mankind relied on what we now refer to as the seven classical metals.

The earliest familiarity with metal would have been in its mistaken identification as stone,[3] which, along with bone, was the primary material used to fabricate tools and implements in the lithic ages extending from 30000 to 4000 BCE. This peculiar, shiny rock* differed from others in that it possessed a particular softness that allowed it to be hammered and shaped, whereas typical stone would chip or shatter. Sometimes these stones would have had a lustre that attracted the eye, as with the pieces of gold that could be found in riverbeds. Just as these nuggets attracted stone-age man, they drew prospectors several millennia later in the Gold Rushes of California and the Klondike.[4] It is believed that these found pieces of native metals would have formed man’s first metal artifacts, as is suggested by the oldest found metal object shaped by a human hand: a copper pendant dating from around 9500 BCE, unearthed near Shanidar in northern Iraq.[5] The rock most revered by primitive peoples was that which originated from the sky, the “fire from heaven” now known to have been meteoric iron,[6] the fragmented remains of small

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* Some of the classical metals are found in nature in their native forms, meaning that they occur in fragments independent of their ores. Gold, silver, copper, and (in rare instances) lead can appear as native metals; native telluric (earth-sourced) iron is extremely rare[7].

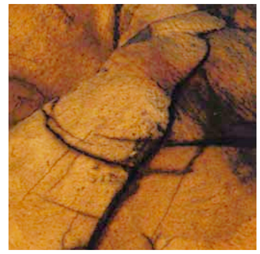
fig. 0.3- Representation of a portion of the Turin Papyrus, depicting metallurgical techniques, circa 1150 BCE

planets and asteroids destroyed in space. Having descended from the sky, these iron meteorites were often imparted with the symbolism of local divinities. One such example existed at Pessinus in Phyrigia, part of modern-day Turkey, where an iron meteorite was worshipped as a representation of the goddess Cybele.[8]

The earliest uses of metal as ornament would have capitalized on the qualities of shine and lustre inherent to gold, copper and silver- all metals available in their native form. Other characteristics such as hardness and durability (particularly in comparison to stone) were found useful in the development of toolmaking, and it is here that metals have made their most significant contribution to human society. Man's desire to manipulate and tame his environment, notably through the advance of agriculture, demanded new tools. Some of these implements could not be effectively made of brittle, breakable rock, such as can be seen in the 5000-year-old copper chisels found in the area of the Dead Sea.[9] For these early toolmakers, the growing demand for metallic materials would eventually outstrip the availability of native metals found on the earth's surface; in time, man would descend into the ground in search of veins of the shiny rock. Archaeologists believe they have traced dedicated copper mining on the continent of Europe back to 6500 BCE,[10] a date which anticipates the development of written language. Interestingly, one of the oldest written accounts of metals relates to mining: the Turin Papyrus, dating from 1150 BCE, depicts a map of an ancient Egyptian gold mine.[11]

While the development of mining was certainly an important aspect of man's growing knowledge of metals, it was not until the application of fire that the metallurgical age was born. Historians believe it was likely by chance that a piece of ore was dropped into a Stone Age fire, causing molten metal to emerge from the rock.[12] The earliest metallurgical age is known as the Chalcolithic, meaning "copper and stone". In the Western world, the Chalcolithic began around 5000 BCE in the Nile River Delta, while in western Asia it began a full millennium earlier.[13] Copper tools for agriculture were more robust than their stone counterparts, but copper was still somewhat soft. The need for harder, more durable materials eventually led to the discovery of alloyage, the combining of two or more metals into one product. Experimentation would sometimes reveal a resulting alloy that improved on the properties of the original metals. In the case of copper and tin, this process would yield one of mankind's most important alloys: bronze. Bronze was hard and resistant to corrosion, making it an ideal material for a range of uses, from common articles such as mirrors to specialized implements: razors, armour, even prosthetic limbs.[14] The advances in metallurgical technology made through experimentations with bronze were to pave the way for a new age: that of iron, the large-scale production of which became possible with the development of smelting, a process that generated the more intense heat required to draw the metal from its ores.

The influence of metals on civilization extends beyond developments in metallurgy and toolmaking; a significant part of this history concerns the spread of culture as well as technology. The ever-growing need for metals facilitated the prospecting of new territories and the establishment of networks for trade across the ancient world,[15] many of which continue to be used today. Exploration, at one time rooted in the search for fertile land for farming,[16] switched focus to the location of metals and their ores to feed an ever-growing demand. For example, the expansion of the Roman Empire into northwestern Spain and the British Isles would serve to satisfy the culture's appetite for tin, needed to make bronze.[17] These explorations were to extend across continents and hemispheres, and were to have their place in the conquest of the New World, as voyagers eager to find a shorter route to the riches of the Orient found themselves in a new land with untapped bounties of gold and silver.[18] The movement of goods and people also facilitated the transfer of knowledge and traditions between different cultures, so that the sharing of bronze or iron technology also transferred the symbolism and rituals comprised therein.



figs. 0.4-0.7- The Empedoclean elements: fire, air, water, earth

philosophia metallica

The historical significance of the metals as physical materials tells only part of the story of their importance in the development of human civilization. The earliest philosophical thinking on metals would have formed part of a larger discussion: that of the nature of matter. In the 4th century BCE, the Greek thinker Empedocles theorized that matter was constituted of four indivisible elements: fire, air, earth and water.[19] Varying compositions of these would form different entities; as an example, mercury was considered to possess an inner flame (fire) whereas common, solid silver did not.[20] The philosopher Democritus, a contemporary of Empedocles, proposed a different theory: that matter was made up of miniscule and indivisible units that he called atoms, and that each substance was comprised of a different number and structure of these small parts.[21] The latter explanation would eventually be proven the more accurate of the two; however, it was the four classical elements that would form the basis of the theory of matter for centuries to come. Indeed, the theory was to endure until 1770, when the French chemist Antoine Lavoisier first proved that one element - water - could be broken down into another - air (hydrogen and oxygen).[22]

Plato also offered a theory on the nature of matter, perceiving it as an inert and passive material onto which various qualities could be imposed.[23] This would not have been incongruent with the Empedoclean theory of the elements, for the natures of fire, air, earth and water could effectively be imprinted onto a base substance. Applied to the domain of metals, this *prima materia* found definition as the metal mercury, which was interpreted by metallurgical and alchemical thinkers as a liquid matrix onto which a catalyzing substance, sulphur, could be projected. The mercury-sulphur theory of metals was first proposed by the Arabian alchemist Abu-Musa-Jabir-ibn-Haiyan (popularly known also as Geber) in the 8th century,[24] but its roots can be seen in the theories of Aristotle. In Book I of his *Meteorologica*, Aristotle proposes that all metals are formed through a two-part exhalation of the Earth upon being warmed by the Sun: a moist exhalation and a dry exhalation, later to be characterized as the moist and dry vapours respectively.[25] According to this theory, the congealing of the moist vapours of the earth, catalyzed by the influence of a dry vapour, created the metals. That metals could be melted was seen as evidence of their provenance from the moist exhalations of earth; the solid metals also embodied the effect of the dry vapour.[26] Aristotle's theory thus supported the idea that each metal was comprised of moist (mercury) and dry (sulphur) vapours in varying proportions, the mercury effectively curdled by the addition of the sulphur.[27] The differing constitutions of individual metals were attributed to the varying levels of purity and clarity of their constituent mercury and sulphur. Gold, for example, was made of the cleanest sulphur and mercury,[28] while iron was thought to be comprised of very dirty, heavy mercury as well as earthy, impure sulphur.[29]

Another significant aspect of philosophical thinking on the nature of metals concerned the belief that they contained life. In fact, metals were perceived to be living substances akin to plants and animals until well into the nineteenth century. One of the earliest "proofs" of this theory considered the sources of native metals: streams running through areas of rock, which carried with them particles of gold, silver and copper. In cultures that likened the Earth to a maternal force, these waterways had a very specific significance. In ancient Mesopotamia, for example, the source of the sacred rivers of the Tigris and Euphrates was believed to be the vagina of the goddess Inanna.[30] In this belief, the flow from caves or caverns in the rock was perceived as a menstruation, carrying with it the fertile products of the womb of the Earth.[31] When man entered the rock in search of metal and found rich veins within it, the observation of an organic pattern noted in other living things further bolstered the idea that metals grew in a similar manner to plants and animals. The theory of 'organic' metals would also find its place in mining culture. In the first mines, veins of metal and ore would be worked until exhausted, at which point the mine would be abandoned. However, at a few locations it was perceived that, after a period of several years, new metal had sprung from the rock.[32] The Roman historian Pliny in his *Natural History* speaks of the black lead of Spain, which not only regenerated in abandoned mines, but came back more prolific than before.[33] While modern science shows that metal does not grow organically, there must have been evidence enough to convince these early miners. The belief was so widely held that it became common practice to close mines routinely, while making careful assurance that some of the metal was left as seed for the future supply.[34]

The notion of life within metals could also be evidenced by the presence of small particles of one metal in larger pieces of another: fragments of silver in a chunk of lead, for example.[35] This observation contributed to the theory that not only did metals grow within the Earth, but they were also in a process of transmutation from base metals into noble ones.[36] Particles of gold found in a piece of silver were perceived to be the intended end-state of the Earth's gestation; the silver simply needed more time to develop.[37] This hypothesis is eloquently described by John Webster in his *Metallographia* of 1671: "…Nature's ultimate labour is in time to bring all Metals to the perfection of Gold: which she would accomplish, if they were not unripe and untimely taken forth of the bowels of the Earth."[38] Indeed, gold's incorrodible surface and sun-like brilliance were seen to represent the striving of nature towards perfection, while other metals, pulled from the ground too soon, were viewed as abortions, even aberrations.[39]

fig. 0.8- Evidence of late Bronze Age copper smelting, circa 11th century BCE. The flat discs are ingots of copper smelted from antimony tetrahedrite ores.

metallurgia

Man's metallurgical age was ushered in approximately nine thousand years ago, with the first application of fire to metal and rock. The practice of metallurgy fundamentally encompasses the procurement of metal from its ores, the working of metal by fire, and processes of alloyage by which two or more metals are combined into a distinct product. The earliest metallurgical act may have been accidental, stemming from the observation that certain types of rock, when set in fire, would melt out liquid metal. The early appearance of artifacts of lead,[40] with its relatively low melting point, supports this theory. Several key developments in metallurgical technology were made in the early part of written history, such as annealing*, which would have been discovered as metal softened by fire became easier to work. The hammering of metals while hot made the cooled material harder - an important quality for tools. It was also during this early stage, from the sixth to fourth millennia BCE, that the smelting of metal from rock moved from the campfire to specially designed furnaces, where temperatures could be raised dramatically, and more specifically to the threshold of 1083°C, the melting point of copper.

Alloyage stands as one of the most influential of early metallurgical developments. One theory of the origins of alloyage proposes that the smelting of single ores in which two metals were constituted could have yielded some simple alloys, possibly including bronze.[41] However, a more plausible theory presents the first alloys as the results of experiments in copper casting.[42] With the discovery that certain impurities, known as fluxes, facilitated the casting of copper by reducing its melting point, experimentation yielded various different bronzes. The earliest of these were arsenical bronzes, artifacts of which have been found in the vicinity of the Dead Sea, dating from around 3000 BCE.[43] Other experi-

* Annealing is a heating and cooling process that both improves upon the hardness, and reduces the brittleness, of metals. The process is used on glass to the same effect.

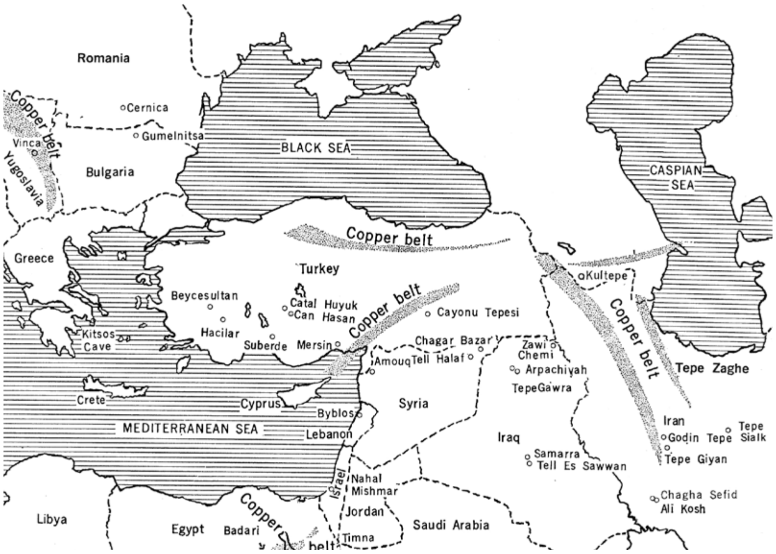


fig. 0.9- Earliest copper metallurgy, dating from 7000-4000 BCE. Copper-bearing areas are shown hatched.

ments led to the development of brass, by adding zinc oxide to copper, and electrum, made with a combination of gold and silver.

The wonder of creating and working metal by fire would come to impart a weighty symbolism and significance to the individual who controlled the flames. The fascination with fire that exists even today is part of a long global history. In Christian tradition, for example, the Devil is commonly depicted within an arena of flame in the depths of Hell; conversely, fire is also referenced as a purifying force in the Bible*. To ancient sensibilities, the provenance of fire was magical, a creation of the gods. Whether given to man or stolen by him, the privilege to keep and work fire was not only evidence of man's position as the most favoured of the world's creatures, but also attested to the presence of a certain divinity in himself. The connection made by the sharing of fire between man and the gods would apply to the wider practice of metallurgy, particularly in the process of smelting as man discovered that he could fundamentally transform substances by fire. Because of the contemporaneous belief that metals were living things in a state of transmutation from a base condition to the perfection of gold, the ability of the ancient smith to change common rock into metal was tantamount to performing the work of nature,[44] something hitherto the exclusive domain of the gods. He further took on the mantle of divinity not only by performing the work of Nature but also by accelerating the transformation,[45] and in so doing assumed power over natural processes, *and* took control of Time.[46]

It was not merely man's possession and use of fire that likened him to the gods; the connection was further asserted in his ability to emulate the deities through the creative act, and in particular through the act of toolmaking.[47] Like the immortal blacksmith Hephaestos, who fitted

* "In the whole land," declares the Lord, "two thirds will be struck down and perish; yet one-third will be left in it. This third I will bring into the fire; I will refine them like silver and test them like gold." (Zechariah 13: 8-9).

the Greek gods with swords, shields and thunderbolts, the man who could pull tools from the fire was possessed of a mystical skill. Toolmaking in general would have had its basis long before the age of metals, when the materials at hand were limited to stone and bone.[48] For this reason, tools of the Lithic ages were mostly limited to functions of striking, although some types of stone and bone were capable of creating an edge which could be used to cut or pierce. Even at this time, the making and use of tools had a divine significance; the crack of a stone tool was likened to the crash of thunder made as the gods created lightning and storm.[49] These early individuals thereby imitated the gods through the act of toolmaking as well as through the use of their creations.

The workers of metal and fire, while serving as repositories of technical knowledge, were also highly ritualistic figures. The smith, in his mastery of fire and power to turn rock into metal, was believed to be a descendant of the gods in many ancient cultures: a civilizing hero* who passed on the secrets of divine knowledge, both practical and spiritual. The metalsmiths of the island of Java were believed to be connected to a mystic fraternity, one with an ancestry linking them to their ancient deities. As custodians of the secrets of metalworking, passed to them from the gods, they enjoyed certain privileges otherwise afforded only to royalty, and even today they are still regarded with respect on the basis of their profession.[50] In the ages of bronze and iron, the smith was responsible for sharing his practical knowledge of metalworking, and in so doing also passed on the rituals and superstition seen to be just as critical to the success of the process.

In line with the belief that metals were effectively gestated, the ability of the smith to undertake the task of transformation required a surrogate matrix to take the place of the womb of the Earth: the metalworker's furnace.[51] Many of the rituals associated with the furnace were connected with the symbolism of sex, of birth and of blood. Sexual abstention was often seen as crucial to metallurgical processes in order to preserve both the purity of the matrix and the virility of the metalworker. In Africa, women are forbidden to approach the furnaces in Bayeke culture, and metalworkers of the Pangne people were made to abstain from intercourse for a period of several months before they were permitted to operate their furnaces.[52] Animal and human sacrifices, both actual and symbolic, were established in certain traditions to baptize or purify the furnace.[53] Again in Africa, the Tanganyikan smiths participate in a ritual in which two hens and a cock are slaughtered and their blood spread around the inside of the furnace so that the forge would not "blemish" their iron.[54] In Chinese tradition, the sacrifice was more representative: hair and fingernail clippings were offered as a substitute for a human sacrifice to the spirit of the furnace.[55] This complexity of rites and ritual would contribute to the casting of the smith as a character of both wonder and fear for thousands of years.

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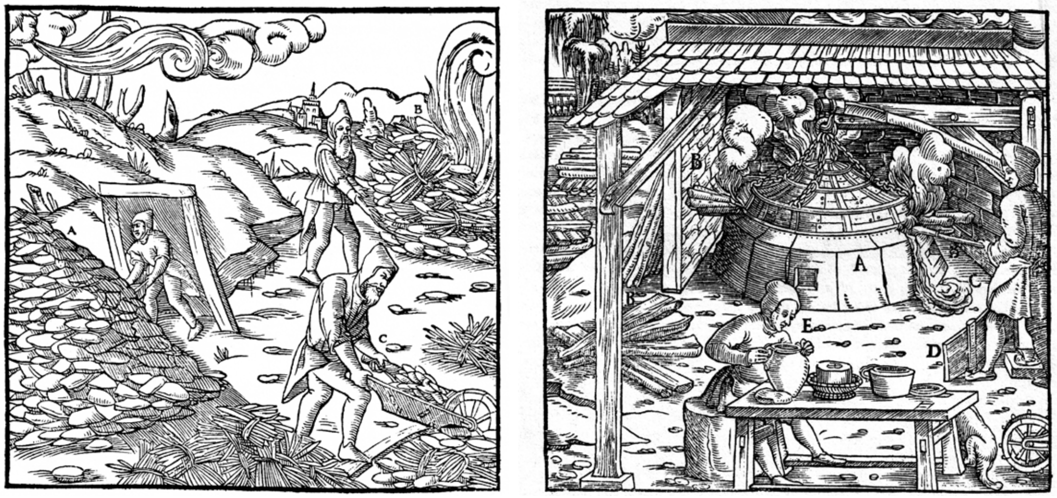
* The figure of the civilizing hero not only transferred to common man the knowledge of such things as fire and toolmaking; he was also the individual that tamed wild space by establishing the first built forms, such as Heracles did by setting up new altars at Cenaeum as the catalyst for the development of the city.[56]

fig. 0.10- Bronze helmet, Corinthian type,
Greece, circa 600-575 BCE

fig. 0.11- Bronze armour, France,
late Bronze Age, 9th-8th century BCE



figs. 0.12 and 0.13- Woodcuts from Agricola's *De Re Metallica*: method of roasting copper-bearing ore; separation of gold-silver alloys in a cupellation furnace.

The mystical realm of metallurgy was contrasted with its more practical aspect. One of metallurgy's greatest minds was a German scholar by the name of Georgius Agricola, a true Renaissance man who was educated in philosophy, physics and medicine before taking an interest in mining and metals. His *De Re Metallica*, first published in 1556, is considered to be one of the definitive metallurgical texts;[57] in it Agricola provides a rigorous analysis of mining, smelting and metalworking techniques. A comparison of modern practices and equipment reveals that many of the principles displayed in Agricola's woodcuts have remained in use over the past five hundred years, from roasting beds for copper ores, to cupellation furnaces for precious metals, to the construction of mine shafts. Agricola developed his processes around a premise which resonates well with modern sensibilities: the observation of natural phenomena as a basis for practice.[58]

Agricola debunked many cherished beliefs passed down through centuries of metallurgical progress, including Geber's mercury-sulphur theory of the genesis of metals. However, he did support the notion that metals were living, growing entities gestated within the womb of the earth.[59] The 17th century chemist John Webster argues the concept a century after Agricola in his *Metallographia*:

> *The like we may judge of Minerals, that they were not at first created perfect, but disposed of in such sort, as they should perpetuate themselves in their several kinds…. And what prerogative have Vegetables above Metals, what God should put seed into them, and undeservedly exclude these. Are not Metals of the same dignity with God that Trees are?* [60]

Just as metallurgy was to involve twin aspects of the mystical and the

Fig. 54. Three smelting furnaces in operation. At A, right, the smelter pours the molten metal from the forehearth into iron or copper molds. The man behind him opens the tap-hole of the middle furnace with a tapping-bar. The third man is cleaning furnace C. In the foreground are a strong chest and weighing scales.

fig. 0.14- from Agricola's *De Re Metallica:* three smelting furnaces in operation.

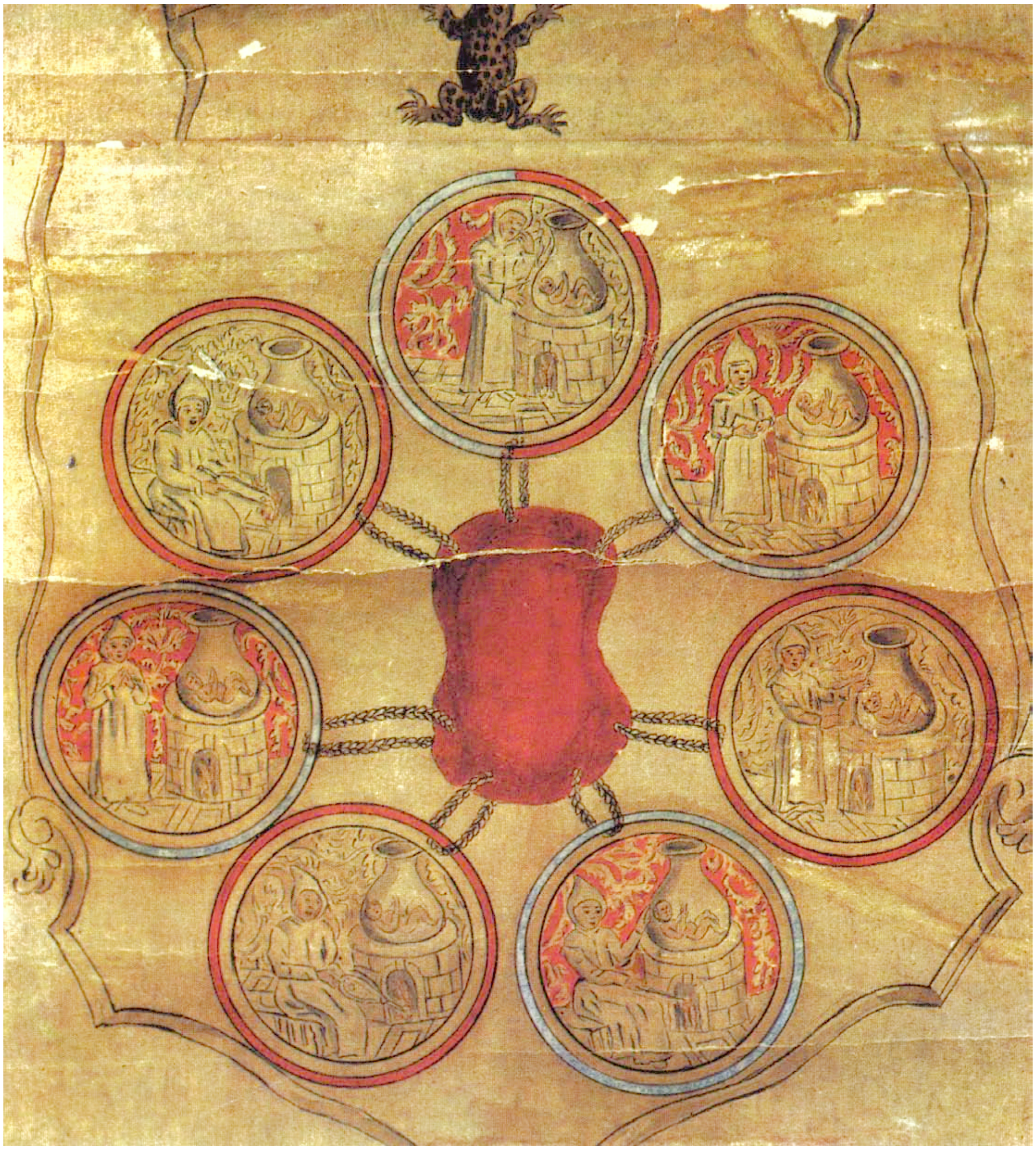
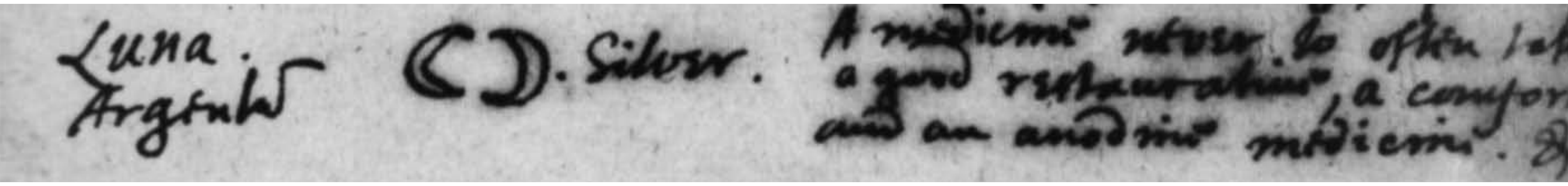


fig. 0.15- The seven processes of the alchemist as depicted in the *Scrowles,* by 15th century British alchemist George Ripley: calcination, dissolution, separation, conjunction, fermentation, distillation and coagulation.

practical, so too would ancient alchemy. Most likely, the word *alchemy* had its origin in the land where the earliest appearances of the mysterious art took place: in China, where it derived from the word *kim* or *chim*, meaning aurifaction.[61] From there the term became *khemia*, the molten metal of ancient Greece, and was eventually prefixed by the Arabic article *al*, so that alchemy's name would come to encompass several of the cultures that figured so prominently in its development.[62] The emergence of alchemy in the West would fundamentally draw from two cultures: the empirical Egyptians, who focused on techniques of experimentation and process, and the Greeks, who sought to weave philosophy with science.[63] The two strands were to merge in Alexandria, where alchemy first figured into the colouring and dyeing so important to the area's textile industry.[64] The Alexandrian influence, with its combination of empiricism and philosophy, was to pervade alchemical thought through to the Renaissance, when the rediscovery of classical texts was to split alchemy into two streams not dissimilar to the dual influences from which it began. The first school focused on the sciences of mathematics, physics and medicine and applied them to an understanding of the world. This was the alchemy of the Swiss physician Phillipus Theophrastus Aureolus Bombastus von Hohenheim, better known as Paracelsus, who sought to revolutionize the world of medicine through the study of anatomy and chemistry. Paracelsus maintained that physicians must be chemists as well,[65] and vigorously promoted experimentation in chemistry as a means of furthering the field of medicine.[66] The second theme was established around the ancient texts that focused on the relation of man to things great and small. This path was followed by Heinrich Cornelius Agrippa, a German astrologer and mystic who synthesized the domains of elementary, celestial and religious magic in formulating a more metaphysical expression of alchemy.[67] These two branches are the recognizable ancestors of modern-day chemistry and occult philosophy respectively.

In similar fashion to the metallurgist and the smith, the alchemist was a figure both revered and reviled. Many early alchemists had an altruistic focus, concocting potions and ointments for the curing of



diseases and designing intricate mechanical devices for the treatment of specific illnesses. However, more popularly known is the character driven by the prospect of transforming base metals into gold. What is not commonly understood of this pursuit is that such a transformation was not purely based on greed or lust for riches; the alchemical quest for gold was as much metaphorical as it was literal.[68] Like the metallurgists, the alchemists saw gold as the paramount expression of perfection in nature: incorrodible, brilliant, eternal. In his book, *The Forge and the Crucible: The Origins and Structures of Alchemy*, the historian Mircea Eliade comments that "the texts of the ancient alchemists show that these men were not really interested in making gold and were not in fact talking about real gold at all."[69] Their 'gold' was more about the perfection of the self than the transmutation of matter. Thus, the continuous transformation by which nature created gold from simpler lead or iron was likened to the lifelong quest for learning and self-improvement.[70]

Definitive historical accounts of alchemical formulae and experimentation are not abundant. Where such evidence exists, alchemical texts are invariably cryptic and bound in allegory, the meaning of which may have only truly been clear to those initiated into the inner circles. John Webster, in his *Metallographia,* states that the alchemists "took little care of framing methodical Definitions or Descriptions of it, as little valuing such trifles and niceties, but contented themselves with the true understanding of it: and yet to their Disciples which they termed the Sons of Art, they gave sufficient hints of the way and manner of it, but still as veiled and obscured."[71] This commentary suggests that a significant portion of alchemical knowledge would have been passed only within the closed circles of master alchemists and their initiates.

Alchemy was not a purely Western phenomenon, with Indian and Chinese alchemies predating those of Europe and the Middle East. While Western alchemy placed its focus on the transmutation of matter, the primary goal in Eastern alchemy was the preservation and restoration of youth.[72] Chinese alchemists believed that a transformative process could be facilitated by a single substance: one that they called the *elixir*.[73] The elixir was imagined as a red liquid, likened strongly to rust-coloured cinnabar, but not simply for its colour. The significance of cinnabar to the Eastern alchemist rested in the capacity of the ore to release mercury when set in fire: in this way, cinnabar embodied the ability to regener-

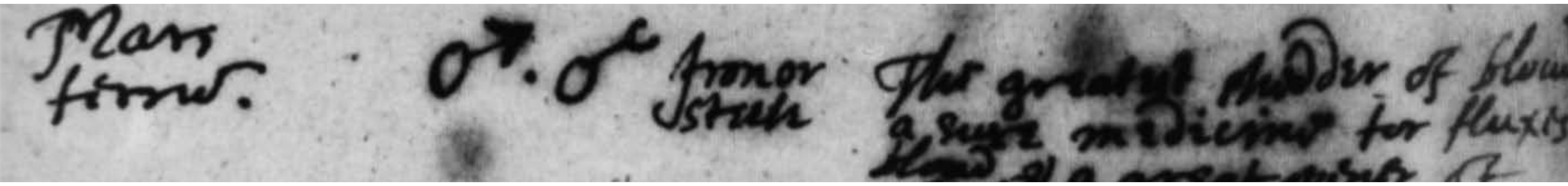
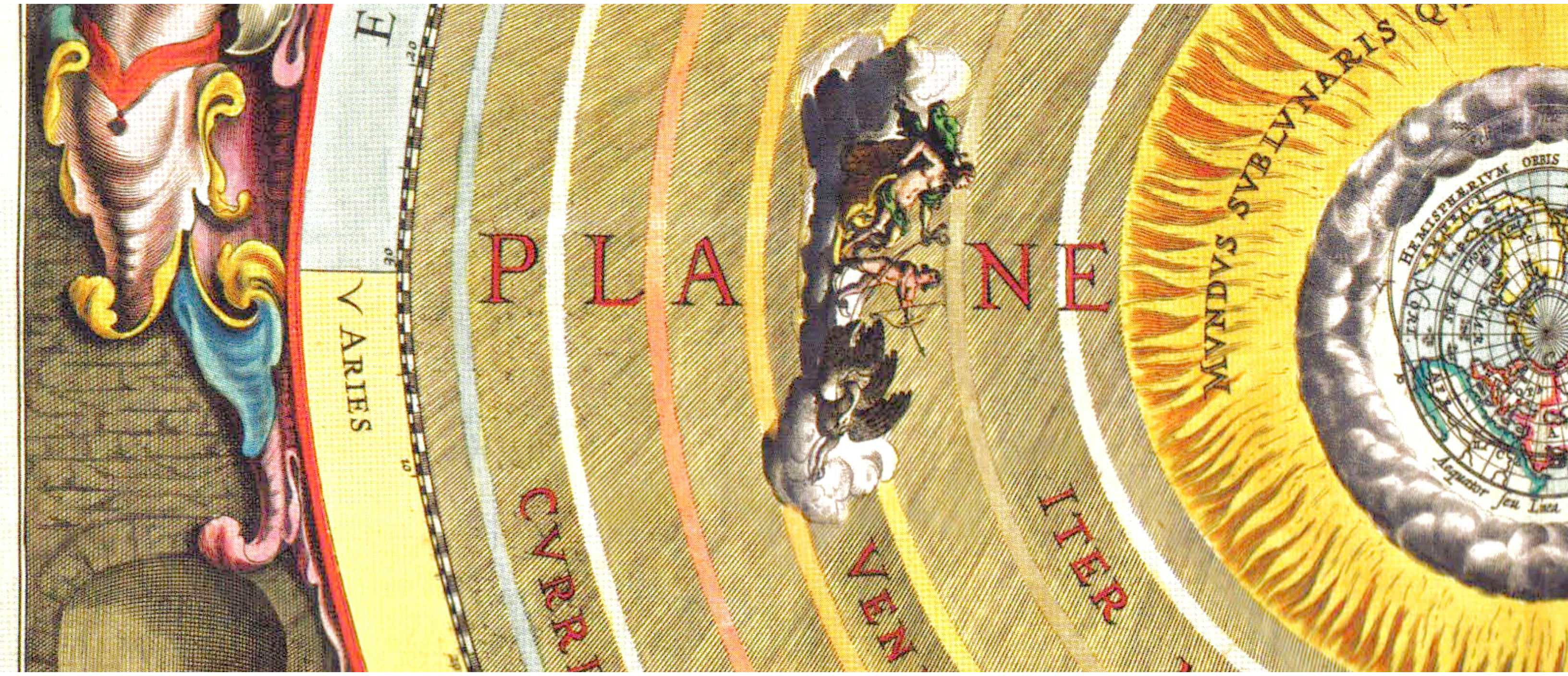


fig. 0.16- Alchemical symbols matching metals and planets, taken from Ripley's *Cantilena*.

ate after the symbolic death represented by fire.[74] Producing a similar kind of transformation, the restorative powers of the elixir were fabled to return grey hair to black, and to regrow teeth that had been lost, as well as imparting vigour to the limbs.[75]

For Western alchemies, the transmutation of matter and the processes that could effect this change were to remain a major focus. One of Geber's theories proposed that transmutation relied on either adding or subtracting from a base substance, or by rearranging its parts, in order to facilitate the process.[76] In relation to the theory of the four elements, this could be achieved by altering the proportions of a substance's earth, water, fire and air. The alchemist might also find the means to accelerate nature's maturation of base metals into precious ones, much as the smith was able to catalyze the changing of rock into metal by the application of fire. Experiments in transmutation had another goal: to locate a mechanism for catalyzing the desired outcome, a single, universal substance which would instantaneously spark such a transformation. In the West, this would be referred to as the Philosopher's Stone.

The nature of the Philosopher's Stone to induce metamorphosis made its substance capable not only of transmuting metals, but also of transforming man:[77] it was believed that the ability to accelerate the processes of nature could similarly reverse the effects of age on the body. In this capacity, the application of the Stone bears great similarity to the elixir of Chinese alchemy, with its powers to restore youth. Alongside the Philosopher's Stone and the elixir, a third interpretation of the transformative substance was developed: the *tincture* of Arabian alchemy.[78] Taking its roots from the Alexandrian preoccupation with colour, a theory was developed proposing that a red substance, absent from such metals as silver, tin and lead, was what imparted gold with its richer colour. According to this logic, the tincture would precipitate a similar transformation in the baser metals by imparting this absent quality.[79]



astronomia | astrologia

What a thing of mystery and wonder must the night sky have been to early man: its myriad stars, sparkling comets and flashes of shooting stars. This fascination, so elemental even today, surely predates the first attempts to order the points of light into a comprehendible system. The regular configuration of certain stars allowed early cultures to define constellations by imagining the forms of men, animals and objects between points of brightness. It was observed that some stars did not remain fixed in their position in the sky, and so came to be known as the wanderers, later to be understood as planets. These wanderers could be seen to move along a continuous band of constellations, a path called the ecliptic that represents the vantage point of Earth on the flattened plane of the solar system. Observations of the fixed and moving stars would form the basis of man's earliest cosmic sciences, astronomy and astrology.

The study of the cosmos that defined astronomy and astrology was to form part of a larger philosophy. The ancient Greeks believed in a great harmony of the universe that extended from things imperceptibly small to the magnitude of the heavens, and in this looked skyward for the explanation of common earthly occurrences. Ptolemy provides the first extensive written account of the effects of celestial events on earthly phenomena - both naturally occurring events, such as earthquakes and weather, as well as those caused by men, including wars.[80] The refinement of these concepts of cosmic influence would be the basis of astrological theory.

A rudimentary understanding of astrology must first begin with its structure. Astrology offers both a temporal and spatial frame of reference, for the zodiac can be understood in terms of time (the movement of Earth and the planets over the course of a day or a year) or space (the placement of stars and planets in relation to the Earth, the Sun and each

fig. 0.17- The Planisphere of Ptolemy, or the Mechanism of the Heavenly Orbits Following the Hypothesis of Ptolemy Laid Out in a Planar View.Andreas Cellarius, *Harmonica Macrocosmica*, 1660

other), with both dynamics operating simultaneously. The main spatial relationship in astrology is the placement of the Earth, Sun, Moon and planets in relation to the twelve constellations of the ecliptic, also known as the zodiac. From the vantage point of Earth, it appears that the Sun and planets move along the ecliptic, and therefore through the constellations representing the twelve astrological signs:

Aries — Taurus — Gemini — Leo — Cancer — Virgo —
Libra — Scorpio — Sagittarius — Capricorn — Aquarius — Pisces

Because of this dynamic, it can be said that a planet is within a certain sign when it is observed to be moving through one of the twelve constellations. Astrologers would come to attribute significance to the position of the planets in the signs, and their influence on life on Earth.

To each planet was ascribed a particular spirit that affected events on Earth, an influence corresponding to the character of the deity for which the planet was named. In this manner Venus, named for the fertility goddess, influenced the growth and prosperity of crops, while Mars held sway over the outcome of wars. The planets were also given rulership over the zodiac's twelve astrological signs:

Sun- Leo
Moon- Cancer
Mercury- Gemini and Virgo
Venus- Taurus and Libra
Mars- Aries and Scorpio
Jupiter- Sagittarius and Pisces
Saturn- Capricorn and Aquarius

Similarly, characteristics of the planets (as reflections of their constituent deities) were projected onto the signs connected with them. Using the same planetary examples, the Taurean eye for beauty meets the harmonic nature of Libra under Venus, the planet governed by the goddess of love. Conversely, Aries and Scorpio are susceptible to Martian flares of temper. Astrologers propose that the planets (as active forces in movement through the sky, each characterized by a particular energy) hold influence over earthly occurrences, and that this influence is filtered as a result of their placement in one of the zodiac's twelve signs.

What occurs over the course of a year with the cycling of the twelve signs is scaled to the quotidian through the twelve houses, another astrological structure through which the planets are perceived to move. The division of the twelve houses can also be understood in terms of time and space, as one cycle of the houses is equal to both the 24 hours of the day and a single rotation of the Earth. In terms of time, this division creates twelve "watches"[81] equal to two hours each, whereas spatially the divisions are based on the horizon and meridian. These two lines are emulated by the figure of the upright man: his feet placed on the horizontal, and the line of his body creating the vertical.[82] These breaks establish what are called the four cardinal angles: the Ascendant (the horizon where the sun rises), the Descendant (opposite, where the sun sets), the zenith (straight up, through the head) and the nadir (straight down, through the feet). This four-part division has several interpretations. The Baroque astrologer Sir George Wharton proposed that the partitions created by the four angles constituted the Four Ages of Man: Childhood, Youth, Manhood and Old Age.[83] He also tied these four stages with what he called the four actions: Childhood relating to life, Youth to action, Manhood to marriage and Old Age to passion.[84] In a more modern interpretation, the humanist astrologer Dane Rudhyar associates the break lines with selfhood (marked by the Ascendant), personal integration (the orientation downwards, establishing one's foundations), relatedness (marked by the Descendant) and social integration (the upwards gaze).[85] The subsequent division of each section into three, reasoned Wharton, was necessary as each "has a triplicity of its own nature; by these four Tripicities Heaven is divided into twelve parts."[86] Rudhyar elaborates by correlating the divisions with the three modes of the development of consciousness, which he classifies as thesis, antithesis and synthesis. The first, thesis, characterizes a beginning in which the individual gathers information and experience; the second, antithesis, occurs as this information and experience is used by the individual; and the third, synthesis, constitutes the lessons of the first two stages as they are interpreted and integrated.[87]

Each of the twelve astrological houses relates to a phase of human experience, with the most fundamental break in the twelve occurring at the horizon line of the Ascendant and Descendant. This bisection delineates the private and the public houses. Houses one to six relate to the individual's personal development, while houses seven to twelve speak to the relationship with the outside world: to one's place in society and his impact on it.[88] Wharton relates the Baroque interpretation of the twelve houses:

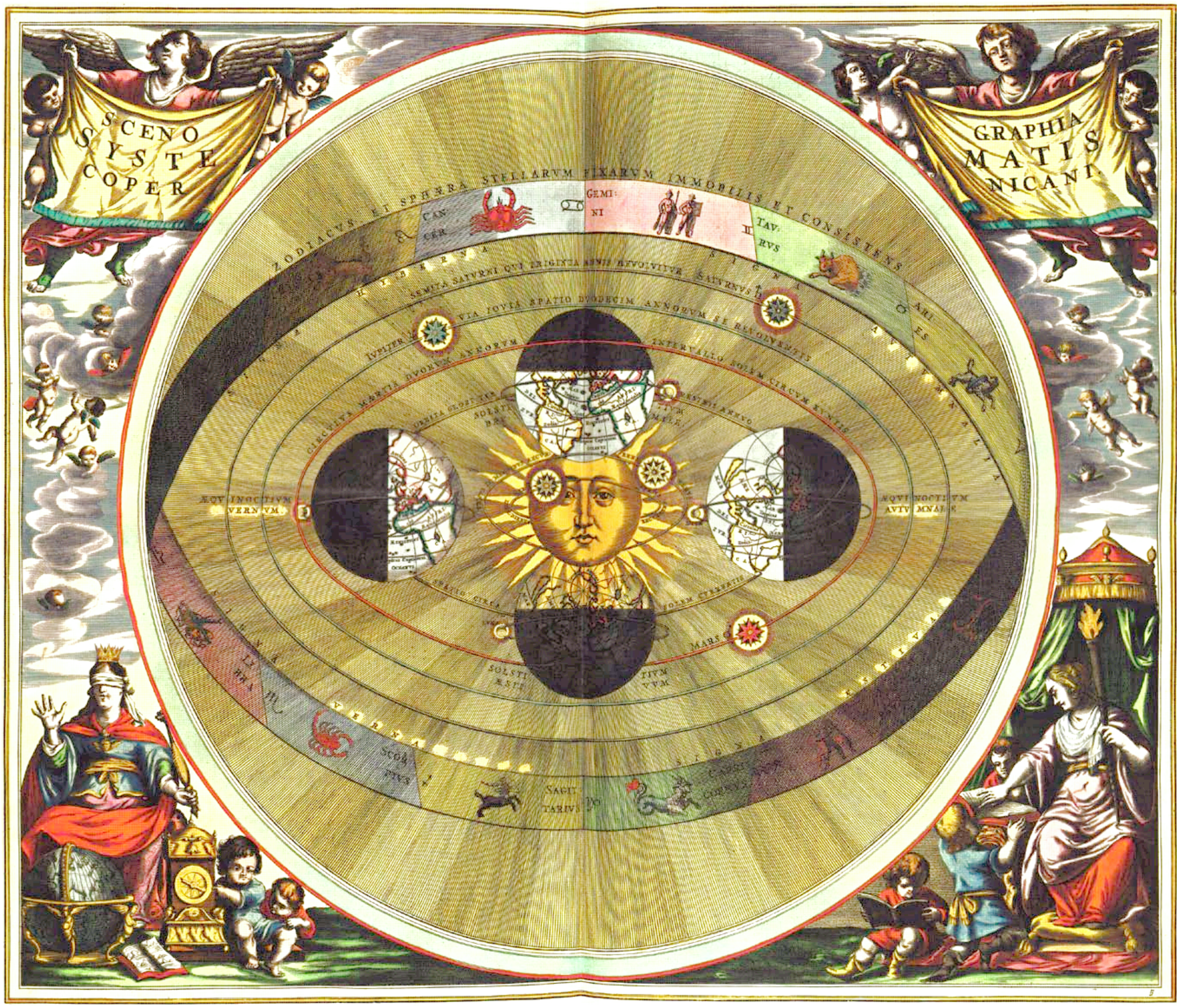


fig. 0.18- Scenograph of the Copernican World System,
Andreas Cellarius, *Harmonica Macrocosmica*, 1660

First house: Life
Second house: Riches
Third house: Brethren
Fourth house: Parents
Fifth house: Children
Sixth house: Servants
Seventh house: Marriage
Eighth house: Death
Ninth house: Religion
Tenth house: Magistracy
Eleventh house: Friends
Twelfth house: Enemies[89]

The meaning of the houses was reinterpreted over time, and modernist associations certainly follow these same themes (in spirit if not in name). One particular focus of a modernist reading of the houses is the reconciliation of aspects shared by houses located opposite each other on the astrological chart. For example, the third house is considered the house of the immediate environment, and the lessons learned from one's close personal experience with it;[90] across the chart is the ninth house, associated with philosophy, travel and education.[91] While both the third and ninth houses are host to imperatives of learning, the third's experience is more immediate (what can be of direct use to the individual), while the ninth house is more concerned with a broadened learning (beyond one's familiar world and how that contributes to a wider cultural understanding). The daily cycle of the twelve houses can be overlaid with the yearly cycle of the astrological signs, so that a correlation is made between the two, with the first house being tied to Aries and the twelfth to Pisces. According to this logic, planetary rulership of the signs is transposed to the houses as well:

First house: Aries, ruled by Mars
Second house: Taurus, ruled by Venus
Third house: Gemini, ruled by Mercury
Fourth house: Cancer, ruled by the Moon
Fifth house: Leo, ruled by the Sun
Sixth house: Virgo, ruled by Mercury
Seventh house: Libra, ruled by Venus
Eighth house: Scorpio, ruled by Mars
Ninth house: Sagittarius, ruled by Jupiter
Tenth house: Capricorn, ruled by Saturn
Eleventh house: Aquarius, ruled by Saturn
Twelfth house: Pisces, ruled by Jupiter

Through these correlations, it can be seen that the seven planets influence the astrological signs and houses; in turn, the energy of each planet is filtered through the lens of the house and sign in which it resides.

Astrology's interpretation of planetary influence as facilitating the outcome of earthly events would accordingly affect the growth and prosperity of the animal, plant and mineral kingdoms, including the world of metals.[92] The first written example relating metals to the seven classical planets dates from the second century CE, as written by the Christian historian Origen.[93] Origen wrote of the connection of Saturn with lead, the Sun with gold and the Moon with silver, and linked the other four planets with the metals iron, copper, tin and bronze. In the sixth century CE, the Roman philosopher Olympiodorus the Younger would add the connections of Mars with iron and Venus with copper, but would link Jupiter with mercury and Mercury with electrum. Finally, roughly a century later, the Byzantine astrologer Stephanos would make the final associations of Jupiter with tin and Mercury the planet with the metal of the same name.[94] The seven planets and their metals are so described by Geoffrey Chaucer in his Canones Yeomans Tale:

> *The bodies seven, eek, lo heer anon.*
> *Sol gold us, and Luna silver we declare;*
> *Mars yron, Mercurie is quyksilver;*
> *Saturnus leed, and Jubiter is tyn,*
> *And Venus coper, by my fathers kyn*[95].

The links between planets and metals were likely first made through perceived affinities: the brilliance of the Sun and the lustre of gold, the white clarity of both the Moon and silver. The god Mars would have cemented his affiliation with iron with the emergence of the metal in common warfare; quicksilver, with planet Mercury's fast, erratic movement*. Through their connections with the planets, the metals can be associated with the astrological signs and houses:

> Sun: Gold- Leo and the Fifth House
> Moon: Silver- Cancer and the Fourth House
> Mercury: Mercury- Gemini and the Third House, Virgo and the Sixth House
> Venus: Copper- Taurus and the Second House, Libra and the Seventh House
> Mars: Iron- Aries and the First House, Scorpio and the Eighth House
> Jupiter: Tin- Sagittarius and the Ninth House, Pisces and the Twelfth House
> Saturn: Lead- Capricorn and the Tenth, Aquarius and the Eleventh House

As projections of each planet's influence, the astrological signs and houses can be related to the seven classical metals as expressions of their shared mythology.

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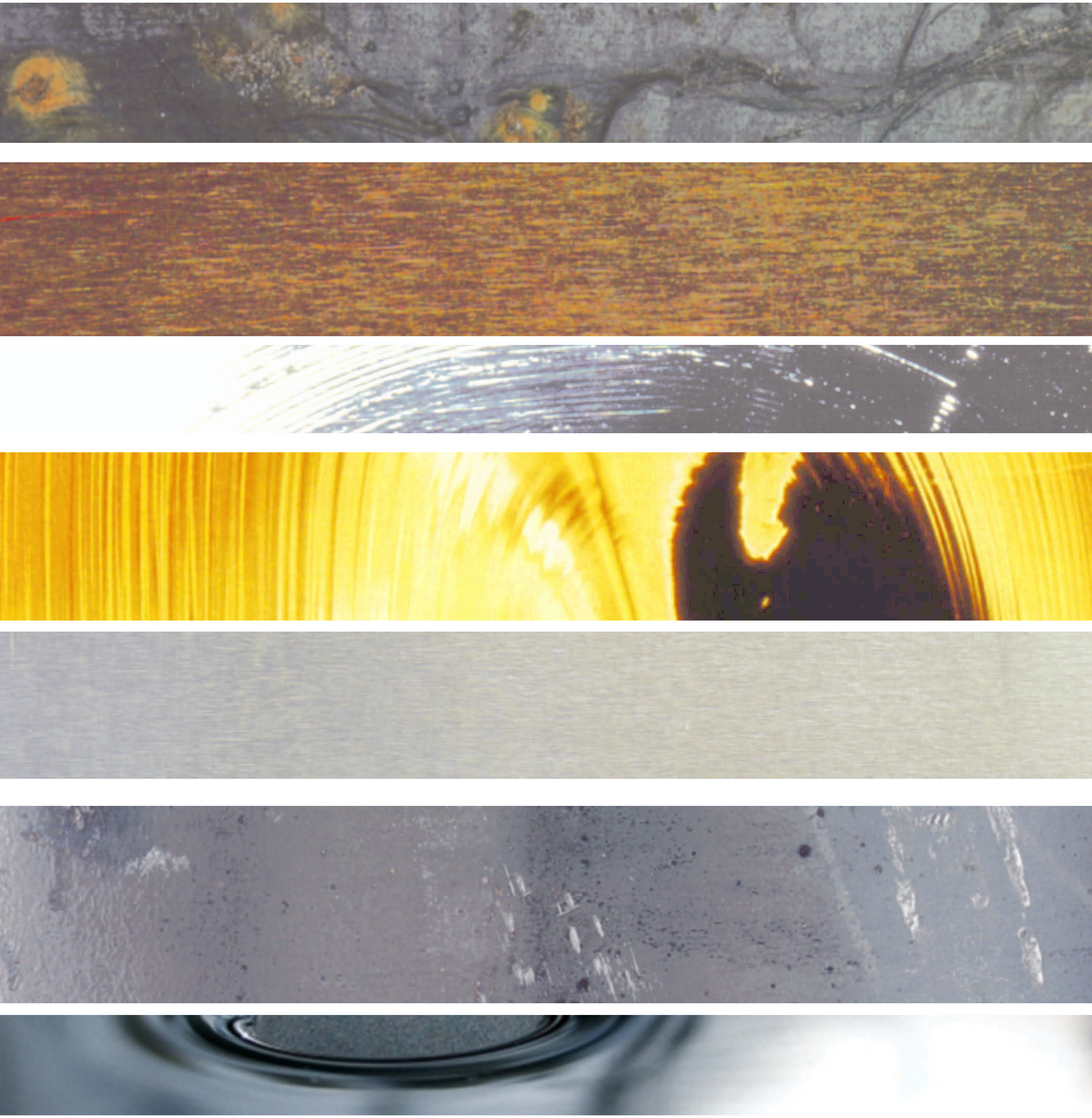
* The Ptolemaic theory of planetary revolution held that the planet Mercury revolved around the Earth. This revolution would have seemed fast and erratic as Mercury was actually making a much smaller orbit around the Sun, and because of this would appear from Earth to be moving both backward and forward in its orbit.



All of the seven classical metals, whether they are used for utilitarian purposes or adornment of the body, made invisible as structure behind other materials or exposed for aesthetic effect, have a rich pedigree that extends back thousands of years. Handling a tool of copper, a blade of iron or a ring of gold connects us to Paleolithic man who first made use of shiny, malleable stones. The presence of metals in everyday life is so common as to be taken for granted, yet it offers a tangible link back to the ancestors of mankind. We marvel at the same gold as the pharaohs, and silver catches our reflection just as it would have caught the reflection of Cleopatra. The recognition of such a legacy cannot help but affect one's perception of the world of metals, restoring part of the wonder that predates the beginning of the Age of Metals, thousands of years ago.

The following survey delves into the history of the seven classical metals, their traditional and contemporary uses, symbolisms and mythologies, and astrological associations. From this research, a concept will be presented that attempts to capture the essence of each metal, established as the metal's *imperative*. The imperative not only embodies the metal's physical characteristics and how these have influenced the manner in which it is used; it proposes that the very spirit of the metal compels man to consider and use it in a particular way. The definition of these imperatives, as a way of forming a different understanding of materiality, is the main objective of the metals survey.

The design component of the thesis will test the imperatives of the seven classical metals as generators for design. On a barren, open landscape in the Sudbury area south of Coniston, Ontario, the imperatives are expressed through seven interventions, seven spaces that communicate the nature of the metals in a manner that transcends their physical qualities as elemental materials.

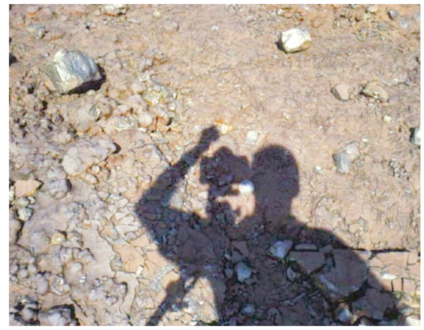
Opposite page:
figs. 0.19-1.25- the seven classical metals: iron, copper, silver, gold, tin, lead and mercury.

Book I : genius loci


fig. 1.1- Regrowth of trees over the blackened rock of Sudbury

The design of the seven metal spaces necessitated the selection of a site in which to ground the work and give it context. This site would allow the establishment of a single point of reference from which to calculate celestial events; it would also provide a terrestrial setting in which to explore those aspects of the research that are necessarily rooted in the landscape and one's experience of it. The former considers the immediate terrestrial conditions of the site rather ambiguously: it is a point at the intersection of lines of latitude and longitude from which celestial configurations can be determined, such as the viewing of the stars and planets as well as passing events such as eclipses. The latter interprets the context of the site at a range of scales, from the large - the broader landscape, the geology of the area, the massive wind and water patterns that extend beyond the line of sight - and the smaller, human scale - the textures of the surface conditions, the vegetation, the immediate corporeal sensation of proximity or vastness. These considerations provided a variety of lenses through which to further explore the metals.

Intuitively, it seemed important to find a site that provided, above all else, a quality of austerity in which the subtle movement of wind, the sun and the stars could be sensed and observed. Such an elemental landscape would also allow greater focus on the intricacies of the site, such as the feel of the ground underfoot, the burst of colour from small outcrops of grasses or moss, or the sheen of water on wet rock. Qualities of rockiness and austerity, desired for the project site, provided a preliminary starting point in situating the thesis.

coniston

figs. 1.2, 1.3 and 1.4- Sudbury imagery: scenic lookout at slag pouring site, devastated lands around the Coniston smelter, shards of solidified slag

The Sudbury area, with its long mining history, was chosen as the ground for the project site. From an aerial map, the Sudbury area can be seen as part of an oblong formation approximately 200 km across at its widest point. This oval, also known as the Sudbury Structure, is the remnant of a colossal meteor impact 1.8 billion years ago, a strike of such magnitude that it is second only to the one that created the globe's largest crater, the South African Vredefort Dome.[1] The cause of the crater's oval shape was long the subject of speculation; the meteor could have been similarly oval-shaped to the resulting crater, or it might have come in at such an angle as to have grazed the surface in its descent. The most plausible explanation offers that the crater was originally round (as is typical) but was deformed during the Penokean Orogeny*, when the crater was crushed by the Huronian Supergroup,[2] a mass of rock underlying most of the Great Lakes area. The meteor strike, known as the "Sudbury Event",[3] was to greatly affect the geology of the Sudbury Structure. The downward force of the meteor strike created a deep crater into which flowed molten rock rich in minerals.[4] Concentrated in the perimeter of the crater of the Sudbury Structure, there is a bounty not only of copper and nickel but also of gold, silver, lead and platinum as a result of this ages-old impact.

The selection of the exact project site was to follow a somewhat organic, intuitive process. Given a lack of familiarity with the area, a first overview was done through an investigation of aerial maps. Some of these maps displayed what seemed to be a rocky terrain, a desired quality for the project site. Several of these locations were singled out and studied according to contour maps of the area. From the aerial photos and contour maps, a first choice of site was made, and a trek planned into a roadless expanse south of Coniston, a smelter site only a few kilometres east of the city of Sudbury.

The barrenness found on the aerial photos was not to be seen as a matter of course in the Sudbury area. This was not the city popularized by the acid rain controversy of the 1980s. Sudbury first gained dubious notoriety in the 1960s for environmental degradation caused by a century's worth of unsustainable mining and forestry practices.[5] Early efforts to improve conditions, including the closure of two of the area's smelters and sintering plants in Coniston and Falconbridge,[6] made a minor

* An orogeny is a phase of mountain-building, caused by the upheaval of tectonic plates[7].

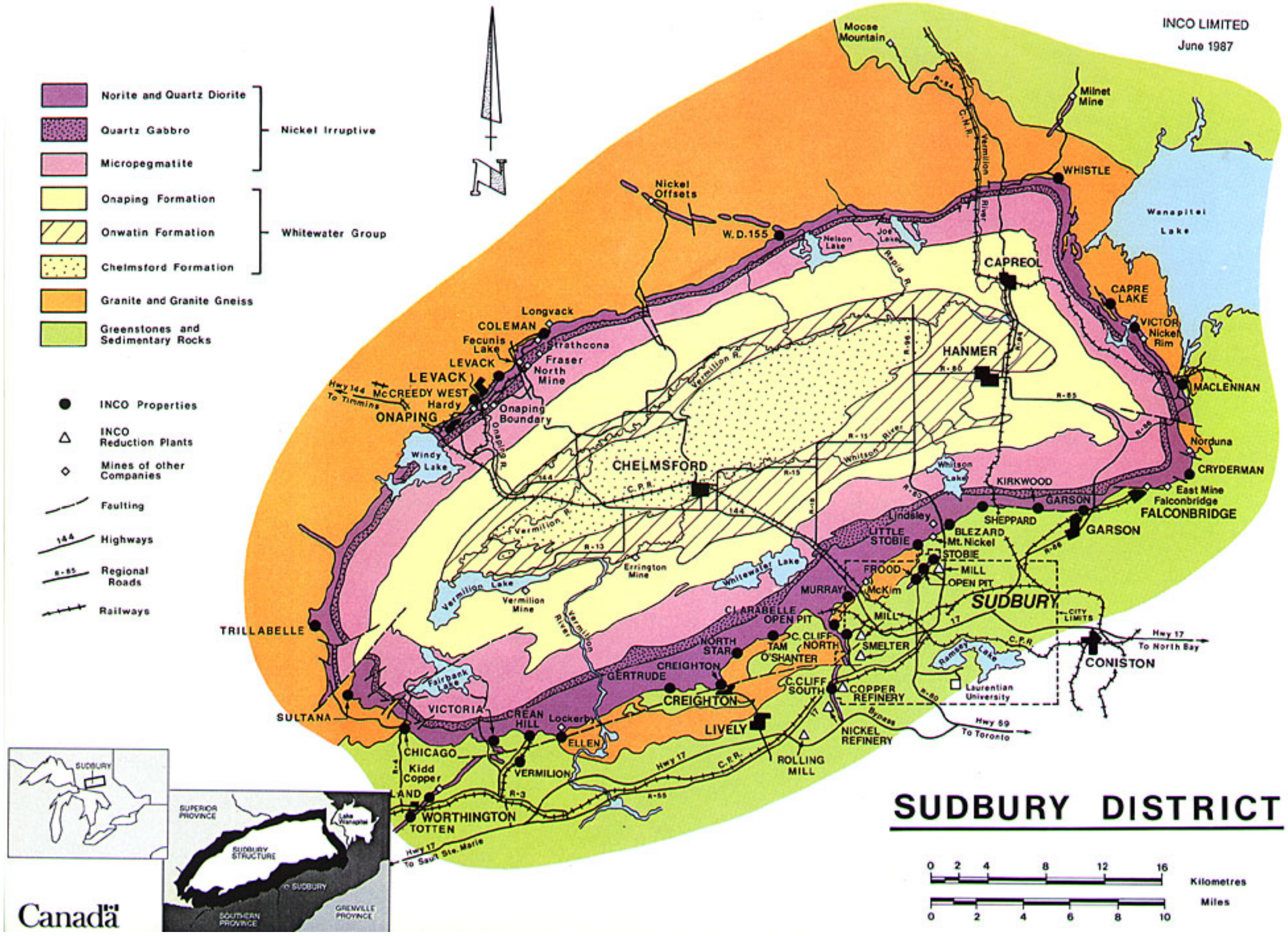
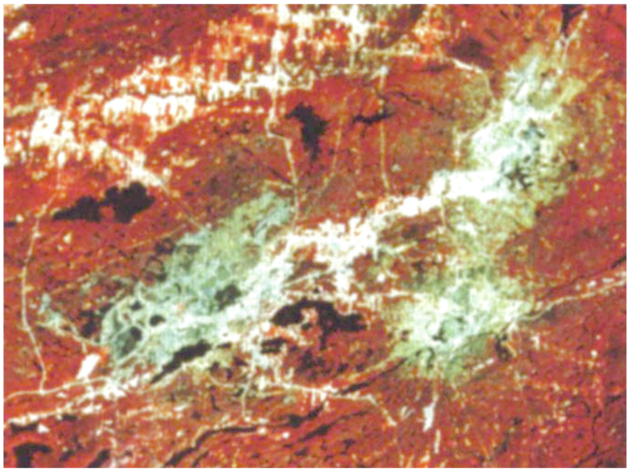
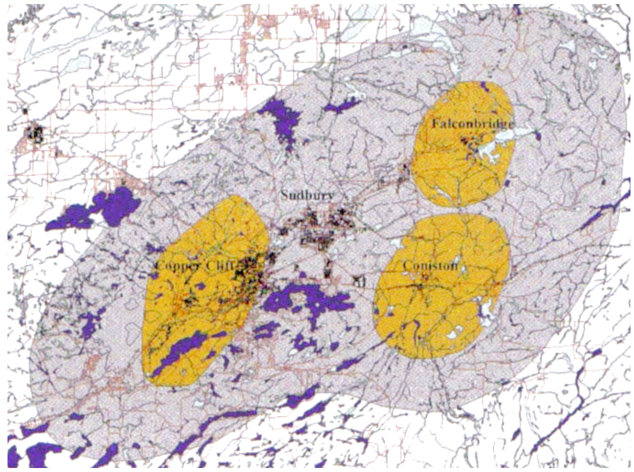


fig. 1.5- Diagram of the Sudbury Basin, indicating rock formations; note the oval shape which marks the meteorite's impact crater.

figs. 1.6 and 1.7- Barren and semi-barren zones in the Sudbury area: at left, an infrared satellite image taken in 1986 depicts barren (white) and semi-barren (green) territory; at right, barren lands in yellow and semi-barren in grey indicate locations of Sudbury's most prolific smelters at Copper Cliff, Falconbridge and Coniston.





improvement on the local surroundings, but the long-term abuse of the environment had already taken its toll, degrading soils and waterways to the detriment- or, in some cases, eradication- of vegetation and animal species. Of major concern to local residents was the poor air quality resulting from smelting emissions,[8] and strategies to improve on the problem proved to be fundamentally misguided. During the late 1970s and early 1980s, the new, taller smokestack at the Inco smelter - designed to discharge and disperse sulphur dioxide pollutants away from the air of local citizens - was determined to be simply shipping the contaminants downwind to other locations in Canada and the United States, where they fell as acid rain.[9] Even the city's name became synonymous with poor air quality, as air pollution in cities was calculated on a scale of 0 to 1 "Sudbury".[10]

In the midst of this bleak period, change was underway that would promote a new environmental era for the city. Starting in 1975, test plots for rehabilitation trials were established, beginning simply with dispensed limestone, fertilizer and grass seed.[11] The success of these early tests was to lead to increased volunteer support, and over the next two decades considerable advances were made, to the point where vegetation could be seen to develop spontaneously without having been planted. So remarkable were the results of the city's efforts that Sudbury was awarded a United Nations Local Government Honours Award at the 1992 Earth Summit.[12]

As part of the rehabilitation strategy, some 13000 hectares to the south of the Coniston smelter were reserved from the restoration efforts.[13] This neglected area, called the barrens preserve, serves as a reminder of responsibility to the land and what comes of a disregard for it. This reserve is apparent in aerial photographs, which record the transformation of the terrain in the greater area while the rock encircling Alice Lake and Baby Lake remains stark. Nevertheless, the primacy of this environment still manages to make one feel very close to nature in its naked vulnerability.

figs. 1.1.8, 1.9 and 1.10- Recovery efforts: resilient species such as birch and metal-tolerant grasses gain a foothold in the landscape.

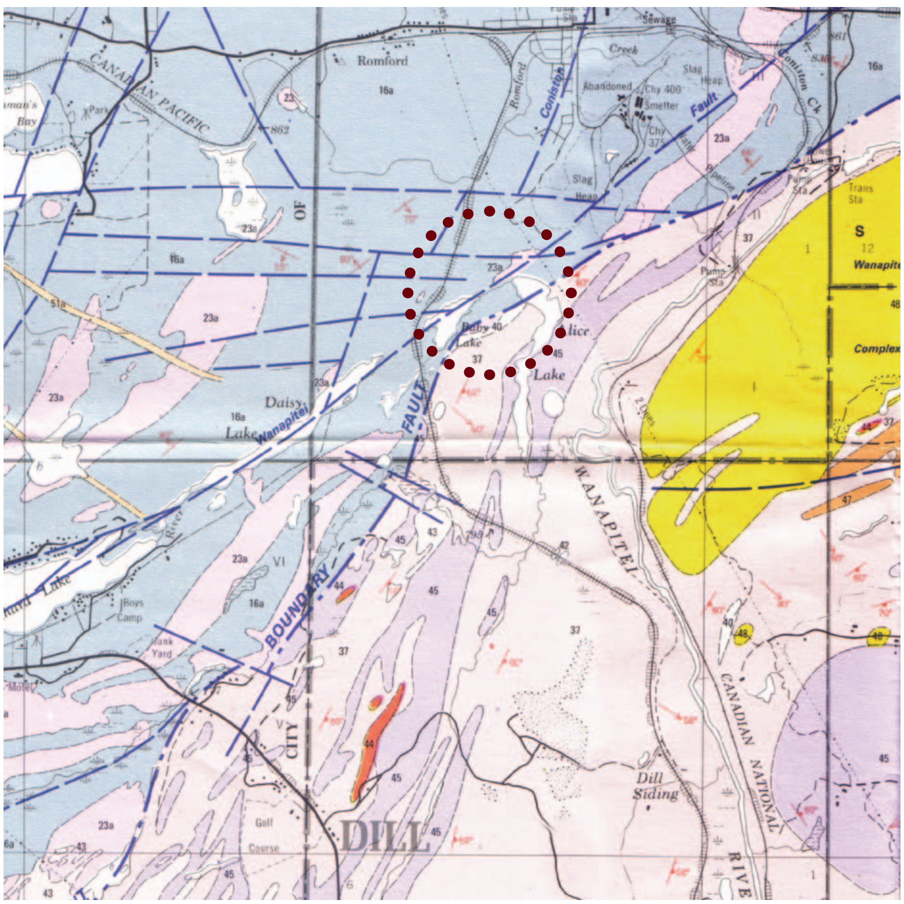


fig. 1.11- Map of Subsurface Geology, Sudbury/Coniston Area

The geology of the Sudbury Area can be seen to differ on either side of the Grenville Front Boundary Fault. To the south, the underlying rock is primarily gneiss; the Wanapitei Complex has a distinct geology of metagabbro intrusive rock. North of the Grenville Front, rock types are predominantly gabbro and basalt (both igneous rocks) and arkose (a sedimentary rock similar to sandstone). Also to the north is the Sudbury Igneous Complex, an area rich in quartzes such as granophyre (a rock resembling both granite and porphyry). The vicinity of the project site is circled.

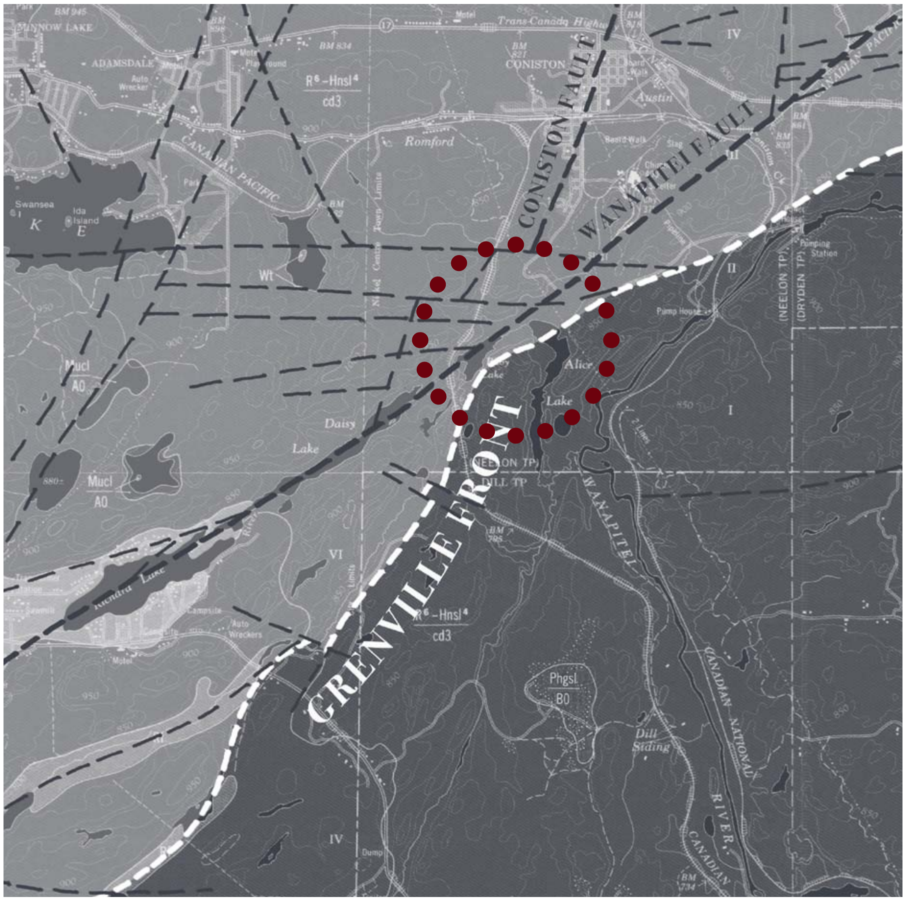


fig. 1.12- Map of Fault Lines, Sudbury/Coniston Area

The main tectonic feature of the Sudbury Area is the Grenville Front Tectonic Zone, which terminates along the Grenville Front Boundary Fault. This is an area of characteristically different rock, the roots of a massive mountain range created by the collision of the North and South American continental plates. To the north of the Grenville Fault are a series of smaller features including the Wanapitei, Coniston and Garson Faults.

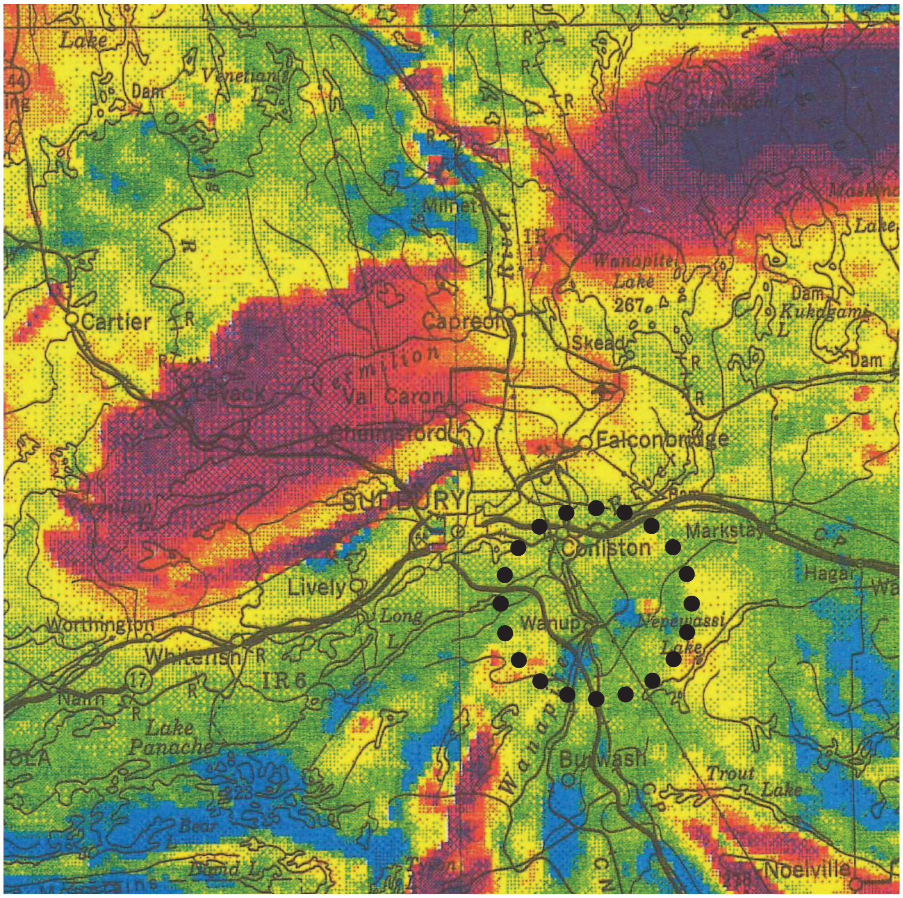


fig. 1.13- Map of Magnetic Anomalies, Sudbury Basin

Magnetic anomaly maps are used to predict underlying rock formations, particularly the location of magnetic mineral ores, through layers of vegetation and other rock. These pockets of ore tend to cause a deviation of the compass point from its heading towards magnetic north (itself typically an inaccurate indication of true north). Yellow areas provide the most neutral reading, while those ranging from orange to purple cause the greatest positive deviation, and green to blue the greatest negative deviation. Dark purple areas, such as that in the area of the Subdury impact crater, are locations of highly magnetic rock; these can shift the compass point by as much as five degrees from a true reading.

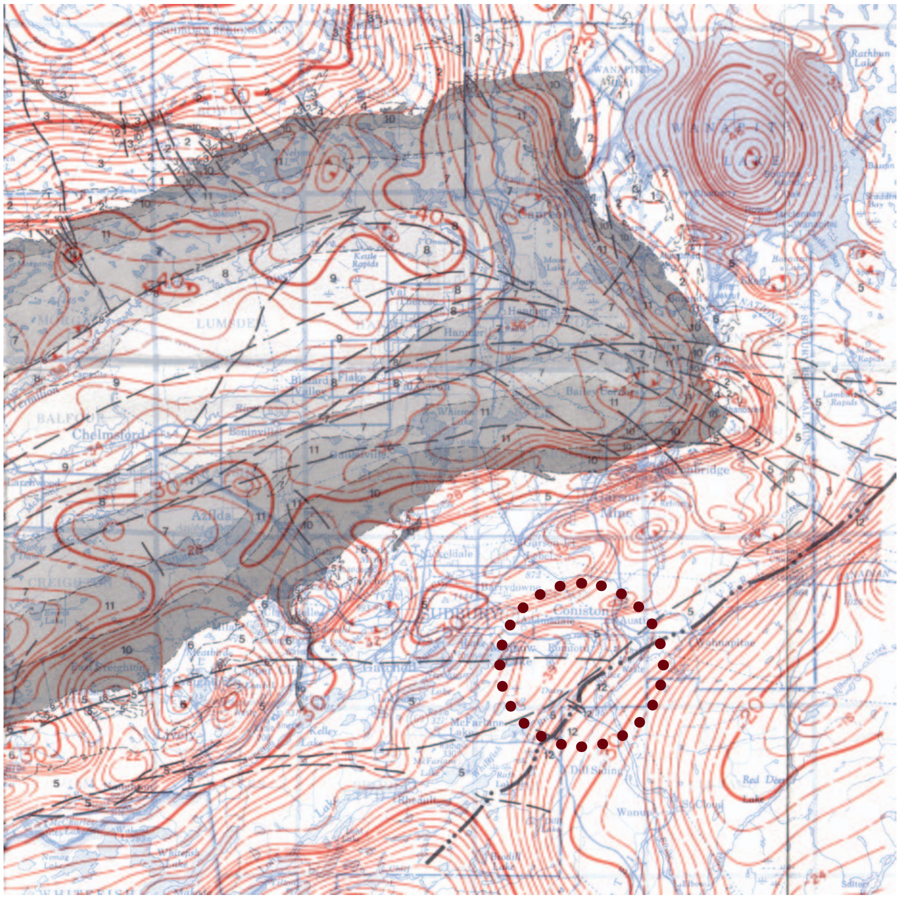


fig. 1.14- Map of Gravity Anomalies, Sudbury Basin

Gravity anomalies are realized as a discrepancy between a theoretical gravity reading for a certain area (calculated by formulae) as compared with its actual measured reading. These disturbances are typically caused by an uneven distribution of mass on the Earth's surface; given that the crust of the Earth is not a constant and unvaried terrain, gravity anomalies exist in all locations and at a multiplicity of scales. Gravity anomaly is often used in archaeological prospecting as subterranean open space provides a distinct gravity reading from its surroundings.

fig. 1.15- Map of Contours, Waterways, Marshland and Vegetation, Coniston Area

Sudbury has long epitomized the environmentally devastated landscape. Up until the 1980s, the mining industry degraded soils and waterways to the detriment of vegetation and fish species. In the years since Sudbury's environmental low-point, the local population has instrumented a rehabilitation plan that has seen thousands of hectares restored of plant and animal life: restoration of the pH balance of the soil and the introduction of resilient species has helped reestablish biodiversity.

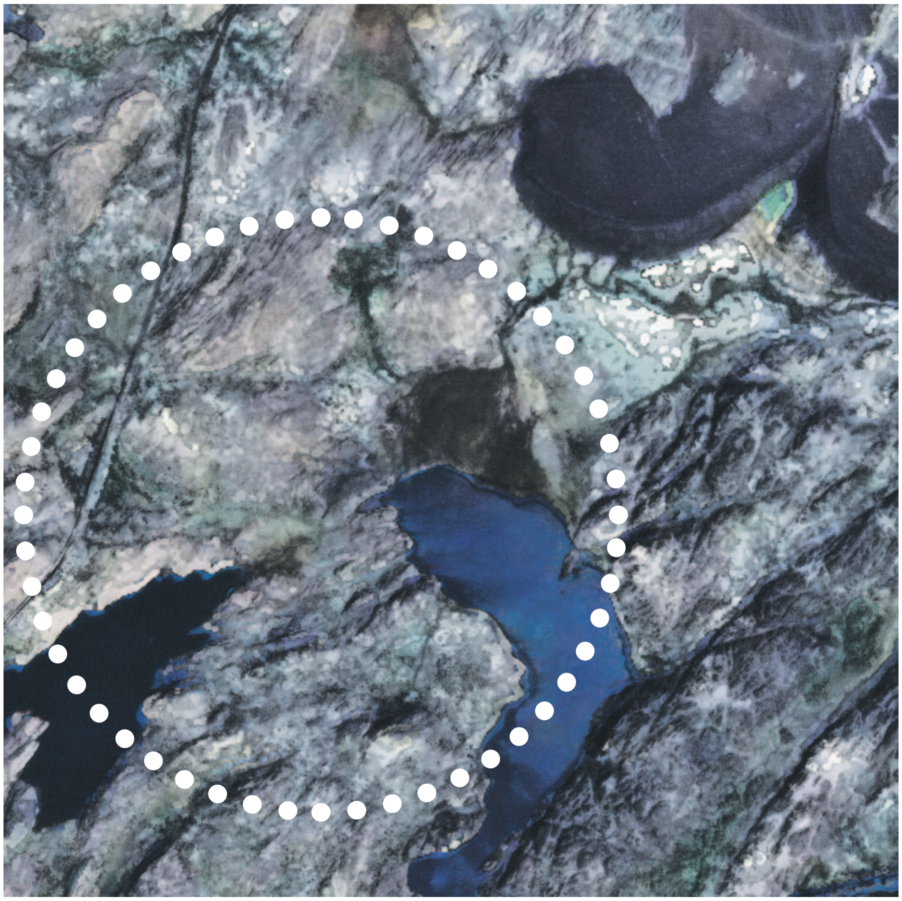


fig. 1.16- Aerial View of the Coniston Area

A bird's eye view of the area south of Coniston demonstrates the barren, rocky terrain that once characterized the Sudbury Area. 13000 hectares of this landscape has been set aside from the rehabilitation efforts to stand as testament to the effects of unsustainable industrial practices, and to give perspective to the success of the community's restoration efforts. Despite being omitted from the dedicated rehabilitation effort, certain species of vegetation, including stands of birch trees, have begun to resettle the area.

The drive from North Bay to Sudbury, Saturday 01 September 2007, 11.30h

There is a chill in the air; is it because we are getting farther north, or does the coldness come out of the rock? The landscape exposes pieces of rust-stained rock at intervals, but it's mostly stands of birch and pine, some deciduous trees already showing signs of yellow, even red. Then pastureland: that isn't what I expected here. I guess I thought it would be just miles and miles of barrenness. Of rock. It's not.

But looking down as we cross the Sturgeon River, it seems there are moments of the landscape I'm looking for.

My criteria for this landscape are vague - proximity of water, some kind of promontory, evidence of movement, a path? Perhaps it is a wild goose chase. I am operating purely on the assumption that the site is here somewhere and that intuition will take hold, pulling me to the right place. I am operating on the assumption that my naivete in this respect will also allow me to move with less resistance.

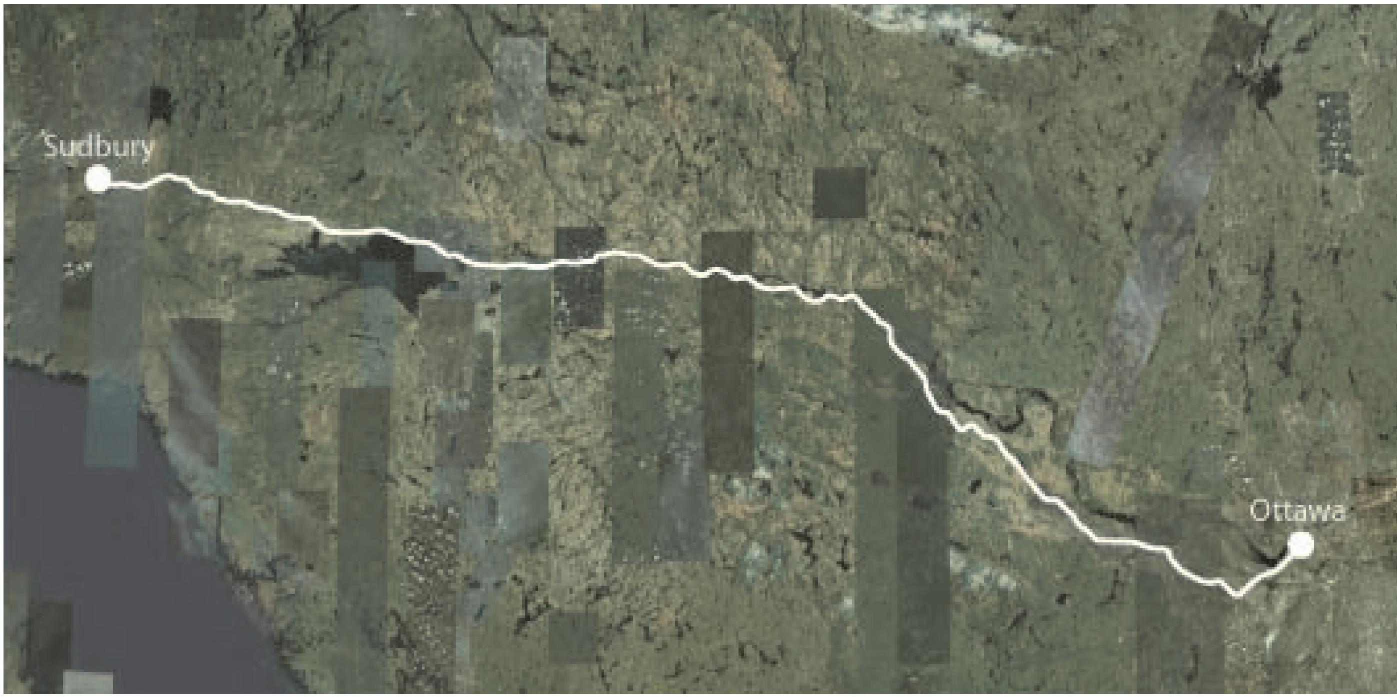


fig. 1.17- drive from Ottawa to Sudbury

First attempt to approach Alice Lake site, 13.15h

We follow Coniston Hydro Road, not knowing whether we are allowed to be down here or not. The Wanapitei River leads down from the dam a couple of kilometres east of Alice Lake, but the terrain is impassible: there's no riverbank to follow, just steep shears of rock topped with thick trees. A small waterfall I hadn't noticed on the aerials, and evidence that someone has moved through here: bent grasses, snapped twigs. Empty bottles.

There are strange traces here that I can't identify, chunks of burnished rock that look melted on the top. Large boulders that do not match the rock of their surroundings. Glacial freeloaders then?

The terrain is impassible. Must find another route.

fig. 1.18- view down river towards Alice Lake

fig. 1.19- waterfall feeding into river

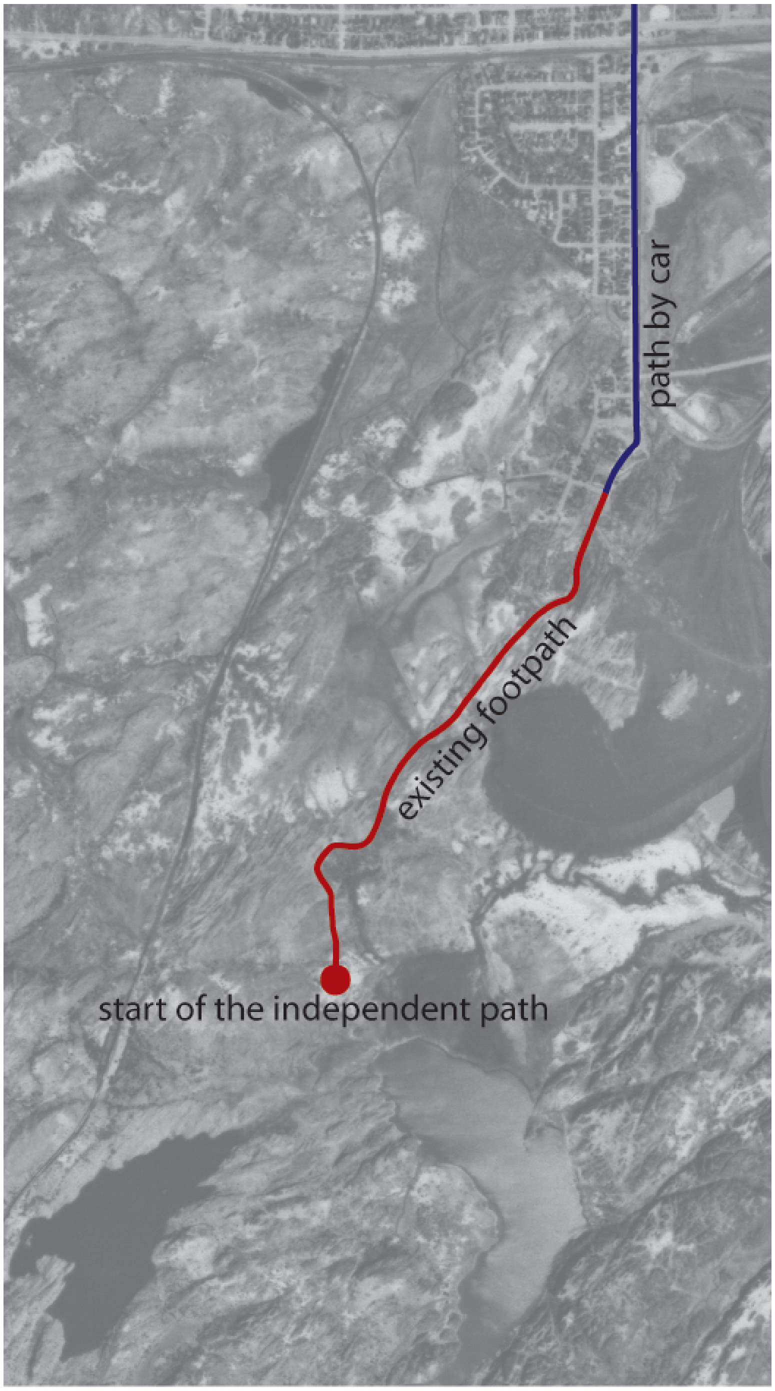


fig. 1.20- second attempt to approach Alice Lake: through town of Coniston

Second attempt to approach Alice Lake site, 14.10h

From satellite imagery, it appears that there is a path leading down from Edward Street that goes in the direction of Alice Lake. We park the car, pack bags and start walking. We run into a senior couple who notice our fishing rod, so we ask about fish. Alice Lake got the runoff from what used to be the city dump, south of the slag heap; not much fishing there. We find evidence of the dump on the trail. Construction waste - concrete pillars, twisted rebar. Broken glass. The trail goes from looking drivable to looking drivable only in a 4x4, to looking formerly drivable in a 4x4 before sections of the road washed away in a rainstorm. The slag heap comes into view on the left. Expected it to look black, but it doesn't - it looks more brown. Getting closer there are chunks of this brown on the road. I recognize in it the piece of rock from nearby the dam. Looking closer it's more obvious that these pieces of rock were liquid, some full of bubbles, most with a patina of rust. Slag is mostly iron and silica. Rusty dirty glass.

The first lookout: standing on glass embedded into the soil, someone's long-ago refuse, looking towards the south: the first view of the lake.

There are massive power line towers in the area, probably leading from the dam upstream. The wind is picking up the further south we go. It sets the wires to singing over the dull drone of electricity pumping. The couple said we'd find Baby Lake and Daisy Lake west of Alice and that they'd be more likely to have fish.

At the end of the old 4x4 trail is a flat where vehicles must have turned around at some point. To the left, the north end of Alice Lake is surrounded by marsh. To the right is Baby Lake, accessible over rock. We decide to go right. Seems easier going.

Within only a few metres we go from walking on hardened mud to walking along this sand-coloured rock, deeply banded, like sedimentary rock that was layered and then turned on its side. Or is it deeply scratched by glaciers? The bands run southwest and stretch for several hundred metres, which becomes clearer once we realize we have followed the bands for some time. As we pass over one stretch of rock, the next one appears, similarly banded. There's several hundred metres worth of this. We follow the lines in the rock. Sometimes there are the bleached bones of trees, shards of them that have worked their way into the grooves in the rock like brittle compass needles.

We follow the bands until they are intersected by a line of birches. The trees hide a cleft in the rock with a small stream running through it. We climb to get across the wider part of the break. Once clear of the trees the bands resume their intent directionality. They drag us uphill, cresting one ridge to find the train tracks settled into a tight valley below. Looking into the depths, my foot hits something strange: a railway spike, bent and rusted, the corrosion leaving the surface pockmarked. Likely it's been here since they constructed the railroad, which was at the turn of the century. It's a sign: a pivot point in the path. Looking south the whole expanse of Baby Lake opens up to view, draining into Alice to the east, and Daisy to the west. It is 3pm and the sun glints off the water. Following the direction of the sun I look east, and the bands align again. They appear to align with a high point on the edge of Alice Lake. The promontory?

Perpendicular to the bands we descend, heading south, to the water's edge. The bands lead into the water. Looking back, this becomes evident: that during the entire walk inland, following the bands, we were pushing into the wind- and a strong wind at that. And from this point, looking towards the sun, its position in the sky with the direction of the wind and the orientation of the bands, all three fall into perfect alignment. We begin to follow the bands eastward, the wind and sun at our backs, pushing us along the pattern in the rock.

We are getting closer to the promontory when a striking change in the rock occurs. What was striated rock, sandy brown in colour, now abruptly transforms to hard, black rock which breaks into solid chunks that fit together as neatly as puzzle pieces. The black rock makes a high-pitched clink when two pieces strike each other. The edges of this rock seem not to have eroded at all. At one point there is a line of white quartzite inscribed in a break in the black rock, pointing due south. When standing on the promontory there seems to be a lot of variation in the line of the horizon: the natural undulations of the rock, the slag heap to the northeast. But lying down is another experience. I go to the edge of the promontory that is cutting sharp into the wind and lie down here, pointing my head north. From here, from this vantage point, the horizon is simply massive. It is massive and it is just the effect that I want. Straight north of my head is a little tree, fighting its way out of the rock. I stand up to a wind that seemed but brisk on the walk here, but now almost blows me over. Get out of here. You have what you came for.

Back through the bands, back onto the muddy flat, the jeep track, the slag heap. Looking back, between the tin and silver spaces, on an outcrop of rock, a short, hardy jack pine stands defiant against the wind.

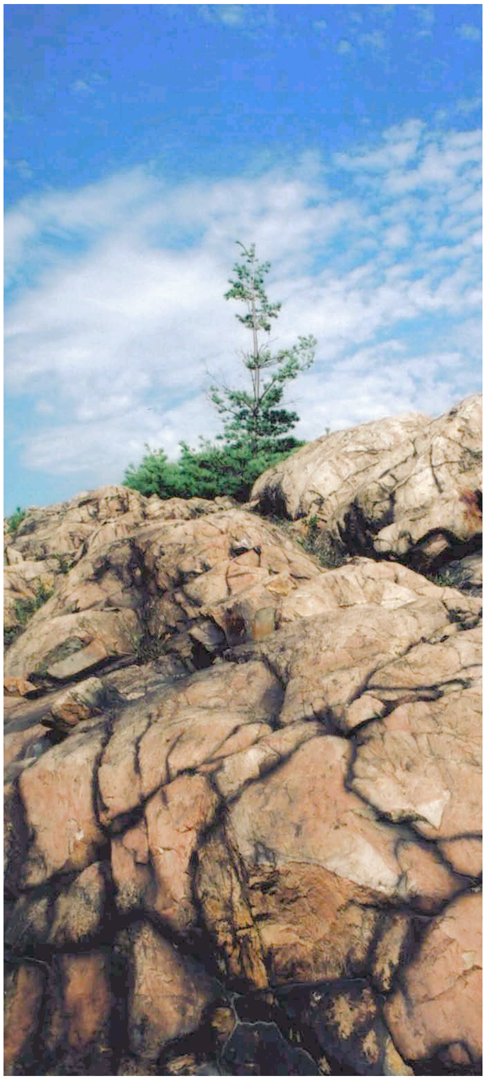
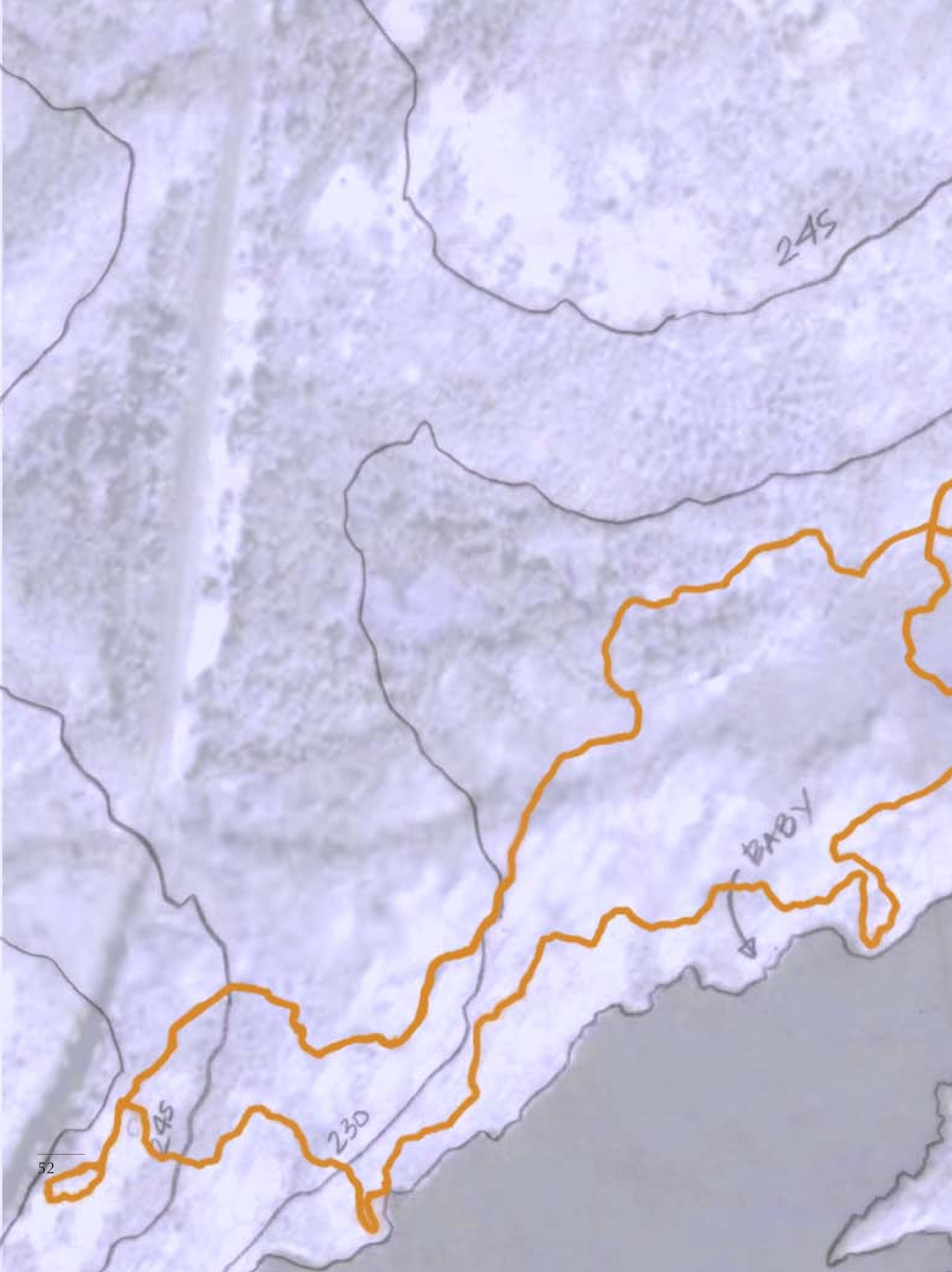


fig. 1.21- Jack pine, watching over the landscape

fig. 1.22- Following page: path of the first foray across the site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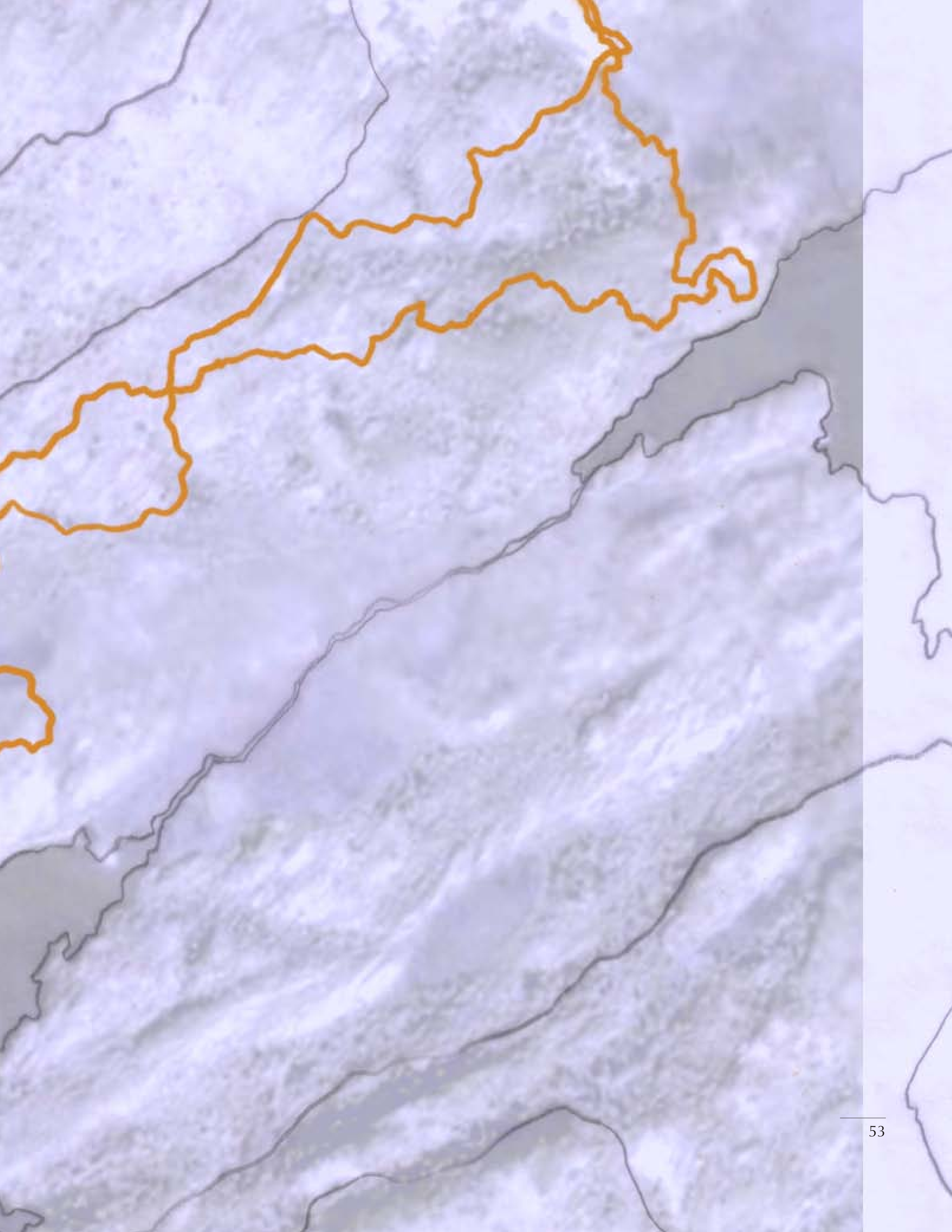


Pervideo Metallico
survey of the metals

fig. 2.0- The Periodic Table of the Elements

1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.0121											5 B 10.811	6 C 12.010	7 N 14.006	8 O 15.999	9 F 18.998	10 Ne 20.179
11 Na 22.989	12 Mg 24.305											13 Al 26.981	14 Si 28.085	15 P 30.973	16 S 32.065	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.955	22 Ti 47.867	23 V 50.941	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.38	31 Ga 69.723	32 Ge 72.64	33 As 74.921	34 Se 78.96	35 Br 79.904	36 Kr 83.798
37 Rb 85.467	38 Sr 87.62	39 Y 88.905	40 Zr 91.224	41 Nb 92.906	42 Mo 95.96	43 Tc (97.907)	44 Ru 101.07	45 Rh 102.90	46 Pd 106.42	47 Ag 107.86	48 Cd 112.41	49 In 114.81	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.90	56 Ba 137.32	57-71	72 Hf 178.49	73 Ta 180.94	74 W 183.84	75 Re 186.20	76 Os 190.23	77 Ir 192.21	78 Pt 195.08	79 Au 196.96	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (208.98)	85 At (209.98)	86 Rn (222.01)
87 Fr (223)	88 Ra (226)	89-103	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (271)	111 Rg (272)	112 Uub (285)	113 Uut (284)	114 Uuq (289)	115 Uup (288)	116 Uuh (292)	117 Uus (unknown)	118 Uuo (294)

57 La 138.90	58 Ce 140.11	59 Pr 140.90	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.25	69 Tm 168.93	70 Yb 173.05	71 Lu 174.96
89 Ac (227)	90 Th 232.03	91 Pa 231.03	92 U 238.02	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

- Noble Gases
- Alkali Metals
- Alkali Earth Metals
- Transition Metals
- Poor Metals
- Metalloids
- Nonmetals
- Lanthanoids
- Actinoids
- Classical Metals

Book II : plumbum

♄ Pb 82

the fable of mnemosyne

For many millennia, peace reigned
Upon the rock of the seven spirits.
Only the four winds, migrating birds
Flying overhead, herds of caribou
Ranging the plains for food came
As visitors to the site.
Then came women in worship
Of the blood-red eclipsed Moon,
Their secret rituals enfolded in words.
Mnemosyne's great gift of language
And the stories made from it
Fell from the sky to peoples the world over.

But strife soon was to threaten words,
Sacrifice language, slaughter stories.
For in the lands to the west, the Parcae,
Spinning and measuring and cutting the threads of life
Found themselves busy, as they were
In any occasion of war.
They visited Mnemosyne as she sang
With the visiting Eurus,
Songs of distant lands in tongues
Newly sounded on these shores.

Nona, spinner of the thread
Of life, spake first:
Fair goddess, the threads of which
These nomad lives are spun
Is thin. Time grows short,
For the tales they tell amongst themselves
Will perish with the people.

Decima, measurer of the threads
With her rod of years and days,
Supported her sister:
Yea, the threads of these peoples
Do not measure long,
And with no other threads to
Pass to, their names
Are destined to be lost,
Sweet Mnemosyne. Goddess of words,
Let them not fall into obscurity.

Lastly, Morta, the most distant
And hard-hearted of the sisters,
Wielder of the shears which sever
The living from the dead,
Found herself sympathetic.
Goddess, she pleaded.
If you were but to catch these threads
As they fell
You would catch their names, their stories,
Their legacies as well.
Would that they could be safe-kept away
From the fickleness of men,
Until the day when they might be rediscovered,
Life breathed back into them,
Floating ancient and lost words
On the wind anew.

Mnemosyne, aware of quick-moving
Time, called on Vulcan
To build for her a vault of lead,
Deep, narrow, cut into the rock.
All sides lined with lead, encased
Completely, so that no air, nor water,
Nor words could move in or out.
At the bottom, compartments,
Each closing flush
Into the wall of rock,
Each one for a story:
Each one for a thread that had been
A life,
Each one a name.
Vulcan laboured over the vault,
Its thousands of thousands of drawers,
Its steep descent into the rock, all seams sealed
As tight as a water pipe.

Mnemosyne held her hands
Beneath the shears of Morta, catching
One, ten, one hundred threads.
Descending into the vault, she placed each
In its tiny drawer, first holding them to
Her ear, for the gift of its name.
Again and again she descended
Until the vault, with its many drawers,
Was filled, until
Mnemosyne's head rang
With a cacophony of syllables.
And with that, Vulcan lifted his hammer,
And with fire and force
Sealed shut the vault.

And inside the archive of lead
The names and stories lay safe,
Their songs mixing together
Like the constellations in the sky: all distinct,
Yet weaving a tapestry of points of light.
The lead became heavy with the stories
Until the very walls of the vault
Became epic.

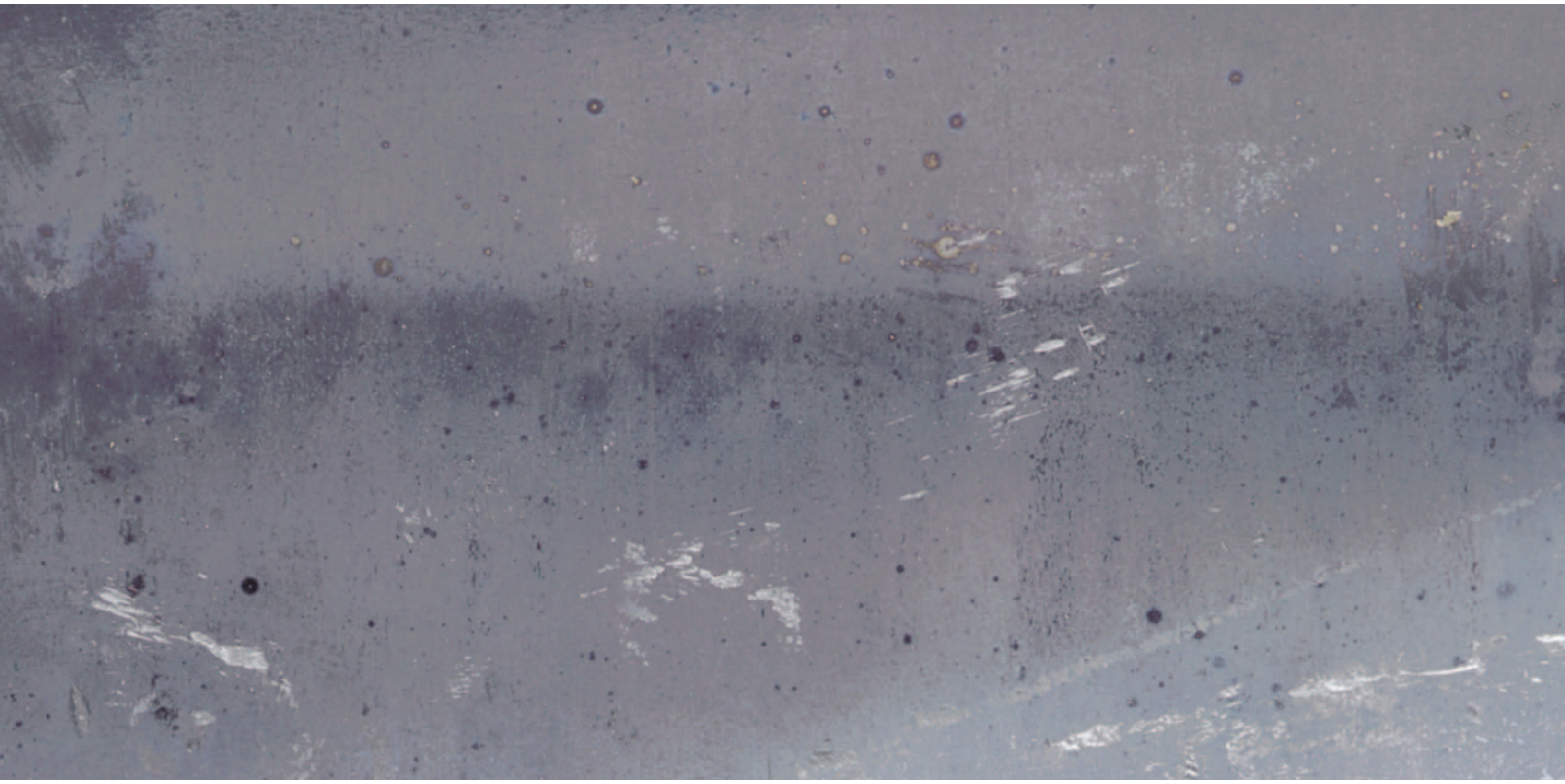


fig. 2.1- Lead

Lead is applied in accordance with traditional practice following the normal precautions necessary for the use of metals for cladding and roofing. Loose-lock seams must be provided at joints and except in exceptional circumstances all the fixings should be concealed under the lead. Any brass screws passing through lead sheeting from the outer surface are normally covered with caps of lead which are 'lead-burned' on to the surrounding lead sheet. The high density of lead, and its general lack of rigidity, requires a strong supporting structure and firm, well-designed fixings.

- John W. Simpson and Peter J. Horrobin,
The Weathering and Performance of Building Materials

Pb from the latin *plumbum,* likely from the greek *pelios,* meaning bluish black

North of the city centre of Rome, the three pods of Renzo Piano's Parco della Musica sit like silvery scarabs with their backs to the sun, their skins the chalky patina of lead. Sheets of the metal are joined together in long seams, running downwards as paths for rainwater. The patina is thicker where drops of water have become trapped in the folds of the metal. Lead is deceptively soft, so much so that sheets of the metal will droop over time, like somber drapery drawn to gravity's pull. Did Piano know this of lead, that the metal would yearn to reintegrate itself with the ground from which it came, its very molecules orienting themselves to the centre of the earth? Do these roofs of lead, like heavy metal cloaks, keep his scarabs from scurrying away?

A soft, malleable grey metal, lead has been used in human civilization for some seven thousand years. Its discovery likely resulted when a piece of the mineral galena, commonly used in ancient Egypt as a cosmetic,[1] was dropped into fire, and by virtue of its low melting point the metal would have been separated from the rock. To ancient philosophers, lead was considered to be the oldest and most base of the seven classical metals.[2] With an atomic number of 82, lead's position on the periodic table establishes it as the heaviest of the stable elements, meaning that all other heavier elements are radioactive in nature. Through the process of radioactive decay, elements such as uranium and radium lose atomic weight and eventually turn into lead, at which point their transformation ceases.[3] In this process, lead represents a final limit state: theoretically speaking, a piece of the metal could have been, at one time, plutonium*,

* The process of radioactive decay is highly variable for each unstable element. For practical purposes, this is expressed in terms of *half life*. An element's half life is the period of time in which 50% of its radioactive atoms have decayed. Therefore, after one half life, 50% of an element's radioactive atoms remain; after another, 50% of these remaining radioactive atoms have decayed. The final result of this decay would be zero radioactive atoms, or lead. Half-life can be quite short, such as the 20 minutes of plutonium isotope Pu-233, or extremely long as with the element bismuth, which has a half life of 1 900 000 000 000 000 000 years[4].

fig. 2.2- lead sling pellets, Roman, 1st century BCE to 4th century CE

fig. 2.3- lead curse tablet, Roman, 1st to 3rd century CE. The softness of the lead allowed messages to be embossed into the sheet.

before radioactive decay brought it to a state of atomic inertia. This is not altogether divergent from ancient theories that considered lead as the basest of metals, given that it represents an end point to this particular process of transformation.

Too soft to make into tools and possessing a dull surface lacking in lustre, lead's humble utility nevertheless became widespread throughout the ancient world. The earliest appearance of lead in human civilization dates back to 5000 BCE as found in the ceramic glazes of Egyptian pottery.[5] The use of lead in glazes imparts vibrancy of colour,[6] and it is for this reason that it continues to form a component of paints, particularly where durability is a concern, such as that used for highway markings. Vessels made of lead have been discovered among Mesopotamian artifacts of 3500 BCE;[7] in fact, most of the lead articles that date from this period have the function of carrying water, whether the metal was shaped into tumblers, ewers or plumbing pipes. The earliest example of lead plumbing is found in Egyptian ruins of the 5th dynasty (circa 2500 BCE),[8] and it was similarly used in Mesopotamia in the centuries that followed. However, the use of lead to transport water was relatively limited until the Romans sought to carry large volumes of water for their many public baths and fountains. This remained a significant use of the material for several centuries, despite warnings from such authorities as Vitruvius about the dangers of lead to the human body:

> *"…lead is found to be harmful for the reason that white lead is derived from it, and this is said to be hurtful to the human system… This we can exemplify from plumbers, since in them the natural colour of the body is replaced by a deep pallor. For when lead is smelted in casting, the fumes from it settle upon their members, and day after day burn out and take away all the virtues of the blood from their limbs."* [9]

Since the observations of Vitruvius, science has confirmed that lead poisoning negatively affects a number of bodily systems, from the circulatory to the gastrointestinal to the reproductive. It is also linked to disorders of the brain and central nervous system, causing cognitive function and reduced IQ, and may be a cause of schizophrenia.[10] The dark, brooding moods that accompany some lead-induced mental disorders have been informally termed as Saturnism in reference to the moody and irritable Roman god. A significant source of lead poisoning in the ancient world related to foodstuffs, namely lead acetate or sugar of lead.[11] In ancient Rome, it was common practice to boil new wine in lead pots to impart sweetness. It has been speculated that the insanity besetting a number of Roman emperors might have been attributable to lead poisoning as a result of their frequent and vigorous libations.[12]

Predating this early understanding of the detrimental effects of lead on health, the metal had associations with death and funerary tradition. One of the oldest of these is the Egyptian myth of the murder of Osiris, tricked by his brother into entering a lead coffin that was sealed over him and cast into the Nile. Coffins either constructed or lined with lead have been widely used since the Roman Empire, often for persons of higher social standing. The metal would also be used for coffins of very

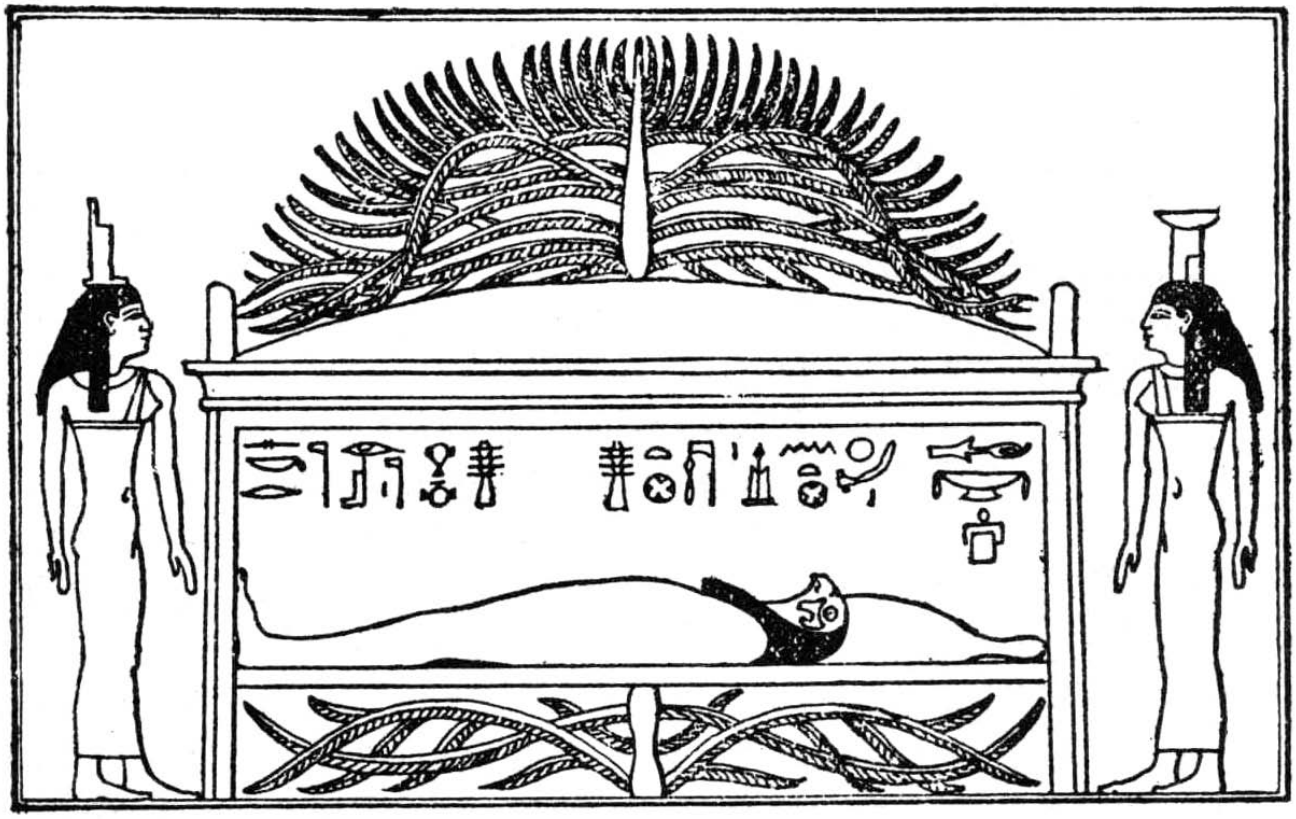


fig. 2.4- The funeral coffer of Osiris, tended by Nephthys at the head and Isis at the foot. According to legend, the Erica tree grew around the coffin after it washed up on the shores of the Nile. From a bas-relief at Denderah.

specialized purpose, such as that of Geoffrey Mandeville, a 12th century English outlaw. Excommunicated by King Henry I, Mandeville was not permitted burial in consecrated ground; instead, he was sealed in a lead coffin by Templar knights, and hung from a tree.[13]

One of the more distinctive characteristics of lead is its unique capacity among metals to absorb, which can be attributed to its softness and poor conductivity. This quality has been particularly useful in applications where sound, vibration and radiation need to be controlled.[14] The metal's acoustic properties create a specific quality of tone in traditional organ pipes: while different metals are used to create varying pitch, the lower registers make use of lead for an incomparably deep and resonant tone,[15] absorbing incidental vibrations that would rattle pipes of other metals. Lead is commonly used in environments handling radiation, as it capably absorbs and neutralizes many different wave frequencies, including those of x-rays.

The overlap between ancient alchemy and astrology tied lead to the planet Saturn, a connection that dates to at least the second century CE, as first presented by the Christian philosopher Origen.[16]

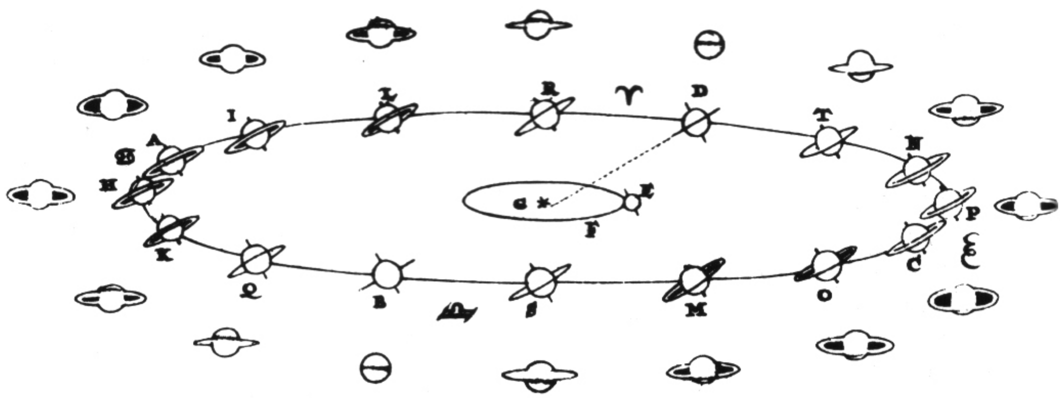


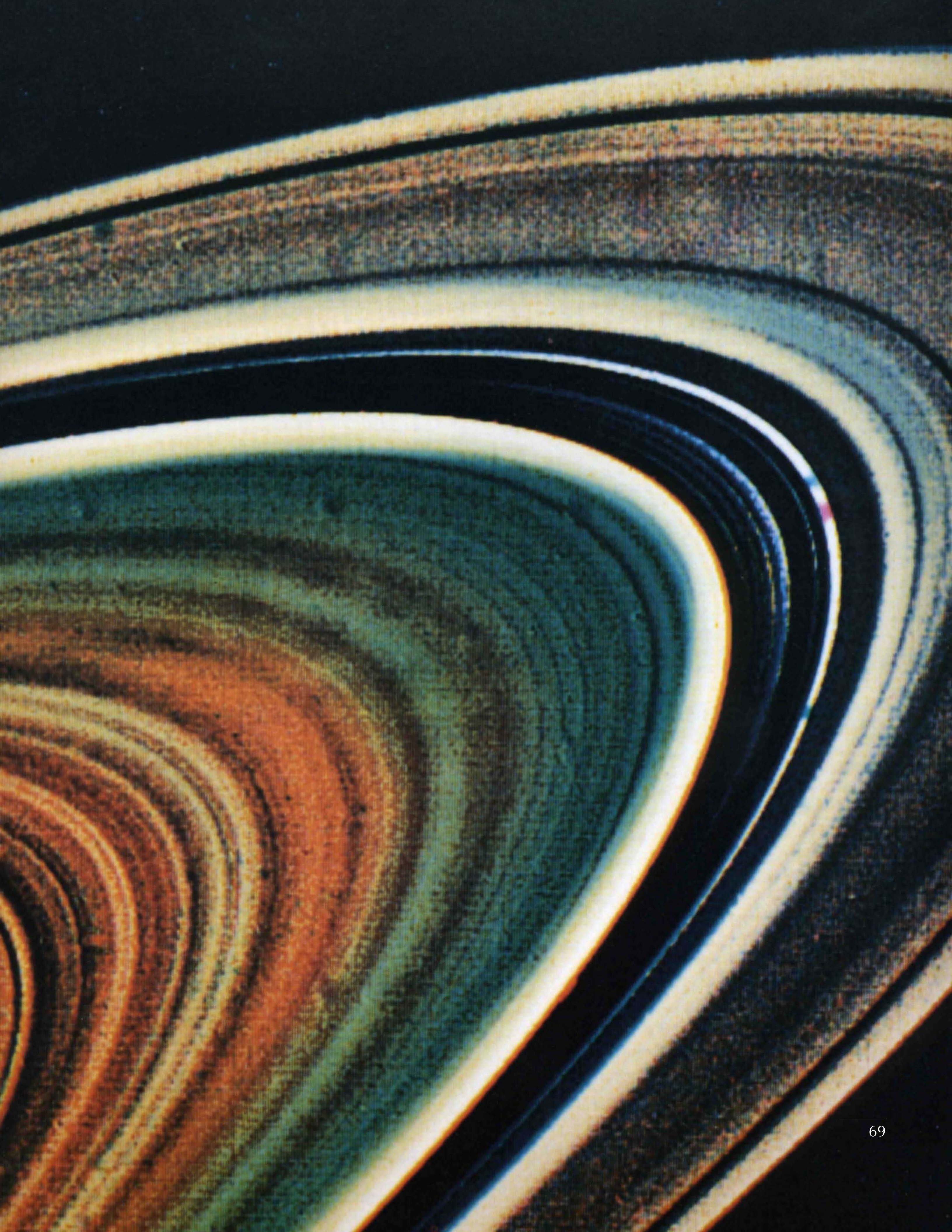
fig. 2.5- Sketches from Huygen's *Systema Saturnium,* providing explanation of the appearance of Saturn's rings as observed from Earth.

saturn

Saturn is the sixth planet from the sun and the second largest in the solar system in terms of both size and weight. Its composition is a mixture of hydrogen and helium, similar to that of Jupiter and somewhat similar to that of the Sun.[17] Along with Jupiter, this particular composition creates a phenomenon that operates as an internal heat engine, meaning that these planets generate heat and energy in greater abundance than that which they receive from the Sun. The volume of Saturn could contain over 750 Earths, but in spite of its great size it revolves on its axis more than twice as quickly, meaning that a day on Saturn lasts less than 11 hours. This velocity creates tremendous winds exceeding 500m/s, leaving the surface of Saturn in a permanent state of storm unmatched by that on other planets.[18] The number of moons orbiting Saturn form a tapestry of characters from Greek mythology: Titan, Atlas, Calypso, Pandora and Prometheus among others. Before the discovery of Uranus in 1781, Saturn was the outermost planet in the solar system, being the furthest planet still visible to the naked eye. It is fairly bright at that, outshining all but the night sky's two brightest stars, Sirius and Canopus.[19]

The most distinctive and well-known feature of Saturn is its series of rings. Without the aid of a telescope, Saturn appears simply as a yellow star; magnification is needed in order to see the rings, as Galileo Galilei first did in 1610, describing what appeared to him as a planet with ears.[20] Galileo would not see his riddle solved; this would be left to the Dutch astronomer Christiaan Huygens. In 1659, Huygens successfully hypothesized that the bulges on the sides of Saturn were in fact a thin series of rings, and that when Galileo's "ears" periodically disappeared from sight, it was a matter of viewing the thin rings in profile.[21] Decades of speculation on the constitution of the rings were to follow, as the bands were interpreted as solid, fluid and gaseous by turn until it was determined definitively that they were comprised of a thin, flat cloud of satellites: pieces of ice, rock and rust. Early thought postulated that these fragments were the remains of a moon which veered too close to the Saturn's surface, and was torn to pieces by the battle of its own gravity

Opposite page:
fig. 2.6- The rings of Saturn.



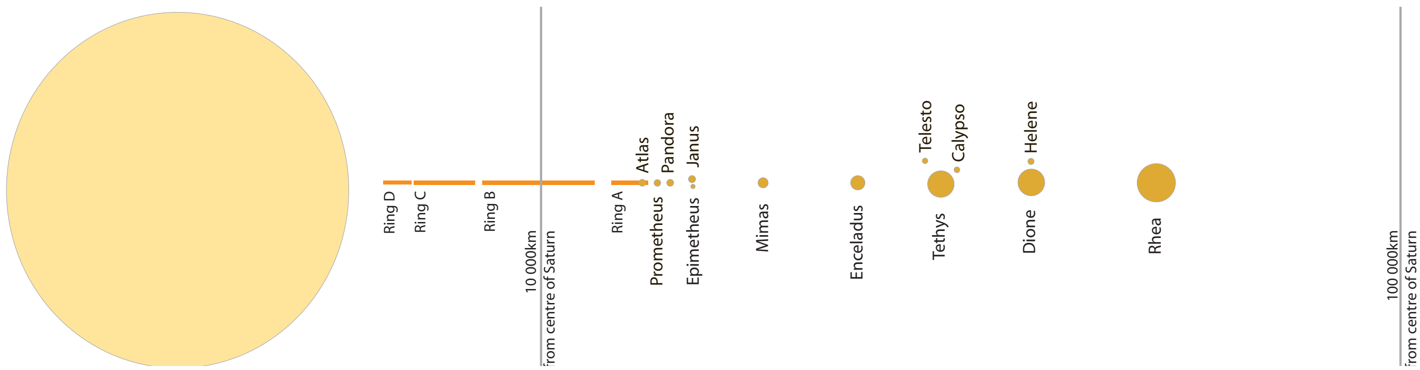


fig. 2.7- Profile of Saturn, Rings A through D, and 17 of the planet's identified moons

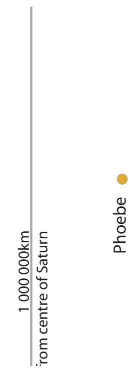
against that of Saturn*. It has since been conclusively determined that they are instead the result of comet impacts on the small satellites orbiting the planet.[22] Interestingly the rings are a dynamic phenomenon: like everything in the universe, they are subject to processes of entropy and exist in a constant state of weathering and decay, their perpetuation reliant on future comet impacts.

The planet Saturn takes its name from the Roman god, who in turn is based on the Etruscan Satres, the god of agriculture. In their appropriation of the Greek pantheon, the Romans passed onto Saturn the mythology of Chronos, ruler of time and patriarch to the gods. According to legend, Saturn assumed control of the universe by castrating his father, Uranus. It was prophesied to Saturn that he, too, would be deposed by his offspring. Intending to defy this fate, Saturn devoured each of his children at birth- all except for Jupiter, who was spirited away by his mother. Jupiter would dethrone Saturn and assume for himself the highest position among Roman gods. Drawing from this mythology, the planet Saturn came to represent time, death and the father figure

* The first widely accepted theory of the genesis of Saturn's rings was based on the principle of Roche's limit, devised by the French mathematician Edouard Roche. Essentially, the explanation offered via Roche's Limit proposed that the differential between the gravitational forces that Saturn exerted on the near and far sides of an ancient asteroid or moonlet caused a massive shear force that crushed the planetesimal to fragments, pieces of which settled into orbit to form the famous rings[23].

Deep in the shady sadness of a vale
Far sunken from the healthy breath of morn,
Far from the fiery noon, and eve's one star,
Sat gray-hair'd Saturn, quiet as a stone,
Still as the silence round about his lair;
Forest on forest hung about his head
Like cloud on cloud. No stir of air was there,
Not so much life as on a summer's day
Robs not one light seed from the feather'd grass,
But where the dead leaf fell, there did it rest.
A stream went voiceless by, still deadened more
By reason of his fallen divinity
Spreading a shade: the Naiad 'mid her reeds
Press'd her cold finger closer to her lips.

- John Keats, *Hyperion*



in Western astrology, its slow pace through the constellations and dull, inauspicious light interpreted as the physical expressions of Saturn's character.

Astrologically, the planet Saturn rules the sign Capricorn and the tenth house of the zodiac. Called the House of Magistracy by the 17th century astrologer Sir George Wharton, the tenth house begins at the zenith, otherwise known as the *medium coeli* or Midheaven; Wharton also described the Midheaven as the beginning of the fourth Age of Man, that of Old Age.[24] The starting point of the house at the zenith, looking upwards to the sky directly above, is believed to represent that to which the individual is reaching as they move through life: their ambitions, aspirations and goals. This is a house of achievement,[25] but its expression has a broader significance than simply the fulfillment of the individual. There is a decidedly social orientation to the tenth house, as revealed through its baroque name: magistracy refers to individuals in civil service, those with an obligation to responsibly use their influence and power. This theme is expressed through the modern interpretation of the tenth house, which addresses the importance of the individual finding his place in greater society.[26] Because of this, social occupations such as the public service or the military are related to the tenth house, particularly roles where social responsibility and integrity - and the refusal to abuse power - are required.

Astrologers represent Saturn with a glyph based on the sickle, iconic to the agriculture god as well as the messenger of death. This symbol, ♄, is the same as that used by alchemists to represent lead.

lead : to entomb

Interpreting the imperative of lead needs first to look at the mythological connections between the metal and the planet. In the case of lead and Saturn, these can be summarized in the concepts of death, of time and of limits. Certainly the associations of lead with death have a basis in its effects on the human body: beyond being ingested or inhaled, lead can be absorbed through the skin at a simple touch. The metal sinks into the very bones, particularly the long bones of the legs and arms, where it is most effectively locked into the body.[27] This notion of locking is evidenced at the cellular level: it is believed that part of the toxicity of lead is due to its attachment, in place of beneficial calcium, to the binding sites of cells, thus inhibiting the absorption of the essential mineral.[28] Symbolically, death finds expression in lead not only in ancient myth, such as that of Osiris, but also through its use in funerary objects, notably coffins lined with the metal that could be soldered shut. Here again, lead presents an example of locking, in this example sealing an interior condition safe away from the domain outside. The portentous figure of Saturn as the god (or enforcer) of time likewise casts him as a figure of death; the character of the Grim Reaper is derived from Saturn's agricultural roots, depicting him with the scythe. Saturn and lead can also be considered through the idea of *limits*. Before the invention of the telescope, Saturn circumscribed the outermost boundary of the solar system, beyond which only the fixed stars existed: it constituted a limit within which all other planets revolved. Lead can also be proposed to embody the notion of limits, through its unique placement among the elements of the periodic table. It holds the distinction of being the heaviest of the stable elements, meaning that all heavier elements are unstable or radioactive in nature. These elements, in a process of gradual stabilization, are effectively losing atomic weight and transforming towards an

fig 2.8- The remains of a Roman noblewoman, encased in a lead coffin, discovered in England in 2007

end state of lead, at which point they become completely stable. In this way, lead constitutes a threshold in the periodic table, both as the heaviest stable element, and as an end state to processes of radioactive decay by which uranium, plutonium and other unstable elements transform into inert materials.

Of the concepts of time, death and limits is a sense of finality, even inevitability. How this might be interpreted through the zodiac's tenth house helps to reveal the imperative of lead. The tenth house, as one of magistracy and social responsibility, is bound in formality: it is tied to organizations, particularly those depending on a hierarchical structure, and it is also connected to ancestry and legacy. This formality finds physical expression through the metal's tendency to lock in the icon of the seal. The seal serves a symbolic purpose as a physical validation of authority. Individuals in offices or occupations where the public trust is at stake often hold official seals as a means of confirming or asserting their position. The significance of applying the seal is matched by the symbolism of breaking it. The breaking of the seal may also be seen to represent death: after the passing of a Pope, his official seal is ceremoniously broken in two and sealed in a lead tube before being placed inside his coffin.[29]

It can therefore be suggested that through the themes of time, the imposition of limits (of which death is a part), and the symbolism of the seal, a lead imperative can be proposed: *to entomb*. The seal that encloses the tomb establishes limits between the dead within and their reintegration with the world of the living, defying natural processes, and therefore, time. It is this concept of challenging time that expresses the characteristics of lead through its planet, Saturn.

lead space : the vault

The concept of entombment on the site finds a connection with the industry of mining so critical to this area: the orientation downwards, below the surface of the Earth. The subterranean explorations by miners, working their way through the deep underground, draw resources from the same essential domain into which we inter our dead. One might consider the act of sealing a body into the ground as effectively removing the individual from the realm of time: it is a ceremony of finality, while also anticipating an infinite future. The subterranean space is more than a place for the entombment of the dead; it is also the ground for sealing other objects safe from the light and similarly arrested in time. The creation of such a space, a dark realm of frozen chronology, is the intent of the lead intervention.

On the expanse of rock that is the Coniston site, there are several locations where a break in the stone might suggest the starting point for the lead space. Blasting into one of the clefts creates a narrow, deep trench into which the viewer descends; the break in the rock continues beneath the surface to a hollowed-out open space, above which an opening has been cut to allow light to penetrate into the ground. This opening casts a dull light down a lead-clad concrete surface into the subterranean space. This compressed space is the site for the lead intervention as a single-person vault for the experience of entombment.

Descending into the space follows the broken wall of rock into the ground by way of a simple, prefabricated metal stair. At the bottom of the descent, the passageway underground is lined and sealed with lead sheet, a shroud separating the viewer from the rough rock. The separation created by the lead sheet is a transforming surface, as the softness of the metal and its inherent creep creates an ever-changing profile: not only do the sheets start to hang from their supports, but they also begin to pick up the detail of the underlying rock, so that the transformation of the metal's surface takes on the profile beneath it.

fig 2.9- artifact collage

Lead sheet is hung from copper stiffening bars, which fit into a matrix of copper clips bolted into the rock. The thickness of the lead sheet varies depending on the height at which each sheet is hung: sheets increase in thickness as they are installed higher above the finished floor. Because the thinner sheets will begin to show evidence of creep more quickly, the lower panels of metal will be the first to drape towards the ground. This is intended to create a sense that the ground itself acts as a catalyst for the metal's response to gravity, an effect that is contagious as sequential panels begin to react. The drape of the lead sheets subsequently increases the individual's sense of being both wrapped in lead and pulled into the ground. The walls of the passageway are spaced closely enough that the viewer can touch both simultaneously, although the toxic nature of lead repels, making the space feel even more compressed. The effect of the lead space is that the viewer, upon descending to the base of the space, becomes effectively entombed in lead, buried beneath the surface. A break in this lead seal is made by light reflecting down the lead-clad concrete wall; this serves to inform the viewer of the depth of his removal from the surface, and with his back to the stairway, provides the only access to light. It is intended that the space be experienced by a single individual, so that the sense of solitude is augmented.

The unique quality of lead to absorb, whether it is sound, energy, vibration, or radiation, makes possible another metaphor for the use of the metal. Given its ability to take in and diffuse physical energy, lead is used metaphorically as a device to assimilate other kinds of energy as well: imagery, sentiments, emotions. In this manner the very materials of which the tomb is constructed begin to take on the quality of an archive, storing the memories of visitors who descend into the space.


PRECAST CONCRETE WALL, CLAD
WITH UNTREATED LEAD SHEET
CAST-IN-PLACE CONCRETE FLOOR SLABS,
SET ON LEVELLING BED OF GRAVEL

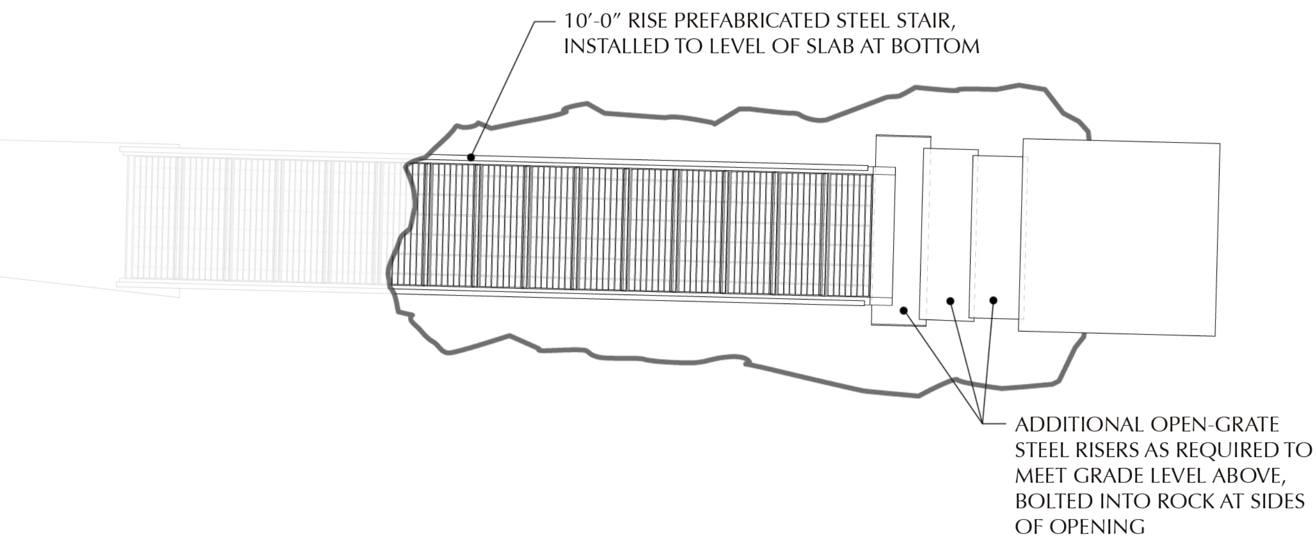


fig. 2.10- split plan at below grade and grade levels

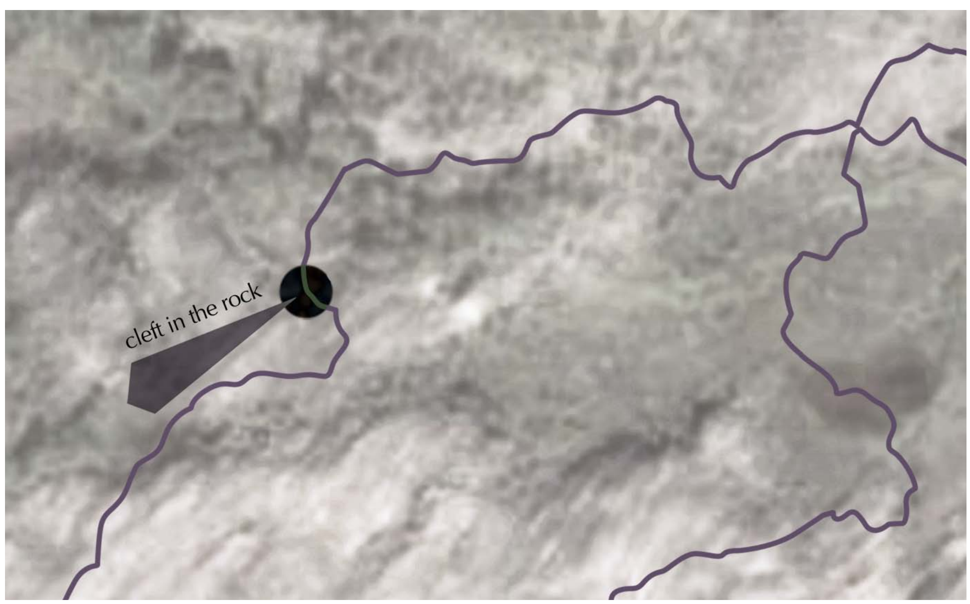


fig. 2.11- location of lead site along path

Lead surface treatment: Lead sheet hung on copper stiffener bars, attached to continuous copper clips installed vertically at 300mm intervals, screw connections at top of sheet and burned (welded) connection at bottom of sheet. Lead sheet conforming to ASTM B749 Standard Specification for Sheet Lead, thicknesses of 16 ga (4lbs/sf, 1.60mm), 14 ga (5lbs/sf, 2.00mm), 13 ga (6 lbs/sf, 2.38mm), 9 ga (10 lbs/sf, 4.00mm) and 7 ga (12 lbs/sf, 4.76mm). Copper components C110 Copper H04 (full hard) temper, composition Cu 99.9%, O 0.04% maximum, conforming to ASTM B 370-92 Standard Specification for Copper Sheet and Strip for Building Construction: continuous copper stiffener bars, 19mm x 3mm; copper clips not less than 25mm wide, minimum 18 gauge. Screws: brass or stainless steel, not less than 30mm long.

fig. 2.12- lead sheet

fig. 2.13- section through lead-lined passageway

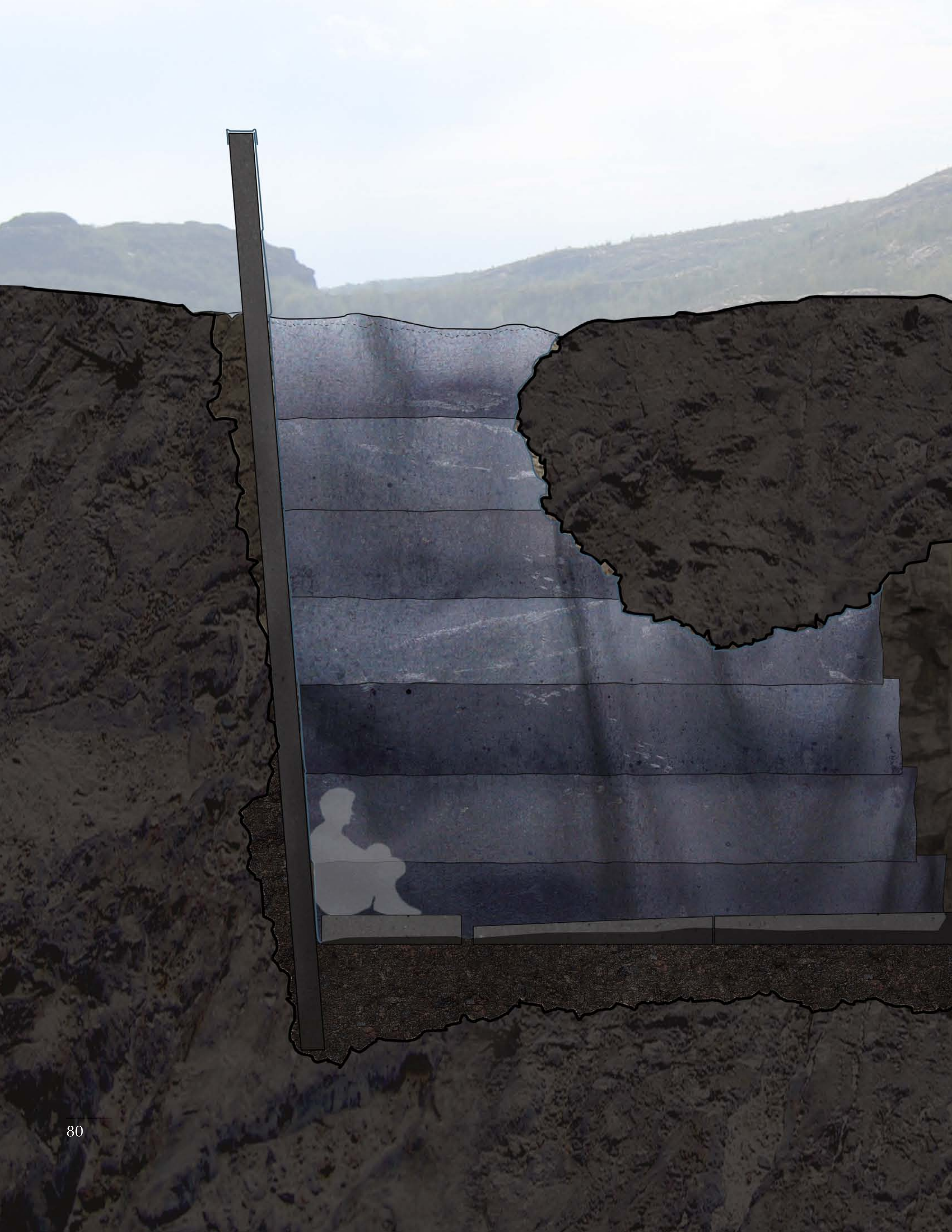


fig. 2.14- section through descent into tomb

Book III : ferrum

♂ Fe 26

the fable of mulciber

Mulciber packs lightly for the journey ahead:
A flint, a photograph,
The two halves of his broken heart,
And departs
To search out solitude's locale.
He finds the edge of the sea,
Moves along the barren coast,
Tugged by the point of his compass.
His guide, a sinewy relic with eyes
Set deep into his hollow skull,
Skin stretched tight over cheekbones, folding
Back to reveal his toothless smile.
He points his craft
Inland, and there,
Hidden from the salt swells,
A settlement lies.
Far as she goes, he mumbles
From between his gums.

A second craft,
Less sturdy, swaying dangerously
On the waves stirred up by a cold Eastern wind
Moves him closer north.
Pointing himself to a break in the jagged coast,
He docks, abandons the boat on a rocky shore.
Always obeying the compass point,
He proceeds on foot, and on intuition.
His destination must lie here
On this barren and lonely landscape
Uninhabited by men,
Away even from the gaze of the gods.

A cleft of rock, in perfect alignment
With the compass draw:
Against this he builds a wall to protect
The burning fires of his forge.
Stacking stones in a circle, filling
The pit with dry grasses and coal,
Mulciber constructs the forge, and holding
High the flint, sparks the fire
With a lightning strike,
The thunder-crack setting
The surrounding hills to quiver.

Here Mulciber spends his days
Lamenting the betrayal of his wife,
Her fickle heart, his fallible one.
He burns his eyes on the photograph
Where her beauty, so ephemeral in life,
Is magically captured, as if
The skin of the image itself might breathe.
In his despair, intoxicated with
Grief and heady wines,
He fashions for himself the most
Exceptional armour, impenetrable
To the bolts of Zeus himself,
And a helmet, eyeless, mouthless, earless,
A cave for a head
That would protect him from the burning beauty
Of love, from speaking love,
Or hearing it on winged voices:
A suit of armour to protect his broken heart.
The long winter did Mulciber spend in this armour,
Hearing, seeing nothing, sensing
Only the heat coming from the forge,
Warming the metal around his body
And slowly softening his cold, hardened heart.

Mulciber removed his helmet,
Tear-streaked eyes readjusting to the light.
Turning them to the forge, still burning
White hot,
He begins to craft, of thinnest iron,
Worked smooth and fine, hinged
With delicate pins,
The pieces moving with each other
As if formed from flesh, not metal,
A pair of organs: one for man,
One, smaller, for woman.
An entire summer, working under
The long daylight of the Sun, into
The brief nights, without sleep,
Mulciber laboured to finish
His masterpieces.
Come the eve of the autumn equinox
When light and darkness are at parity,
Under a cloudy sky
Threatening storm, he emerged from his shelter,
Fingers blackened from his travail.
One heart in his right hand,
One in his left, smaller,
Still glowing red-hot, just pulled from the fire.
Both wonders of the finest craftsmanship
Beating strongly and rhythmically
With their own energy,
With their own fire.
One heart in his right hand: his,
A heart
That would never break.
One heart in his left, smaller: hers,
A heart
That would never beat for another but him.
And as the skies opened up
To pour down over his tired, broken shoulders,
Mulciber curled his body over the two hearts,
Clutching both tight to his chest
To protect them from the storm.

fig. 3.1- Iron

Iron is by its properties the strongest of metals and the most necessary to man. Its sharp strength in battles has caused the downfall of great monarchies in the world.

Its sharpness will destroy everything in the world; it will cut through the greatest tree and cleave rock. Terrible is its sharpness with which a furious marauder may inflict incurable wounds in a fight.

It brings shameful death to unworthy malefactors, and immortal glory to the worthy who use it in a knightly manner in the defense of their native land from the infidel.

Hence noble people esteem iron for its great virtue above all treasures and jewels; they value it more highly, especially since they can use it for purposes of war.

- Walenty Rozdzienski, *Officina Ferraria*, 1612

Fe from the latin *ferrum*, meaning sword or arms

Before metals were understood to be distinct from stone, ancient peoples knew of a special rock that they called 'fire from heaven', depicting it with the pictograms for fire and sky.[1] The Etruscans would come to call it *aisar*, 'from the gods', and the word was carried through the centuries until it became, in English, iron. Iron remains the only one of the classical metals to come from both terrestrial and meteoric sources, the latter being essentially the only source of the isolated metal until it was discovered that iron ore, likely haematite, could be heated and hammered and iron separated from the spongy mass of dirt and slag.[2] For its rarity and provenance, meteoric iron was one of the most precious substances in the ancient world, and one charged with divine significance.[3]

Iron is the most abundant metal on Earth and the sixth most common element in the universe. It is highly magnetic: the Earth's core is primarily iron with a small quantity of nickel, and is responsible for generating the planet's magnetic field. Although its use by man predates written history, ancient artifacts of iron in good condition are almost impossible to find; the inevitable corrosion of the metal leaves, in most cases, only evidence of iron. At present, the oldest artifact of such is suggested by rusty voids in a string of gold, agate and carnelian beads, found in remains dating from pre-dynastic (5500-3100 BCE) Egypt.[4] Because its earliest sources were meteoric, the first uses of iron reflected its rarity and sacred power: amulets, magical weapons and idols for worship were some of the items created from pieces of the raw metal.[5] Smelting processes for softer metals such as copper and lead were not adequate for working iron from rock, but dwindling resources of tin, needed to make bronze, forced cultures to seek out alternative metals and alloys. With improvements to smelting technology, which allowed furnaces to be driven hot enough to work the metal's raw ores, the Age of Iron was born, and from the first millennium BCE iron has remained foremost among the useful metals. The Age of Iron brought with it many practical applications such as tools for farming and building, but it was also an era characterized by war. The expansion of the Roman Empire was one of the first large-scale manifestations of the new technology of ironworking[6] which so improved the quality of weaponry.

fig. 3.2- Iron mask, Karmenne, Zehrovice, Czech Republic, circa second century BCE

The utility of iron was to take a second leap forward with the industrialization of steel in the mid-nineteenth century. Replacing labour-intensive cast and wrought iron, the new steel incorporated additional elements such as carbon, which made it stronger and more resilient. Several industries were to experience a renaissance with the introduction of the material: architects could build taller buildings, and engineers had more flexibility in bridge design. As happened in the first iron age, steel facilitated unprecedented advances in weaponry, ushering in a new age of warfare. Today steel is ubiquitous at all scales of human life, from massive transports down to the most intricate machinery.

The fundamentality of iron in civilization is paralleled by its necessity to biological life. In human physiology it is the most abundant metal in the body, critical to the transportation of oxygen in the blood and therefore essential to life. Iron is part of hemoglobin, a blood component which turns bright red as it takes on oxygen; this colour change is reminiscent of the one by which iron changes colour in nature as it oxidizes. The level of iron in the blood has a direct effect on an individual's health and vitality, and a deficiency of the element causes fatigue and weakness. It has been shown that during the life of a human being, the point at which iron levels are the highest is in the immediate weeks before birth,[7] as though fortifying the infant for its imminent independence.

CYCLOPES VNOCVLI FRATRES

Filii Neptuni ex Amphitrite egregii mineratores & artifices in arte Vulcani.

Gnauiter accensis operas fornacibus vrgent
Et conflant igni mortalibus vtile ferrum
Vnoculi fratres, monstrosa propago Cyclopum
Brontesq; Steropesq; & nudus membra Pyracmon.

fig. 3.3- The Cyclopes.

Zealously, their forges kindled, they press on with their work and with fire smelt the iron that is useful to mortals. They are the monstrous race of Cyclopes, the one-eyed brothers Brontes and Steropes and naked-limbed Pyragmon.

- Walenty Rozdzienski, *Officina Ferraria*

While the origins of iron's rich mythology began with its provenance from the heavens, a symbolism would also be applied to the individuals who tamed the metal with fire. One of the best-known myths of the origins of ironworking surrounds Hephaestos, the blacksmith of the gods and the crippled son of the goddess Hera. Hephaestos presents a deplorable figure, bending his broken body over his anvil, working his craft in the fires of volcanoes.[8] Rejected by his mother on account of his ugliness, Hephaestos epitomizes the blacksmith as a cursed, dark creature. Hephaestos also employed the assistance of three of the Cyclopes: Steropes, of lightning; Brontes, of thunder; and Pyragmon, the fire-anvil.[9] These sinister figures from Greek myth further reveal a cultural apprehension towards ironworkers, for the ability to manipulate fire held associations with the demoniac, and to be able to transmutate materials - fundamentally something only a deity could do - imparted the ironworker with an awesome, fearsome power.

The prolific influence of iron on warfare was a likely reason for its connection with the Roman god of war, Mars. Originally, iron had been linked to the planet Mercury, but by the 6th centure CE, Olympiodorus the Younger, a philosopher and astrologer of the Alexandrian school, had linked it with the planet Mars.[10]

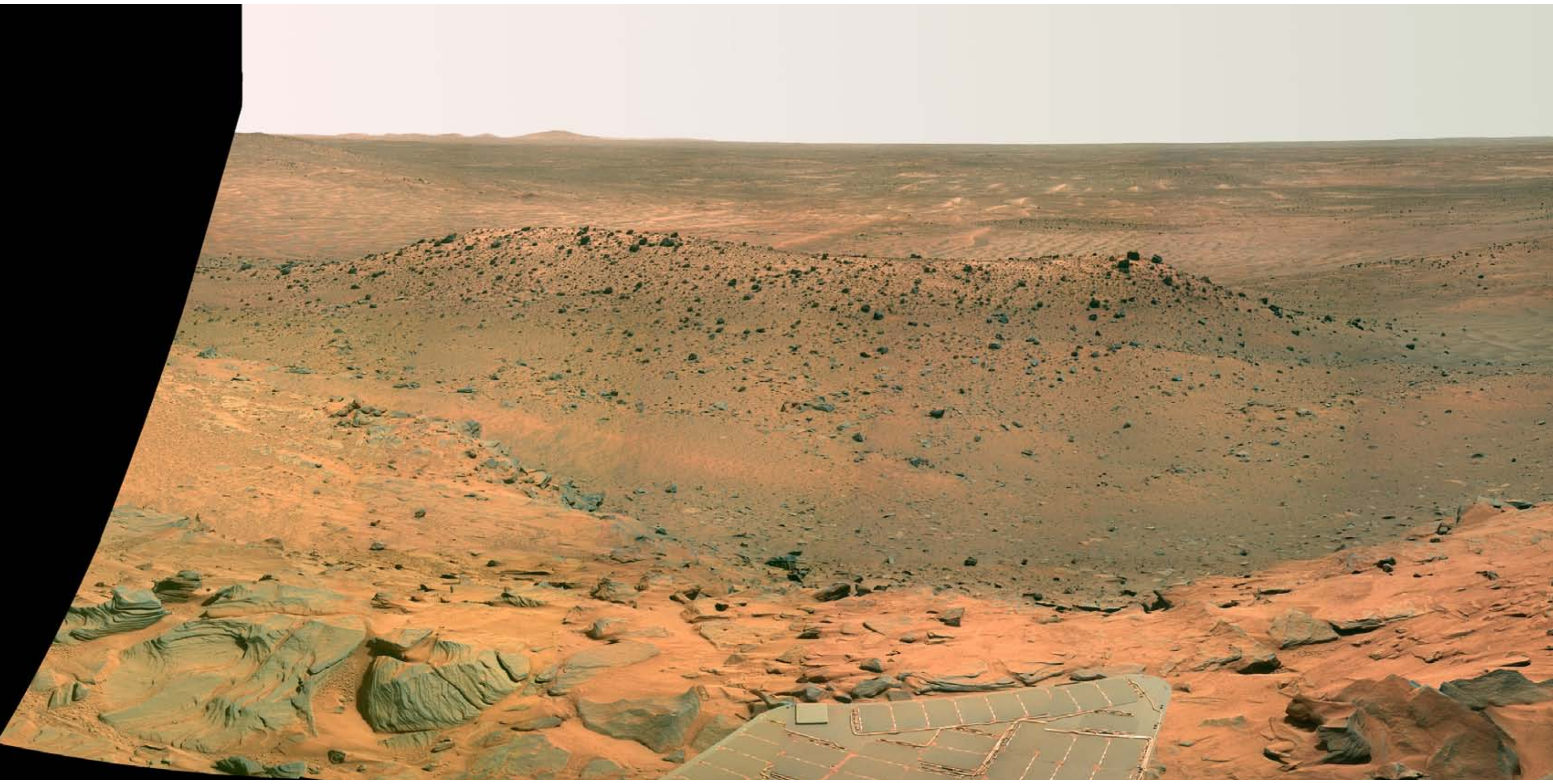
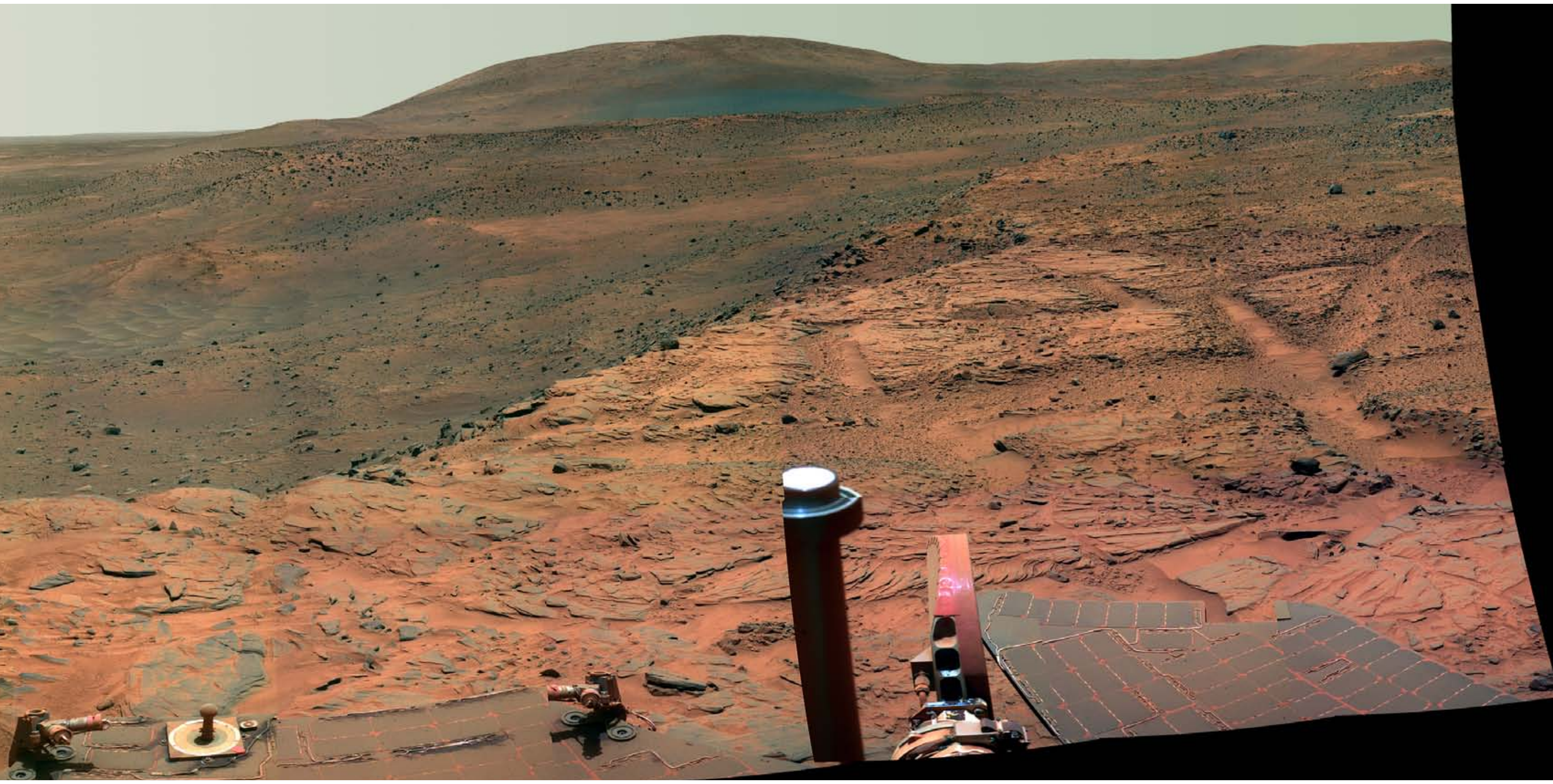


fig. 3.4- The Martian surface as photographed by the NASA Mars Rover, taken 03 January 2008



mars

Mars is the fourth planet from the sun and the outermost of the terrestrial (rock-based) planets. It appears as a bright, slightly pinkish star in the night sky; the Martian surface is covered with a layer of iron oxide, the colour of which is diluted before its light reaches Earth. Athough alchemy had connected Mars with the metal iron by the 6th century CE, the association long anticipated scientific knowledge of the planet's surface composition. Just over half the diameter of Earth, Mars shares the phenomenon of seasons with our planet, one of which is characterized by planet-wide dust storms several months in duration.[11] Mars has two small moons, named for the sons and fellow warriors of the Greek war-god, Ares: Phobos, meaning fear, and Deimos, meaning terror. As one of the two planets closest to Earth, its proximity could explain the age-old fascination with Mars, from its ancient mythologies to modern science fiction to the current real-time broadcasts of its surface.

The name Mars is derived from the Etruscan god Maris, who ruled farming and was revered as a fertility god. From his origins as an agricultural god, the Roman Mars became more closely associated with the Greek Ares, especially as the extents of the Roman Empire grew. While Ares remained, by comparison, less important to the more cerebral Greeks, Mars was to become one of the most significant gods in the Roman pantheon, and great temples were built to commemorate his support in battle. One of the grandest of these was the temple of Mars Ultor, or Mars the Avenger, built by the emperor Augustus Caesar as the largest and most impressive temple in the Roman Forum. The importance of

Mars in Western mythology is evidenced through the incorporation of the planet's name into those of the months and days of the week. Mars is connected to Tuesday (in Latin, *marti*; its English name derives from Tyr, the Norse god of war); that it is the first planet to follow the days of the Sun and the Moon is indicative of its prominence in Roman culture. The month of March also derives its name from Mars; the spring equinox that marked the beginning of the Roman year occurs during this month.

Known in the West for its association with the god of war, the planet Mars was in fact a harbinger of malefic force across the ancient world. The Babylonians called it Nirgal, the Star of Death,[12] ancient China referred to it as Ying-Huo, the fire planet;[13] and it was known to the Aztecs as Huitzilopochtli, a being of fire who destroyed cities and peoples.[14] It is not known why Mars has such consistent connotations over many global cultures, for while the surface is red in colour, it does not appear that way from Earth. Fear of the red planet was carried into the modern age with the birth of science fiction, as new generations turned their eyes to Mars in search of a civilization there- widely believed to be as warlike as the god for whom the planet was named. H.G. Well's *War of the Worlds* was premised on an invasion of Earth by a violent Martian race. Famously broadcast by Orson Welles as a radio drama in 1938, the story was so vivid that thousands of listeners took it for fact and evacuated their homes, in flight from marauding Martians.

The planet Mars is ruler of the astrological sign Aries and the zodiac's first house. Sir George Wharton declared the zodiac's first house the House of Life, marking the beginning of the first Age of Man, the Age of Childhood.[15] The first house begins at the moment of birth, considered most poignantly as the point at which an infant takes their first breath as their primary assertive, independent act.[16] The first house begins at the Ascendant, the dawn horizon of the astrological chart. This position is imbued with significance as it delineates between earth and sky, marking the start of a new daily cycle just as it marks the beginning of life. The humanist astrologer Dane Rudhyar attributes to the Ascendant the principle of the self,[17] as this position also marks the beginning of the six private astrological houses. The notion of the self is an important aspect of the first house, for it is here that the infant, as an empty vessel, begins to absorb experience and be transformed by it. Just as the infant begins to realize their potentialities and power, they also start to grasp the isolation that is the nature of selfhood.

The glyph for Mars shares the symbol for the male gender: a circle intersected with an arrow. The symbol ♂ is believed to emblematize the shield and the spear of the war god, but it also represents the circle as spirit and the arrow as matter.[18] Astrologers interpret this interaction between matter and spirit through the planet Mars as signifying the desires of the flesh overcoming the powers of the mind. This is the same symbol as that used for the element iron in classical alchemy.

Opposite page:
fig. 3.5- Partial map of the Martian surface


FOSSAE
Mariner
SIRENUM
Gorgonum Chaos
140°
Newton
Ptolemaeus
Hipparchus
Copernicus
Eudoxus
Li Fan
Liu Hsin
TERRA
Nordenskiöld
Nansen
Kuiper
Wright
Fossae
Icaria
Trumpler
Clark
Hussey
SIRENUM
Charlier
Dokuchaev
Stoney
Reynolds

fig. 3.6- The Menhir of Champ Dolent à Dol De Bretagne (Brittany), circa 2000 BCE. Height 9.5m.

Looking at the research on iron and the planet Mars, there seem to be two consistent themes. The first, the notion of *prevalance*, relates to the prominence of the metal in everyday life, its importance to biological life, the powerful mythology and symbolism of the planet and the fundamental personality as expressed through the astrological aspects of Mars. The second concept is *struggle*: the metal, used to defy forces of nature and man, must also fight its own weakness, corrosion. Likewise, the war god ruling the red planet epitomizes external conflict, and the glyph for both the metal and the planet expresses the battle between the will of the mind and the impulses of the body. Taking these two ideas, of prevalance and struggle, it is proposed that the imperative of iron is *to assert*: to declare one's independence, rights and power to shape the elements of their world in a demonstration of will.

The desire to impose oneself on the land dates back to prehistoric man, for whom two constants were always maintained: the horizontal represented by the line separating earth from sky, and the vertical as expressed through the movement of the sun as it crosses below the horizon.[19] The verticality of the Sun's path is most recognizable at the moments of sunrise and sunset, shifting at an angle during the rest of the daylight hours, whereas the horizon line created more of a constant in the world of the nomad. In his book *Walkscapes*, Francesco Careri suggests that it was the desire to stabilize the vertical that compeled man to create the first artificial landscape through the erection of the *menhir*, a massive stone pillar raised on end, pointing to the sky.[20] Careri elaborates that prehistoric menhirs could have had many functions, from memorializing persons of significance, to establishing boundary lines, to marking locations where water could be found. It is also believed that they may have been used in rituals of Sun and Moon worship, such as those observed at Stonehenge.[21] Regardless of their function, the effort that would have been required to procure, shape and raise the stones suggests a great significance to the choice of site where they were ultimately placed. There is also a decidedly anthropomorphic expression made through the erection of the menhir: as a man standing on the land, signifying the struggle of maintaining the vertical in an environment where everything ultimately surrenders to the horizontal.

The significance of the imposed vertical on a horizontal plane has not lost its charge in the millennia since the first menhir was raised. This primitive act was to establish the ground not only for architecture but also for art, as representations of man in stone maintained the vertical after the death of the physical body. However, stone does not live; its fulfillment of the upright is passive. It is the upright individual human being who projects an active expression of assertion on the landscape, in his defiance against the weather's attempt to blow him over, and against time waiting pull him into the ground.

The concept of assertion over nature that forged ahead mightily with the Industrial Age presented nature as servant, and man's control over it as his birthright. The Victorian mantra of "order in freedom; stability in progress" characterized a time when man's will over the land, and his future, was limited only by his imagination. The myth was to crumble against the backdrop of the Depression-era dust bowl, as man's ability to control his own fate against the forces of nature was threatened.

fig. 3.7- Takao Tanabe, *The Land, 4/75- East of Calgary*, 1975

At this time a new character replaced the image of the man at the helm of nature, this one resigned to his relative lack of power: the pioneer exposed to the elements, yet determined to forge for himself an existence.

The Prairie author and literary critic Laurence Ricou describes the vertical man in a horizontal world as a solitary figure, yet grand against the starkness of the landscape around him.[22] The motif of the lone man's isolation in the illimitability of nature would come to be a key theme not only in Prairie poetry and fiction, but in all of Canadian literature as well as art. Author Hugo McPherson describes the development of the national literary style as "a struggle against the violence, or the snowy indifference of nature- as an effort to humanize and give articulate shape to this vast landscape; to encompass it in imaginative terms, and in so doing, to discover the self."[23] It is through this discovery that man learns from, suffers through, and eventually transcends his struggles with nature. It is this character, the upright man, that persists to survive the forces of nature working relentlessly to reduce all things to the horizontal.

Lessons of humility in man's attempts to control nature are present in many world myths. In the tale of Cain and Abel, Careri presents the idea of the brothers as Homo Faber- Man the Maker- and Homo Ludens- Man the Player.[24] Cain, a farmer, occupies himself with transforming the world around him, while the shepherd Abel roams the landscape with no intent to alter it. The brothers make sacrifices to God of the fruits of their labours: Cain, of grains, vegetables and fruits, and Abel, of the blood and flesh of his newborn lambs. When God rejects Cain's sacrifice and accepts that of Abel, Cain murders his brother out of rage. While it stands as an iconic parable of jealousy, it might also be framed as a lesson in humility and the peril in asserting one's will over nature. In this case, the modification of the landscape, or perhaps the audacity of rulership and the sense of entitlement that accompanies it, is Cain's condemnation. Interestingly, while the Bible depicts Cain as a farmer, his name derives from the ancient South Arabian *qyn*, meaning metal-smith.[25]

fig. 3.8- Rust

In conformity with her usual benevolence, nature has limited the power of iron by inflicting upon 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.

- Pliny, *Natural History*

rust

Considering its strength, one of the greatest paradoxes of iron is its vulnerability: the propensity to rust. While virtually all metals react in varying degrees to exposure to air and water, not all experience the same corrosive effect. For example, copper and lead patinate and silver tarnishes, but these surfaces are only superficially altered by comparison. Rust *consumes* iron, and its voracious appetite is only satisfied when no trace of the metal remains.

Rust is the smell of blood, the taste of it in the mouth; it is visceral. Iron's weakness to rust epitomizes the anthropomorphism of the metal: it is subject to decay, its very molecules pulled apart by air and water and reintegrated into the soil in much the same manner as all living things. Rust is a process that, once begun, is insuppressible from the first bloom of corrosion. It is a reminder that iron is mortal. Considered in light of the ancient belief that metals were living things and thus in possession of a material body, iron would evidently be a creature with a perishing physical form.

The Bible uses rust as a literary device to symbolize corruption and the danger of clinging to material things. As written in the Book of James 5: 1-3, "Now listen, you rich people, weep and wail because of the misery that is coming upon you… Your gold and silver are corroded. Their corrosion will testify against you and eat your flesh like fire."[26] In this case the incorrodible currency metals of gold and silver are damned by the same vulnerability of iron, an expression of the fallibility of earthly things. Similarly, in Matthew 6:19, "Do not store up for yourselves treasures on earth, where moth and rust destroy, and where thieves break in and steal. But store up for yourselves treasures in heaven, where moth and rust do not destroy, and where thieves do not break in and steal. For where your treasure is, there your heart will be also."[27]

iron space : the wall

The act of walking on the site, of standing upright against the rolling horizontal, provides an immediate corporeal sense of the imperative of assertion. In architectural form, the imperative of iron would likewise stand against the same forces that affect one's experience of the site: wind, sun, water. With this in mind, the search for the iron space headed to the North edge of the site, which was higher and more exposed to the elements.

The location for the iron space was pinpointed with the discovery of an artifact on the site: a rusted steel rail spike. The spike was found on a crest behind which a narrow valley had been blasted for railroad tracks. Historical records show that the railroad to Sudbury was built around the turn of the twentieth century, meaning that the spike would have been left to corrode in a century's worth of seasons. Likely it was tossed away during the construction of the railroad; the spike appeared bent at the tip, possibly rendering it useless. Nevertheless, it had endured in its location for a hundred years, untouched by human hands in that time, waiting to play its role in defining the location for the iron space.

The influence of magnetic North and its relation to iron was also to influence the design of the iron space. The magnetic poles, while influenced by several factors, are essentially the product of Earth's swirling, molten iron core. Some of the smaller influences that affect the compass point include the magnetism of certain types of rock, particularly around the Sudbury impact crater, which distort the reading of magnetic North by as much as five degrees.[28] At present, magnetic North is located in the Canadian Arctic, as it has been for over a century, but is tracking towards Siberia at an ever-quickening pace.

The iron space first sets out three trajectories related to magnetic North: the line of magnetic North as it would have existed during the construction of the railroad, the line of current magnetic North, and the direction of true North. It is along these lines that the iron space is constructed as *the wall*. The wall can be seen to represent the evolution of the menhir, defying not only the force of gravity but of the elements as well. The Prairie author Frederick Philip Grove, whose work centres largely on the struggle of man against the land, comments on the futility of building up from the earth: "Nature abhors an elevation as much as it abhors a vacuum; a hill is no sooner elevated than the forces of erosion begin tearing it down."[29] While the menhir communicates the importance of the point at which it stands, it represents a permeable enclosure, and one offering no refuge from the elements. The wall presents a vertical barrier between man and nature, thereby assuming a piece of land and providing a separation from the environment on the other side.

The iron intervention is in fact two separate walls, the first set aligned with the direction of magnetic north in 1900 and the second with two faces aligned to current magnetic North and true North. The steel structure of the walls is set up along these lines, and steel sheet components are attached between the verticals. Every component of the walls, from the thickness of the steel to the types and numbers of connections, is destined towards a single end: collapse. The concept of iron's mortality- its propensity to rust- is built into a form that will fail in both predicted and unforeseen ways. In planning for the collapse of the walls, 5 different connection types are specified, from a weaker pop rivet to a more sturdy

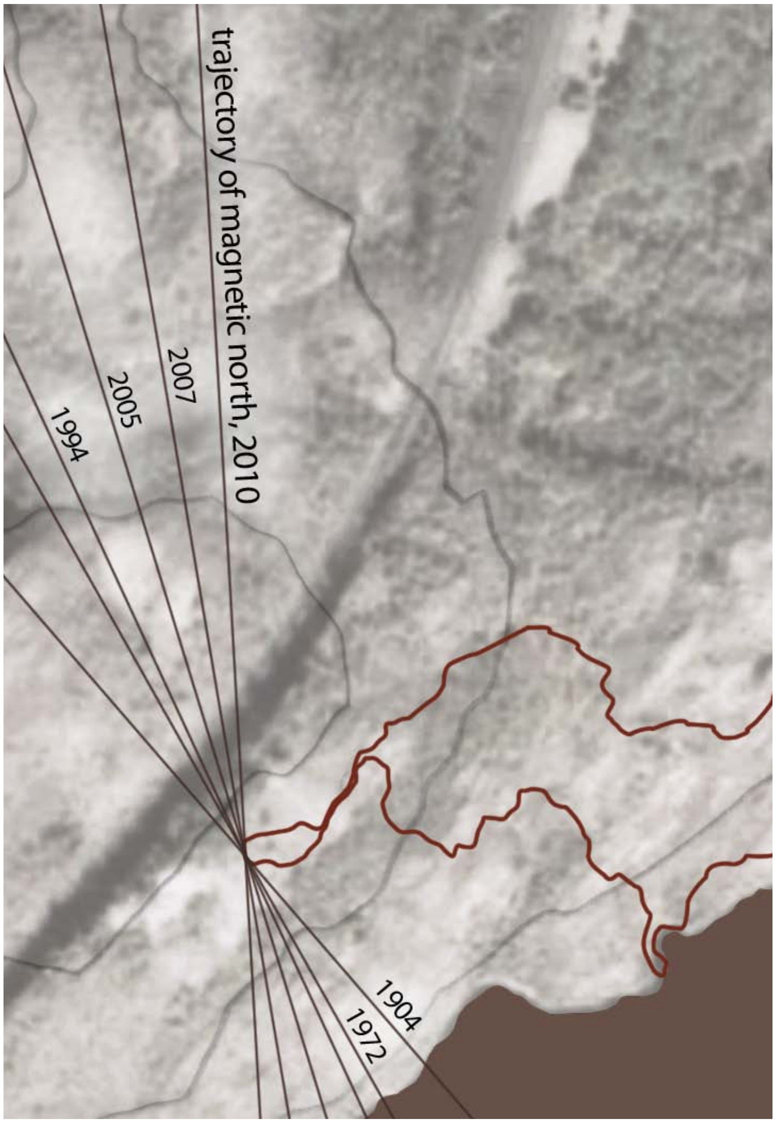


fig. 3.9- location of iron space and trajectories of magnetic North, 1904-2010

gasketed bolt connection. This will cause some connections to fail quickly and others to remain persistently intact. As well, parts of the walls are unevenly weighted, so that connections will start to shear as the weight of one component puts stress on another. Passively, the corrosion of the metal (both the sheet and connections) is an organic process outside the design that will result in unplanned failures. The movement of the structure's collapse is eastward, with the failure of separate pieces of the walls tracking the migration of magnetic North away from the constructed trajectories. The ultimate unpredictability of the wall's collapse mimics the inability to accurately forecast the future location of magnetic North, nor the speed at which the shift will occur. The last remnants of the iron space, once the wall has all but failed, remain where the structure meets the ground. These last points to surrender to the horizontal continue to indicate the trajectories of true North and former magnetic North.

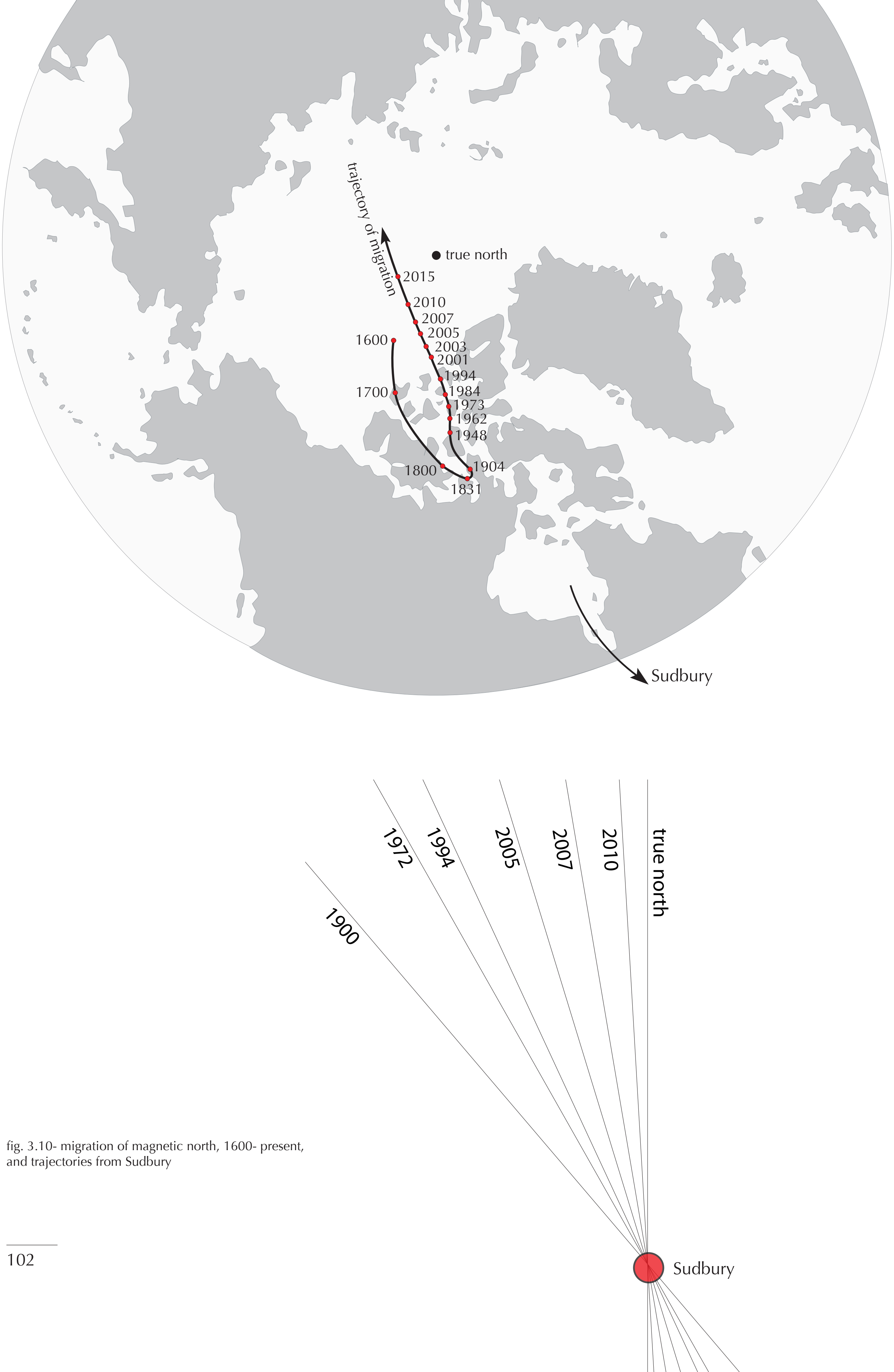


fig. 3.10- migration of magnetic north, 1600- present, and trajectories from Sudbury

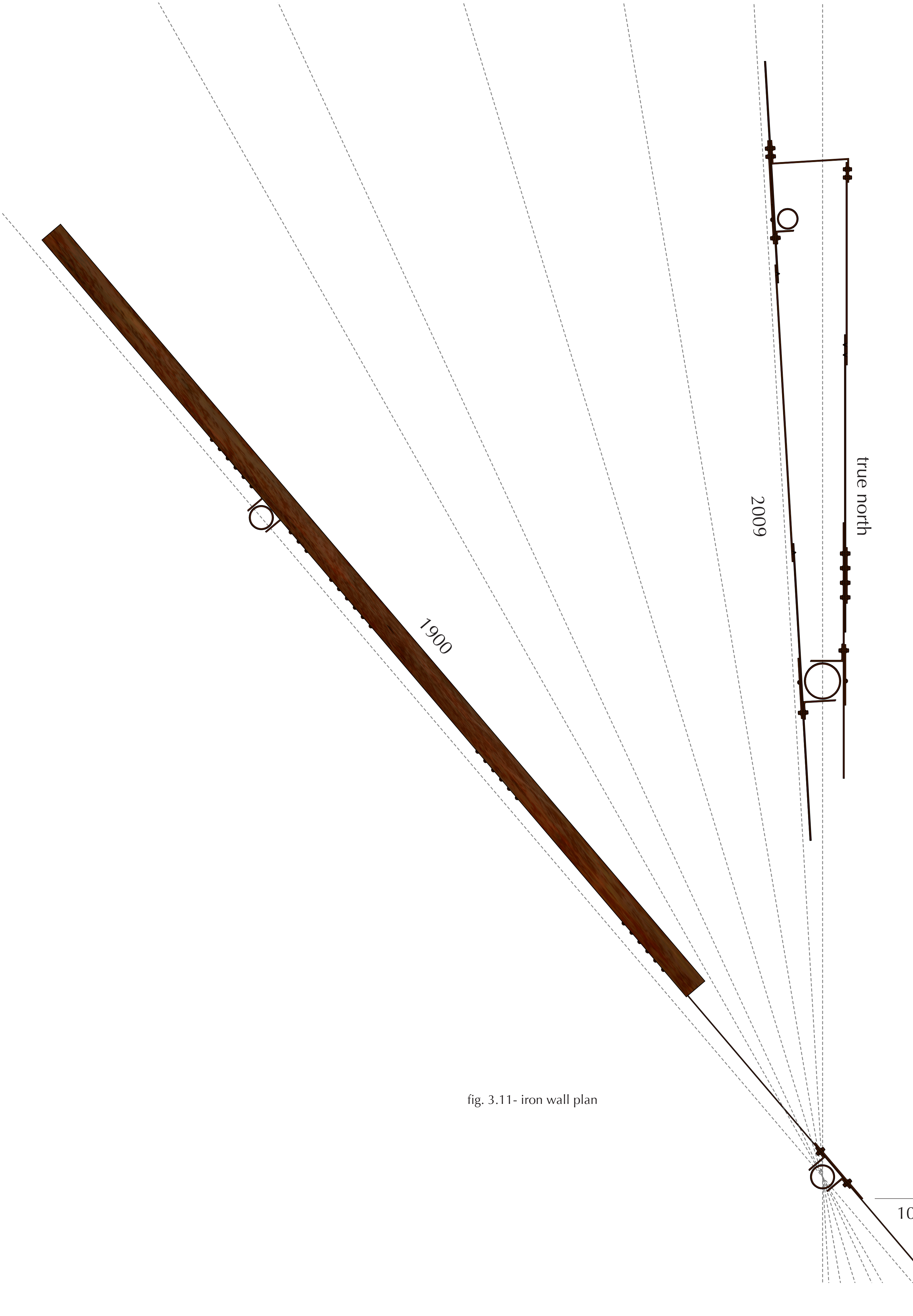
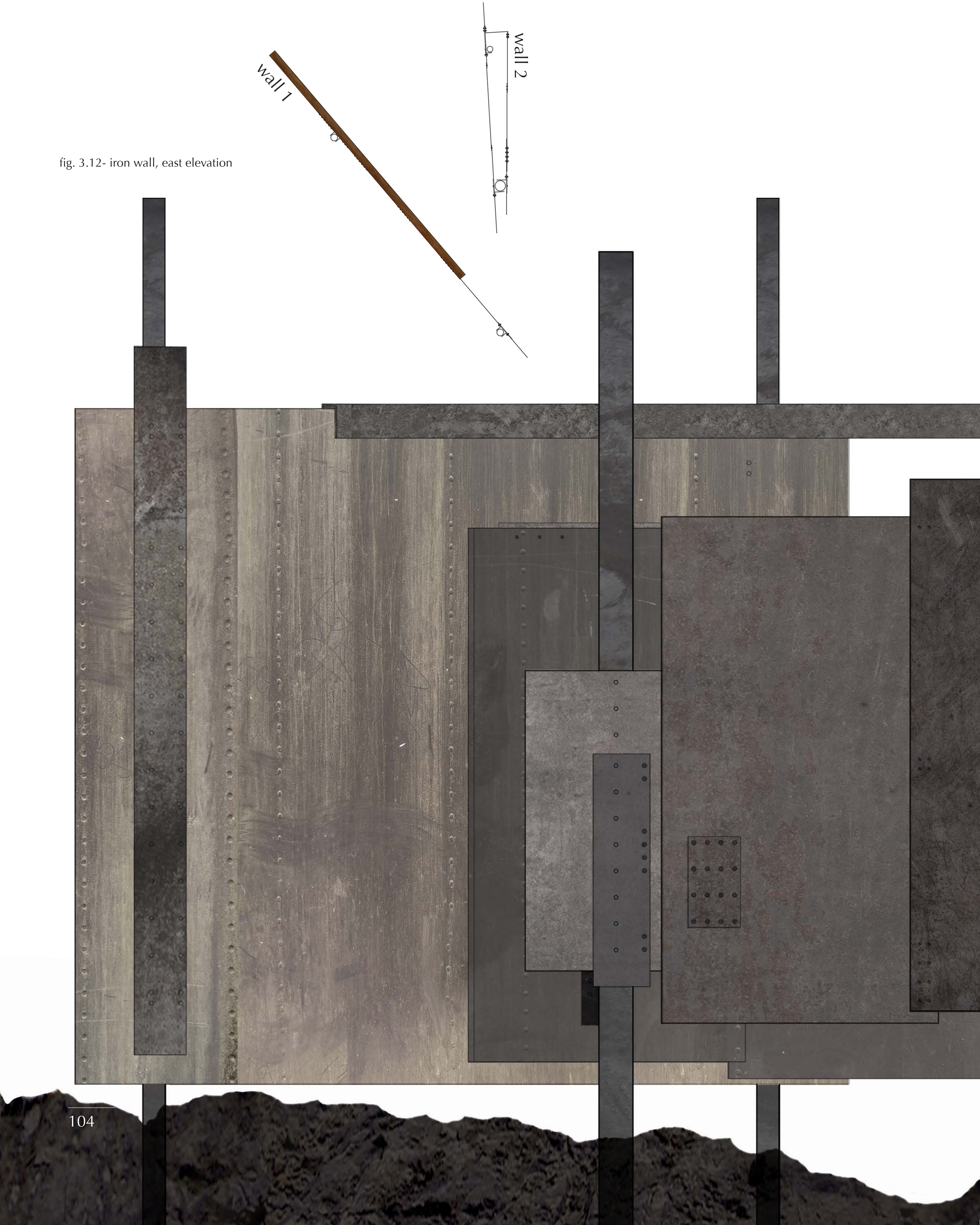


fig. 3.11- iron wall plan

fig. 3.12- iron wall, east elevation



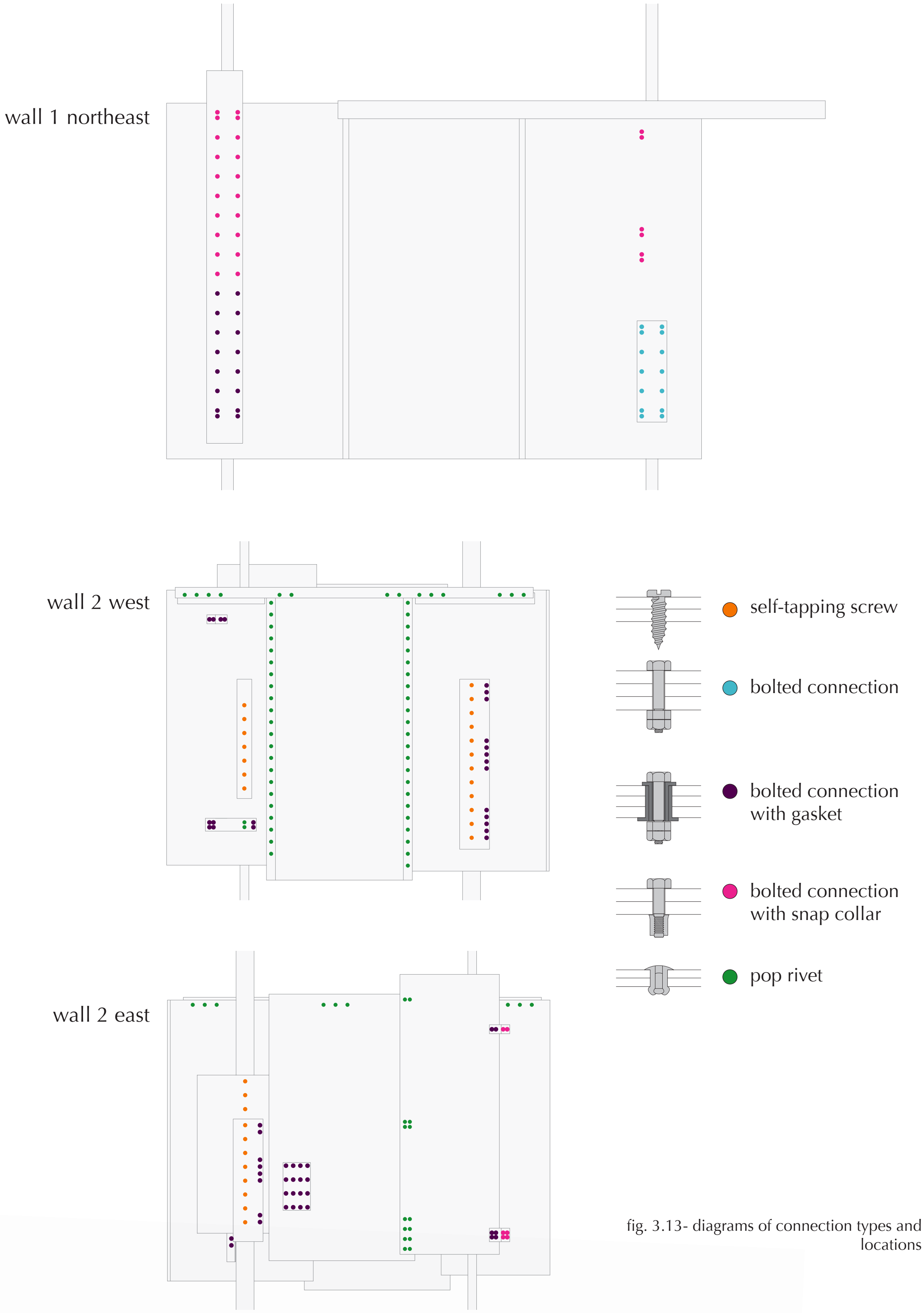


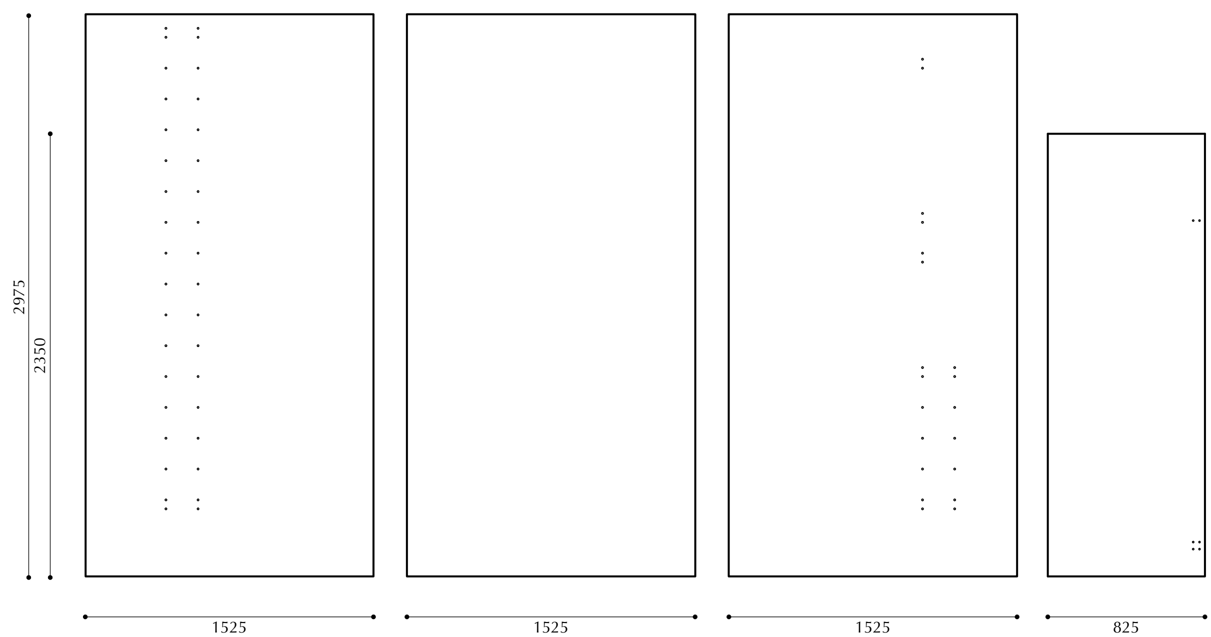
fig. 3.13- diagrams of connection types and locations

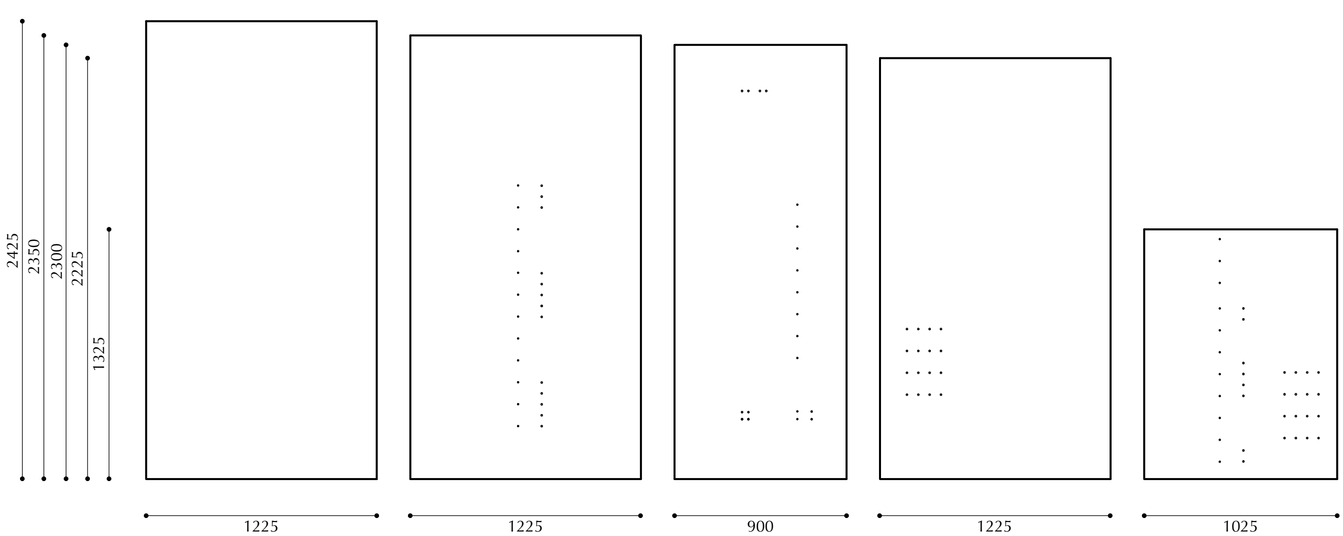
13ga (2.278mm)

10ga (3.416mm)

8ga (4.176mm)

6ga (4.940mm)





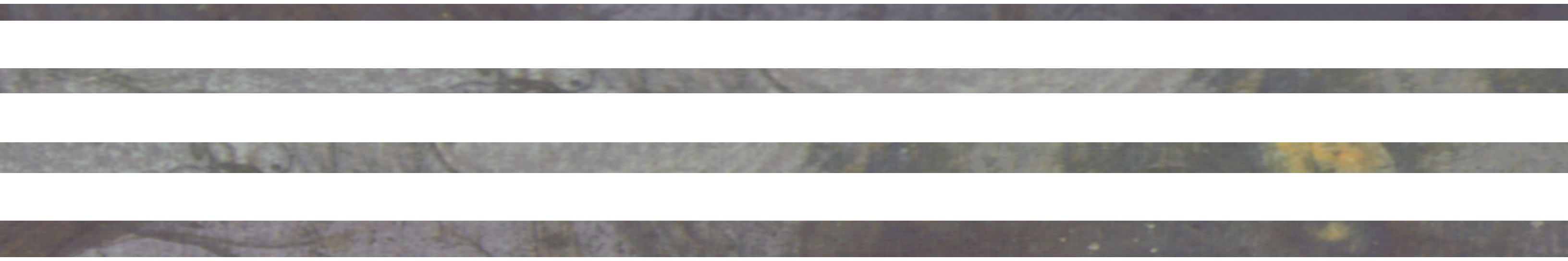
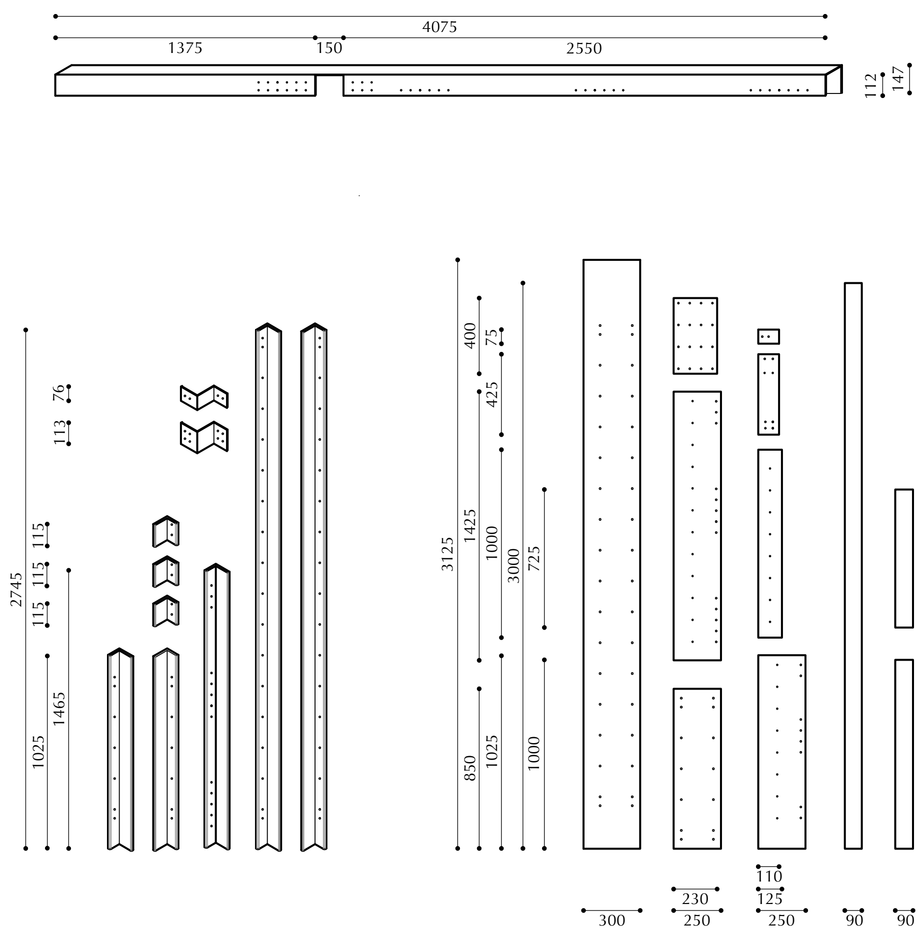


fig. 3.14- steel plate gauges and thicknesses

Wall construction: HSS structure, wall cladding unfinished sheet steel panels with rivet, screwed and bolted connections. Sheet steel conforming to ASTM A108-07 Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished, gauges 13ga (3.66lbs/sf, 2.278mm), 10ga (5.5lbs/sf, 3.416mm), 8ga (6.7lbs/sf, 4.176mm) and 6ga (8lbs/sf, 4.940mm), predrilled for bolted connections. Structural steel conforming to ASTM A570, Standard Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality: HSS 141 x 4.8 and HSS 89 x 4.8, unfinished. Steel angles: L127 x 76 x 6.4 and L89 x 64 x 6.4, unfinished, shop-welded to HSS and predrilled for bolted connections. Bolted connections: Bolts conforming to ASTM A307, Standard Specification for Carbon Steel Bolts and Studs, 60000 PSI Tensile Strength. Nuts conforming to ASTM A307. Gaskets two-piece neoprene. Other connections: Self- tapping steel screws conforming to SAE J78, Type 14 S/D Hex Washer Head. Pop rivets: Stainless steel domed head, finish plain/plain.

fig. 3.15- iron wall elements



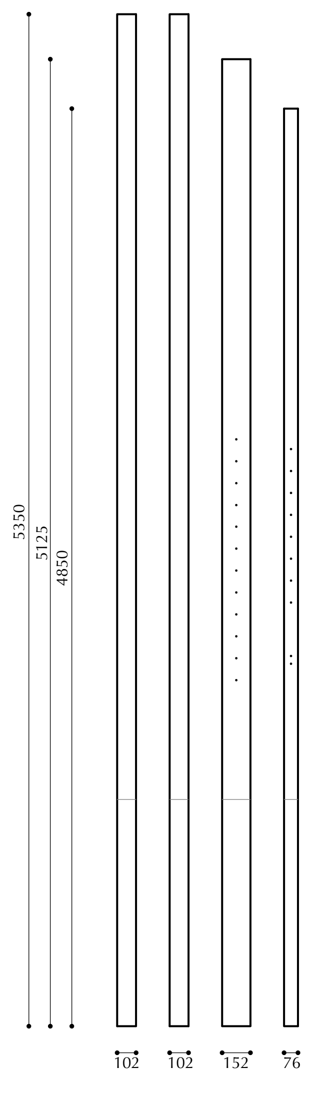


fig. 3.16- wall 1 section

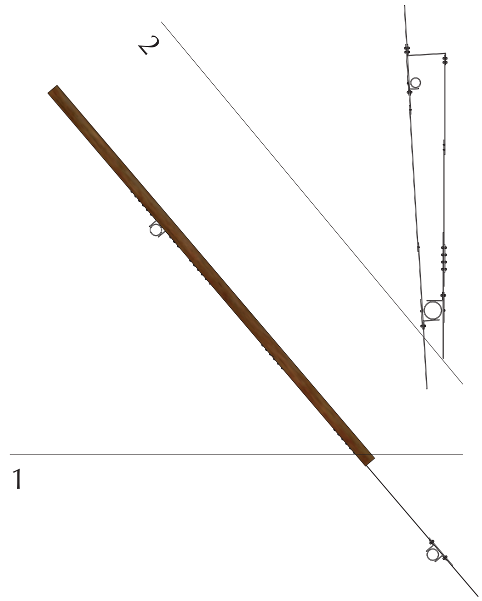


fig. 3.17- wall 2 section

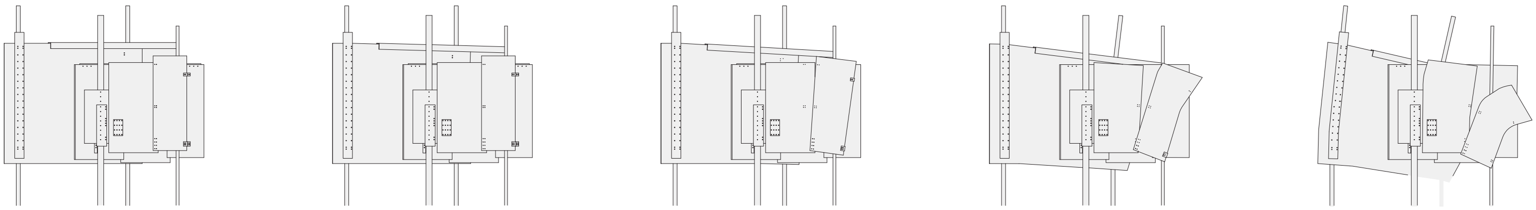
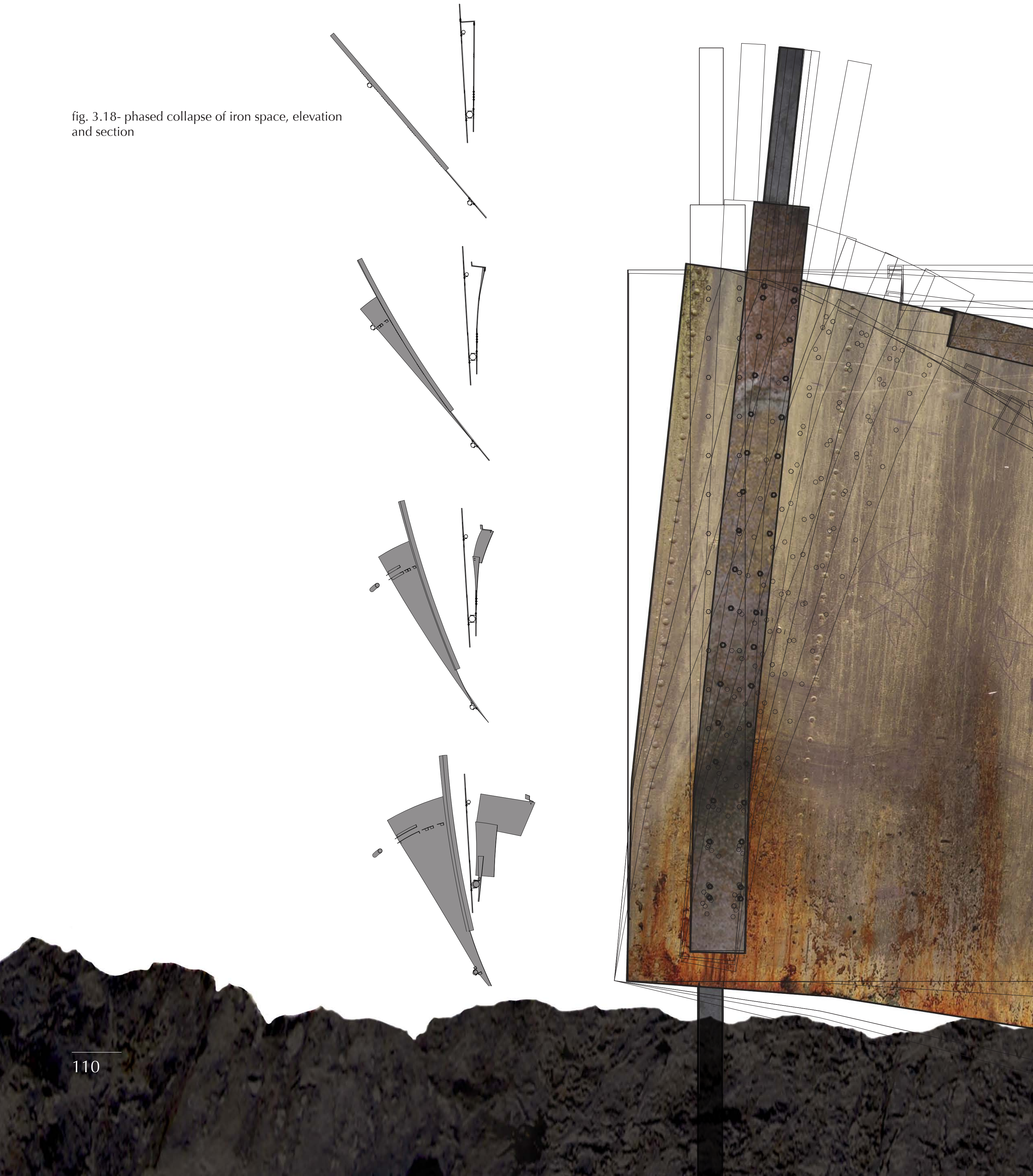


fig. 3.18- phased collapse of iron space, elevation and section



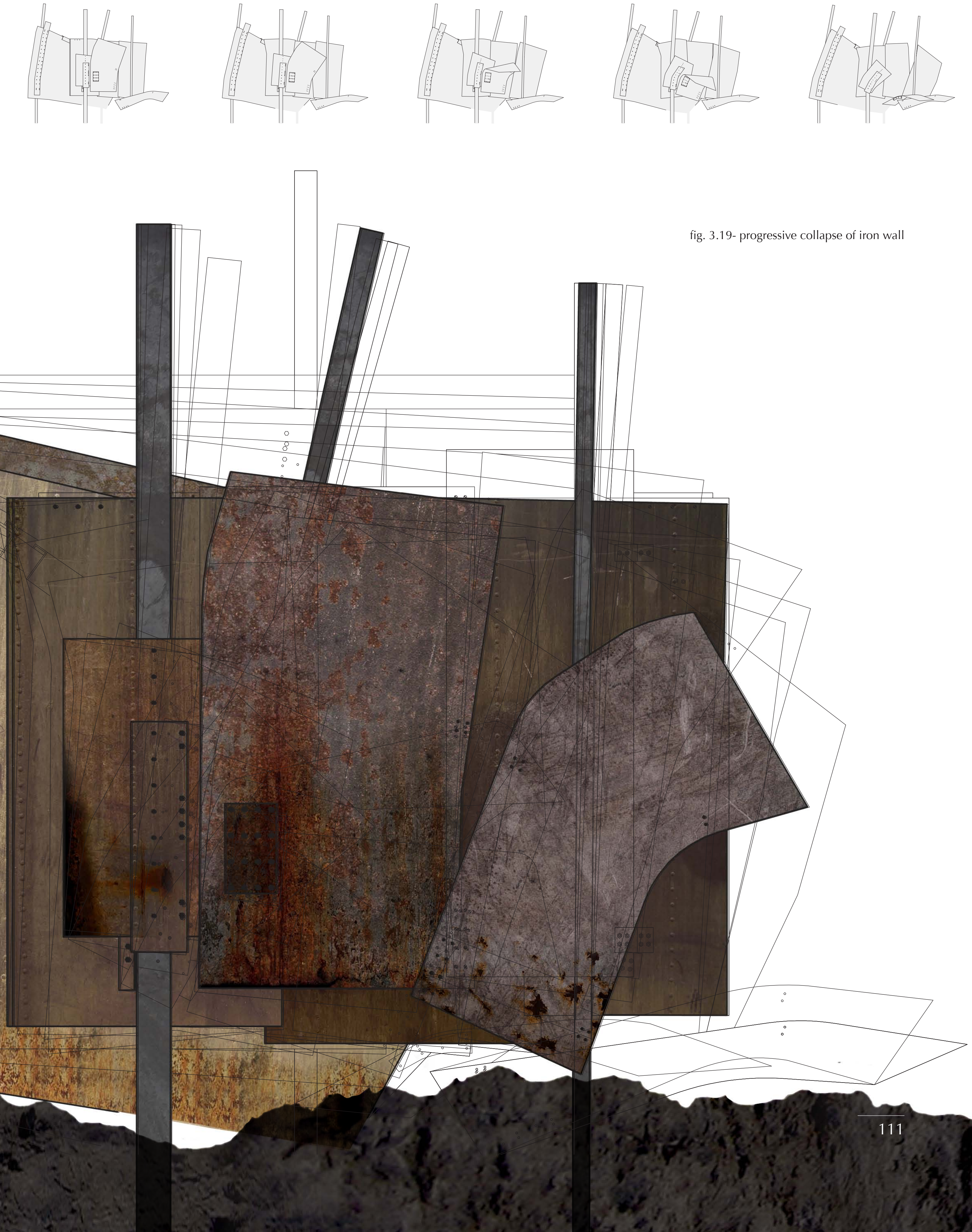


fig. 3.19- progressive collapse of iron wall

Book IV : argentum

☽ Ag 47

the fable of ondina

Spring. The earth is beginning to give way
To early fruits: buds of green on tree branches,
Tufts of life emerging
From the barren land.
Soon the geese will pass overhead,
Returning from warmer abodes to which
They were chased by the fury of winter.
The Matriarch observes their path,
for the shape of the skies
and the passing of eight winters suggests
That the summer, this summer
Calls forth the ritual.

The Moon, suspended in the night skies
Passes through its phases of fullness and void.
But even while it hides from sight,
Its pull, its magic is sensed.
The women in particular: they align
The cycles of their bodies with the Moon,
And with each other, as though they follow
The same celestial clock.
For this the ritual remains hidden
Amongst the women, untainted by manhood.
The location, too, kept secret,
Its destination chosen by the eldest women of the tribe.

They band together
To witness the Moon
In her darkened splendour, and it is
The Matriarch, as eldest, appointed
Caretaker, conductor, and mentor
To the uninitiated.
In this, they address her as Ondina.
Mothers bring their young daughters
For their first glimpse of the Moon
As full-faced, glowing in colours

Not seen in typical nocturnal gazings:
Colours like the fall leaves, burnished gold,
Or more fortuitous still,
The deep blood red.
Girls gaze upon this Moon and sense
Her powers, drawing out
The indications of their impending womanhood.
Women with child utter a special chant
For blessings to their unborn;
Those who observe this Moon from the womb
Become her children too-
Their faces destined to be
Round, luminous and soulful.

--

One moon has passed since the first buds of spring:
The sound of geese overhead,
Flying from the rising sun.
In other years, always from the midday sun
Have they flown;
At the next half moon, the voyage will commence.

They begin gathering food,
For the lands they must cross may be bare.
Five days journey, possibly six will bring them
To their destination.

--

The arrival at the pools was preceded by
An easy journey, though
The last that the Matriarch shall make.
Her weakened bones will not carry her so far again:
This will be her last blood moon.
The cloudy afternoon has given way
To a clear and sparkling evening.
As dusk settles, the women gather at the pool's edge,
Catching reflections of each other
And themselves as the sky
Drains of its light.

They wait in silence, in darkness. And then,
The Moon rises full, starts her journey
Across the sky, and slowly,
Piece by piece, imperceptibly,
She is cut into by shadow, until she is but a sliver.
From the darkness, she emerges, glowing
A deep and bloodlike red.
The world falls silent, the winds lie still,
The water flat and smooth as glass.
From the silence, Ondina begins the chant.
The reflection of the Moon,
Her face, her eyes, her mouth
All red, full of energy, potency,
Full of the power of woman.
Ondina sees her own face reflected in the pool
Along with the Moon. She sees herself
Aligned with her, she sees herself
In her. She calls to the others
To see their reflections joined together
With their sisters, with the Moon,
And with Ondina herself.

She pricks her finger with a stone, the blood
Forming a small, dark orb.
Moving around the water's edge,
She marks each woman's lips with
A red fingerprint
To make secret the ceremony.
Just as Ondina- as her grandmother, her aunts,
As her own mother-
In the ceremonies of years past,
Had marked her lips with a crimson seal.

Before their eyes, the Moon's colour
Fades back to black
As she moves out of shadow, emerging,
A wisp of her familiar silver, and finally
A rebirth into the fullness of her light.
The wind picks up, distorts the image
In the pool's surface.
The Moon casts their reflections back.

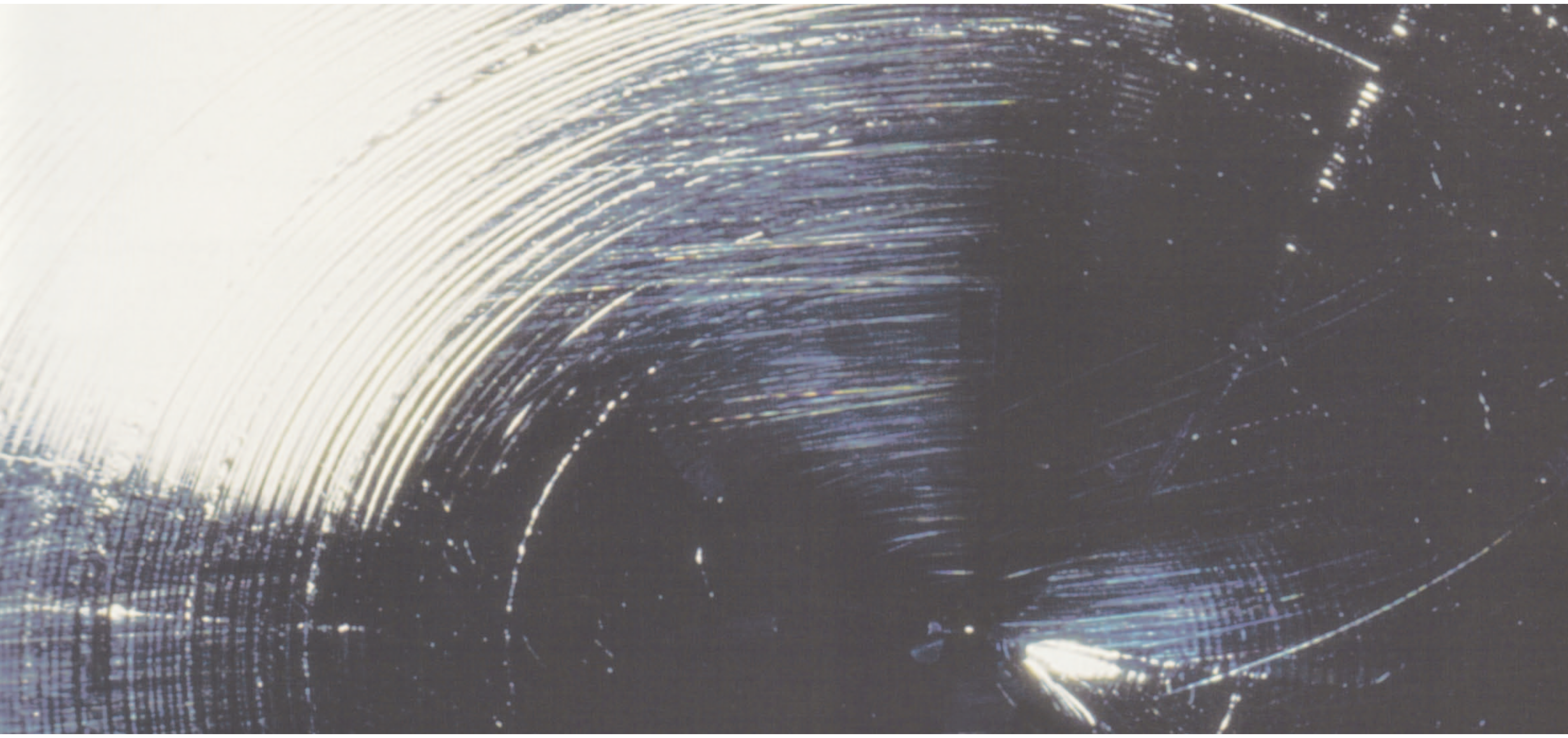


fig. 4.1- Silver

SILVER, the proverbially bright metal,
(Argentum), is of a bright white colour
With brilliant lustre, not affected
By pure Aire. Silver Suboxide is black,
The Monoxide is brown. Silver is the best
Known conductor of Electricity
And Heat; 'tis extremely ductile; fine Silver wire
Of seventy-eight one-thousandth inch diameter
Will support one hundred and eighty pounds weight
Without breaking. Sulphur, if present in Air,
In time tarnishes Silver articles.

- J. Carrington Sellars, *Chemistianity*

Ag from the latin *argentum*, derived from *arguro*, the Indo-European word meaning shining metal, and related to the Sanskrit *arjuna*, meaning light

The silver-tongued individual is one who is eloquent, persuasive and convincing, but the term refes to more than simply the elegant delivery of speech; it implies the ability to influence with words, to lift, to inspire, to coerce or to manipulate. Although silver has long been appreciated for its value and beauty, there is something in the symbolism of the metal that hides a shadow side. This is no better expressed in Christian tradition than in the story of the betrayal of Jesus by his friend and disciple, Judas. For thirty pieces of silver, Judas sent his friend to a certain death, and this quantity of coins has been a metaphor for disloyalty ever since. Not long after the act, Judas died by his own hand. Maybe his reflection in the face of the coins was too much for him to bear. Maybe it was not his own face he saw reflected back.

Silver's English name comes from the Anglo-Saxon *seofur* or *siolfor*, likely of Semitic origin.[1] One of the few metals to occur in native form as solid nuggets, its appearance as such is rare, and almost all of the world's supply is smelted from argentiferous ores. Silver is very malleable and ductile, thus making it highly workable and easily shaped into items of jewelry and ornament. Long considered one of the precious metals, silver articles such as trophies have an extensive history of use in marking achievement, but there has long been a perception of the metal as second to gold: the silver medal, for example, used to award a second-place finish.

Of all classical metals, silver made possible the development of currency systems, for its availability placed its value between that of common coins of copper and bronze and those of more precious gold.[2] While copper coins could manage quotidian purchases, a great (and heavy) quantity of them was required for larger investments in livestock and the like; conversely, the value of gold coins made their possession relatively limited to the wealthy. Silver effectively bridged the gap between the two, and its significance in this regard is reflected in the languages that use the same word for both silver and money, such as the French *argent*. The pursuit of silver and other precious metals has historically compelled widespread explorations over continents and around the globe;[3] the colonization of the Americas was directly related to the hunt

fig. 4.2 and 4.3- Silver scyphi (drinking cups) with relief decoration. Roman, Augustan, late 1st century BCE-early 1st century CE.

for currency metals, and areas most rich in these resources were the first to be devastated by Western greed. The early 16th century invasion by Hernan Cortez on the kingdom of Montezuma on Mexico's Gulf Coast, and Francisco Pizarro's plunder of the Incas of Peru,[4] saw thousands murdered to make Spanish coins out of American gold and silver.

One of silver's most prolific uses, historically and contemporarily, is in mirrors, for the metal when freshly polished has a high lustre and true colour rendition. In ancient mirrors, pieces of the metal were constantly buffed to maintain their reflective surface. Today, high-quality mirrors are still made with silver, although in the modern process a thin foil of the metal is used to back a sheet of glass. The quality of silver to receive and cast back an image can be considered alongside the capacity of the metal to register an image through the photographic process. In the 1830s, Louis Jacques Mandé Daguerre experimented with a thin layer of silver by treating it with various chemicals before and after exposing it to bright sunlight.[5] Through the process he found that he could record a permanent and accurate image, a painting of light, and this early discovery led to the invention of the photographic camera for the recording of still frames and later, the development of motion pictures as a sequencing of these images. While the process has been refined significantly since original experiments, the traditional silver is still the metal of preference for the process, and photography and film continue to consume a significant portion of global silver production each year; in 2006, 145.8 million ounces of silver, or more than 17% of total global production, were used in photography and related arts.[6] Through the use of silver, the mirror, the photograph and the film create a phenomenological trilogy: the fleeting image that is glanced in the mirror, the image in the fixed space of the photograph, and the moving image that seems to lie somewhere in between.

Silver has no known biological purpose in the human body, and its effects once ingested are relatively benign. While it does not figure in contemporary medicines, it was long used to treat infection before the discovery of penicillin,[7] and it continues to form part of some naturopathic treatments.[8] Excess stores of silver in the body manifest in a rare condition called argyria,[9] in which the skin begins to take on a slate grey to a bluish hue. The effects are permanent, and appear most pronounced in areas of the skin regularly exposed to the sun such as the nose, cheekbones and chin- the silver in the skin responding to light in a process not dissimilar from that of photography.

Silver has long been associated with the Moon. This connection is one of the oldest between metals and planets, and is as ancient as the link between gold and the Sun. Mythical creatures of the night, the vampires and werewolves who roam under the Moon's domain, are fabled to have a fatal weakness to silver.


A
Plinius B
JANSEN
Tacquet C
Plinius A
Ross D
(1100)
2500
ROSS
(1800)
Ross E
Ross F
1170R
Ross G
380R
4400
Jansen B
(1800)
Jansen H
Ross H
Jansen G
Arago E
Maskelyne M
(700)
M A R E
Arago D
4300
ARAGO
(1800)
T R A N Q U I L L I T A T I S
LAMONT
Arago C
3600
3000
2400
4200
1200

Ma ditemi: che son li segni bui
di questo corpo, che là giuso in terra
fan di Cain favoleggiare altrui?

But tell me now, what are the marks that show
So dusky on this body, and suggest
The tale of Cain to people down below?

- Dante Alighieri, *The Divine Comedy, Paradise*
(translation Dorothy L. Sayers and Barbara Reynolds)

the moon

In human history, it is the Moon above all other celestial bodies that has inspired the most polarized of sentiments. While artists have turned to her for inspiration and lovers for romance, she has likewise been regarded with much fear and superstition. About one-quarter the size of our planet, it is believed that the Moon formed when a Mars-sized body collided with a still-molten Earth, casting off a mass of rock that eventually formed into a sphere and fell into orbit.[10] It has long been observed that the rotation of the Moon is such that only one side is constantly visible from the Earth; this is due to its particular process of formation. While cooling from its soft, semi-molten state, solidified material from the surface was pulled to the Earth-facing side by terrestrial gravity, so that this face became thicker and more irregular;[11] this also established the celestial dynamics which would maintain the Moon's rotation in this pattern. The thickening of the Earthwards face caused the creation of maria, or seas, which appear as darker areas on the moon's surface, while the surface on the far side correspondingly became thinner, smoother, and free of maria. Because of this the Moon does in fact have a "face", read among the areas of shadow and highlight, directing its gaze towards the Earth in perpetuity[12] while the far side is a featureless expanse.

For millennia, the Moon has been a field for earthly projections. One of the ancient theories of the Moon was that it acted as an enormous mirror, casting back the reflection of the Earth's surface, so that the Moon's features were, in truth, the mirror image of Earth's oceans and landmasses.[13] It is probable that this accounts for the manner in which lunar features have been named according to terrestrial conventions: the Sea of Tranquillity, the Ocean of Storms. This naming reveals an appropriation of the Moon as an earthly domain through the mapping of human culture and history onto its surface, and in this way the Moon becomes both a reflection and a territory of Earth. Different theories were developed to explain the darkened areas on the Moon's face. The Roman philosopher Pliny postulated that, through the pull of the tides, water evaporated upwards to the lunar surface, taking with it terrestrial dust which stained the surface of the Moon.[14] In this case the Moon was thought to act not as a mirror but as an autonomous body, taking on the

Opposite page:
fig. 4.4- the lunar surface in the vicinity of the Sea of Tranquillity

effects of the Earth's influence. Scott Montgomery considers the stained Moon in his book, *The Moon and Western Imagination,* by looking at the poem "A True Story" by second-century Roman satirist Lucian. In the poem, the Moon laments the duplicitous nature of man:

> *But am I not aware of all the shameful, abominable deeds they do at night, they who by day are dour-visaged, resolute of eye, majestic of mien, and the cynosure of the general public? Yet although I see all this, I keep quiet about it, for I do not think it decent to expose… their life behind the scenes… But they for their part never desist from picking me to pieces.*[15]

Lucian depicts the Moon as custodian to man's dark secrets, veiled by the cover of night - and in this, kept hidden by her as well; she sees too the change of face that occurs in man by the light of day. If this moon is to serve as a mirror, it is a mirror terminally stained, its blemishes a reflection (or a revelation) of those secrets that cannot be contained behind the expression man wears by day.

Mythologically, the Moon has been widely associated with female deities. Greco-Roman tradition linked the Moon with female goddesses: the Greek Selene, from *selas*, or light, and the Roman Diana, goddess of nature and fertility. Chinese philosophy connected the Moon with yin, the female principle of passivity and darkness.[16] Conversely, Norse and Germanic cultures considered the Moon as masculine,[17] which perhaps explains the common reading of a male face ("the man in the moon") amidst the areas of light and shadow on the lunar surface.

Astrologers associate the Moon with the sign Cancer and the zodiac's fourth house, historically known as the House of Parents.[18] The essence of the fourth house is family and roots, and their role in the development of the individual's personal foundations. The fourth house begins at the Imum Coeli, also called the nadir; in the Baroque, it was called the bottom of heaven, or the den of planets.[19] This downward direction emphasizes the fourth house focus on roots: the soil in which one is planted (the homeland), the family to which one is tied and, in a broader social sense, the planet that is shared by all:[20] upright man makes a straight line through his feet to the centre of the earth, a shared nucleus that each individual retains regardless of his proximity to his homeland. With the fourth house begins the Age of Youth,[21] Sir George Wharton's second Age of Man, where the lessons of the first three astrological houses, those belonging to the Age of Childhood, are put to use.[22] This period of reflection is one that ultimately provides stability as the individual finds his place beyond the home, in the extended families of their community, culture, or religion.

The glyph for the Moon is a crescent shape, depicting a sliver of the illuminated surface. This symbol, ☽, is also used by alchemists to designate the metal silver.

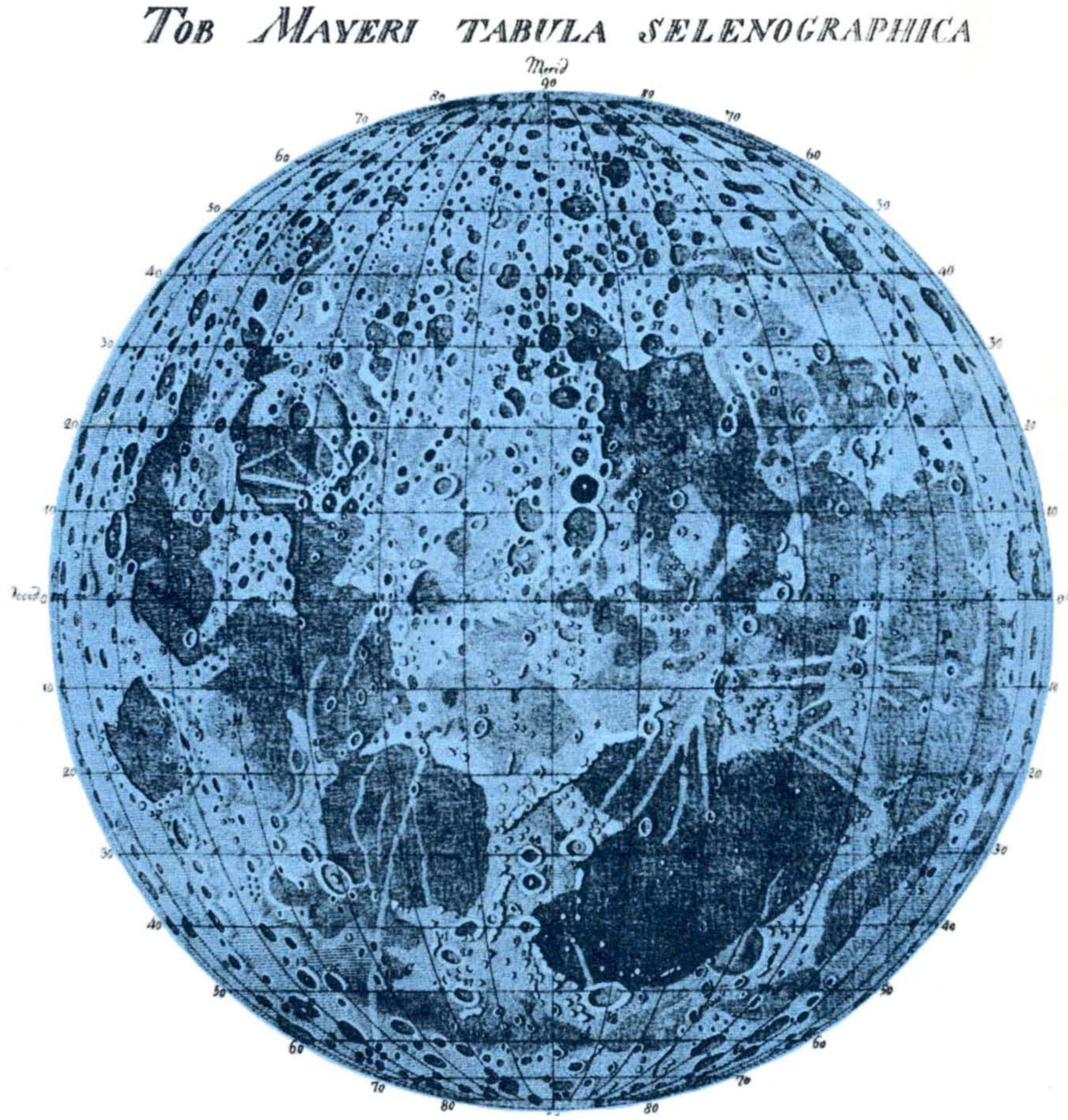
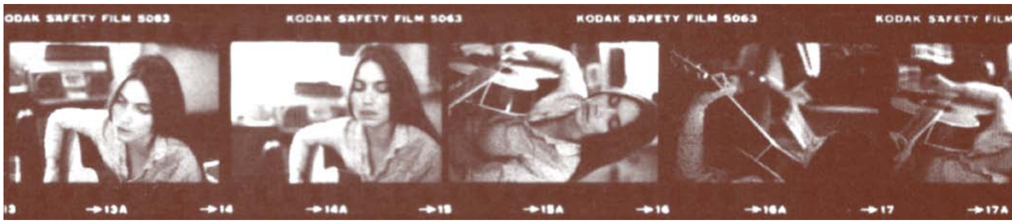


fig. 4.5- Depiction of Moon, Tobias Mayer, 1775



silver : to reflect

The connection between silver and the Moon is an ancient one. Certainly the light of the Moon could be characterized as a silvered glow, its effect seeming to desaturate nighttime scenes as if rendering them in greyscale. The capacity to work with light is one of the strongest similarities between the planet and the metal, most notably in the tendency of both to reflect: the Moon shining with the light of the Sun, silver returning the image cast into it. Silver has the additional ability to create an image made of light by registering areas of brightness and shadow on its surface, thus transforming the tendency to reflect an image into the ability to capture it. Both the metal and the planet have been used, or perceived of, as mirrors; while this is mostly metaphorical in the case of the Moon (for the Moon does reflect the Sun's light towards Earth), the silver mirror maintains an element of magic by capturing a living specimen within a surface of deceiving depth. Considering these qualities, it is proposed that the spirit of silver, and that which it shares with the properties and mythology of the Moon, is *to reflect*, both in the sense of the immediate (the image in the mirror) and the past (the image frozen in time). It is an important realization, when considering the concepts of the image, light and time, that what is perceived by the eye is that which travels by the reflection of light; experienced on a longer timeline, the stars we observe in the night sky are not as they appear in the moment, but as they were several hundreds or thousands or millions of years ago, when their light was first sent outwards into space. What we see is never

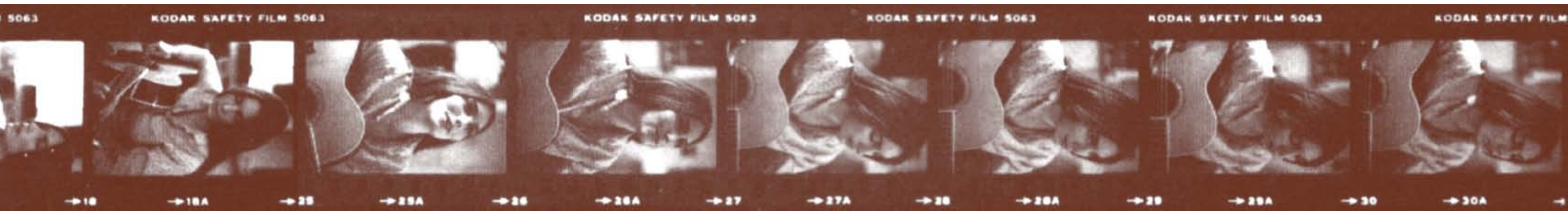
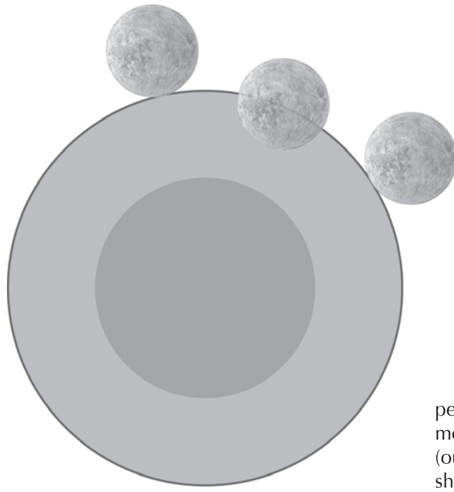


fig. 4.6- black and while filmstrip

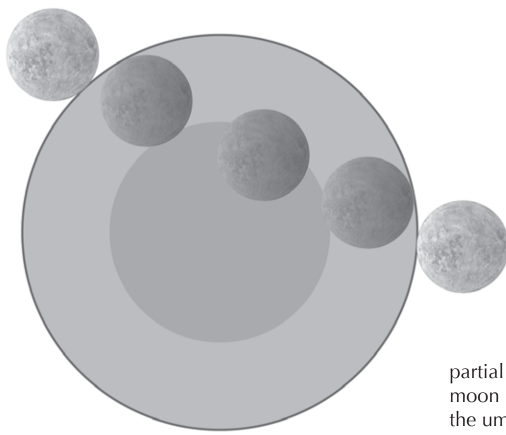
current: we can only see what has occurred, however proximate, in the past, and the sense of immediacy is one of illusion.

Astrologically, the zodiac's fourth house relates to the imperative of reflection through the individual's need to register his place within the family by seeing something of himself - whether physically or behaviourally- in the appearance and mannerisms of the group. The desire to identify with the family leads the child to imitate those around him, essentially becoming a living mirror to his immediate environment. The sense of association is reciprocal, as elder members of the family may relate to the child by revisiting a younger image of themselves. Here reflection can be seen to occur on two planes: the physical reflection of the outward image, and the psychological-spiritual reflection that occurs when looking inwards or backwards to one's past.

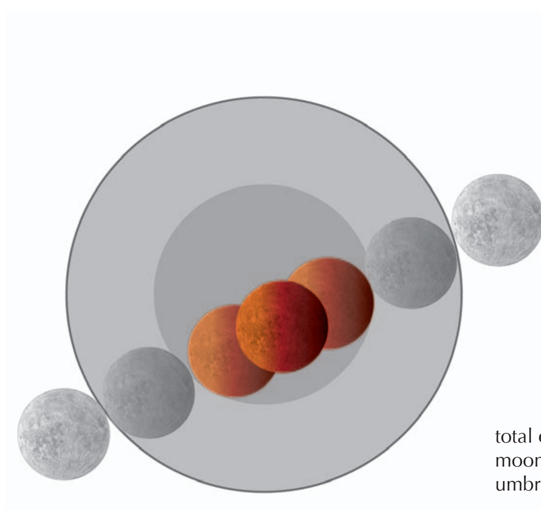
What might be recognized in both the introspective and physical reflection is the desire for reciprocity: that a gaze into the mirror will be rewarded with an image cast back, or the reassurance that questions thrown into the depths of one's spirit will be returned with answers. Reflection may be immediately personal (the reflection of oneself), or it may situate the individual within a place or a group (the collective reflection).



penumbral eclipse:
moon passes through the earth's penumbra (outer shadow), misses the umbra (inner shadow)



partial eclipse:
moon passes through the penumbra, grazes the umbra



total eclipse:
moon passes completely into the earth's umbra (eclipse totality)

fig. 4.7- eclipse types

the lunar eclipse

One of the more regular celestial events as observed from Earth is the lunar eclipse, in which the Earth passes directly between the Sun and the Moon, casting its shadow across the lunar surface. There are three types of lunar eclipses: total, partial and penumbral. A total lunar eclipse sees the Moon pass completely into the inner shadow, or umbra, of the Earth; the Moon takes on a hue ranging from copper to deep red, a result of light refracted around the atmosphere of Earth and through which the eclipse is viewed. A partial eclipse occurs when the Moon skims through the umbra but does not enter it completely, so that the shadow of the Earth can be seen shading part of the lunar surface. Lastly, a penumbral eclipse involves the passage of the Moon through the Earth's outer shadow; because the outer shadow still receives light from the Sun, these events go largely unnoticed.

Lunar eclipses take place approximately two times a year, and on rare occasion appear as often as four times a year.[23] Their occurrence is highly predictable, operating on a period of 18 years, 11 days and 8 hours* known as the Saros cycle.[24] The Saros cycle marks the synchronization of three aspects of the Moon's orbit: the synodic, draconic and anomalistic periods. The synodic period constitutes one cycle in the conjunction of the Moon with the Sun: in one lunar month (from new moon to new moon, or 29.530589 days) the Moon and the Sun will be similarly aspected from the perspective of Earth. The second period, the draconic, relates to the crossing of the lunar orbit over that of the ecliptic. The movement of the Sun across the sky follows the line of the ecliptic because of the rotation of Earth, but the Moon's orbit is canted 5° off the ecliptic. The point at which these two orbits cross is called a lunar node, *ascending* if the moon is moving upwards and *descending* if the moon is dropping, and the period between ascending nodes is called the draconic (27.212220 days). Lastly, the anomalistic period is equal to one complete orbit of the Moon around the Earth, a duration of 27.554551 days.[25] The synodic and draconic periods are critical in predicting both solar and lunar eclipses, the synodic because eclipses can only occur at new or full moons, and the draconic because the Moon's orbit must cross the ecliptic (must be at one of its nodes) for an eclipse to transpire. Therefore, the correlation of synodic and draconic periods allows for the mathematical calculation of lunar eclipses, and alignment with the anomalistic period allows that eclipse to be viewed from the same place with respect to the globe.

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* One Saros cycle may be 18 years 10 days or 18 years 11 days, depending on the number of leap years.

The ancient Babylonians were aware of the correlation of the three lunar periods in the Saros cycle by the 8th century BCE:[26]

Synodic period:	29.53 days x 223 periods= 6585.32 days
Draconic period:	27.21 days x 242 periods= 6585.78 days
Anomalistic period:	27.54 days x 239 periods= 6585.54 days

Because this period includes a partial day (approximately 8 hours), sequential lunar eclipses of one Saros cycle each progress a third of the way around the globe. Therefore, after the passing of three Saros cycles (54 years and 31-33 days) a lunar eclipse can be observed from one geographical location in almost exactly the same place in the sky, give or take a few degrees of altitude and azimuth*.

It is believed that part of the configuration at Stonehenge was a simplified "computer" for predicting lunar eclipses. The English anthropologist John Aubrey discovered a series of 56 holes, forming a circle some 50m in diameter around the main monoliths, and it is speculated that markers placed in these holes assisted in predicting lunar events.[27] Two markers moved counterclockwise, two holes every 13 days for the Sun and two holes each day for the Moon, would follow solar and lunar positions; two more markers, directly opposite each other and moved three holes clockwise each year, would correspond with the repositioning of the lunar nodes. As Jonathan I. Lunine describes in his book *Earth: Evolution of a Habitable World*, a lunar eclipse would occur when the Moon and Sun were opposite each other across the circle, and less than two holes apart from the nodal markers.[28]

Despite the ability of some early civilizations to predict the occurrence of lunar eclipses, the events remained fearful and awe-inspiring, particularly because of the ominous reddening of the Moon that occurs during a total lunar eclipse. Many myths surrounding the lunar eclipse have to do with the pursuit and attack of the Moon, causing her to bleed out over her white surface. The Chinese believed that the eclipsed moon was a pearl, being consumed by a dragon.[29] According to the peoples of the Malay Peninsula, both the Sun and the Moon had many offspring; the children of the Sun were beings of light and energy like herself, and the Moon's were the stars in the night sky. The two conspired to consume their children, fearing that mankind could not survive alongside them, but the deceitful Moon hid hers away while the Sun kept her word. When the Moon brought forth the offspring she had saved, the Sun became angry and pursued the Moon in an eternal chase. The eclipse occurs when the Sun catches up to the Moon, and bites into her.[30]

* altitude refers to the height of the moon in the sky; azimuth, the angle around the 360º of the horizon, starting at 0º North.

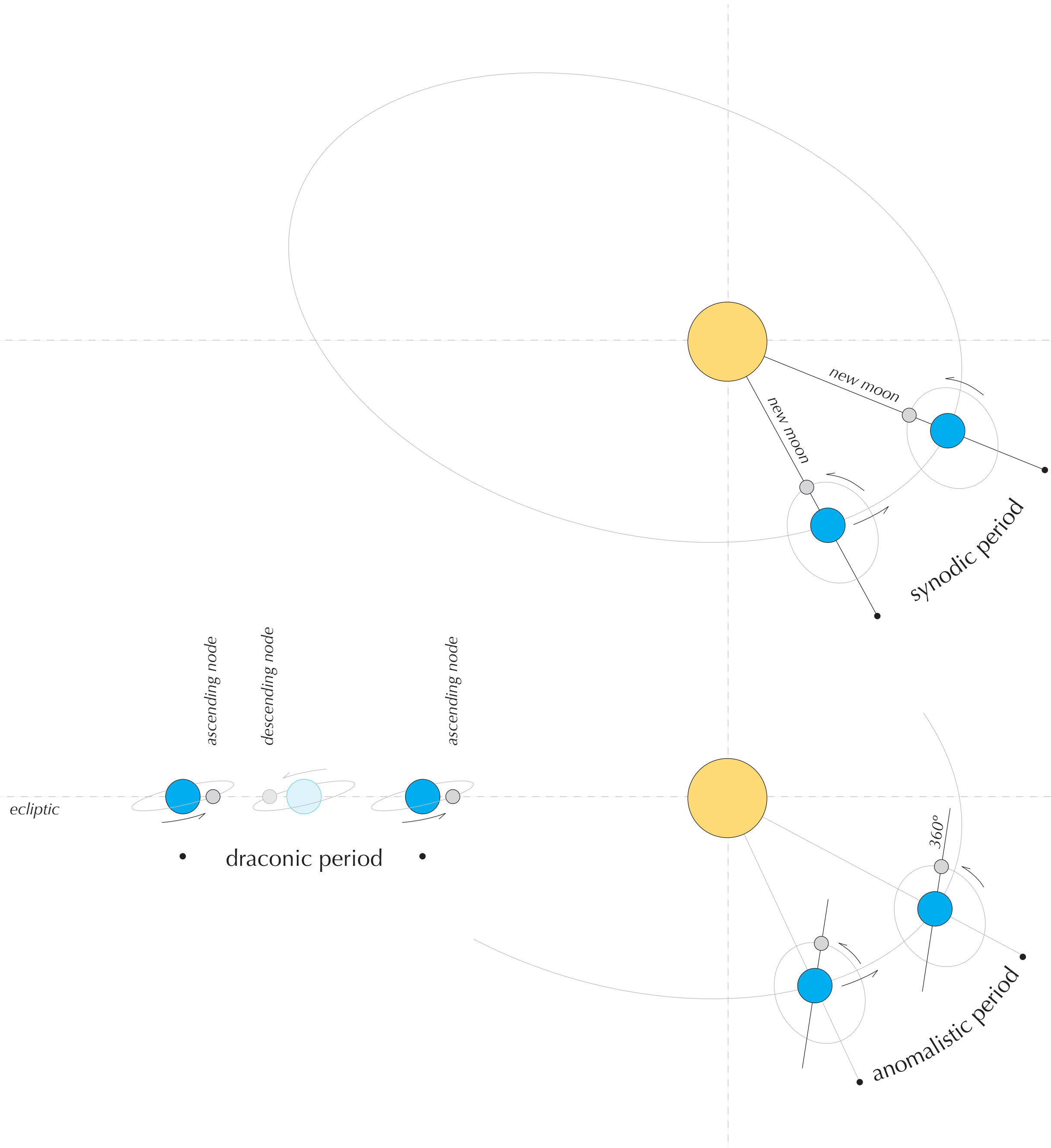


fig. 4.8- diagrams of three periods of lunar orbit: synodic, draconic and anomalistic

silver space : the ribbon

The imperative *to reflect* is articulated by the two lakes on the southern edge of the site, Alice Lake and Baby Lake; these can be seen as two massive mirrors, reflecting the light of the sun and the colours of the sky and surrounding landscape. In locating the silver space on the site, it was important to consider proximity to water, not only for its metaphorical connection to the mirror but also because of the well-established connection between the Moon and the waters of Earth, most notably seen in the motion of the tides. Skirting the edge of Baby Lake was a small horseshoe-shaped cove, only a few metres across. This cove was to provide the starting point for situating the silver space.

The silver space features a series of stone "ribbons", each designed around the view of a specific cosmic sequence: the occurrence of lunar eclipses according to the Saros cycle. There are hundreds of Saros cycles, but over the next decade only five will present eclipses visible from the Coniston site. The five stone ribbons correspond to Saros cycles 122, 125, 127, 134 and 137. The occurrence of a lunar eclipse every three Saros cycles (54 years and a month, approximately) is visible from the same location on the planet. Although the position is quite similar, the eclipses of one Saros do not occur at precisely the same point in the sky; there is a small shift in altitude and azimuth. By diagramming the moon's altitude and azimuth at the midpoint of lunar eclipses, a precise view angle for each can be defined.

Eclipses are easily viewed with the naked eye; however, the purpose of the silver space is to focus this view through the ribbon's mirror. This realizes an idealized view of the moon, one that captures the mythology of the moon as a mirror in itself, but the effect also highlights the mathematical derivation of lunar position, juxtaposing scientific calculation with a historically romanticized perception of the Moon. The mirror is a disc of real silver with a smooth, untreated surface. It is the nature of silver to oxidize, and exposed silver will begin to discolour rapidly, especially with exposure to the elements. However, to serve its function as part of the silver space, the surface needs to be reflective for only a few hours every 54 years, during the brief period of the eclipse. For this reason, the silver will be polished to a high lustre for the eclipse, and allowed to go dark in the interim.

In viewing the reflection in the mirror, a moon positioned higher in the sky creates a steep view angle best accessed when standing; low angles, with the moon near the horizon, require the viewer to take a prone position. Because three different basic viewing positions are needed - standing, sitting upright and lying prone - markers for each are carved into the ribbon's surface. A small circle, to be placed between the feet, represents a standing position; a larger circle, a place to sit for mid-sky views; and a triangular shape the resting point for forearms as the viewer lies down. The shape of the stone ribbons is derived from the locations of these viewing positions.

The ribbons are shaped of white stone, distinguished from the surrounding landscape both in colour and texture. The initial selection for this stone was white quartzite: it is available locally, and its weather-resistance would make it ideal for this application, but is difficult to procure in thicknesses exceeding 40mm. For this reason, white granite, which is also frost-resistant, was selected, although granite does not possess quite the same sparkling qualities of quartzite. The stone is finished in smooth and sandblasted surfaces, the polished surface catching the light and the textured surface making a band across the viewing locations. Each ribbon is anchored in place to steel supports at grade level. The five ribbons are located on the site according to the time of year in which the eclipses of each Saros series transpire. Summer eclipses are located closer to the lake's edge, approaching the water at the time of year when the lakes are most likely to act as mirrors as well, while winter eclipse ribbons are removed to a higher altitude, away from what will be the lake's matte, opaque surface.

The design of each ribbon displays no more than three lunar eclipses. Because the orbit of the moon is not perfectly regular - it is subject to external forces that exert small variations in its path - forecasts of lunar positions decades into the future cannot be accurately made. For this reason, eclipses of the Saros cycles captured in the silver ribbons cannot be precisely determined beyond this century. However, it is intended that the reflective silver of existing ribbons be used for the viewing of future eclipses, with new ribbons constructed to set up ideal views of the eclipse. These mirrors may also be used for eclipses of other Saros cycles, with multiple ribbons spinning out from a single mirror.

fig. 4.9- time lapse photograph of total lunar eclipse. Photo credit: David Ball, www.davidball.net

Saros 122
(70 eclipses, 1244 years- 991.04.17-2235.05.17)

1888.01.28 23:20 (total)
1906.02.09 07:47 (total)
1924.02.20 16:09 (total)
1942.03.03 00:21 (total)
1960.03.13 08:28 (total)
1978.03.24 16:22 (total)
1996.04.04 00:10 (total)
2014.04.15 07:46 (total)
2032.04.25 15:13 (total)
2050.05.06 22:30 (total)
2068.05.17 05:40 (partial eclipse)
2086.05.28 12:41 (partial)
2104.06.08 19:35 (partial)
2122.06.20 02:24 (partial)
2140.06.30 09:08 (partial)

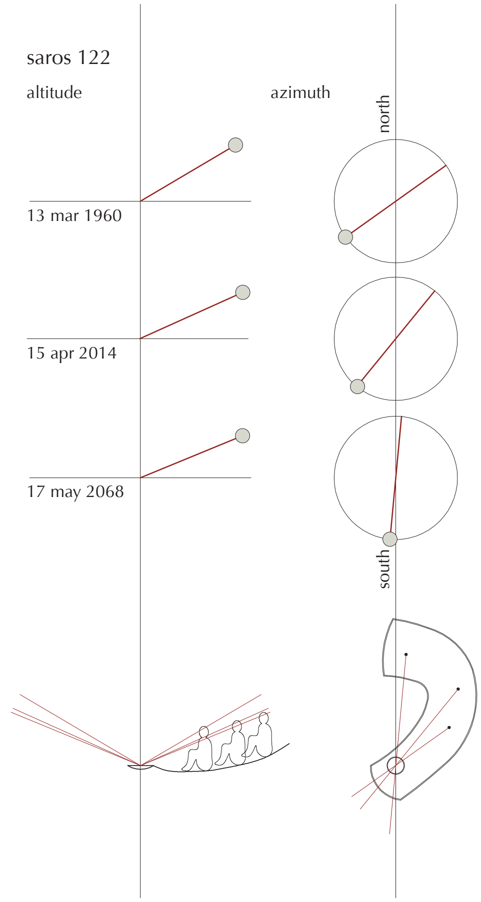


fig. 4.10- diagrams and dimension drawings, Saros 122 ribbon

fig. 4.11- view of total lunar eclipse, 15 April 2014

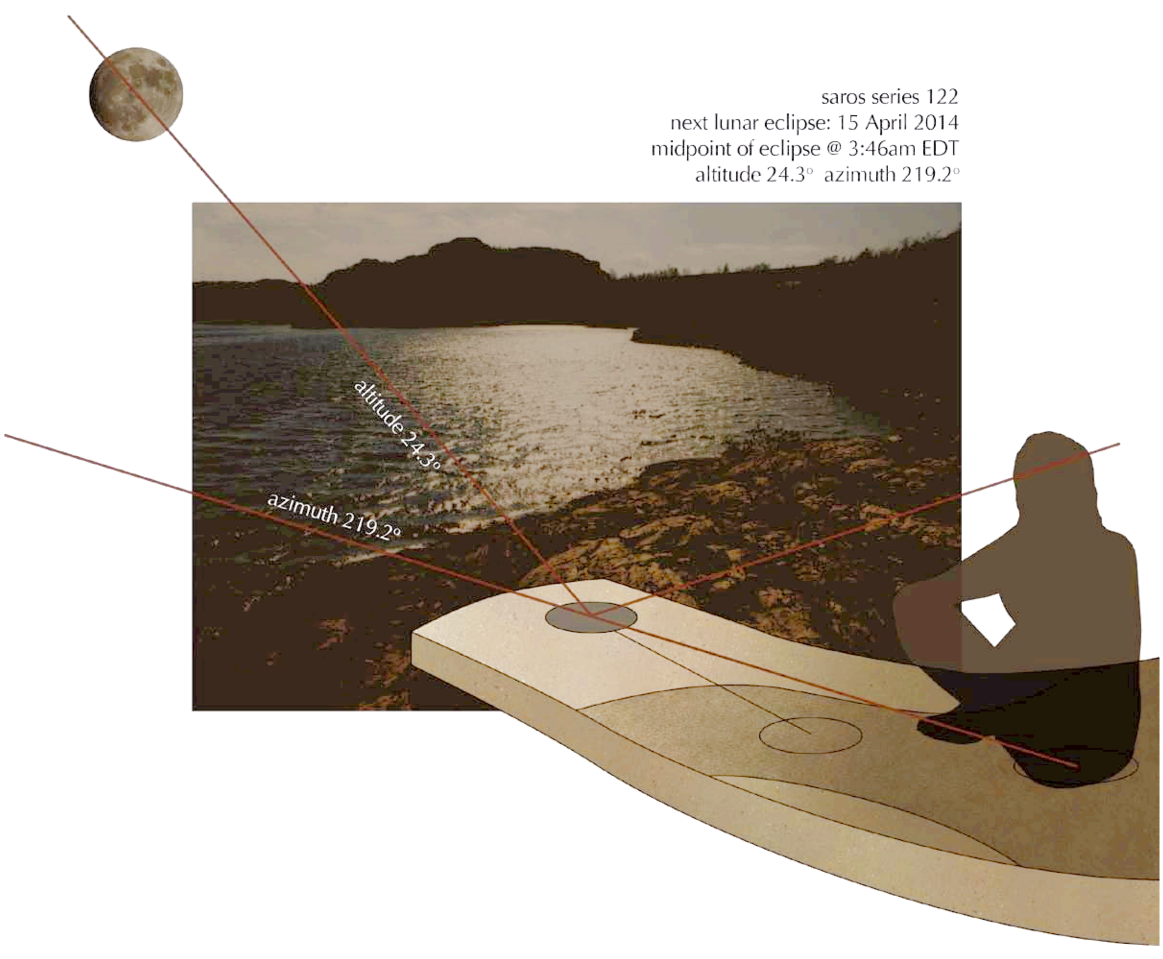
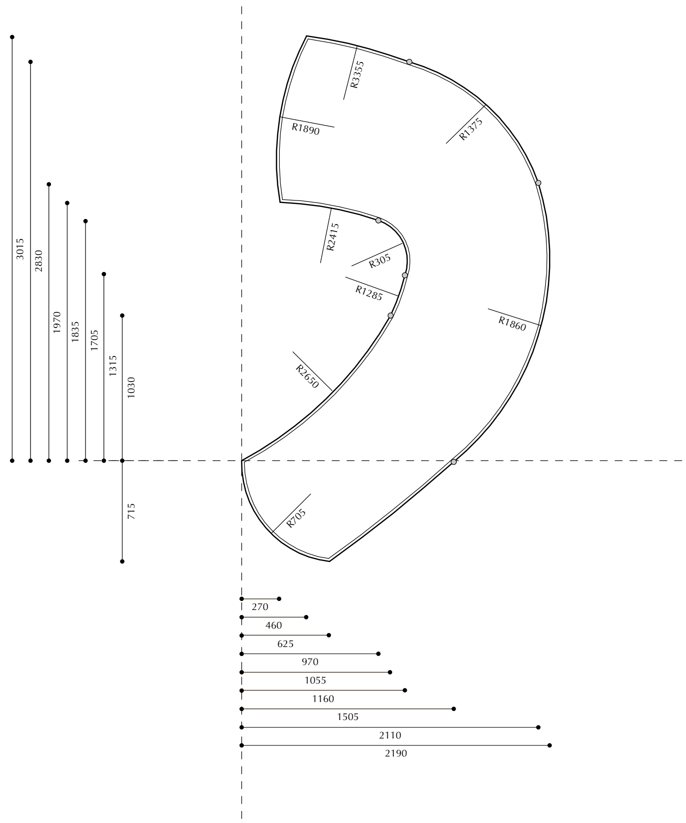
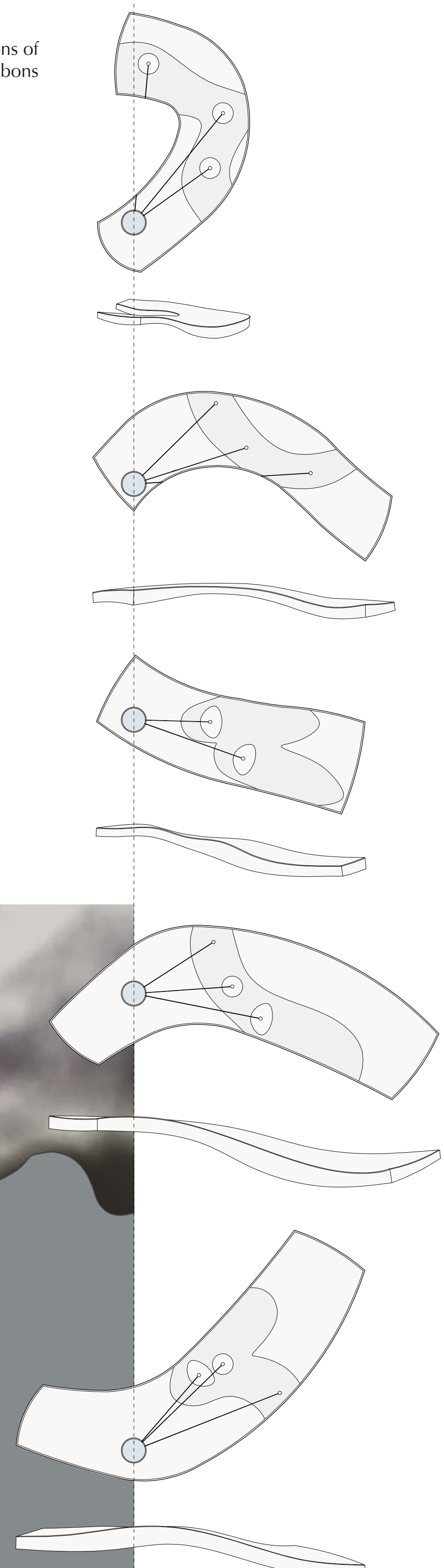


fig. 4.12- plans and elevations of silver ribbons





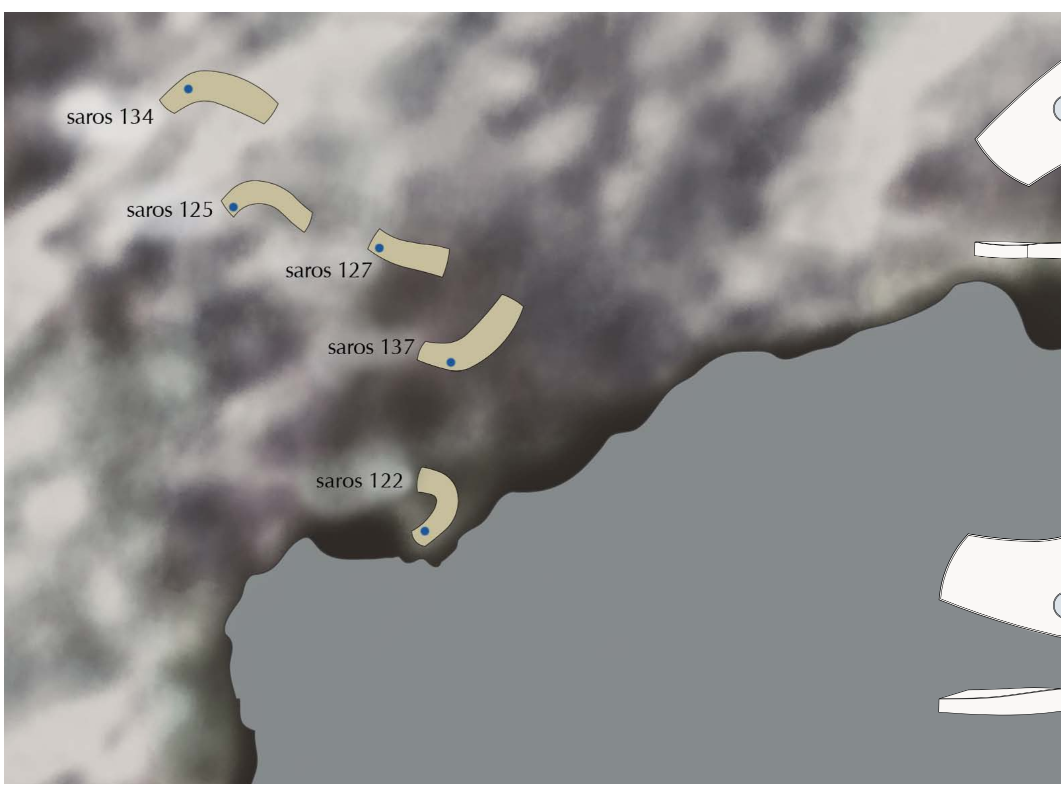
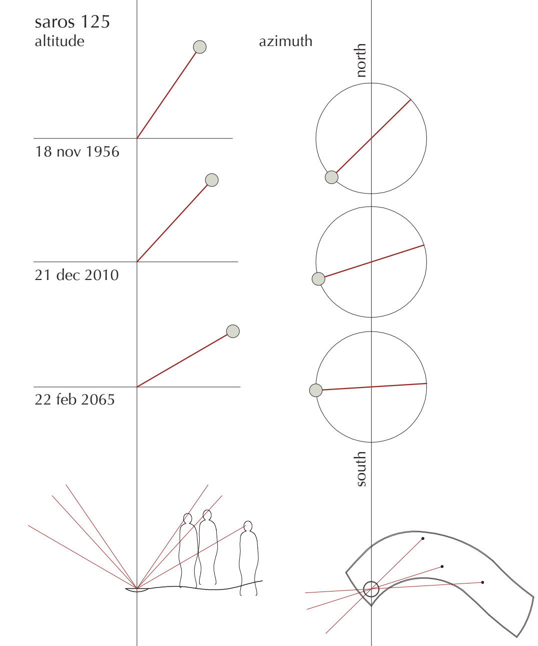


fig. 4.13- site plan of silver ribbons

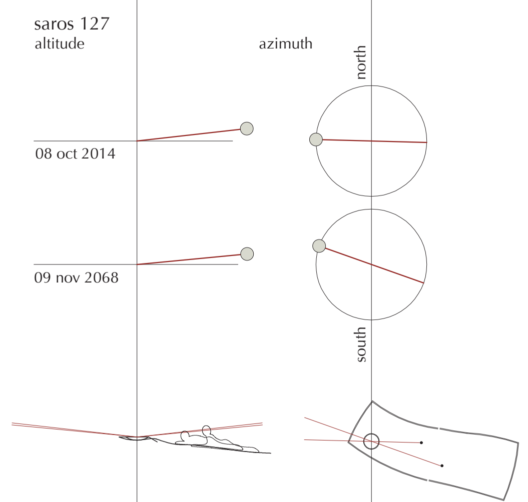
Saros 125
(73 eclipses, 1298 years, 1060.02.04-2358.04.09)

1884.10.04 22:02 (total)
1902.10.17 06:03 (total)
1920.10.27 14:11 (total)
1938.11.07 22:26 (total)
1956.11.18 06:48 (total)
1974.11.29 15:13 (total)
1992.12.09 23:44 (total)
2010.12.21 08:17 (total)
2028.12.31 16:52 (total)
2047.01.12 01:24 (total)
2065.01.22 09:57 (total)
2083.02.02 18:24 (total)
2101.02.14 02:46 (total)
2119.02.25 11:01 (total)
2137.03.07 19:09 (total)



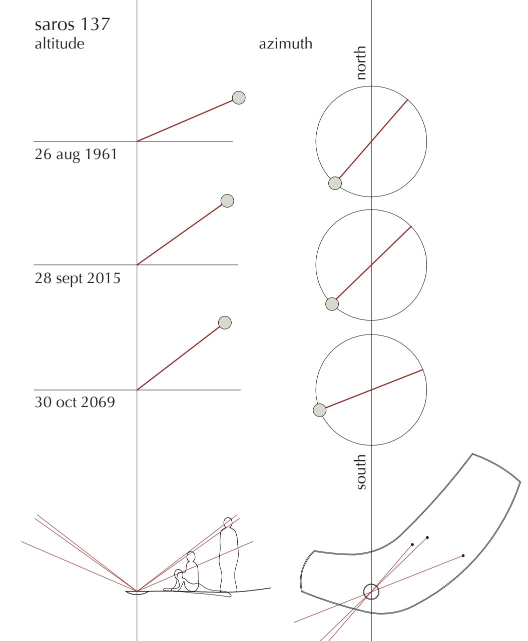
Saros 127
(82 eclipses, 1460 years, 991.10.01-2453.03.21)

1888.07.23 05:45 (total)
1906.08.04 13:00 (total)
1924.08.14 20:20 (total)
1942.08.26 03:48 (total)
1960.09.05 11:21 (total)
1978.09.16 19:04 (total)
1996.09.27 02:54 (total)
2014.10.08 10:55 (total)
2032.10.18 19:02 (total)
2050.10.30 03:20 (total)
2068.11.09 11:44 (total)
2086.11.20 20:17 (partial)
2104.12.02 04:54 (partial)
2122.12.13 13:38 (partial)
2140.12.23 22:25 (partial)



Saros 137
(70 eclipses, 1244 years, 1380.05.25-2633.06.28)

1889.07.12 20:54 (partial)
1907.07.25 04:22 (partial)
1925.08.04 11:53 (partial)
1943.08.15 19:28 (partial)
1961.08.26 03:08 (partial)
1979.09.06 10:54 (total)
1997.09.16 18:47 (total)
2015.09.28 02:47 (total)
2033.10.08 10:55 (total)
2051.10.19 19:10 (total)
2069.10.30 03:33 (total)
2087.11.10 12:02 (total)
2105.11.21 20:38 (total)
2123.12.03 05:20 (total)
2141.12.13 14:05 (total)



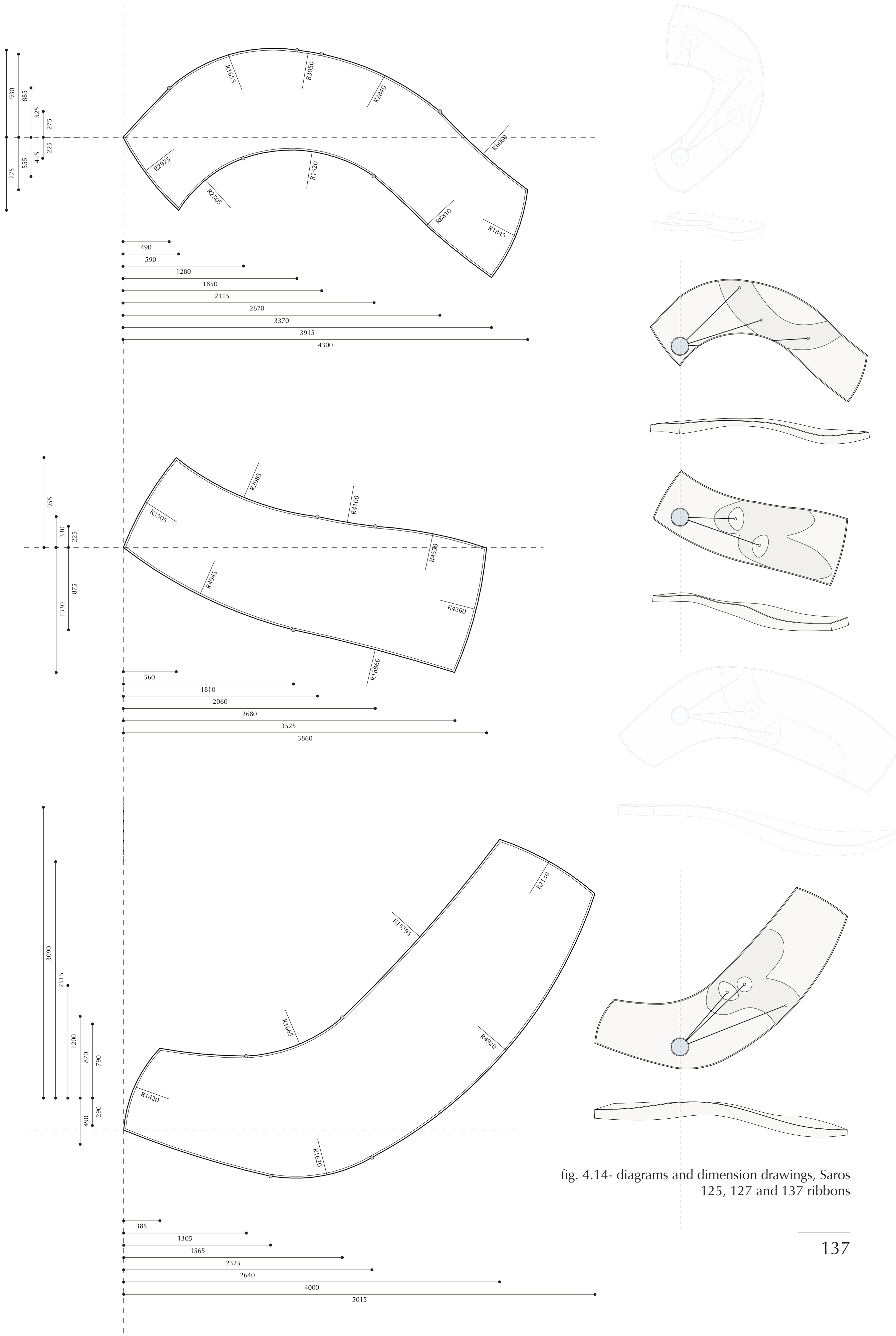


fig. 4.14- diagrams and dimension drawings, Saros 125, 127 and 137 ribbons

Saros 134
(71 eclipses, 1262 years, 1248.06.22-2510.08.06)

1910.11.17 00:21 (total)
1928.11.27 09:01 (total)
1946.12.08 17:48 (total)
1964.12.19 02:37 (total)
1982.12.30 11:29 (total)
2001.01.09 20:21 (total)
2019.01.21 05:12 (total)
2037.01.31 14:00 (total)
2055.02.11 22:44 (total)
2073.02.22 07:22 (total)
2091.03.05 15:55 (total)
2109.03.17 00:19 (total)
2127.03.28 08:36 (total)
2145.04.07 16:43 (total)

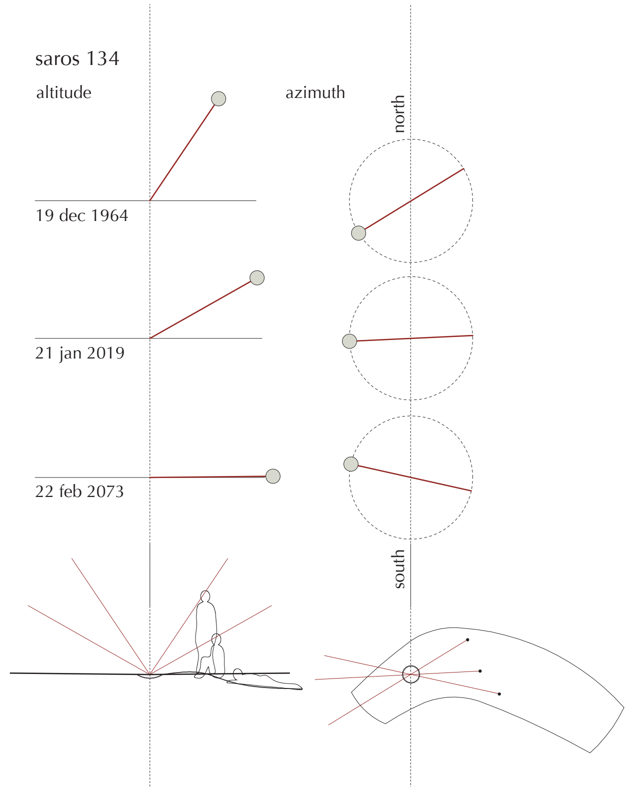
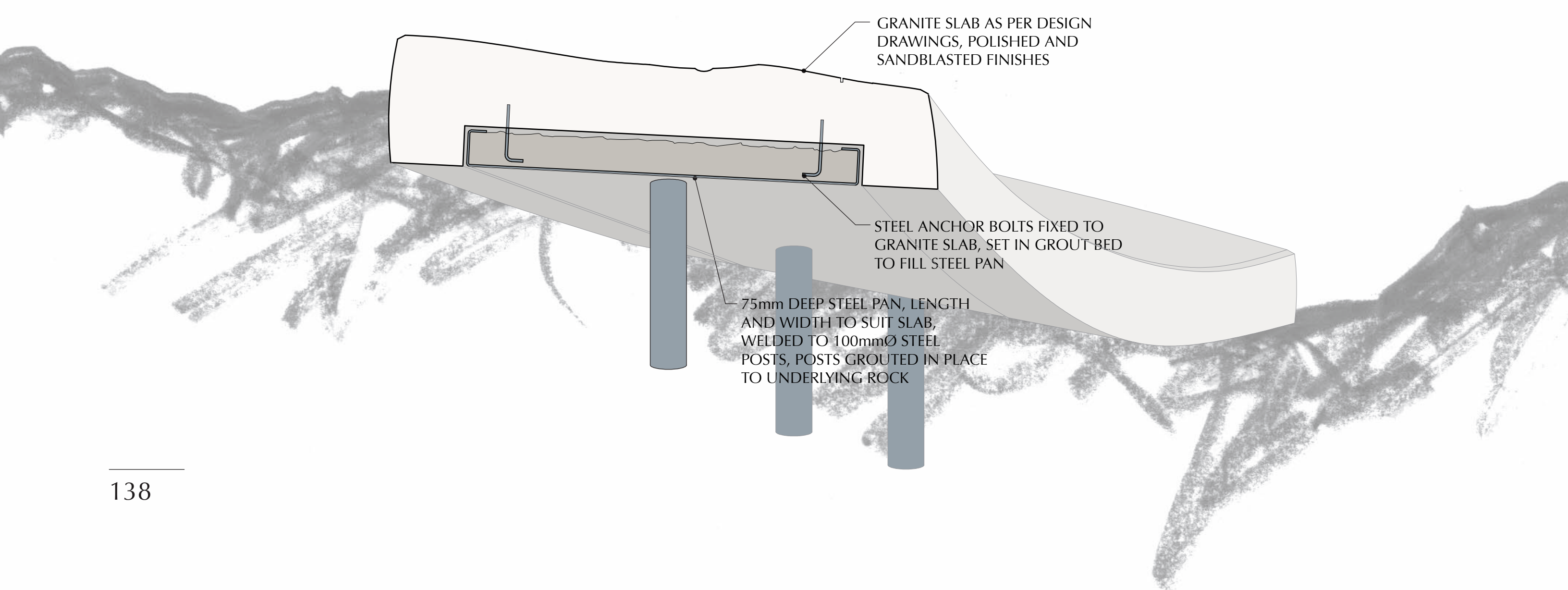


fig. 4.15- diagrams and dimension drawings, Saros 134 ribbon

Slab construction: articulated granite slabs, factory-milled and installed on grade, polished/ sandblasted finishes with untreated silver inlays. Stone conforming to ASTM C615-03 Standard Specification for Granite Dimension Stone: Oconee white granite, custom cut as per design drawings. Stone finishes: polished and sandblasted. Slab to be sandblast-engraved with number of Saros cycle and eclipse dates as per design drawings. Installation: slabs to be installed over gravel leveling bed and bolted into place. Silver inlay: Tarnish-resistant Argentium sterling silver, composition Ag 92.5%, Ge 1.2%, Cu 6.3%, thickness 2mm, inset and adhered to granite.

fig. 4.16- section through Saros 134 ribbon



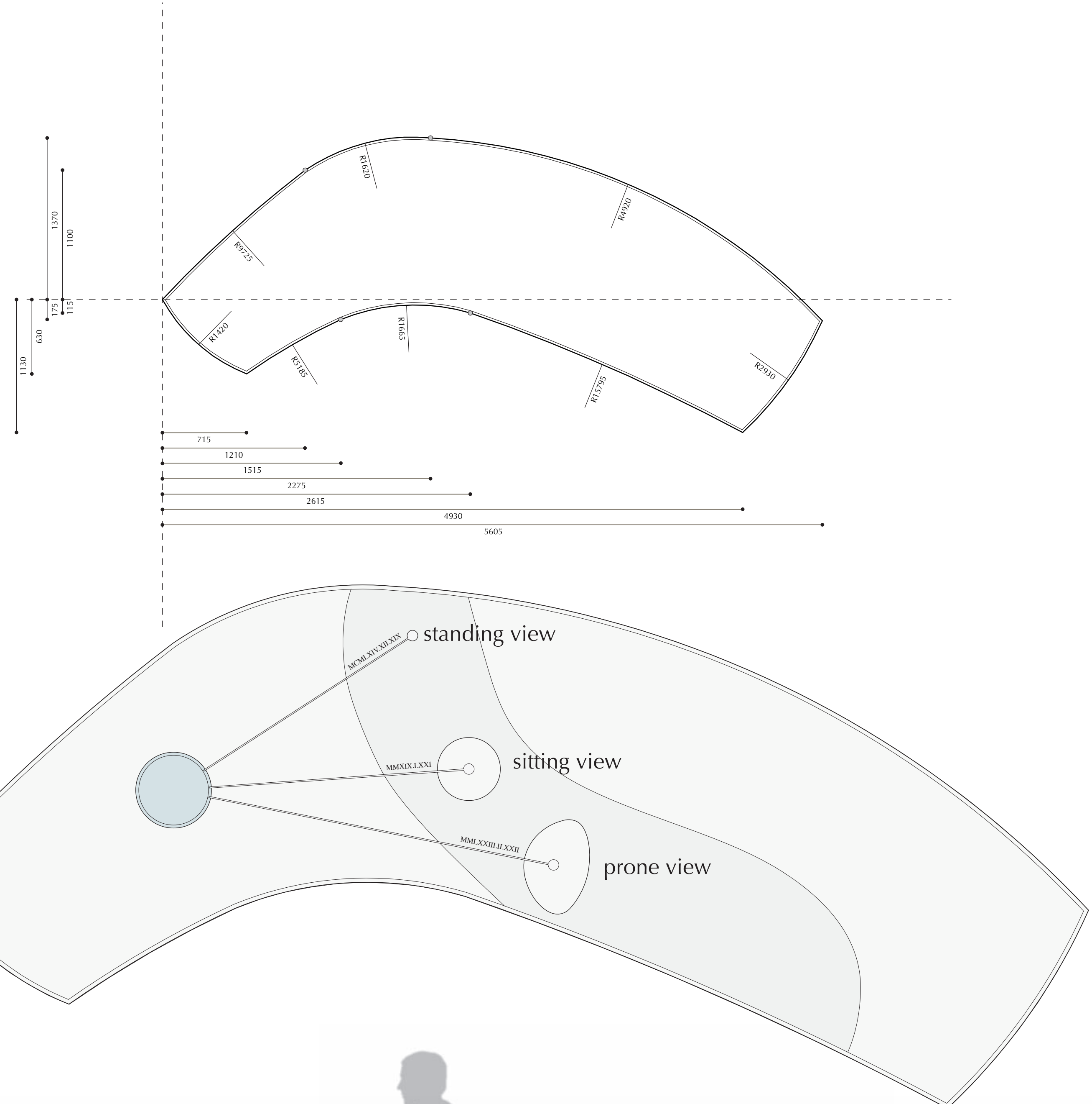


fig. 4.17- plan of Saros 134 ribbon

fig. 4.18- elevation of Saros 134 ribbon:
1964.12.19 lunar eclipse (standing view),
2019.01.21 lunar eclipse (sitting view),
2073.2.22 lunar eclipse (prone view)

Book V : hydrargum

☿ Hg 80

the fable of chione

The wind-child Chione occupied her days
With wanderings over the plains of rock, searching
For secret spots amongst the crags and cracks,
Endless preparation for games of hide-and-seek.
Some spots she would carve smooth with her breath,
A comfortable hollow. In other places she would wear a path
Where her light feet scraped the ground,
Racing from one hideout to the next.
She played with the small, hardy flowers
Growing from out of the rock,
Coaxing forth with the warmth of her exhalations
Colours of vivid blue and violet.
Basking in the sun, she would lay herself
Prone on soft moss, her hair spinning
In eddies around her.

With the change in seasons she would rush
Towards the edge of the endless ocean,
Stopping herself short of the brisk fall
Off the rock face marking the limits
Of land and sea.
Here at the top of the cliff
She would wait for visits from her uncles:
Notus, with tales from the South,
Eurus, bringing stories from the East, and
Her dearest uncle, warm and kindly Zephyr,
With news from the great continent to the West.

Notus spoke of the temperate lands to the south,
Of the men there who governed themselves
By the movement of the morning and evening stars.
He told young Chione of the stone temples
That rose, only to be scaled
By men adorned, embellished with gold,
Appearing like the Sun, shining down on the masses.
Masters of crops, these people
Tamed and tended the oft-ungrateful soil for seeds
Of yellow gold, brought forth by the Sun,
Or scorched by him to dust.

Eurus told of the worlds to the East,
Here too man had learned to shape rock
And lift rock, building temples
To honour the gods watching over their lands.
Metal, too, had these people started to master,
Working it into tools and ornament,
But also into instruments of war:
Swords and shields, axes and arrowheads,
For these men the gift of metal has
Held within it, a curse.

Of the West, Zephyr told of a people
Not tied to place, nor crop, nor temple:
A people as free as the winds themselves.
Who worshipped the winds, and all of nature-
The magnificent Gaia,
Her plains, pools, mountains and creeks one great temple,
One great home.
These people followed the herds, followed the Sun
And its warmth as both migrated across the land.

But all three uncles spoke of the same phenomenon,
One that Chione could never have imagined
In all her days:
How man had learned to capture wind
Within his chest, and, exhaling it,
Began to create stories of his own.
Stories he passed onto his children,
And they to theirs: stories about the beginning of worlds,
Of love and tragedy, victory, loss and hope,
Stories wound with such beauty and grace
That even the ruling winds stopped to listen.

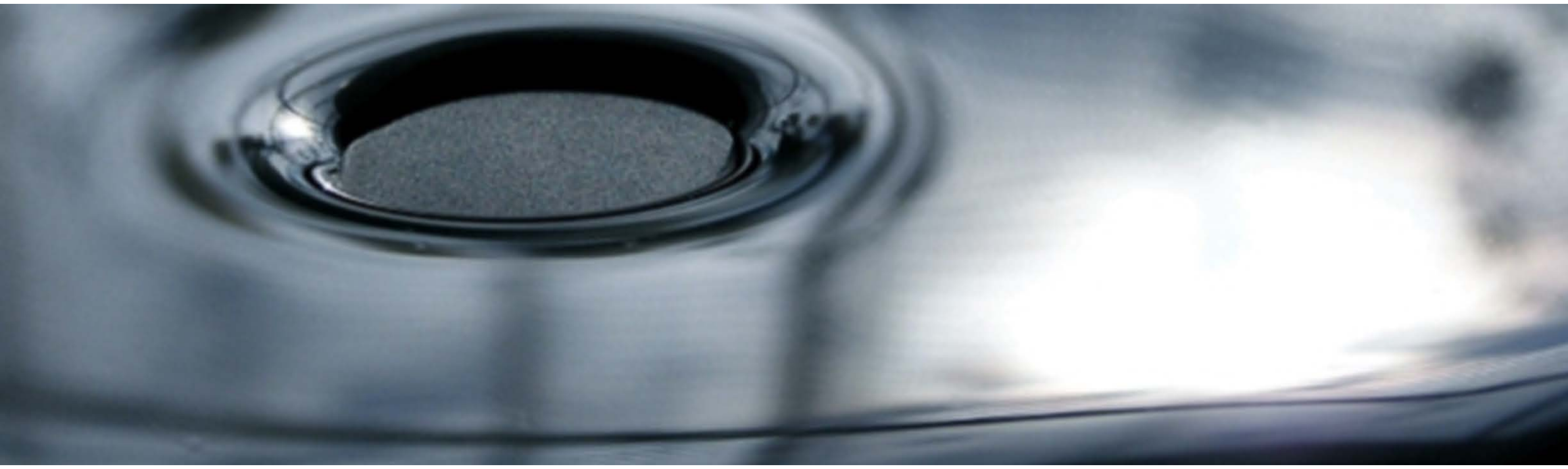


fig. 5.1- Mercury

Mercury is a fox, and will be too crafty for fooles, yea and will oft leave them to their disgrace, when they relying upon so uncertaine a medicine, promise health, and in the stead of healing make their Patient worse then before.

- J. Woodall, *The Surgeon's Mate of Military & Domestic Surgery*

Hg from the latin *hydrargum,* meaning *watery silver*

In present day, mercury is a carefully managed substance and a known toxin, but this was not always the case. In Grade 8 science class, we set up Bunsen burners and glassware as our teacher handed out small pieces of a soft, red rock she called cinnabar. We lit our burners under flasks and watched as the rock emitted a strange steam that started to condense into silver droplets. By the end of the experiment every student in the class had made a small globule of mercury. We were fascinated by its movement and brilliance. The teacher came around to collect the product of our efforts, telling us to make sure we did not pour it down the sinks. I stole a small particle in the chamber of a disposable pen sealed with tape, a droplet hardly as big as the head of a pin. There is no more mercury in schools; it has been abolished in all its forms, including those rudimentary science experiments. Certainly teenagers are no longer chasing droplets around their palms in science class.

Mercury is distinct among the seven classical metals for its state of liquidity*. Because of its colour and lustre, it was initially given the name *quicksilver* by the ancients. That this colloquial name infers a quality of velocity can be attributed to mercury's physical qualities: it moves rapidly, in a manner that appears erratic and noticeably distinct from that of other liquids. This spirited unpredictability contributed to the historic belief that mercury possessed within it an inner flame,[1] one that not only maintained its molten state but also empowered it to act with a will of its own. One of the more unexpected and perhaps arresting qualities of mercury is its weight: a pint glass of mercury weighs about 17lbs, or 16 times the weight of the same volume of water. Despite its liquid state, mercury is heavier per volume than lead, iron, copper, silver or tin; of the seven classical metals, only gold is heavier by volume. Understanding this quality of mercury helps explain the behaviour of the metal, for the sheer weight of the liquid is simply acting in response to gravity. Without this knowledge the movement of mercury appears volatile and random, but in truth it is the weight of the material that governs its behaviour as it seeks the most direct path downwards.

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* Mercury freezes to a solid state at a relatively conservative -39°C.

It is difficult to track the initial appearance of mercury in human civilization, for it was long taken for a liquid manifestation of silver rather than an autonomous substance in its own right. Aristotle provides the earliest written reference to mercury in the fourth century BCE, calling it "fluid silver";[2] around the same time, the process of the distillation of mercury by the heating of cinnabar and condensing the resultant vapours was first recorded.[3] Pliny the Elder made the first reports of the potential health risks of mercury, describing how workers polishing cinnabar wore masks of animal bladder skins, "to prevent their inhaling the dust in breathing, which is very pernicious."[4] Indeed, mercury volatizes rather readily, and is most effectively absorbed by the human body when inhaled as vapours, although it can be absorbed through the surface of the skin as well. The heavy metal acts detrimentally on the central nervous system, causing a host of symptoms ranging from erethism (characterized by spontaneous laughter and crying) to brain damage and death. Most are familiar with the term "mad as a hatter"; those afflictions of behaviour popularized by the Lewis Carroll character in Alice in Wonderland are now believed to be the result of mercury poisoning. The manufacture of felt, as the main material in the making of hats, began with the separation of fur from animal pelts, a process made easier by soaking pelts in a mercuric solution.[5] Despite the early recognition of the toxic effects of the metal on the human body, mercury was still used medicinally for centuries. It was a common anti-syphilitic, but the psychosis seen in patients - long attributed to the illness - may well have been compounded by the effects of mercury poisoning.[6]

Contemporarily, mercury is most commonly seen in devices of measurement, and is the traditional material used in common thermometers, blood pressure monitors and barometers, for its reaction to changes in temperature and pressure is markedly consistent and predictable. One of the more interesting historical uses of mercury, and one the metal shares with others such as silver and bronze, is in the fabrication of mirrors. During the Renaissance, a process was developed that trapped a layer of the liquid metal between a sheet of glass and a tray of tin;[7] this remained the predominant method of mirror manufacture for a period of almost four hundred years. Mercury is still used in mirrors today, although of a different sort. In liquid mirrors for large-scale telescopes, a thin layer of mercury is poured onto a rotating disc several feet in diameter, the spinning of which creates a perfect paraboloid, the ideal shape of surface for astronomical observation.[8]

The ancient alchemists of the East and the West had a particular and unique regard for mercury among the classical metals. In both traditions, there was a special significance to the pairing of mercury with the element sulphur. In China as in Alexandria, mercury was considered the embodiment of yin, the feminine principle,[9] serving as the matrix from which all other metals were born.[10] Thus mercury was more than simply an element unto itself: it was the mother of all metals, from base lead to purest gold.

Metallic mercury was linked to the planet of the same name by the Byzantine astrologer, Stephanos of Alexandria, in the 7th century CE. Before this time, the planet was associated with other metals: Origen attributed the metal iron to Mercury in the 2nd century, and in the 6th century Olympiodorus the Younger tied the planet to the metal tin.[11]

ARgentum viuũ. ¶ Ysidore. ¶ Ar
gent vif est ainsi dit pource quil
trenche les matieres esquelles
il est mis/aussi il est luysant et q̃
court tousiours. On le treuue ꝑ
especiales metaulx: ou es four
naises dargent adherãt aux parois par petites
goutes. On le treuue aussi bien souuent en fiẽ
tes bien vieilles des latrines ou en lymon des
puys.

fig. 5.2- One of the earliest pictorial representations of quicksilver, from the *Hortus Sanitatis, Le Jardin de Santé*, circa 1500.

We're a very expensive group; we break a lot of rules. It's unheard of to combine opera with a rock theme, my dear.

- Freddie Mercury

mercury

Mercury is the smallest of the seven classical planets, and keeps the tightest orbit around the Sun. It is somewhat difficult to observe from Earth, as its small size and proximity to the Sun make it easily lost against the bright light. When it can be seen, it presents as a morning or evening star, before the Sun rises or after it sinks below the horizon. Twinkling in the twilit skies, the ancient Greeks referred to Mercury as Stilbon, the Scintillating One;[12] they would later rename the planet Hermes after the fleet-footed messenger god.[13] On closer investigation, the surface of Mercury is similar to that of the Moon: it is heavily cratered, and similarly grey in colour. The small, heavy planet, denser than any other in the solar system, has no moons of its own and is shrouded by only the thinnest of atmospheres; this shallow blanket of gases provides little protection from the warming of the Sun and the freezing of the vacuum of space, causing what are the most extreme temperature variations seen on any planet. At its coldest, the Mercurian surface hits -185°C, or cold enough for air to liquefy; at its highest, temperatures rising above 400°C are hot enough to melt lead. Given its close proximity to the Sun, the notion of Mercury as a scorching, fiery planet has been prominent since the dawn of heliocentrism*, as described in the writings of 18th century author Bernard de Fontenelle, who speculated that the Mercurian inhabitants were a people "so full of Fire, that they are absolutely mad; I fancy that they have no Memory at all… make no reflections, and what they do is by sudden starts, and perfect haphazard; in short, Mercury is the Bedlam of the Universe."[14]

Opposite page:
fig. 5.3- Partial map of the Mercurian surface with named features, taken by NASA's Mariner 10, 1974-1975.

* Heliocentrism is the Copernican theory that the planets revolve around the Sun; this is in contrast to the Ptolemaic theory of geocentrism, which places the Earth at the centre of solar and planetary revolutions. While both theories have their roots in ancient Greece, it was Ptolemy's theory that was to predominate until the Renaissance, in part due to support by the Church: elements of biblical scripture placed the Earth at the centre of the universe.


Mena
nes
Chu Ta
Cézanne
Mark Twain
han
Philoxenus
Schoenberg
Beethoven
Bello
Bartók
Sayat-Nova
Rūmī
Ives
Surikov
Delacroix
Shelley
Michelangelo
Hawthorne

The planet Mercury shares the name of the Roman god of trade and commerce, although the deity was linked with many other dominions as well. The Romans would connect Mercury with the Greek Hermes, for which he also became associated with travel and language. That Hermes classically held influence not only over literature, but also over thieves and liars, provides an interesting insight into the ancient regard for cunning in the crafting and manipulation of words. Mercury was credited with the invention of the four-stringed lyre, and was known as a patron of the arts; because of this, he was particularly well-received in the Roman colonies of the North, where the gods of the arts were highly revered.[15] The Norse Odin, and his German counterpart Woden, were gods of poetry and wisdom;[16] the third day of the week, Wednesday, is derived from their name. The same day in Latin languages references the god Mercury, such as the French *mercredi* and the Italian *mercoledì*.

For many years there have been conventions by which celestial bodies and their features have been named, and these conventions have ascribed themes to lunar and planetary systems. The moons of Pluto refer to characters of underworld myth, such as Charon, ferryman of the dead across the river Styx; features on the Saturnian moon Tethys are named for characters from the Odyssey and the Iliad, including the Ithaca Chasma and the Circe and Achilles craters.[17] In the case of Mercury, different types of surface features call out an international contingent from the world of the arts. Craters are named for famous painters, sculptors, writers and composers, while plains reference Mercury's name in other languages and mythologies. A map of Mercury's surface features reveals the craters Beethoven, Tolstoj and Michelangelo, interspersed between the plains of Budh (from the Hindu) and Suisei (from the Japanese).[18]

Mercury holds rulership over the sign Gemini, which is tied to the zodiac's third house. In the Baroque, Sir George Wharton named the third house as the House of Brethren, and also noted that the third house was the end of the first Age of Man, that of Childhood.[19] The House of Brethren relates not only to the relationship with the siblings; it also encompasses the individual's interaction with all aspects of his immediate environment, including his close personal family. Essentially, this stage is characterized by the individual's acclimatization with the outside world, this world delineated by the boundaries of their own skin.[20] The third house emphasizes the immediate, both externally (the outside world of one's close personal experience) and internally (the individual's most instinctual responses). These responses are physical as well as intellectual.

The astronomical and astrological symbol for the planet Mercury is a circle above a cross, crowned with a half-circle representing the wings of the messenger god's helmet. This glyph, ☿, also symbolizes the element mercury in alchemy.

The histories of mercury as a metal and as a planet reveal several characteristics that are consistent between the two, both scientifically and metaphorically. Certainly both metal and planet are associated with velocity of movement; this is characterized as erratic and volatile in the case of the metal, but is in truth a result of its weight and subsequent response to gravity. Likewise, the orbiting speed of the planet Mercury is due to its tight rotation around the Sun, coincidentally also a response to gravity. It can be perceived in both planet and metal that there is a distinctive reaction to heat and cold: the planet Mercury experiences extreme heating and cooling of its surface, and the metal responds with such marked consistency that it is used as a tool for measurement of temperature as well as pressure. With these similarities in consideration, it becomes clear that one of the characteristic qualities of mercury is its ability to respond - to gravity, to temperature, to pressure and, because of the metal's fluidity, to form. Considered through the third house of the zodiac - that of the immediate environment - responsiveness can be understood as the fundamental need to give and receive feedback through the experience of our inner and outer worlds. In this, the imperative of mercury *to respond* also includes the intrinsic human desire to express ourselves outwardly.

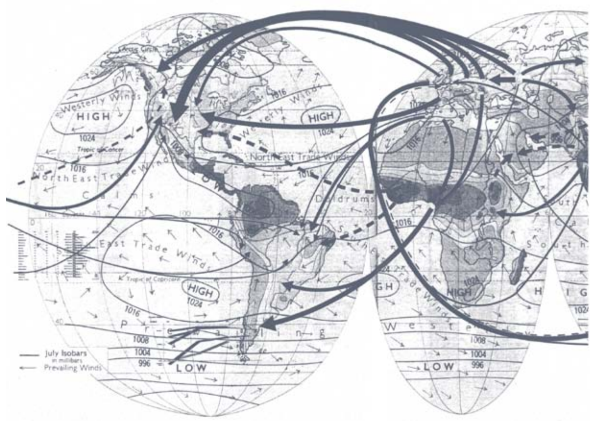
One might consider the concept of responsiveness on two levels: the physical, and the psychological. The physical form of responsiveness may be fluid, such as the movement of water by wind, or it may be imprinted as evidence of past events. Psychologically, the nature of response constitutes more than simple cause and effect: the intrinsic emotional reaction is tempered by thought, by experience and by precedent. The reaction incorporates what is a palimpsest of emotions, and one that continues to be a dynamic entity.

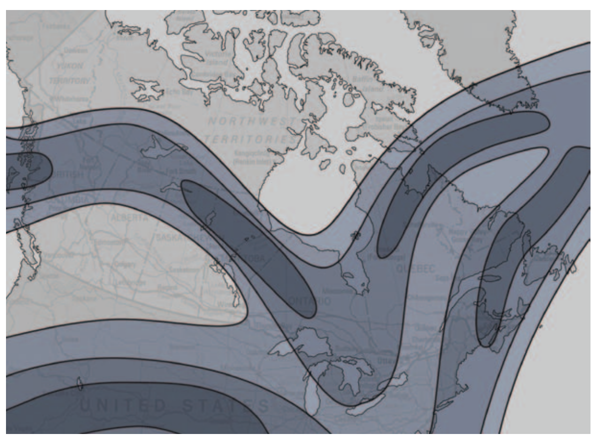
The idea of responsiveness as a study of form has potent implications when applied to an understanding of landscape. It is remarkable to consider that, at some point in history, the ground on which one stands might have been buried under miles of ice, sunken deep under the ocean, or locked beneath an ancient mountain range. The melting of glaciers, the tectonic upheaval of land lifting out of the sea, and the slow erosion of inconceivable weights of rock characterizes responsiveness recorded in form over millions of years. While these changes are virtually imperceptible at the scale of a human lifetime, there are shifts in landscape that can be observed over months or days, through the simple cycling of the seasons. The natural forces of wind, water, temperature, and sunlight act to transform the landscape, and through these processes every site is in a constant state of evolution. These forces can be observed at a number of scales, from the massive push of continental winds to the small breezes rustling leaves and grasses. They can also be perceived in the movement of species, from the cycling migration of caribou to the passage and staging of birds through the seasons.

Just as there are ubiquitous forces of wind and water in nature, so too are there universal forms and patterns created by them. Despite their differing constitutions - liquid, being denser and heavier, moves more slowly than air, thus making patterns easier to observe - wind and water create similar shapes through movement. Whether as a single flow wrapping around an object in its path or creating an eddy, moving water tends towards the form of the spiral.[21] It can be observed that water never flows

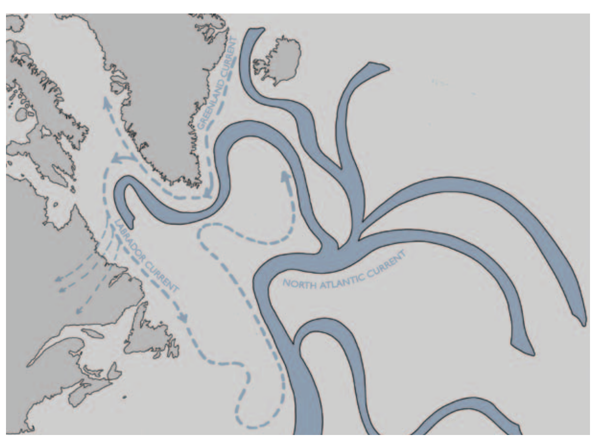
fig. 5.4- *Study of the Flow of Water*, Leonardo da Vinci, circa 1508-9

in a perfectly flat and laminar manner, but twists as it moves, and higher velocities exaggerate this tendency.[22] Leonardo da Vinci made numerous sketches of flowing water, depicting the repetitive patterns that he perceived in the eddies. Essentially the creation of these predictable patterns takes place within a certain set of conditions: of temperature, velocity, and the physical obstacles and boundaries that impact or constrain the flow. When one or more of these are excessive, such as high speeds or numerous obstructions, the visible pattern of the spiral erodes and the phenomenon of turbulence takes place.[23] Turbulence can be observed as the breakdown of predictable patterns, introducing a chaotic state where movement can no longer be determined. This unpredictability can be seen in the flow of water over falls or across rapids. It is important to note that while order appears to erode this may not necessarily be the case, for a chaotic state is simply defined as one in which order does not adhere to any known formula. Patterns, old or new, can emerge from the chaos as a function of *chance*, for even apparent randomness is subject to the laws of probability, however slim those odds might be.[24] This holds particular relevance in an architectural proposition, for although any number of defined conditions may be set up in a project - circulation paths, gathering areas, spaces of immensity and intimacy - the unpredictable flows of human use generate unforeseeable patterns.





figs. 5. 5, 5.6 and 5.7- Wind dynamics at the global, North American continental and Atlantic coastal scales



mercury space : the harp

The imperative *to respond* is realized on the site as the mind and the body react to being placed in an immense landscape. The experience offers a strange contrast of being dwarfed in an untamed natural setting, while sensing an increased intimacy with the surroundings - the land, the vegetation, the qualities of wind, the heat and light of the sun. Responsiveness as expressed in architectural form seeks to capture the dynamism of the forces of weather, and in particular wind, acting on the site. This is addressed through the selection of different moments in the path that are open to the effects of the wind, the most iconic form of movement over the site and one that has laboured constantly over the days and years, in dry and wet and warm and cold seasons alike. This force not only carries temperature and moisture; it also is able to transform the sensation of other phenomena, such as brisk winds diminishing the warmth of the sun on the skin. Prevailing winds in the Sudbury area site originate predominantly from the southwest in summer, while in winter they blow strongest from the north and northwest. In all seasons, easterly winds are markedly weaker than those from the west. Communicating the tendencies of prevailing winds in sound is the focus of the mercury space.

The motivation to design the wind space with sound has its basis in the approach to the site from the North; this path passes underneath several large power-line towers. On the day of the initial visit, the strong winds had set the power lines to singing, the sound an effect of the lines vibrating to a particular frequency. The same effect is captured in wind harps, also known as aeolian harps, some of which have strings tuned to different notes, allowing varying pitches of sound as well as chords to be played. The mercury intervention borrows the concept of the wind harp as a form to communicate the imperative of response on the site.

The theories of German astronomer Johannes Kepler, who proposed that all planets had associated harmonic profiles, are key in the design of the mercury space. In his early career, Kepler was an apprentice to Tycho Brahe, himself an accomplished astronomer (although an adherent to the geocentric view of planetary orbits). One of Kepler's most significant discoveries was the elliptical shape of the orbits of planets, with the Sun located at one of the foci of the ellipse,[25] a theory that

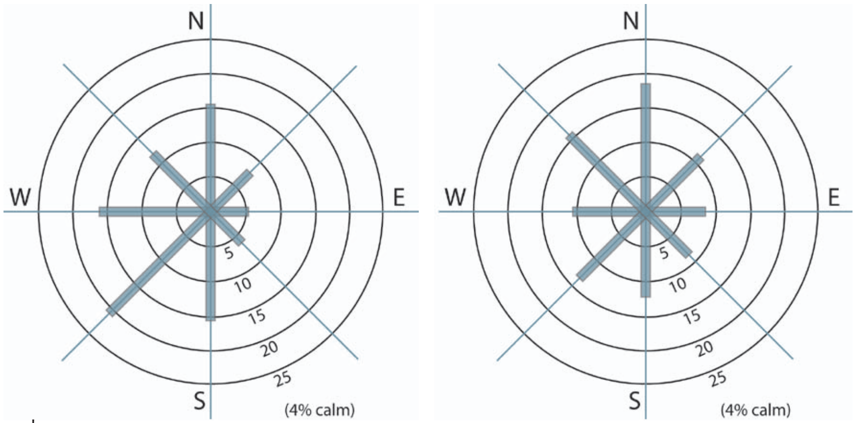


fig. 5.8- wind directionality percentages- summer and winter

irrefutably supported heliocentrism. Because the Sun was no longer the exact centre of the planets' orbits, each planet then had positions at which it was closest to and farthest from the Sun. These positions are known as perihelion and aphelion respectively. Kepler noted that the proportional distances of each planet's aphelion and perihelion could be related to the harmonic scale, such that there would be two "notes" associated with the opposing distances.[26] In some cases the notes were so close as to be almost the same, such as with the nearly circular orbit of Venus; in others, like the more eccentric orbit of Mars, the two tones are farther apart, here creating a perfect fifth. Kepler further proposed that the planetary harmonies could be placed into the four voices: soprano, alto, tenor and bass.[27] Accordingly, the soprano voice is played by the planet Mercury, the alto by Venus, the tenor by Mars and the bass by both Jupiter and Saturn. The four wind harps attempt to translate these theories into form and sound.

The profiles of the harps are abbreviated ellipses, inspired by the shape of cosmic orbits as discovered by Kepler, inside of which are strung a number of strings. The body of the harp is a rolled stainless steel section, the material chosen for its relatively low coefficient of expansion, as any dimensional changes to the harp will affect the length of the strings and impact the tones played by the wind. The strings are steel core, roundwound in bronze, as roundwound strings have more surface texture for the wind to grip; they are of varying thicknesses to suit the tonal ranges of each voice. In typical harps, strings of certain tones are coloured to assist the harpist in locating notes; in standard colour codes the C string is red, while the F string is blue, and strings in between are white. According to this tradition, the C and F strings of the wind harps are coloured. The harps are of a size large enough that one may step or sit inside them, feeling the vibration of the strings pass through the steel and into the body.

The ideal position of the harps in relation to the wind is perpendicular, so that the wind can blow through the ellipse and across the strings: each harp essentially functions as a weathervane. A weathervane's alignment to the force of the wind relies on a balance of weight perpendicular to the wind, and an imbalance parallel to the wind. This imbalance causes the lighter end to point into the wind and the heavier side to trail. Models were constructed to test the effects of weight on different parts of the elliptical form, in order to facilitate the harp's rotation in the desired direction. In testing the shape of the ellipses, it was determined that extra weight applied to the top and open ends of the ellipse would cause the harp to be rotated perpendicular to the wind force. The connection to the ground had to allow this movement to be very free, so that even a light touch would rotate the harp. To this end, the harp pivots on a post connected below the surface to a ball bearing connection that provides very little resistance to the harp's movement.

Essential to the proper functioning of the wind harps is the necessity to tune the strings. As with any musical instrument, strings go out of tune for a variety of reasons: movement, temperature changes, humidity changes, the vigour of being played. The strings of the wind harps will be subject to quotidian and seasonal temperature fluctuations acting on the steel of the harp as well as the strings themselves; the force of the winds will also exert stress on the strings. For this reason it is expected that the wind harps will need to be periodically tuned, not only to keep the separate strings in harmony with each other, but to ensure that the desired tones are sounded from one season to the next. At the top of each string, on the upper side of the steel, is the tuning peg. Etched into the steel section are indicators of the general position of the pegs relative to season: all pegs are perpendicular to the steel channel in spring and fall, turning clockwise in winter and counterclockwise in summer. This accounts for the general lengthening and shortening of the strings according to season; fine-tuning of the individual strings proceeds after the seasonal tuning occurs. The four harps must be tuned to be in harmony with each other as well, for the tones of multiple harps, heard from different locations on the site, must sing together as four separate voices in a quartet.

fig. 5.9- diagram of perihelion and aphelion in relation to elliptical forms of harp sections

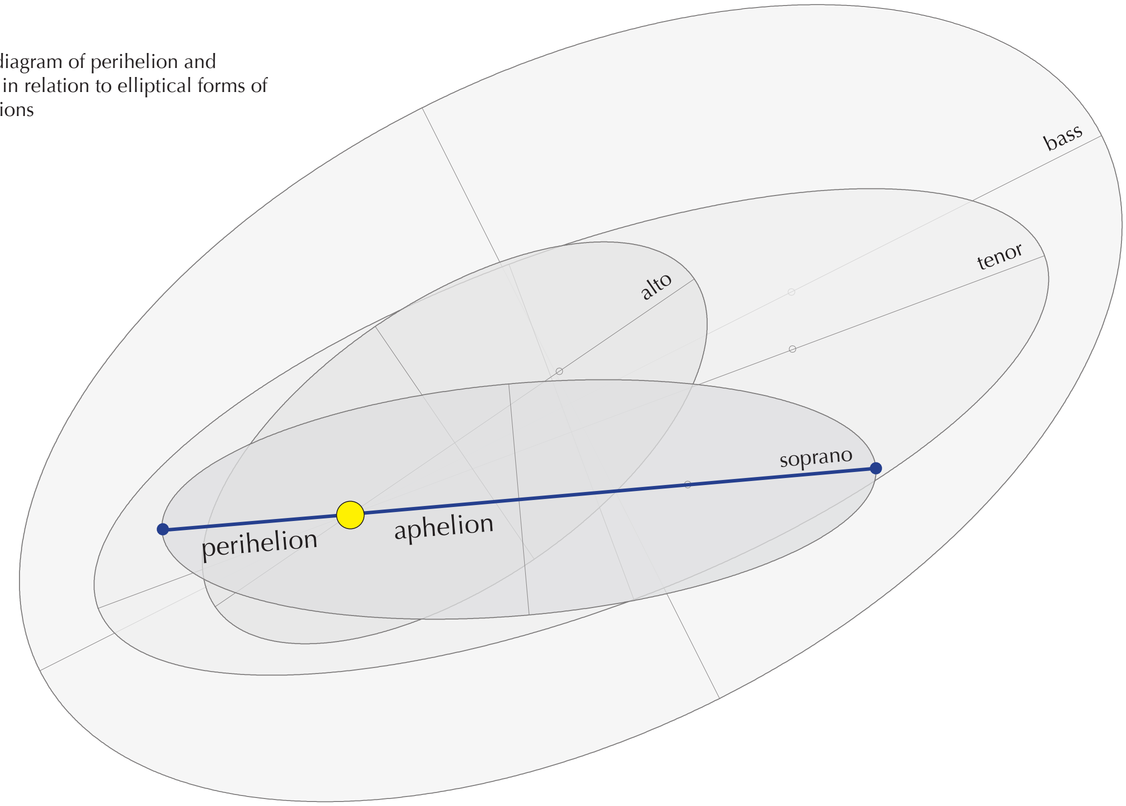


fig. 5.10- proportional comparison of planetary orbits, perihelion and aphelion

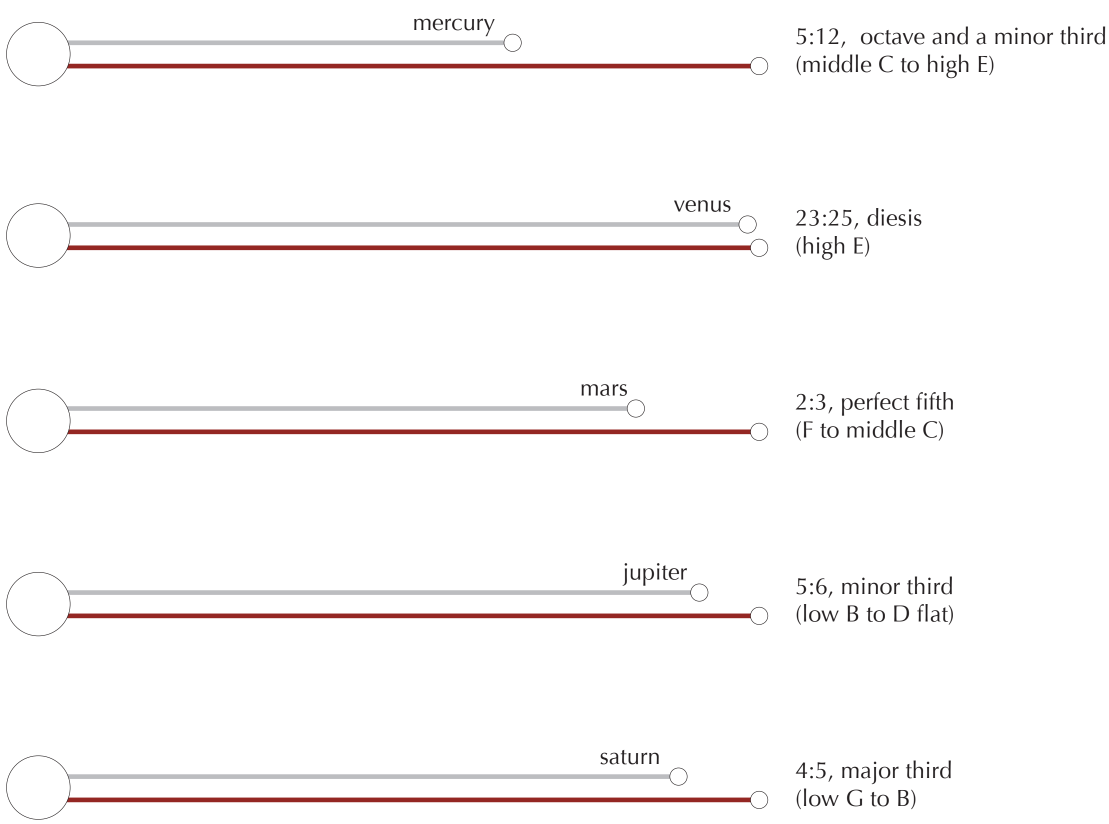


fig. 5.11- tonal interpretation of planetary harmonies as proposed by Johannes Kepler

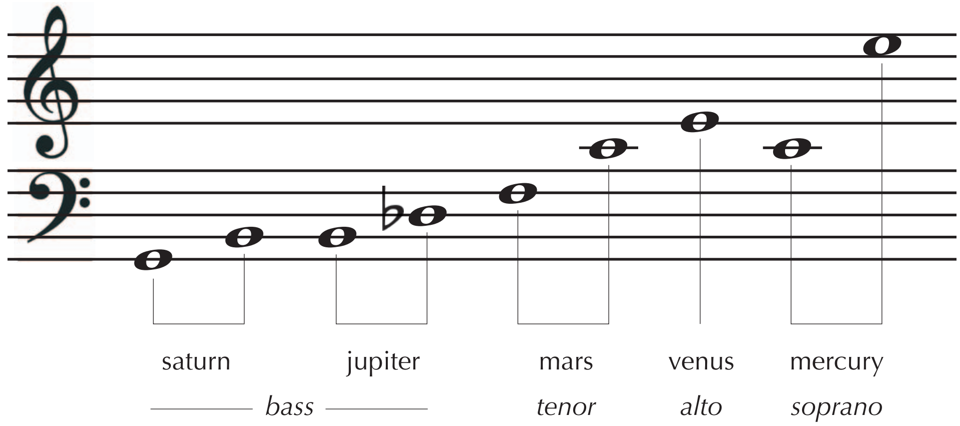
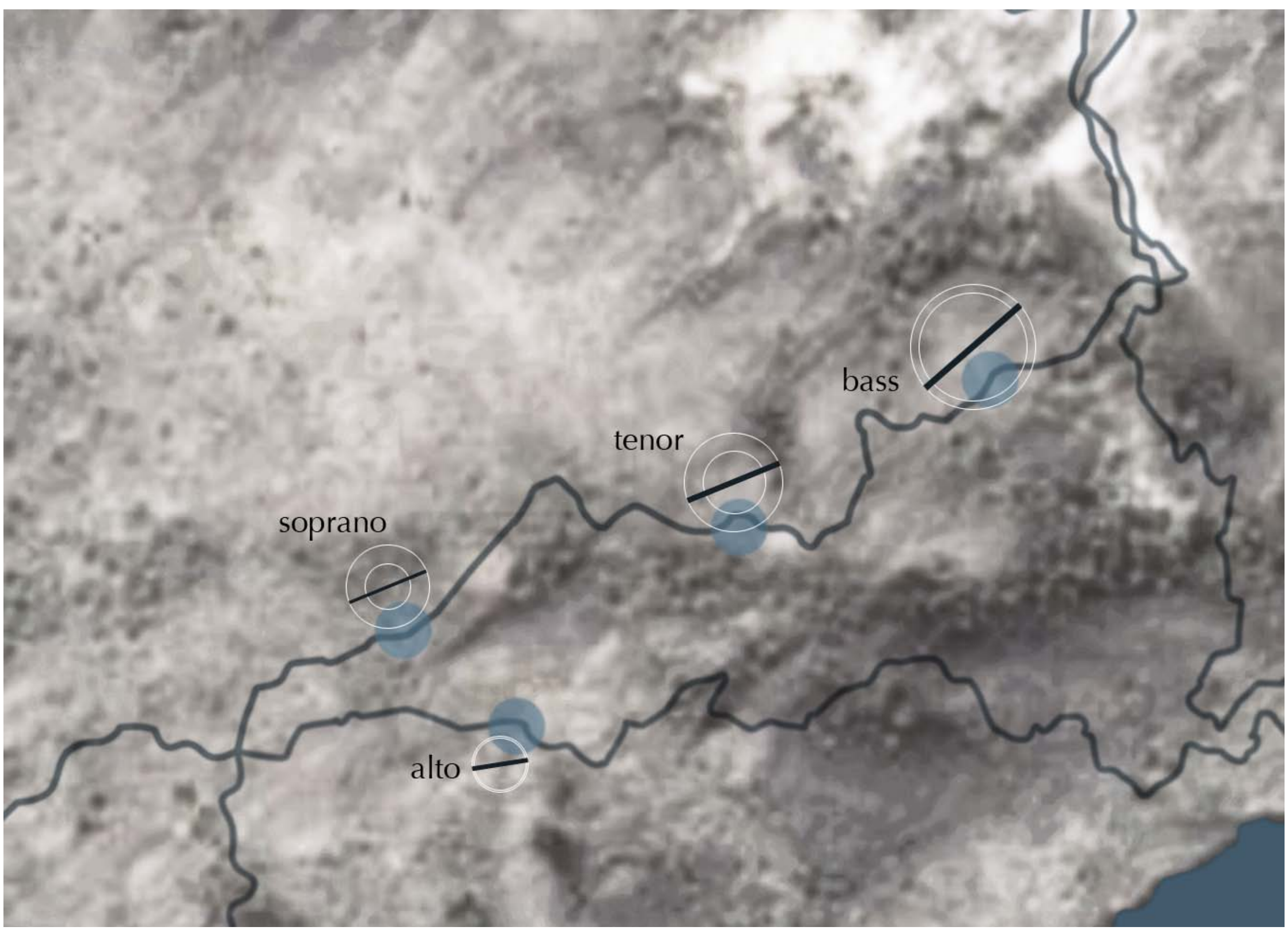
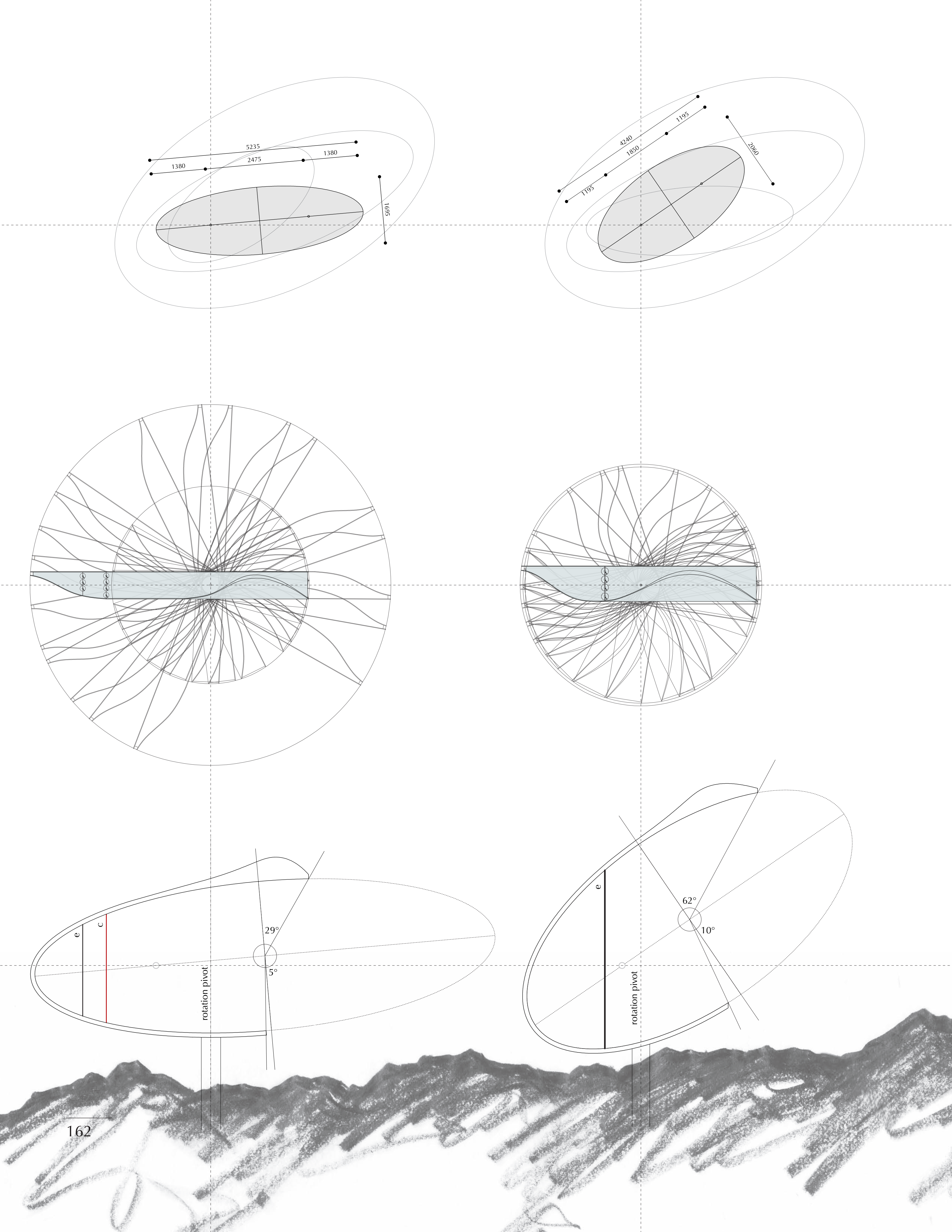


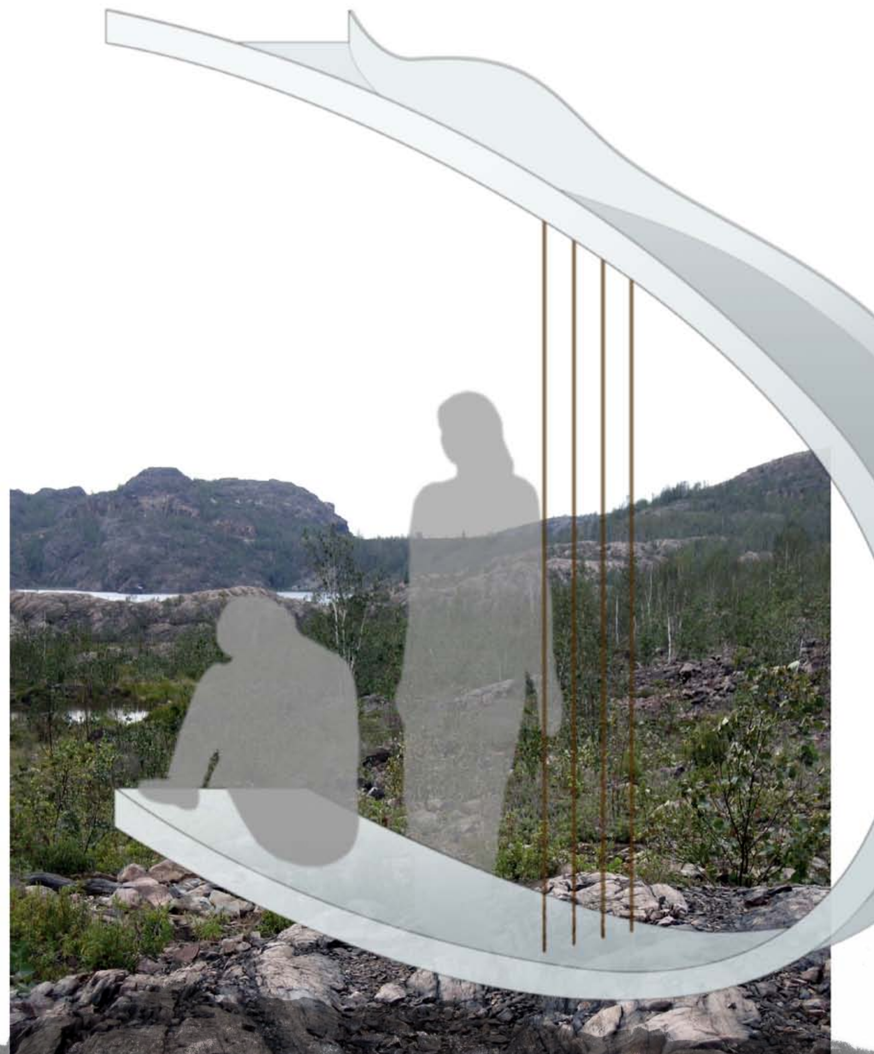
fig. 5.12- locations of mercury harps




5235
1380
2475
1380
1695
4240
1195
1850
1195
2060
e
c
29°
5°
rotation pivot
e
62°
10°
rotation pivot

Opposite page:
fig. 5.13- soprano and alto harps, plan and elevation

fig. 5.14- alto harp, rotation at northwesterly wind



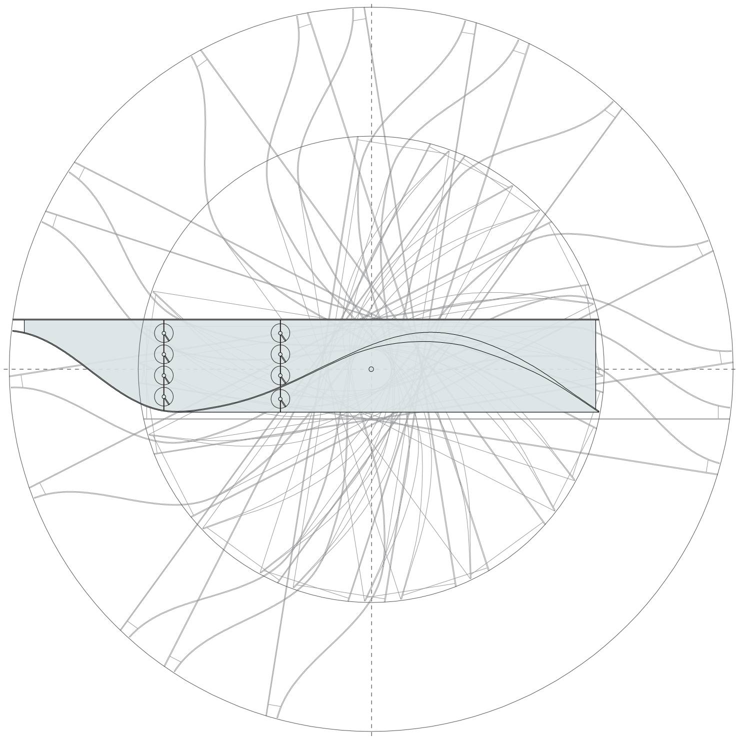
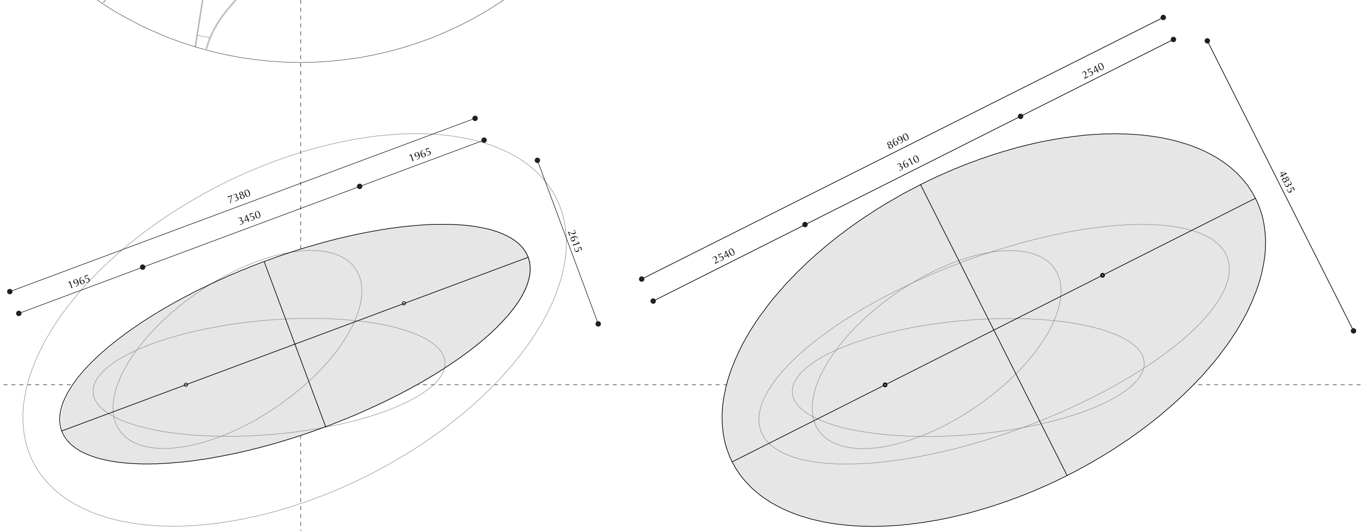
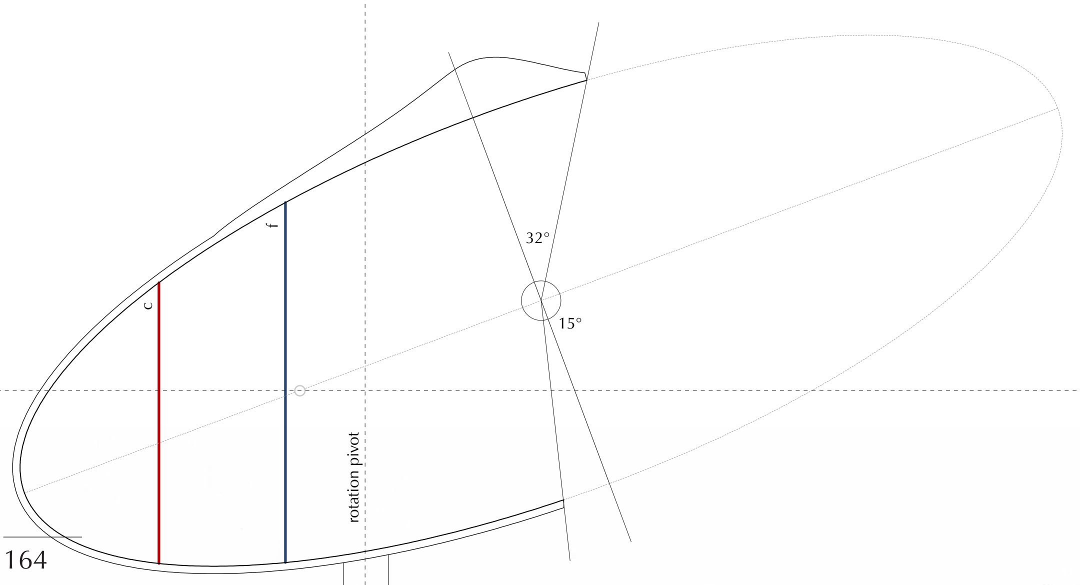
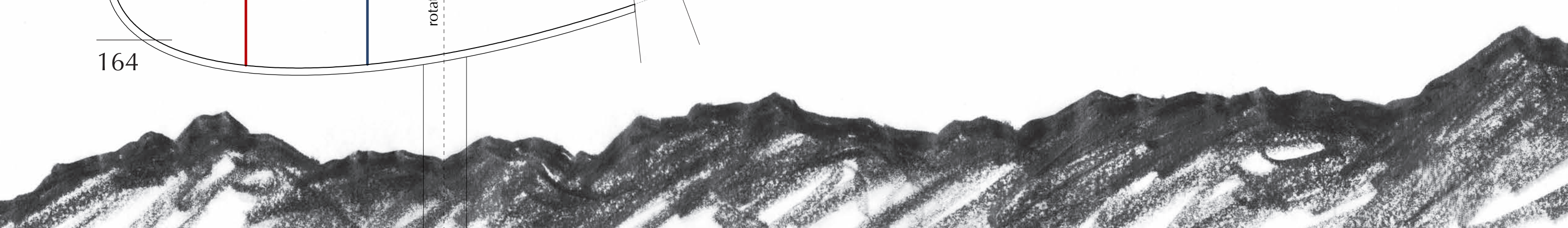


fig. 5.15- tenor harp, plan and elevation







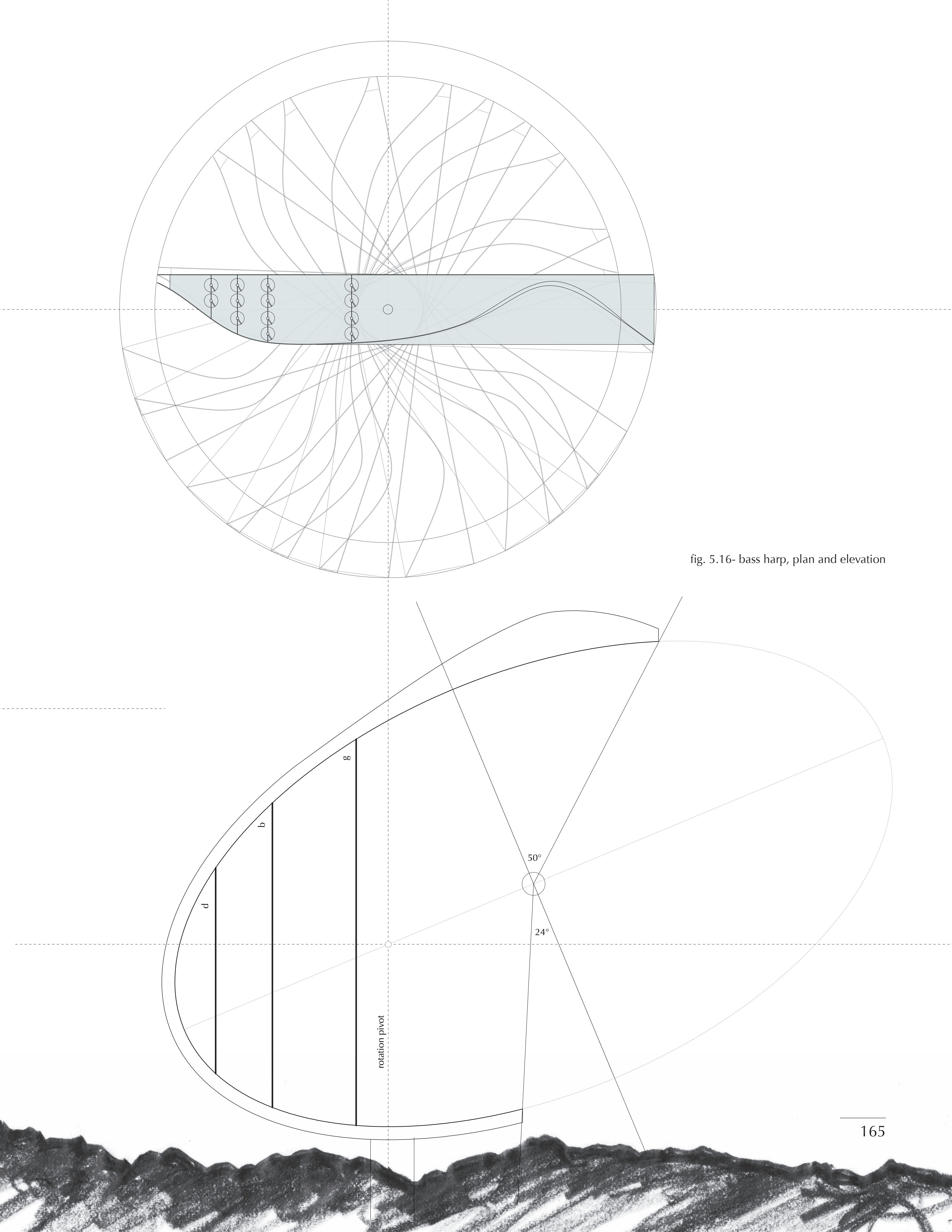


fig. 5.16- bass harp, plan and elevation

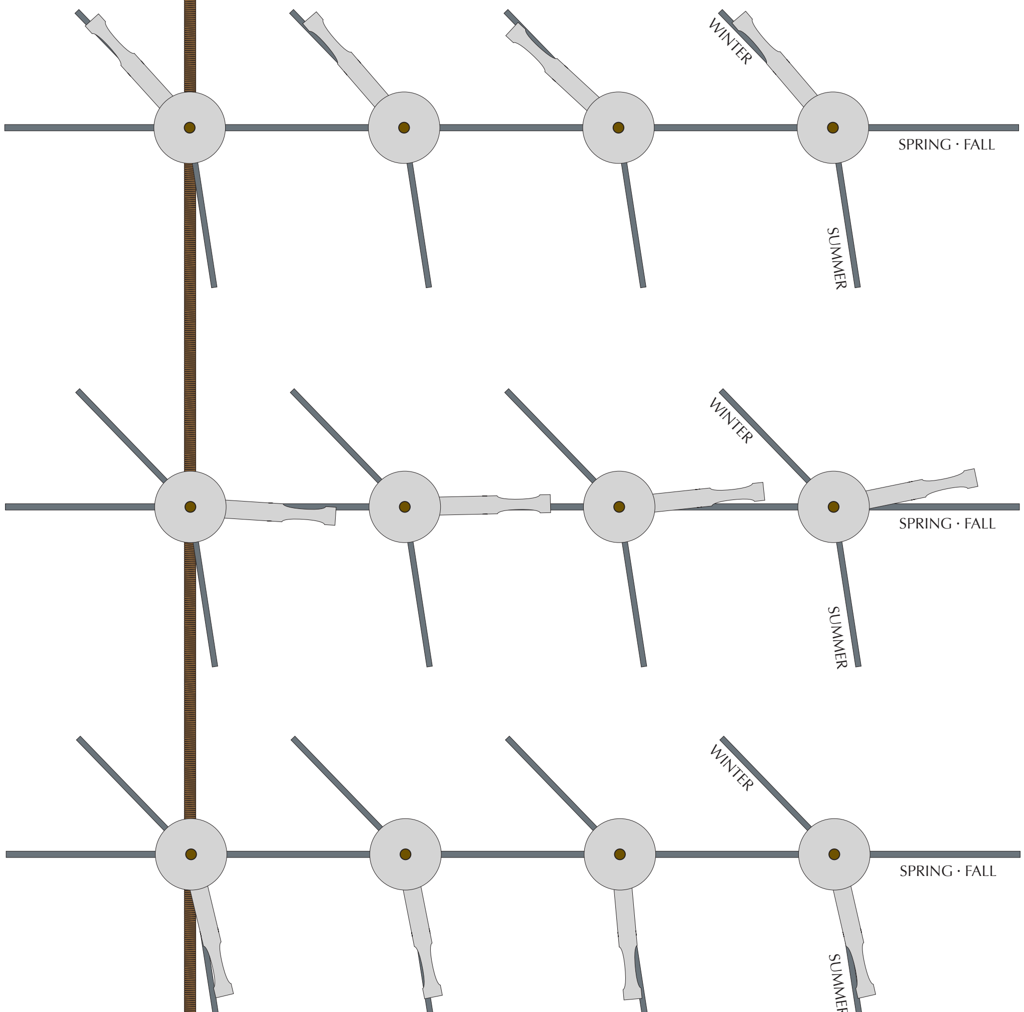


fig. 5.17- tuning mechanisms at seasonal calibration points

Harp construction: rolled stainless steel section, phosphor bronze strings with aluminum tuning mechanism. Stainless steel alloy type S31600, conforming to ASTM A480/A and A480M-93, Standard Specification for General Requirements for Flat Rolled Stainless Steel and Heat-Resistant Steel Plate, Sheet and Strip: sections rolled as per design drawings, minimum channel flange depth 60mm. Harp strings: steel core, roundwound with phosphor bronze, bottom of string mechanically fastened to lower edge of steel section, top of string attached to tuning mechanism, string replacement at maximum two year period or as required to maintain tone. Tuning mechanism: machined aluminum, threaded to shorten string with clockwise turn and extend string with counterclockwise turn, seasonal tuning to occur at solstices and equinoxes.

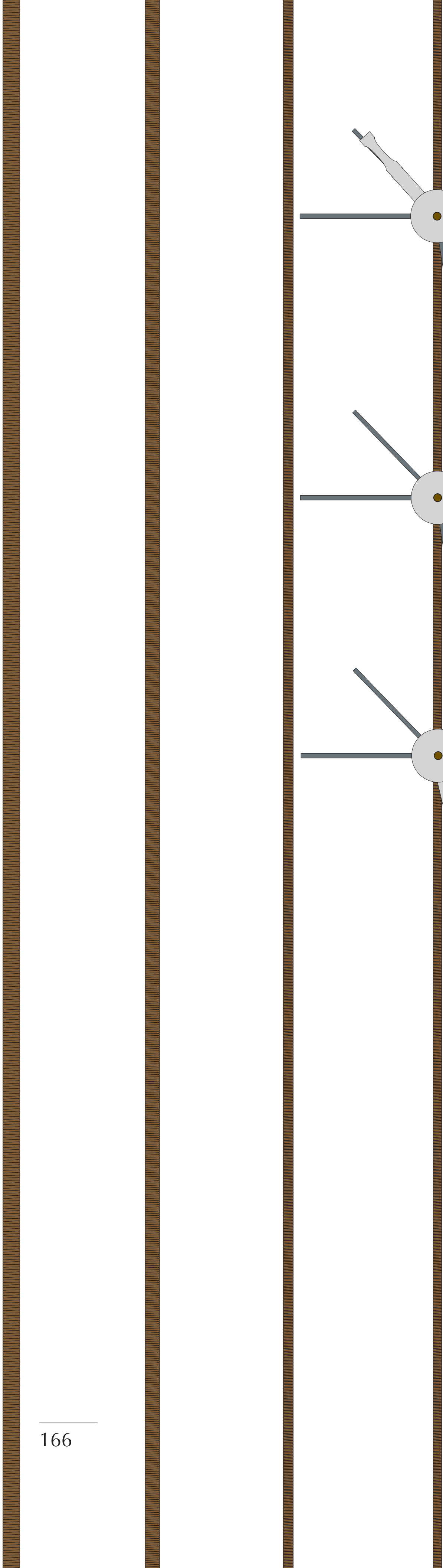


fig. 5.18- bronze roundwound string gauges

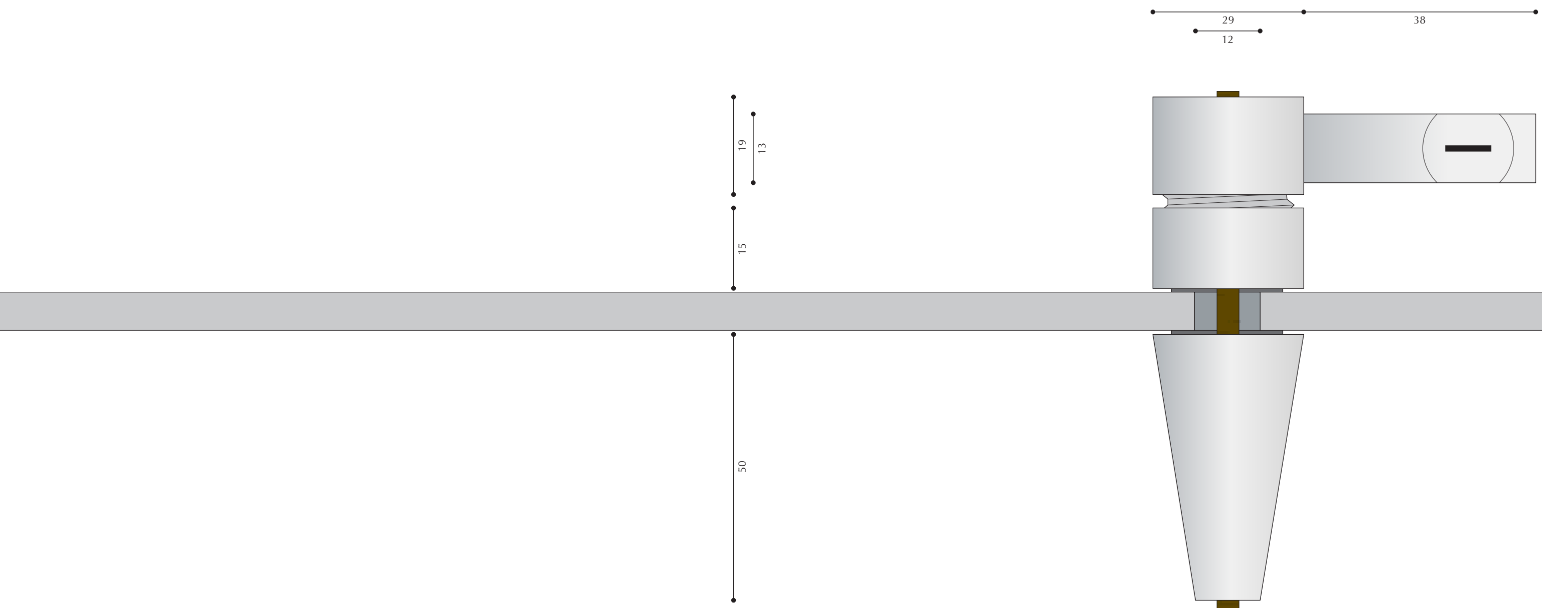


fig. 5.19- tuning peg, machined aluminum construction

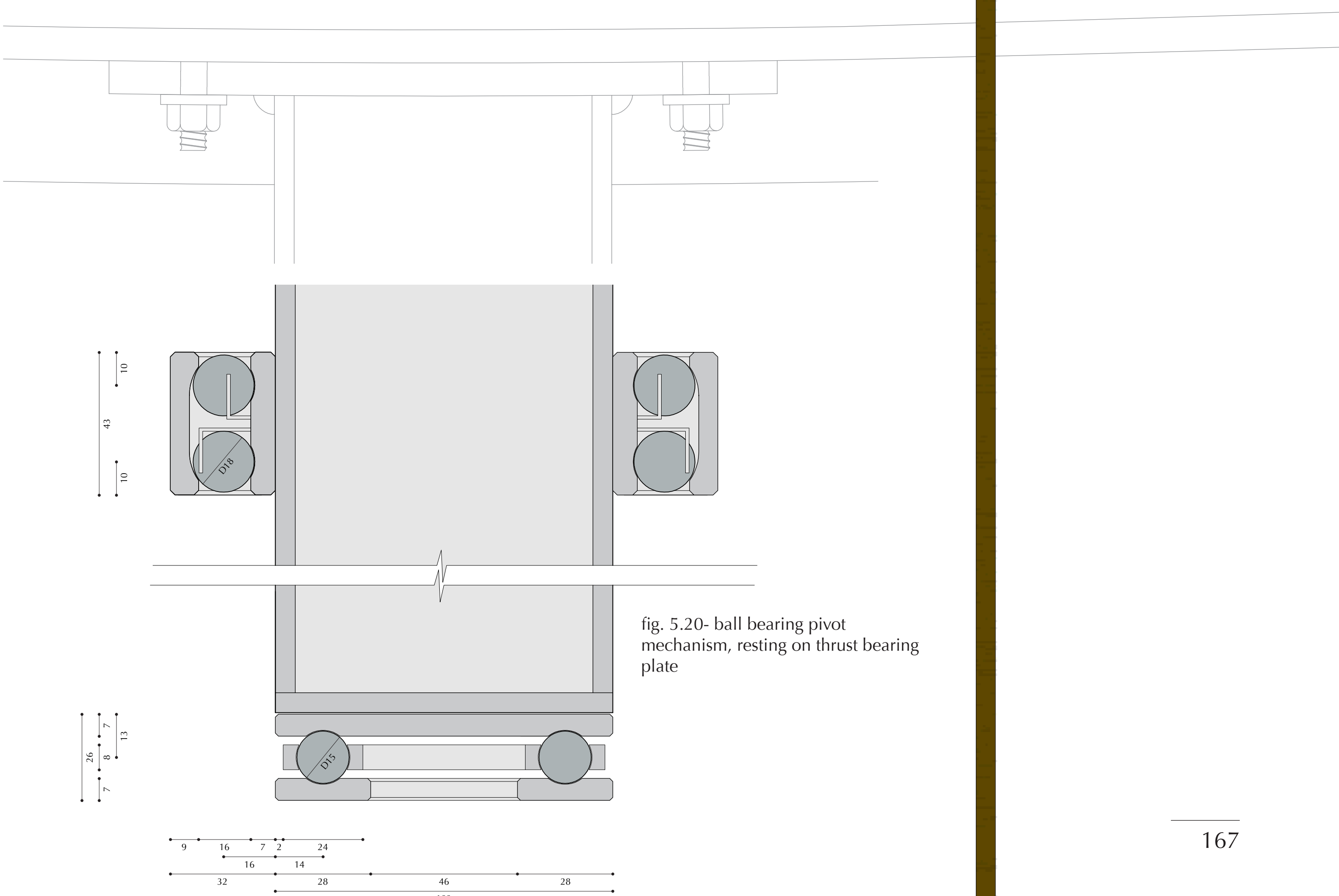


fig. 5.20- ball bearing pivot mechanism, resting on thrust bearing plate

Book VI : cuprum

♀ Cu 29

the fable of hespereia

In the garden of the Hesperides,
The daughters of Atlas, having inherited
Nothing of the weight of their father's toilsome burden,
Spend their days at leisure.
Arethusa, Erytheia and Aegle
Weave each others' hair with flowers,
Compose melodies, and nap
Under trees heavy with golden fruit.
The last sister, Hespereia,
Does not repose herself amongst the others:
She sits intent, eyes transfixed
On the orb of the Sun,
Soaking the light into her skin.

"See how he glimmers,
high in the sky? See
how he winks at me?
See how he verily teases me
To follow him
In his path across the heavens?"
Hespereia coos to her sisters,
Lovestruck, infatuated,
Her idol Apollo, never faltering
In his ascent from the morning horizon.

"He winks not at you!" cried Arethusa,
Ankle deep in the running stream,
Flicking water drops with her toes
Towards the smitten Hespereia.
"He has glinted like that
For thousands of years, nay,
Since you were but a babe in arms.
Dear sister: do not obsess,
Do not lose yourself:
For you will be overwhelmed
By the brightness of the Sun god".

Hespereia responds, “Ah, silly sister!
My dearest Arethusa: you would sit
Your entire life, gaze downturned
At the patterns in the water which flows
Around your feet.
Look up! And turn your eyes to the light,
To the warmth that keeps
Your beloved streams
Alive, and not frozen
In a fleeting image of themselves”.

Aegle, minding her tongue
As she softly polished the garden’s golden apples,
Now raises her voice.
“Oh, naughty Hespereia!
That you should fix your attentions
On one of the violent sex:
Your place is here, safe
Among your sisters, safe
From the dangerous attentions
That beset poor Io, that condemned
The tragic Callisto.
Keep yourself! And recant
This foolish infatuation”.

But Hespereia was lost in daydream,
She stood spinning herself,
Turning all angles to the sun,
Flirting her body to Apollo
On his course across the midday zenith.
“How now, Aegle, could he
whose light brings forth
the fruits of this garden,
how could any evil from him derive?
If he wished me ill, or any
Of us, or any living thing,
He could swoop down in his chariot
And scorch us to dust in a flash.
No, his is a kind light,
And I long to put myself closer to it.

The last sister, Erytheia,
Perhaps wiser than the rest,
Or better acquainted with this
Precoscious character,
Casts her advice.
“Hespereia, darling sister,
Your heart has forever looked
Beyond the limits of this garden.
And Apollo, surely, if he has
Eyes to see, surely
He will love you as dearly,
Be as charmed as us three.
But to catch him! He
Flies faster, on the heels of
His rampant steeds, than even
The thunderbolts of Zeus.
And high as well: you could not
Climb to him, for no ladder
Reaches this part of the sky.
Nay, you must chase him
at the end of his trip
When he slows his stallions towards the horizon,
spent and exhausted from their trip.
Here, you might catch him:
Run behind, and follow
his well-worn path. Do not stop
until you have woven your arms
around his neck.
And then, lovely sister,
Will you achieve the object of your affections.

Greatly encouraged, even
Giddy with her wise sister’s
Unexpected approval,
Hespereia embraces Aegle and Arethusa,
And kisses them farewell.
Erytheia passes to Hespereia
A mirror of gleaming copper:
That she might cast a beam
Of light earthwards,
To show her sisters her place in the sky.
The mirror tied around
Her neck, her sandals bound
Tight to her feet,
The nymph sprints westward,
Jumping into the sky
Behind Apollo.
Often you may see her, lagging
Behind the Sun god on his path.
But catch him she has:
And finally, ecstatically, surrendered
To the fierceness of his light.

fig. 6.1- Copper

Initially on exposure to the atmosphere copper acquires a dark brown colouring which becomes even over the whole surface after about six months. This is the initial oxide film forming over the copper surface, and this may become very dark in urban areas. Thereafter, after several years' exposure, the green patina begins to form, and the whole area of metal acquires an even or a mottled green colour. The normal time for patina formation is five to ten years depending on the degree of pollution, the moisture present in the air, and the temperature.

- John W. Simpson and Peter J. Horrobin,
The Weathering and Performance of Building Materials

Cu from the latin *cuprum*,
named for the Greek island of Cyprus

Of all the metals, copper arguably has the most beautiful patina. The soft shade of bluish-green is also known as *verdigris*, from the Old French *verte grez*, or Green of Greece.[1] Freshly polished copper does not transform to verdigris quickly; it is a process many years in length, the metal's colour first deepening to a thick brown before the bloom of green spreads over the surface. The development of copper's patina incorporates evidence of the weather, in precipitation and particles in air that are brought down by rain and snow. When the full patina has developed, it becomes iconic. The Statue of Liberty in our mind's eye is this characteristic green; it is difficult to imagine what a sight she must have been when first assembled, copper gleaming in the sunlight, or how similarly regal Canada's Parliament was when its roof was first installed. One wonders why a metal with this rich lustre would wish to hide itself behind such a cloak. Perhaps there is a modesty to copper, a reluctance to draw attention to its beauty, like an old penny hiding under a shroud of green.

Mankind's first utilitarian metal was copper,[2] and it has remained one of the foremost useful metals for millennia. It is hard to say which of copper's hues first drew the eye of prehistoric man, who would have seen the matte flecks of chalky green or the shine of burnished gold lying in the beds of streams. It was in use in the ancient cultures of Egypt and the Mediterranean, as evidenced by the remains of an early copper smelter at Har Timna in modern-day Israel which dates from 4000 BCE.[3] Metallic copper was independently discovered by societies in the Americas, while its use by the cultures of India and China may have predated that of the West by as much as two millennia.[4] Between the Stone Age before it and the Bronze Age that followed, there was a Copper Age known as the Chalcolithic (meaning literally, copper plus stone). The workability of copper would have appealed greatly to stone-age sensibilities: it could be hammered into shapes without splitting or chipping, thus making it quite distinct from stone. It is probable that the metal was manipulated in this way for centuries, even millenia before the application of fire ushered in the metallurgical age. In fact, the earliest mining practices of any metal were centred around the procurement and smelting of copper ores.[5] Egypt figures prominently in the history of copper, for the country


figs. 6.2 and 6.3- Bronze mirrors:
Mirror with a support in the form of a nude girl. Greece, 6th century BCE;
Hand mirror with the head of a woman. Greece, 4th century BCE.

was quite rich in resources of the raw ores from which the metal could be drawn. However, it was the mines of the Greek island of Cyprus that were to give copper its name: in Latin, *cuprum*, from the isle of Cyprium.

The earliest artifacts of copper can essentially be categorized as either tools or ornaments. Copper's relative softness was not ideal for toolmaking, but it was discovered that by heating and hammering the metal, strength and hardness could be improved significantly. The magic of alloyage would make copper even more important as it was forged with fluxes and other metals to make stronger and more resilient products, notably bronze and brass, an alloy traditionally composed of copper and zinc. With the beginning of the Industrial Revolution, the global demand for copper would rise exponentially: the inner workings of the new machinery had to be made from materials unaffected by rust, thus ruling out the steel widely used at the time. Here again, bronze and brass alloys of copper facilitated the development of the machine age. Copper on its own would come to be the single most important metal in the burgeoning technology of electricity, as its highly conductive (moreso than any other metal apart from silver), non-magnetic qualities were crucial in the equipment that managed and delivered electricity.[6] The capacity to carry an electrical current would eventually translate into the ability to transfer messages, and by 1844 the first electrically-transmitted message, a series of dots and dashes, was sent by Morse Code via the telegraph*. Today messages sent by radio, television, telephones or com-

fig. 6.4- Bronze mirror depicting Peleus, Thetis and Galene. Etruscan, circa 250 BCE

puter, whether hard-lined or wireless, rely on copper to carry words and images. So important is the metal to electrical equipment that half of the world's annual output of copper is dedicated to this industry.[7]

Copper is a crucial element in human physiology, and there is a fundamental variance, according to gender, in the level of copper in the blood. Whereas men's blood has comparatively more iron than the blood of women, the reverse applies for copper, with women having a higher copper serum in their blood.[8] In addition, the levels of copper in a woman's blood fluctuate in response to two conditions: the menstrual cycle and pregnancy.[9] The copper serum in a woman's blood in the weeks leading up to birth can triple from normal levels, developing alongside spiking blood iron levels in the fetus. This verifies the importance of copper to estrogen metabolism and female fertility.[10]

Its amenability to alloy with other metals characterizes copper as "the friendly metal."[11] There are some 200 copper alloys in use today that address the need for high corrosion resistance, conductivity, workability and strength.[12] The best alloys improve on the individual characteristics of their constituent metals. Tin, for instance, lacks the hardness to make it an appropriate metal for tools or weapons. When it is alloyed

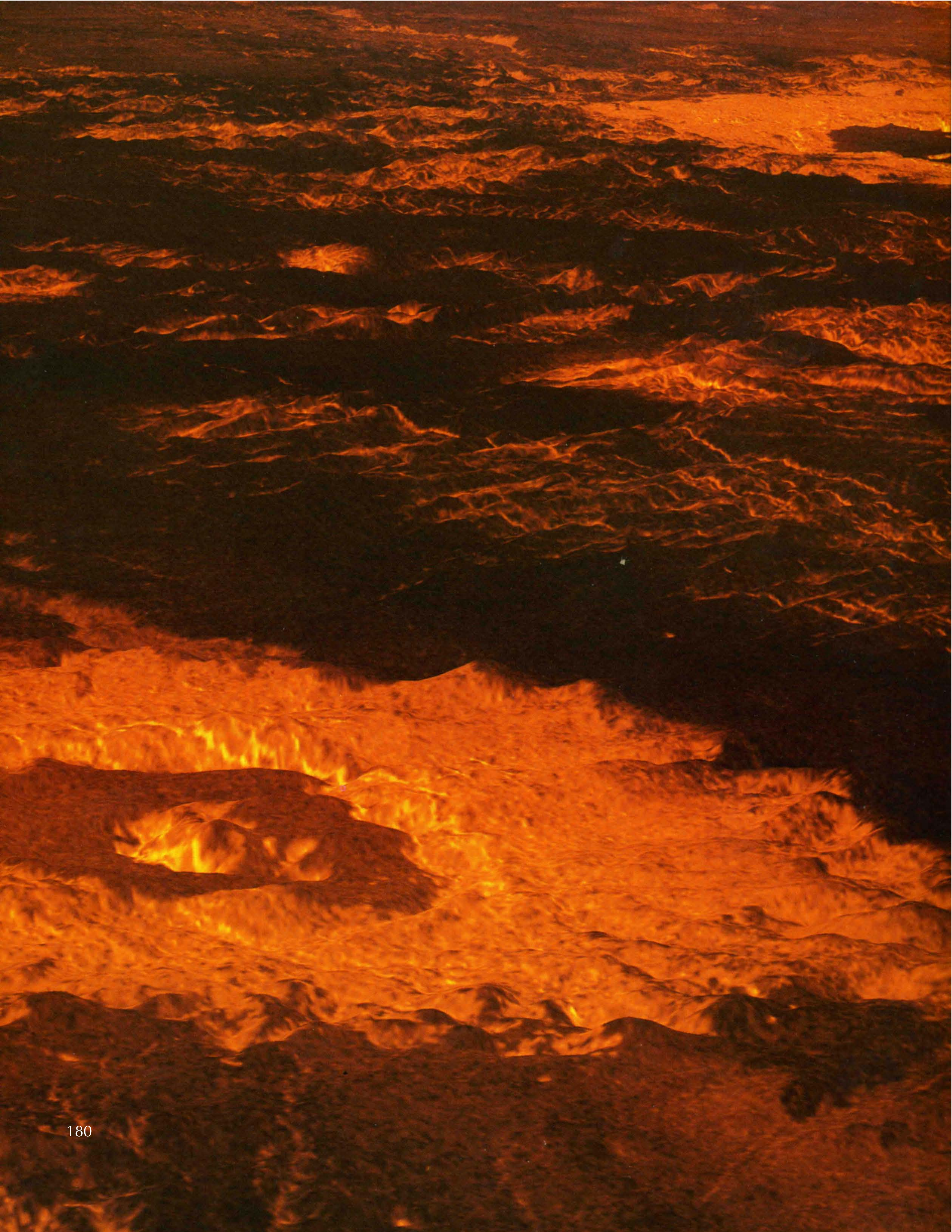
* Sent between Washington and Baltimore, the first Morse code message was selected from the Book of Numbers XXIII, 23: "What hath God wrought?".

Above:
fig. 6.5- Aphrodite, bronze, Greece, circa 150-100 BCE.

Opposite page:
fig. 6.6- Women's copper ornaments, Poland, late Bronze age.

with copper, however, at a ratio of one part to nine, the resulting bronze is strong and resilient to corrosion. The term "bronze" has been appropriated in the naming of other copper alloys, such as aluminum bronze, a highly corrosion-resistant variation of copper used in engine parts. Copper is alloyed with tin and zinc to make gunmetal, with nickel to make cupro-nickel for coinage, and with manganese to make manganese bronze, a metal with powerful corrosion resistance that is used to cast ship propellers that must withstand long-term immersion in saltwater.[13]

In the connection of classical metals with the seven classical planets, copper was initially linked to Mars, as documented by Origen in the 2nd century. By the 6th century, Olympiodorus of Alexandria would associate copper with the planet Venus, a connection that is still recognized today.[14]



As the night sky's brightest object apart from the Moon, the planet Venus has long captured the human imagination as a thing of beauty and wonder. First considered to be two separate entities as distinct morning and evening stars, the Greeks called the morning Venus Phosphoros (bearer of light) and, after dusk, Hesperos (evening star). Venus is the closest major celestial body to Earth after the Moon, and shares similar qualities of size and mass with our planet. Its proximity to the Sun produces a Venusian year of approximately 225 days; this is shorter than the duration of its day, which is 243 days on Earth. The slowness of its revolution, and the fact that it spins in contrary (clockwise) motion to all other planets in the solar system, has led to the theory that Venus was struck by a massive body sometime during its formation, and that the force of the impact set the sphere to spinning in reverse direction at a much reduced rate of speed.[15] The surface conditions of Venus are, from the telescopes of Earth, indiscernible because of the thick mass of clouds that comprise its atmosphere. These clouds, composed largely of carbon dioxide, are of such a density that they are more akin to an ocean than a gaseous atmosphere.[16] This shroud traps heat against the surface and creates an intense greenhouse effect that elevates temperatures to 500°C, hot enough to melt lead. It is this thick blanket of white that reflects the Sun's light so effectively, marking the planet's vibrancy against the black of night.

In the majority of global cultures, the deities with whom the planet Venus has been associated are not only female, but also embodiments of beauty. In China she is called Tai-Pe, which means "the Beautiful White One'.[17] The Roman Venus, who inherited the mythology of the Greek Aphrodite, was the goddess of beauty and love, and was also revered as a goddess of fertility. The Babylonian Ishtar and the Sumerian Inanna were likewise fertility goddesses associated with the planet Venus.[18] The theme of female fertility has been speculatively related to the planet's alternating appearances as a morning and evening star: one of these cycles lasts approximately 260 days, which correlates very closely with the 38-week, 266-day period of human gestation.[19] However, there were also cultures that considered Venus to be a masculine deity, most notably the Mayans of the first millennium CE, who called him Kukulkan, the brother of the sun.[20] In reverence to the deity, elaborate observatories were constructed for viewing the planet, such as the Caracol observatory at Chichen Itza in Yucatan, Mexico.[21]

Because of its placement between the Earth and the Sun, Venus is one of two planets (along with Mercury) that can be observed to pass over the face of the Sun, a phenomenon known as transit. Mercury's small size and distance from Earth make the observation of its transits very difficult, as the small shadow of the planet is overcome by the brightness of the Sun. The greater size of Venus, and its closer proximity to Earth, make her transits easier to observe, albeit much more rare. While the orbit of Venus laps the sun every 225 days, the slight cant of its path (and that of our planet as well) largely prevents the passing of Venus directly across the Sun from the perspective of Earth. In fact, a transit of Venus can only be observed twice, at an eight-year interval, every 113 to 130 years,[22] making the occurrence of this celestial event quite rare on the human timescale. It is infrequent that Venus transits do not occur

Opposite page:
fig. 6.7- Photograph of the Venusian surface

Venus near her: Smiling downards at this earlier earth of ours,
Closer on the Sun, perhaps a world of never fading flowers.

Might we not in glancing heaverward on a star so silver-fair,
Yearn, and clasp the hands and murmur, 'Would to God that we were there'?

- Alfred, Lord Tennyson, *Locksley Hall Sixty Years After*

Opposite page:
fig. 6.8- map of the Venusian surface

in pairs; the last single transit was in 1396, and the next will happen in 3089[23]. Transit pairs are separated by eight years virtually to the day; the most recent transit occurred on 8 June 2004, and its counterpart will take place on 5-6 June 2012. After the 2012 transit, this phenomenon will not occur again until the pair of transits in December of 2117 and 2125. This makes the opportunity to witness a Venus transit something of a privilege, as several generations born between the transits will not, in their lifetimes, have occasion to see one.

Astrology ascribes the rulership of the sign Libra and the zodiac's seventh house to the planet Venus. The seventh house begins at the Descendant, which is understood as the principle of relatedness[24] that marks the start of the six public houses. In the Baroque, Sir George Wharton proposed that the zodiac's seventh house was the first of the Age of Manhood, calling it the House of Marriage.[25] In modern interpretation, the seventh house continues to relate to marital unions but also applies to all kinds of personal relationships, and in particular those that rely implicitly on cooperation. Relationships figure into the profile of other astrological houses, but in the seventh house there is a functional purpose to the union, whether it is a marriage to have children or a partnership to bring a project into being.[26] Critical to this house are the concepts of participation, engagement and collaboration, and individuals who come together in such ways should remain conscious of their common objective. As he writes in his book *The Astrological Houses*, Dane Rudhyar offers that an organism's function "can be known only… if the new entity is related to the other entities with which it has to cooperate,"[27] thereby framing the importance of understanding one's purpose in life.

Astronomers and astrologers depict the planet Venus with the same symbol used in the West for female: ♀, a circle placed above a cross. It is the same glyph used by alchemists to represent copper, and is very similar to the Egyptian ankh, which was likewise used as a symbol for the metal.[28]

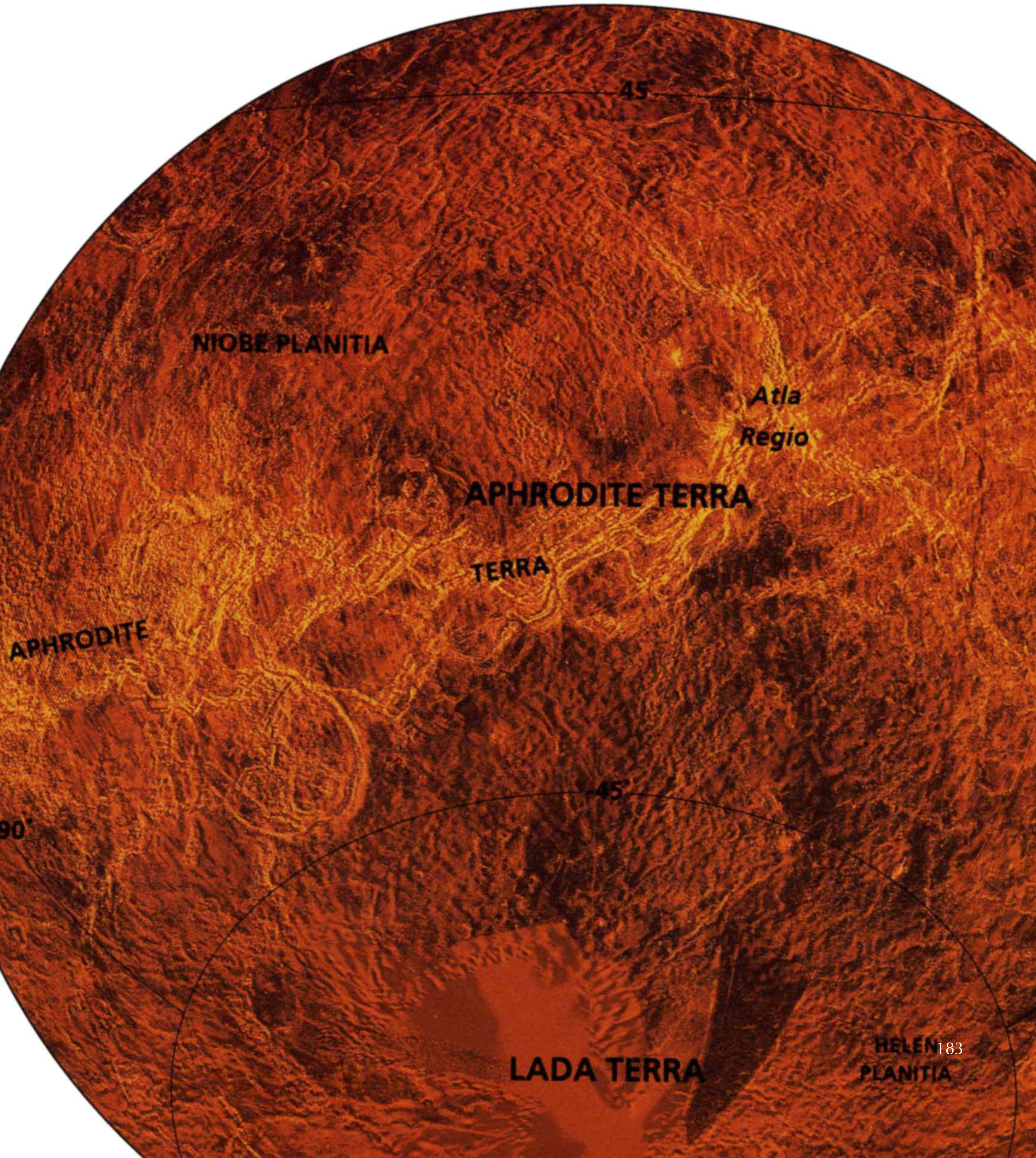
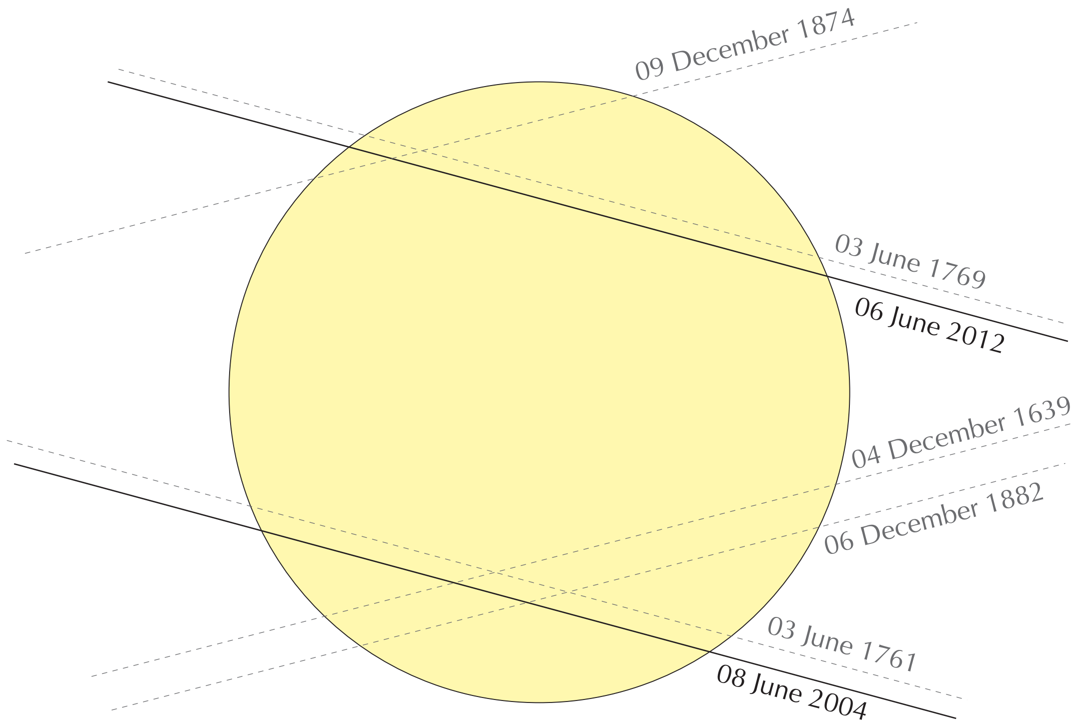

45°
NIOBE PLANITIA
Atla
Regio
APHRODITE TERRA
TERRA
APHRODITE
-45°
90°
LADA TERRA
PLANITIA

fig. 6.9- Trajectory of Venus across the face of the Sun for transits of 1639, 1761 and 1769, 1874 and 1882, and 2004 and 2012



Transits of Venus, 1600-2400 CE

Date	Universal Time
07 Dec 1631	05.19
04 Dec 1639	18.25
06 June 1761	05.19
03 June 1769	22.25
09 Dec 1874	04.05
06 Dec 1882	17.06
08 June 2004	08.19
06 June 2012	01.28
11 Dec 2117	02.48
08 Dec 2125	16.01
11 June 2247	11.30
09 June 2255	04.36
13 Dec 2360	01.40
10 Dec 2368	14.43

copper : to connect

The connection between copper and Venus is indicated in the metal's very name: in classical myth, the goddess of beauty was born from the sea onto the shores of Cyprus. As the island was a major source of the ancient world's copper, it was believed that Venus imparted fertility to the Cyprian rock, causing great reserves of the metal to form within the ground.[29] The metal's connection to the female gender transcends this myth, as it is present in a woman's bloodstream at levels some 20% higher than that of men. The mythology and symbolism of both copper and Venus, as well as the physiological importance of the metal to a woman's health, emphasize the female and in particular the concept of fertility. It has been established that the copper in a woman's bloodstream fluctuates according to her menstrual cycle, and has a significant spike in the months immediately preceding childbirth. Fertility was also the domain of Venusian deities across several societies, from Greece to Sumeria to China. A copper imperative must necessarily consider the importance of the female and fertility.

One of the most remarkable qualities of copper is its readiness to alloy with other metals, improving on the particular qualities of each to creates a new product, bronze being the quintessential example of such. The "friendly metal" has a much greater propensity for collaboration in this respect than the other classical metals, an aspect which relates to the zodiac's seventh house, that of cooperative relationships. Here the functional purpose of unions, a main focus of the seventh house, is embodied in the metaphor of the alloy as two individuals coming together to achieve a common objective. The conductivity of copper, carrying electricity between points, is also representative of an active, uniting force with a functional purpose. The amenability of copper viewed in light of the metal's connection with the female and fertility suggests that copper can be considered as a facilitating force, a conduit between a mother and her child. The alloy as the merging of metals, the bond of a mother and child, the collaboration of the group for a single purpose, and the conductive force that links individuals through communication are manifestations of a copper imperative *to connect*.

There is another idea suggested through the metal, planet and house that takes the feminine characterization of copper and Venus, and examines them through the seventh house phenomenon of the Descendant: the shadow self, that part of one's character that is latent and undeveloped. Gender is one of the most ingrained polarities in human culture. In the gendering of metals, the femininity of copper (connected to Venus, goddess of fertility and beauty, symbolized as woman, ♀) finds its counterpart in iron (aligned with the assertion of the war-god Mars, symbolized as man, ♂). In truth, the gendering of these elements does have a basis at the cellular level, through the distinction of copper and iron levels in the blood of men and women. It has been scientifically established that copper has an effect on brain function, and above-normal concentrations of the metal in the blood can have a powerful effect on mood and behaviour:[30] ergo, copper holds influence over the mind. Conversely, the effect of iron applies directly to the vigour of the body, the metal's impact on hemoglobin being responsible for imparting strength and energy. Thus iron/ man/ body is polarized with copper/ woman/ mind. The physical presence of the body, as compared with the more ephemeral qualities of the mind, further demonstrate how the tangible male body is polarized with the unpredictable, unknowable female mind. This abstract quality of the mental self thus sets itself as *the other* to the physical self.

This presents an idea of otherness, epitomized by the astrological 'shadow self', alongside the unknowable, unpredictable and uncontrollable (female) mind. Otherness also presents the realm of possibility through the domain of latent potential (evidenced through the Descendant) and limitless imagination (the uncontrollable mind). The implications of this concept on the copper intervention find expression through a lack of definition or restriction, inviting an open and personal interpretation of the landscape.

fig. 6.10- *Mars and Venus Surprised by Vulcan*, by Joachim Wtewael, 1606-1610

copper space : the path

Realizing the imperative of connection on the Coniston site must first consider the diversity of conditions to be experienced, from high points blustered by wind, to sheltered coves along the water. Because part of the experience of the site relies on movement between these different points, the concept of a copper space as one of connectivity is well expressed as *the path*. The copper path suggests movement between metal spaces as an organic flow across the site that does not align with a specified route.

The migration of nomadic peoples across the landscape was largely motivated by the changing of the seasons, and the resulting affect on climate and the availability of food supplies. It is to these deep nomadic roots that archaeologist Christopher Tilley attributes the intrinsic quality of man's ambulation through the landscape. In his book *A Phenomenology of Landscape*, Tilley remarks that the act of movement through the landscape picks up on latent cues, that "the creation or maintenance of a path is dependent on a previous networking of movements in particular, and reiterated directions through a landscape; it works in relation to a previous set of precedents."[31] It is interesting then to consider that the impetus to ascend a mountain, descend into a valley, or remain fixed by marking the location all take their cues from something deeply rooted in collective memory. It is this spirit that the copper space, as an individualized path through the landscape, hopes to capture.

The absence of a defined walking route encourages a unique realization of the path, one contingent on the visitor and his or her decision of direction. In this way the path is free to develop rationally, following the compass point or the direction of the Sun; it could also unfold intuitively, by walking with or against the wind, or by following striations where they occur in the rock. The copper intervention identifies the location of the other metal spaces, allowing the individual to choose destination and course. To this end, a series of copper posts, located across the site, serve as navigation markers between metal spaces, suggesting a destination to the viewer without specifying a path.

The posts are copper cores sheathed in bronze. The height of

fig. 6.11- moments along the copper path

the markers, three metres from the ground plane, allows them to be seen at a distance, and their descent 5m into the ground creates a conduit between the deep rock of the landscape and the life above it. Viewing channels are cut into the post, and inlaid with the proper metals to indicate the space to which the view is being directed. The posts are articulated to suggest how they should be held in the hand, with the thumb pointing upwards in alignment with the intended view. The handhold and the viewing channel position the viewer and direct their gaze towards a specific metal space: the view to the lead space, for example, requires the viewer to position themselves lower to the ground, while the iron space is viewed from a standing position. The viewing channel is an open slice, so that the view is directed without being constrained as might be done with other forms of view direction such as telescopes. This emphasizes the connection of the individual metal space to the landscape, as an extension of its surroundings rather than a detached, autonomous end point.

The bronze of the navigation posts will patinate to a dark colour, eventually taking on the verdigris of its constituent copper. The cutaway to the copper, where the handhold occurs, will resist patination through the ongoing touch of viewers. The copper will not remain shiny, as the surface naturally takes on fingerprints; however, full patination will be resisted as the copper surface is rubbed. Because the intent of the post's copper core is to act as a conduit connecting the viewer with the subterranean and the sky above, direct connection to the metal, and not through a barrier of patina, is needed.

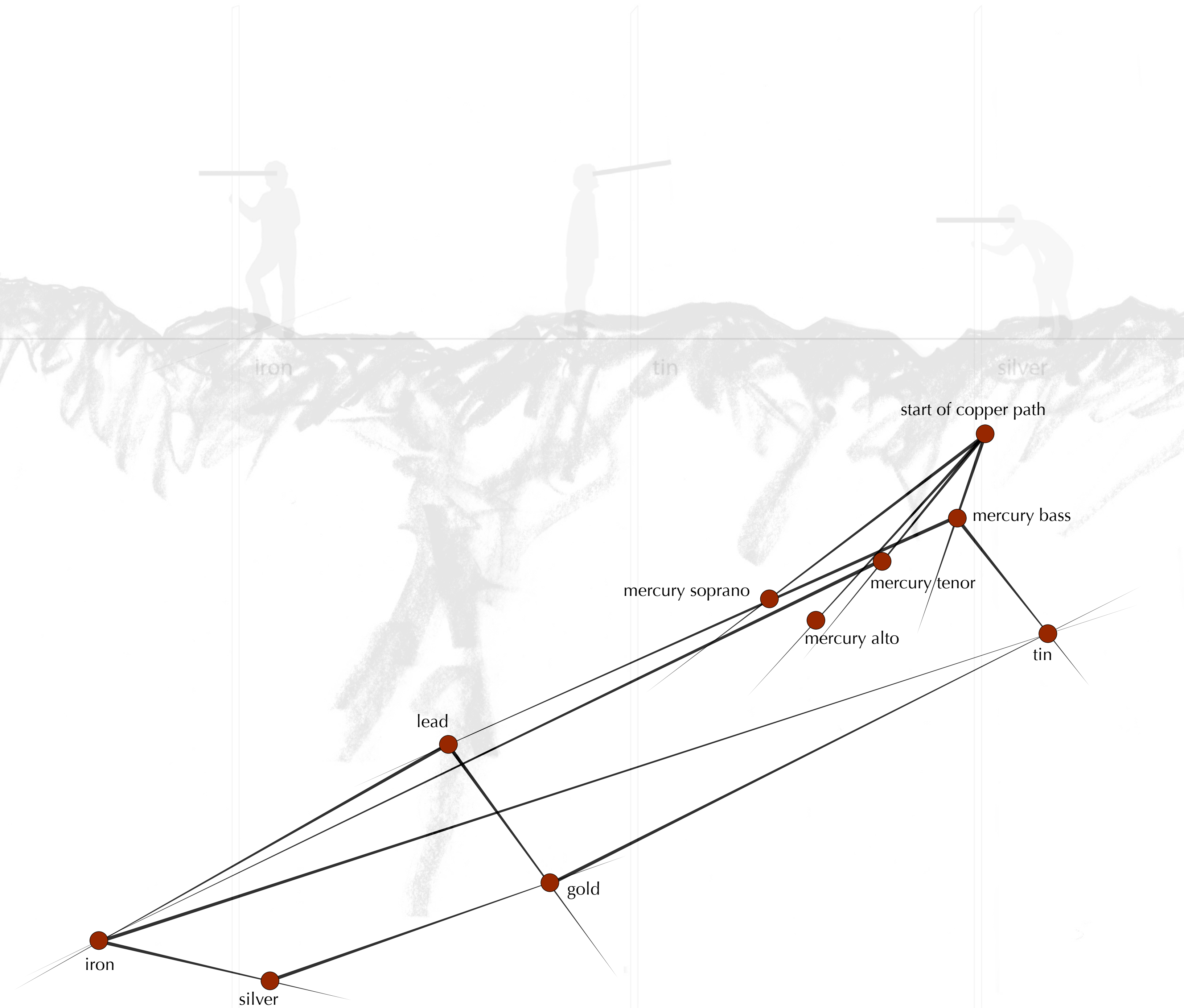


fig. 6.12- viewing trajectories of copper navigation posts

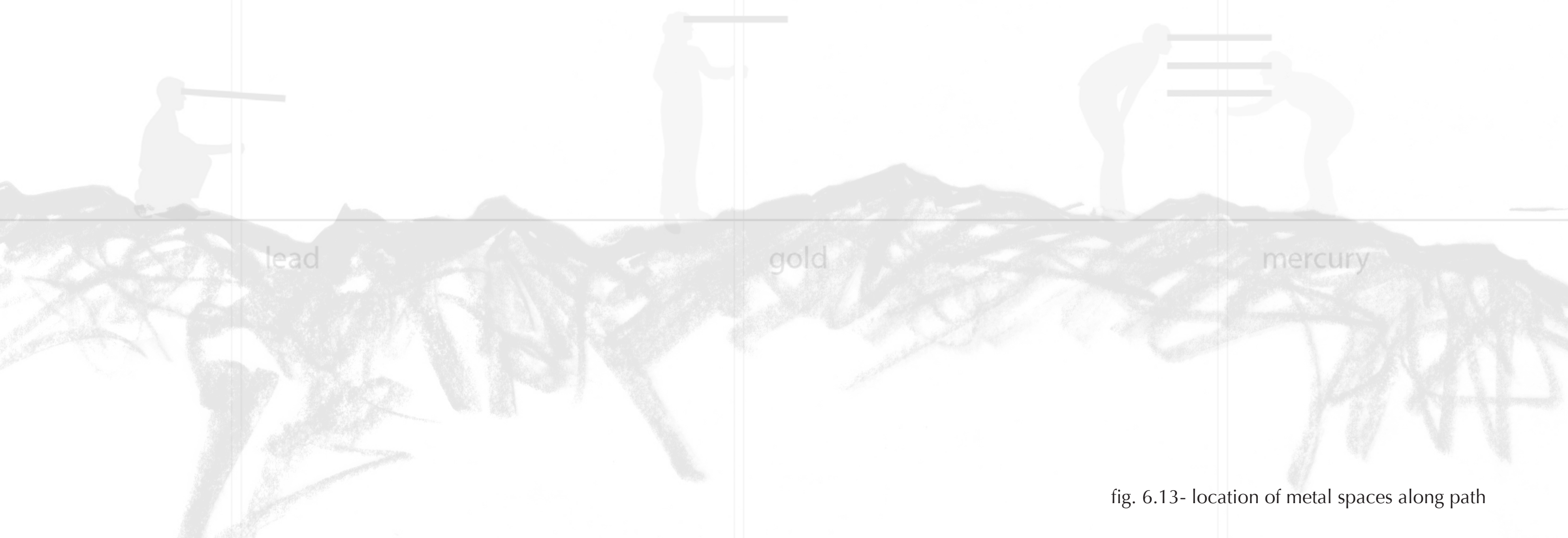
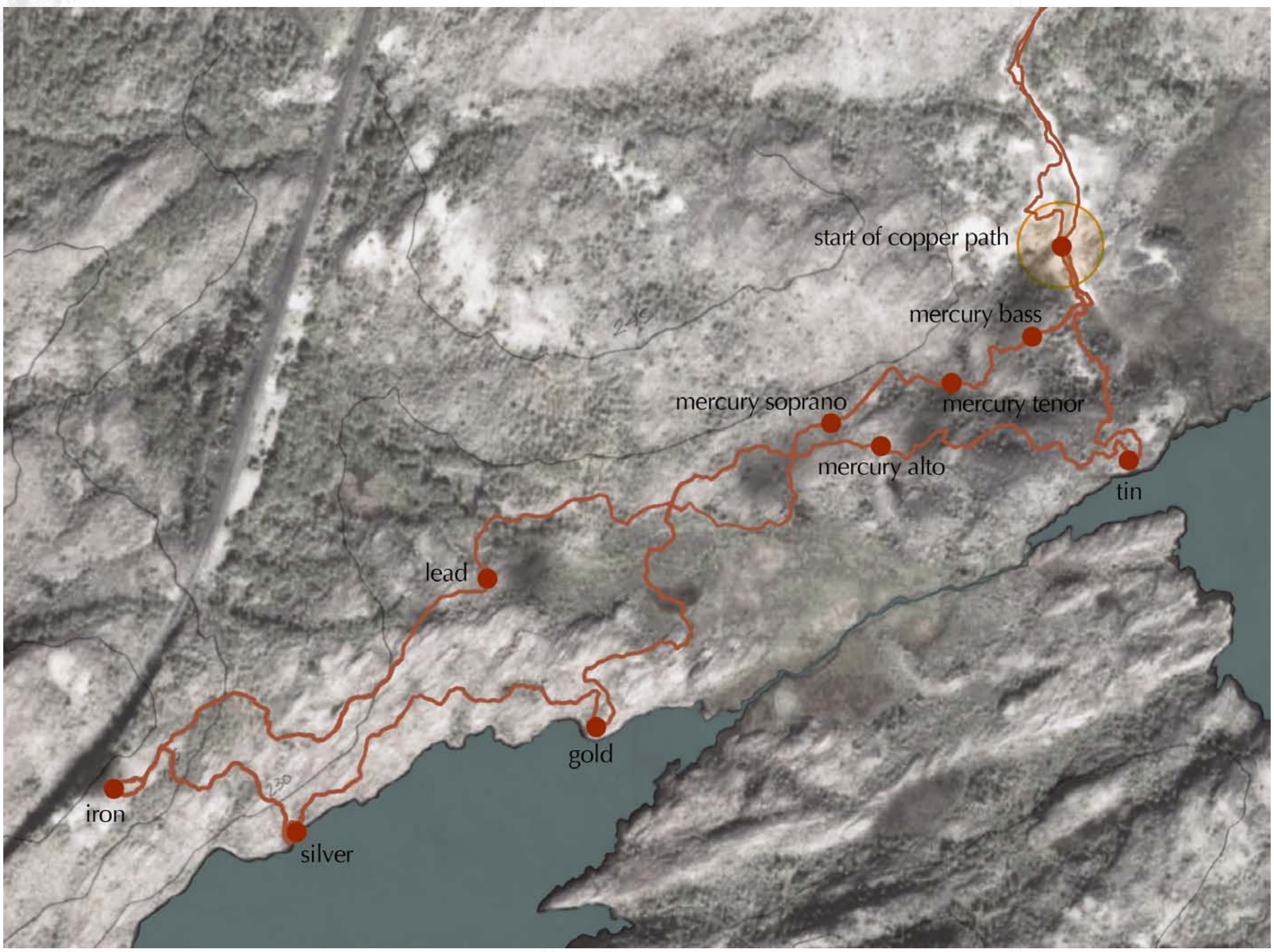
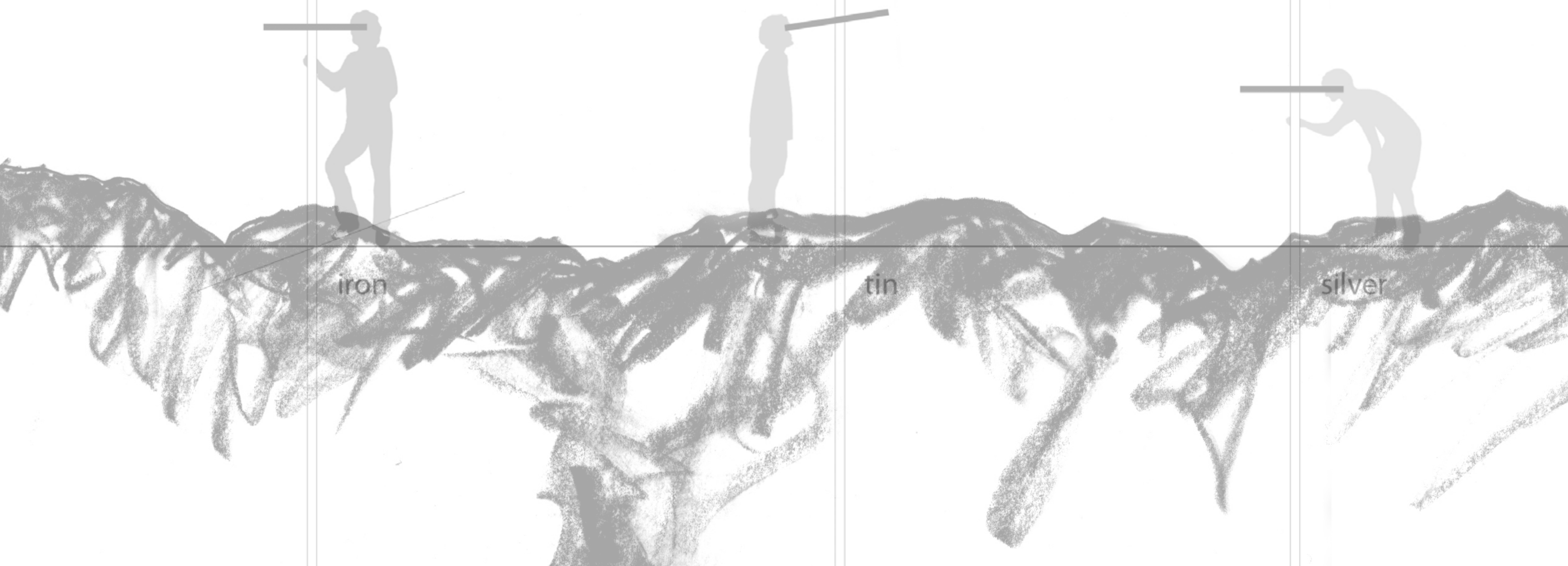


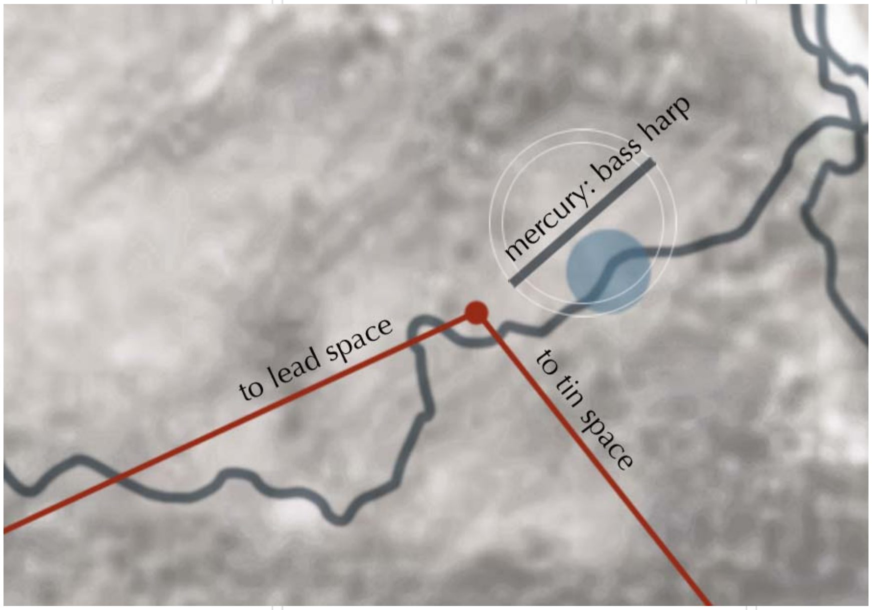
fig. 6.13- location of metal spaces along path





Navigation post construction: 8000mm bronze-copper posts installed to a depth of 5000mm. Copper components C122 Copper, composition Cu 99.9%, P 0.02% maximum, conforming to ASTM B152/B152-06as1, Standard Specification for Copper Sheet, Strip, Plate and Rolled Bar: round section 60mm exterior diameter, 5mm wall thickness, 8000mm length. Bronze C51100 phosphor bronze conforming to ASTM B103/B103M-07, Standard Specification for Phosphor Bronze Plate, Sheet, Strip and Rolled Bar: 6ga sheet wrapped and sealed around copper post. Metal inlays: gold, silver, iron, lead, and tin elements inset flush to exterior diameter of bronze as per design drawings.

fig. 6.14- copper navigation post at bass harp, view angles to lead and tin spaces



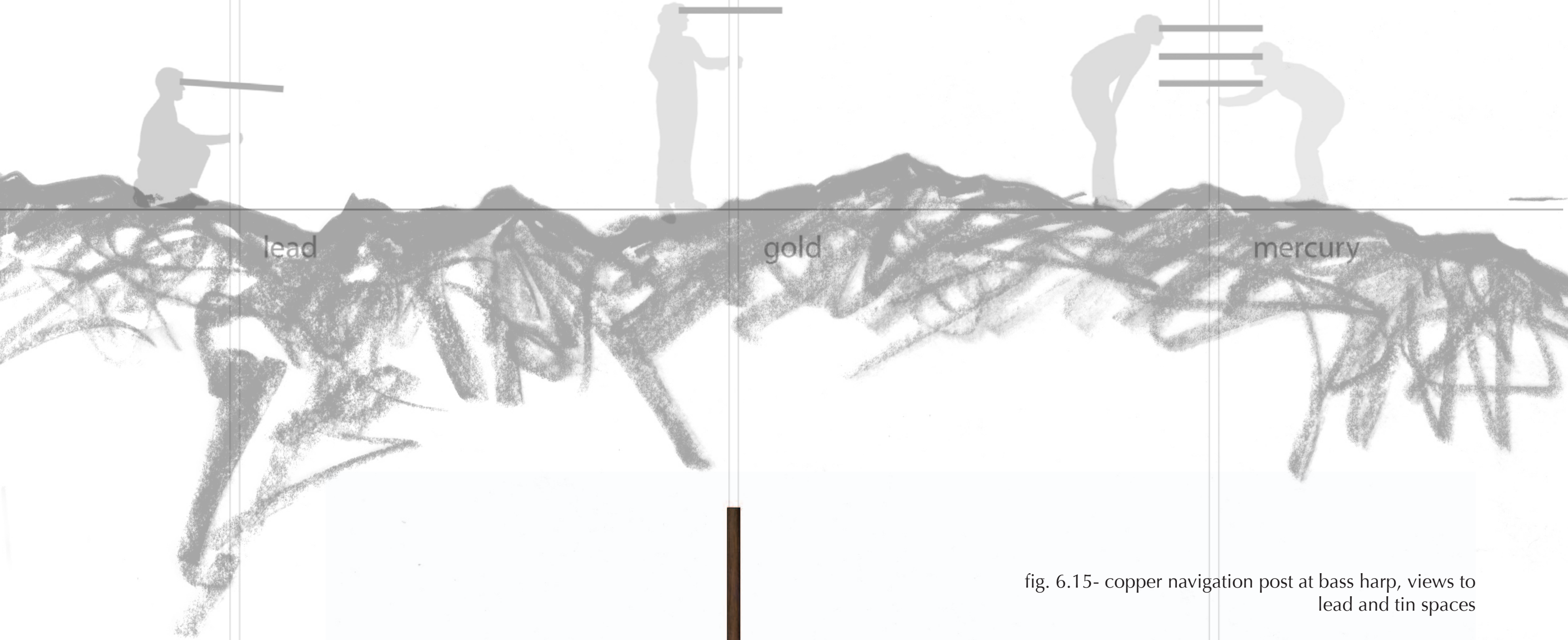


fig. 6.15- copper navigation post at bass harp, views to lead and tin spaces

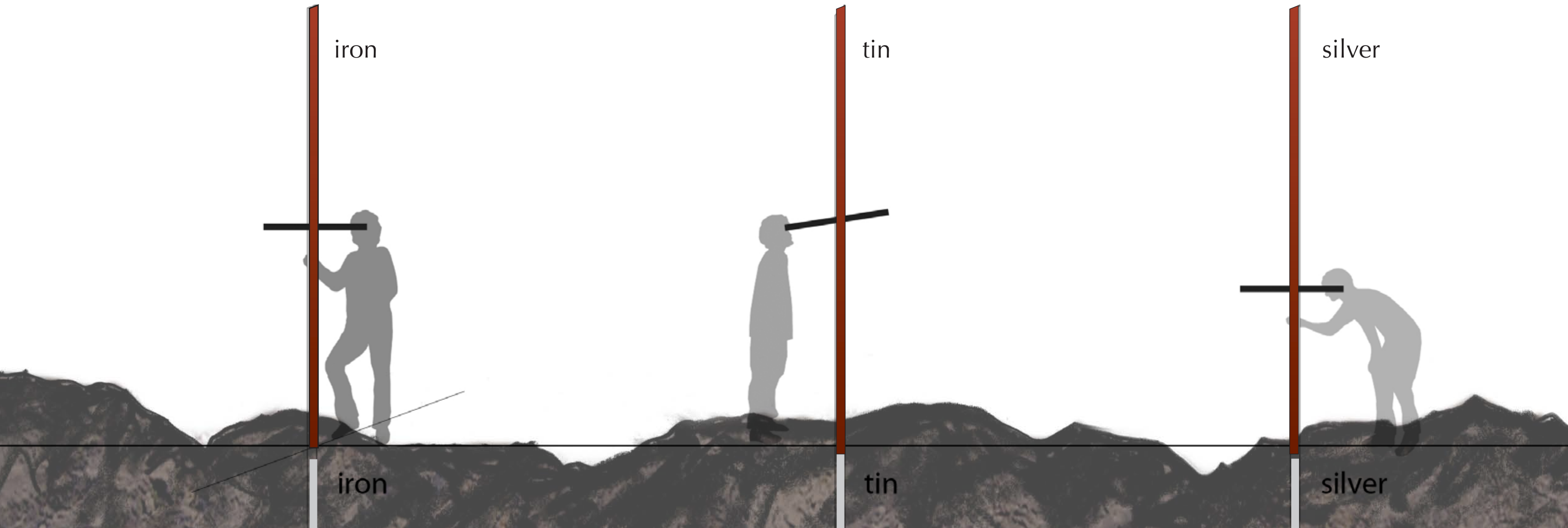
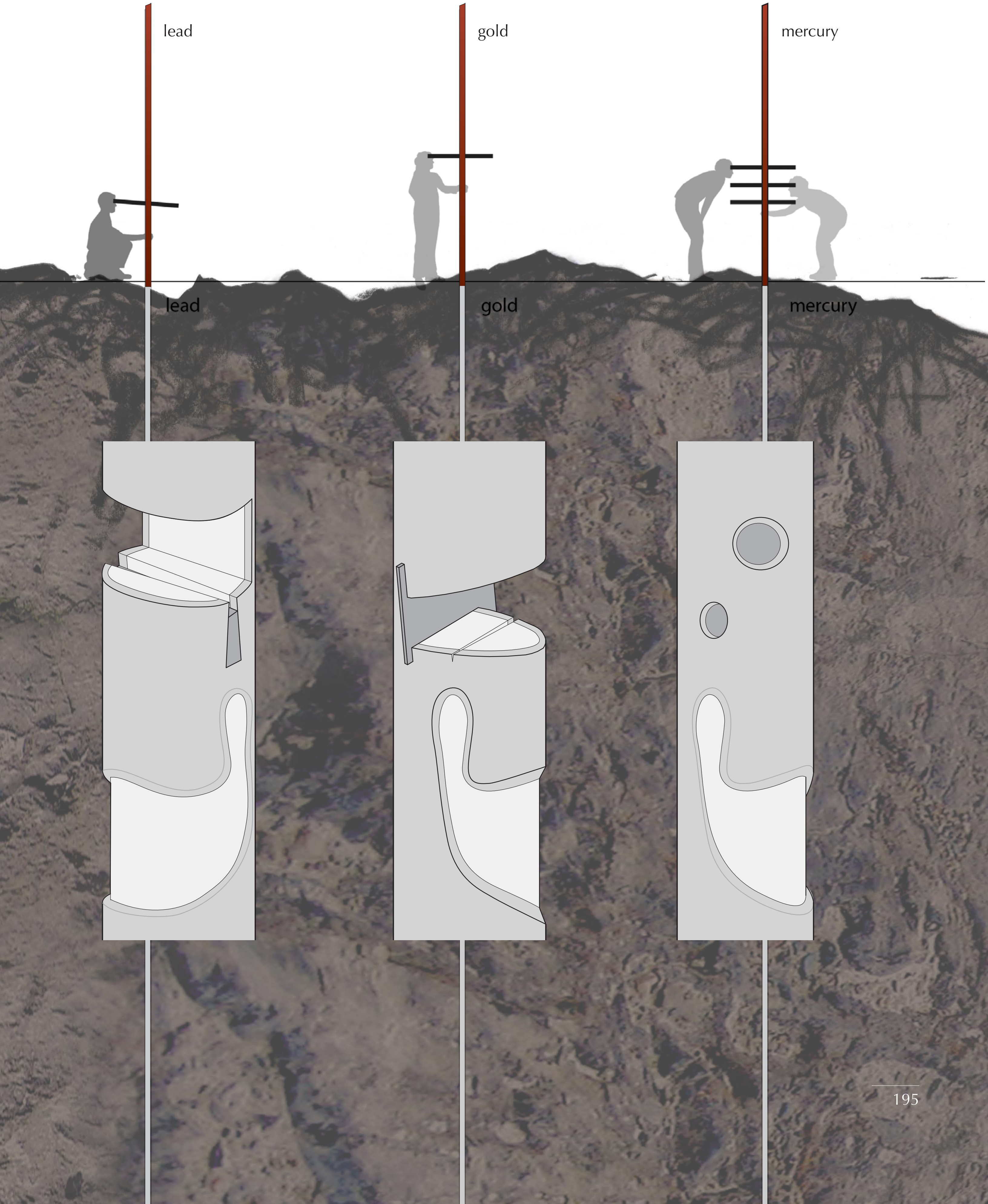
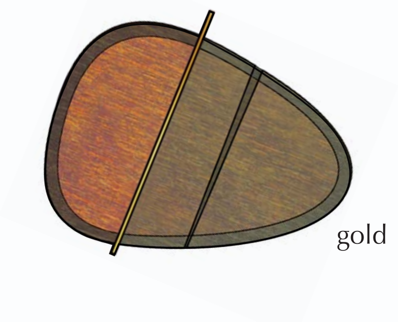


fig. 6.16- view positions at copper posts

fig. 6.17- elevations of copper posts


lead
gold
mercury
lead
gold
mercury



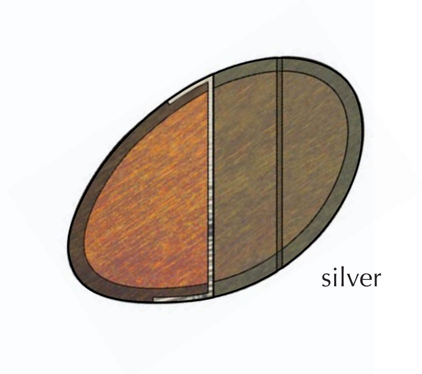
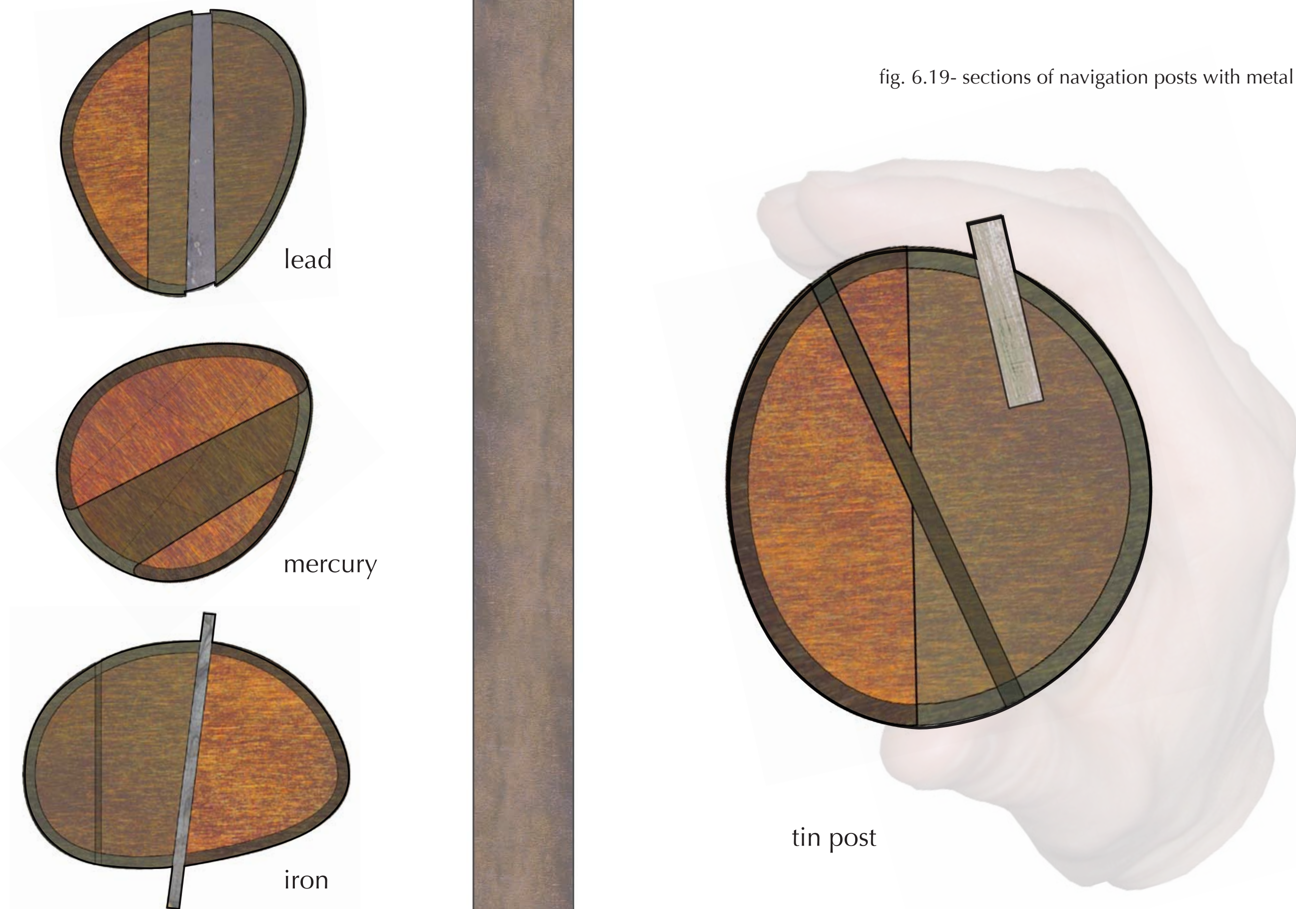


fig. 6.18- view from navigation post at silver space to gold space

fig. 6.19- sections of navigation posts with metal inlays



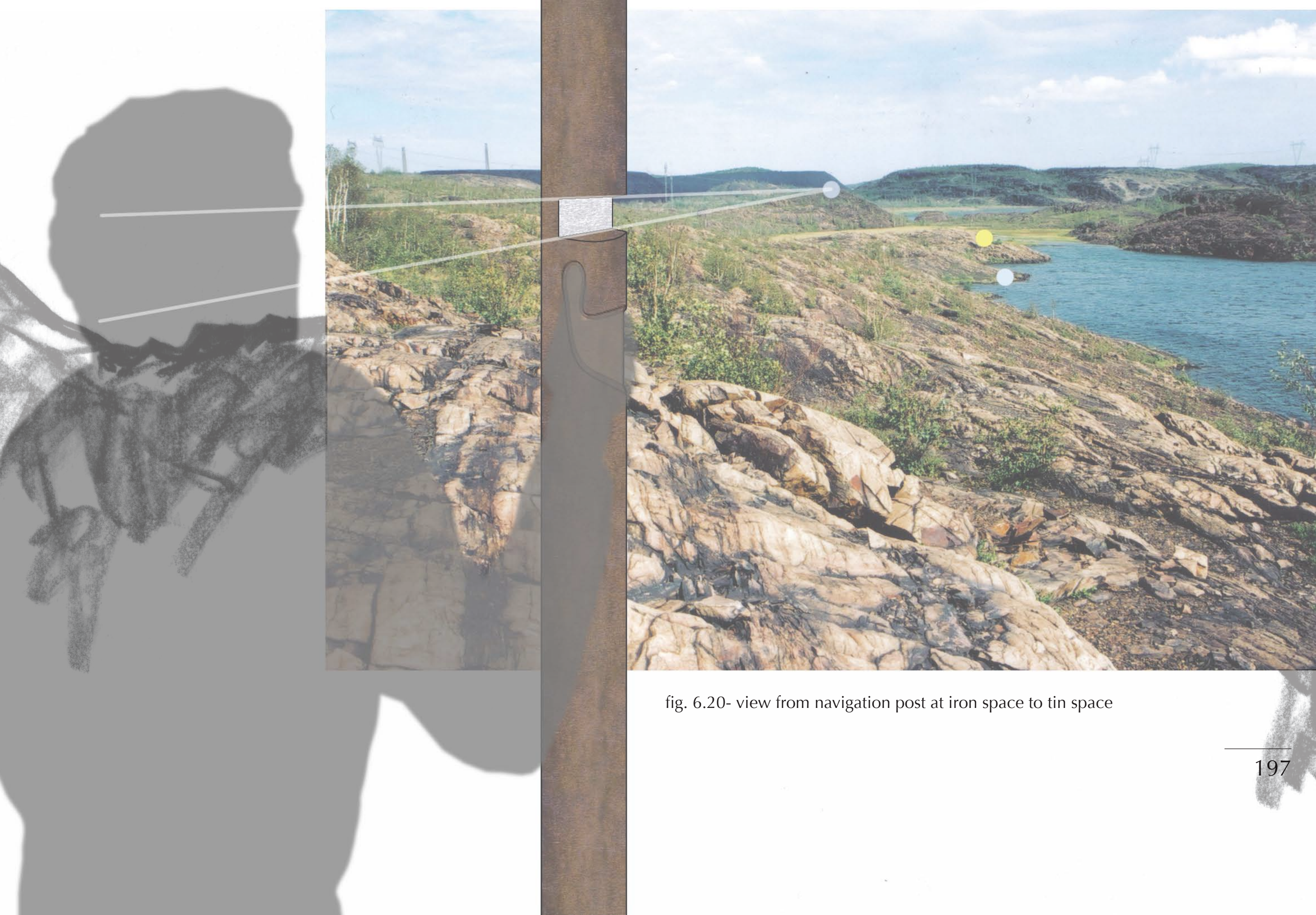


fig. 6.20- view from navigation post at iron space to tin space

Book VII : aurum

☉ Au 79

the fable of musagetes

Echoes over grassy plains,
Mountain peaks, crests of waves, told
A story of nine muses,
Built into a temple, overlooking
The edge of the world.

Musagetes and the Nine,
Travel-weary, yearning for rest,
Steered willful Pegasus over the sea.
A sight of land: and
Just beyond the cliff's edge, a
Clear hilltop, open to the sun:
The wanderers bathed in cool waters below,
Laid their garments to dry on the warm rock.

And here Musagetes found
A peace so overwhelming, so
Liberating; his mind was
Freed to the extents of his imagination.
Only the sound of the ocean, its rhythmic
Crescendo and fall,
A symphony of winds, strings, percussion,
Accompanied his thoughts.
Here on the isolated landscape, he would build
A temple to the Muses-
Each one captured in image,
In poetry and song.

And so, he stacked a base of rock
And made it smooth,
Polished mirror-bright to shed water and light.
Around this, nine columns: each
Sleeved in a skin
Of fine gold, its surface
Ready to take on the shapes and impressions
Of the Muses and their stories.

First Erato, with lyre and bow
In hand, whispering in the ears
Of smitten young couples,
Heartbroken admirers, her
Poetry of adoration and passion.
Musagetes molded the scenes, reciting
Love-poems in his head:
Young Keats, of new love, and
The ageless, timeless love of Neruda.
He found himself
Secretly sorry that the lovers
Caught in the gold would never
Unite in that much longed-for, much
Anticipated embrace.

Then Thalia, Muse
Of Comedy, her impish grin
Half-concealed behind her mask,
Depicted in scenes of mirth.
Tickling the toes of Molière,
Blowing the feathers of Shakespeare's quill,
The entertained crowds
Dissolving into laughter.
Her column set beside that of
Her closest sister, the tragic
Melpomene. Over her chest
Her arms crossed, scepter in one hand,
Dagger in the other.
She watches, ominously,
Knowingly, over the deaths
Of much-loved Adonis, Cyparissus,
The beautiful Hyacinthus, captured
For eternity in petalled splendour.
Musagetes carved the three faces,
Their shoulders, torsos, legs, their
Entire bodies, down to the fingernails,
From memory. For Mnemosyne,

Mother to the Muses,
Had fixed these details forever in his mind.

The fourth column he took
For Euterpe, holding
Her flute in one hand,
Strumming the lyre of Apollo
With the other. She smiles
Sweetly at the orchestra beneath her,
And the masters at her command.
Here Bach, at his clavichord;
Mozart lifting the violin
To his chin; Beethoven,
Head askance, lame ear
Pressed to his piano. Among them
All manner of musicians:
Cellos, oboes, tympanis,
Mallets and bows and mouths at the ready
For the drop of the conductor's baton.

And, as if on cue,
A troupe of dancers, led by
Terpsichore, launched into movement
On the fifth column:
Willowy women on pointe,
Their form impeccable,
Twirled with young girls at play.
Highland kilts and vivid Indian silks
Circled each other, while
Couples in a hot-blooded tango
Pressed their bodies into one.
On the sixth column, the somber
Youngest sister:
Polyhymnia of the golden voice,
Muse of hymns.
Around her head a crown of pearls,
She casts her gaze into a book

Of song, her lips slightly parted
As if sound were to emerge
From the gold.
At her feet, choirs of children,
Women and men,
Their voices united as one in song and chant.
Soloists with arms outstretched- the
Angelic Callas, in duet with
Legendary Bjorling, as Puccini
And Bizet listen, rapt,
From the column's edges.

Also borne on voices
The epic poetry of the Muse
Calliope, her stylus in constant motion
Over her tablet of stone.
At the bottom, the tale
Of Odysseus, warned by blind Tiresias
To beware the waters
Of the Scylla and Charybdis. And
The Trojan Aeneas,
Son of Venus, founder
Of the great city of Rome.
Higher up, the nine circles of hell
Spun by Dante in his Comedy,
And Milton's version, depicted as
A paradise lost.
But the true tales of men
The Muse Clio, of History,
Proclaims with her trumpet
On the eighth column.
To her left, the father
Of history himself: Herodotus,
With countrymen Thucydides and Xenophon
Spell out the triumphs and tribulations
Of the Greek people.
Tacitus and Thallus, here telling

The greatness of Rome's legacy.
The monasteries of the Middle Ages,
Preserving these histories
In medieval darkness.
And the books, statues,
Parchments and temples,
Written, carved and built by men,
Which tell the story
Of civilizations past.

And the last of the columns, dedicated
To Urania, the Muse
Of Astronomy, she whose stories
Are punctuated by stars.
The heavens, so humbling
And unknowable, yet some
Still set their sights here
In the quest for truth.
Here depicted in the surface
Is Galileo, fixed in observation
Of Saturn's mysterious rings.
And Herschel, discovering worlds
Beyond the scope of the ancient
Wandering stars.
Musagetes inscribes the orbits
Of the planets, and beyond,
Sets balls of light, metals
Cast in the colours of the stars
In the shape of the constellations.

And as the sun sets on the temple,
Apollo's chariot sinking below
The horizon, the light
Of the stars emerges,
One shy flicker at a time.

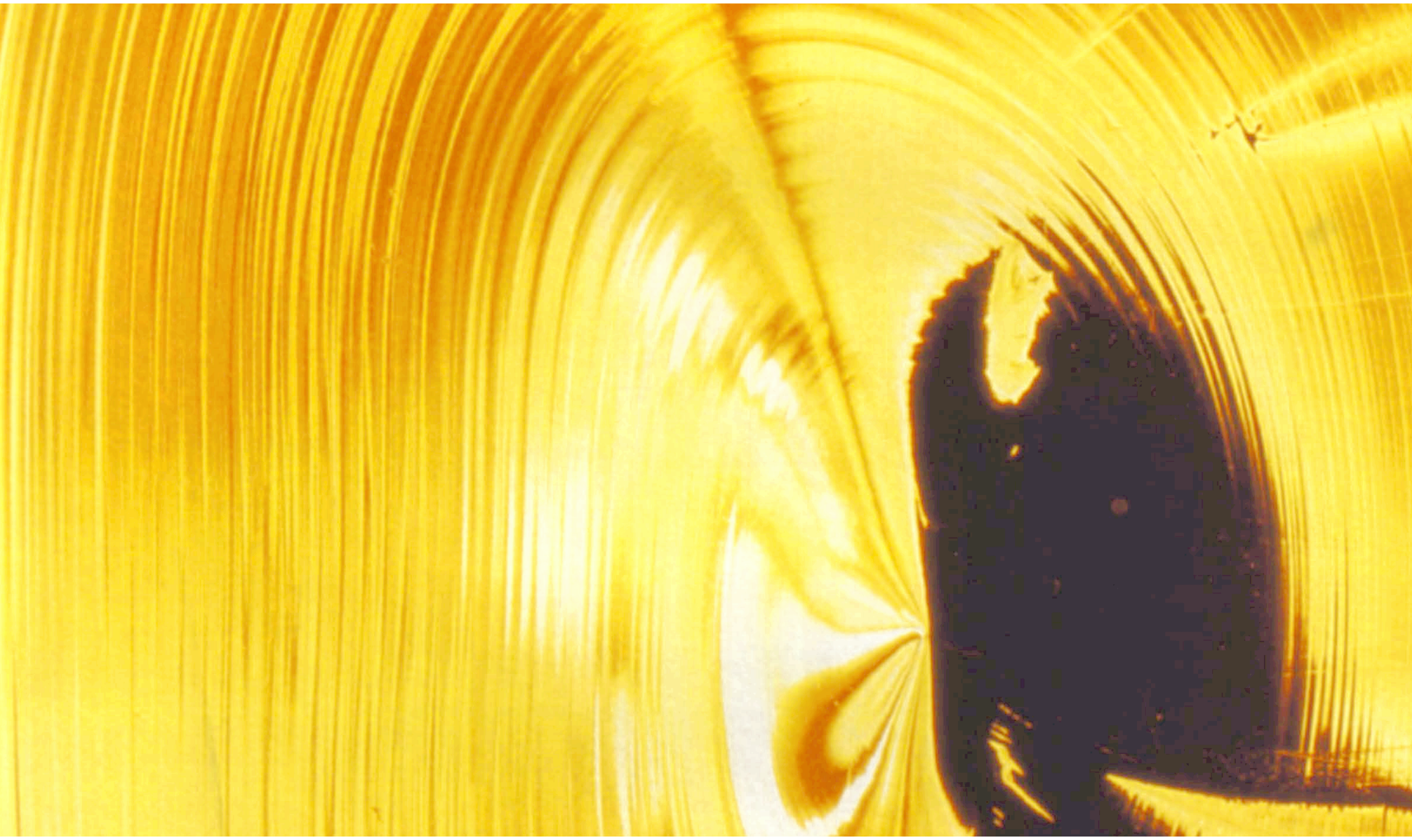


fig. 7.1- Gold

They wonder much to hear that gold, which in itself is so useless a thing, should be everywhere so much esteemed, that even men for whom it was made, and by whom it has its value, should yet be thought of less value than it is.

- Sir Thomas More, *Utopia*

Au from the latin *aurum*, meaning *shining dawn*

The French playwright Molière said, "Gold gives to the plainest thing a pleasing charm: without it all else is a miserable business."[1] Gold has long been a projection of beauty, lustre and attraction. To sensibilities that regarded the metals as living, growing things, even lead, tin, iron, copper and silver aspired to gestate into gold, to be left long enough in the womb of earth to complete the transformation into their intended, perfected state.[2]

Gold is the heaviest and densest of the seven classical metals. While it appears to have a yellowish cast, in truth gold holds within it a spectrum of colours: thin leaf gold held up to light reveals shades of green, and a solution of one part gold per hundred million of water takes on a purple hue.[3] The metal is tremendously malleable, and its softness allows it to be pressed into exceedingly thin sheets: an ounce of gold (1.61 cubic centimeters) can be hammered out to one hundred square feet.[4] Despite this thinness, gold maintains its shine and appearance and is one of the only metals that will not tarnish or corrode. The workability of gold allows it to be easily shaped and reshaped according to the needs of the time, for which it is believed that many would-be artifacts of past societies would have been melted down and used in more contemporaneous ways, often several times over.[5] A gold statue from ancient Egypt might have been reshaped into Greek jewelry, then into Roman coins, and finally ground into powder to adorn the pages of an illuminated manuscript in the Middle Ages.

While it may be said of money in general that greed, avarice and a search for power are a dark side of its nature, the propensity of gold to invoke such responses has been used as a device in many an allegory. In the tale from Greek myth, King Midas of Pessinus was granted a single wish by the god Bacchus; he requested the ability to transform all he touched into solid gold. He soon found he was able to turn into shining metal not only inanimate objects, but also all food and drink that passed his lips, demonstrating that gold means little if it cannot satisfy the basic needs of hunger and thirst.[6] It is also true of the power of gold to inspire reverence, describe beauty, even communicate immortality through a

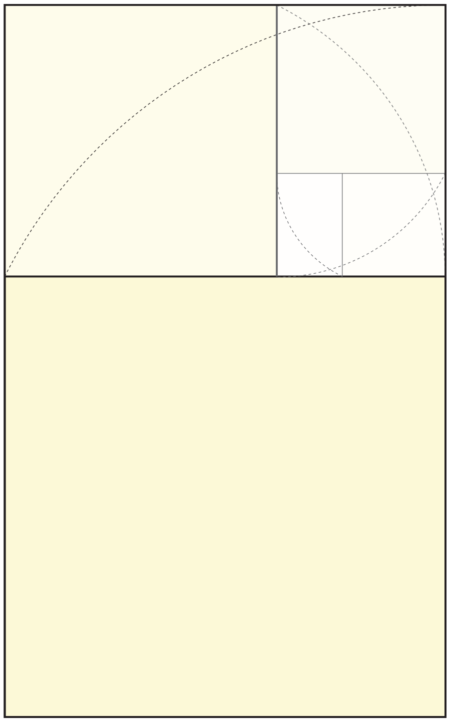


fig. 7.2- Golden section.

lustre that never tarnishes. The timeless attraction to gold has changed little since it was first spotted glistening in the beds of streams.

Gold has been used as a currency metal for millennia, early indications of which can be seen in Egyptian bars dating from 4000 BCE.[7] It has long been considered the universal basis for international monetary standards. As stated by the German economist Hans F. Senholz, “For more than two thousand years gold’s natural qualities made it man’s universal medium of exchange. In contrast to political money, gold is honest money that survived the ages and will live on long after the political fiats of today have gone the way of all paper.”[8] The value associated with gold is part of the symbolism of prestige by which gold represents a standard of performance in athletics and achievement in the arts, be it the Golden Boot awarded to the world’s top soccer player, or the Palme D’Or given to the top film at the Cannes Film Festival. It is widely used as a metaphor for beauty and perfection, as with the Golden Section. The Golden Section, likely developed by the Greek mathematician Pythagoras, is a ratio of proportion that can be understood spatially in terms of a rectangle made up of a square and a smaller rectangle. The proportions of the small and large rectangles are equivalent, and the small rectangle can be broken down into a square and smaller rectangle with, again, the same proportions. Mathematically the proportion is represented as 1:1.618, which can also be understood as the respective lengths of the sides of the rectangle. Plato believed that this dimensional correlation had a deep and mystic significance. It has been used in architecture for centuries, from the proportioning of elements in Greek temple construction to the Renaissance-era Palazzo della Cancelleria in Rome.[9] Conversely, the symbolism of gold has also emblematized greed, excess, hedonism and the incalculable risks that men are willing to take

fig. 7.3- Gold and lapis lazuli bracelet belonging to the pharaoh Ramses II,
13th century BCE

for its conquest. Thus gold is depicted by the Greek lyric poet Pindar in the fifth century BCE as “a child of Zeus, neither moth or rust devoureth it, but the mind of man is devoured by this supreme possession.”[10]

Predating its appearance as a currency metal, gold had a significant ceremonial role in ancient cultures. The scarcity of gold ensured that possession remained exclusively in the hands of rulers. The ability to adorn oneself with the metal of light, and in so doing to exude and control light, would have likened these early rulers to gods in the eyes of their populace. This was the prerogative of the pharaohs of Egypt, who covered themselves from head to foot in articles of gold. Egypt’s only female pharaoh, Hatshepsut, would paint her face with gold dust in assuming her many epithets, including the Son of the Sun and the Golden Horus.[11] Through the use of gold the pharaohs connected themselves to the divine lineage of the Sun god Ra, the most powerful deity in their pantheon. The power of gold, however, was not to remain forever within the domain of kings and other rulers; with the rise of the Roman Empire, it was first evidenced that wealth could be used to achieve political power to a degree competitive with that gained through birthright.[12] With this, the metal worn by kings and pharaohs was democratized, and in the millennia since, gold has appeared on the necks, hands and ears of common citizens as well as kings.

The association between gold and the Sun is likely the oldest connection between the classical metals and planets. The legacy, well established in ancient Egypt, would continue to be a theme in Greek mythology as well, where the moving sun was believed to be the golden chariot wheel of the god Apollo.

the sun

A ball of fire or a burning chariot wheel, a watchful eye or a nuclear reactor, the source of the Earth's light and life: certainly the Sun carries tremendous physical and metaphorical significance. A spherical mass of helium and hydrogen burning at 10 to 15 million degrees Kelvin, the Sun is the crucial pivot in the orbits of eight planets, three dwarf planets and an array of cosmic detritus spanning 12 billion kilometres in diameter.[13] It was born from a swirling nebula five billion years ago, the rotation violently compressing almost pure hydrogen gas until there was produced another of the universe's innumerable stars. This hydrogen is in a constant process of fusion, whereby four hydrogen atoms join to create one helium atom; performed on a massive scale, this reaction generates the sun's heat, and will continue to do so for another ten billion years.[14] Although it is a star, the sun features characteristics normally associated with the planets, such as an axis of rotation (of seven degrees) and a period of rotation (around 27 days).[15] While the round shape of the sun's surface, known as its photosphere, is plainly visible from Earth, in truth the sun's atmosphere extends out beyond the limits of the solar system.[16] In this, our planet does not simply receive the light of the Sun: it is immersed in it.

Because of its intense brilliance, the Sun's surface appears from Earth as smooth and uniform, but with magnification it is evident that the photosphere is marked with a texture likened to grains of rice.[17] Set on this screen of granules are the Sun's most mysterious phenomena: the dark patches known as sunspots. The most characteristic feature of sunspots is their tremendous magnetic force: at these locations the magnetic field of the spot exceeds that of its immediate surroundings by as much as 3000 times, or 10000 times the magnetic field of the Earth.[18] While sunspots are continually present on the Sun's surface, their magnitude transforms according to a cycle just over eleven years in length, ranging from a maximum to a minimum level of intensity. Because the magnetic polarities in each hemisphere reverse after a sunspot cycle, one eleven year turn is immediately followed by another on the other side of the sun; this results in a 22-year cycle that is remarkably consistent as observed in terrestrial phenomena.[19] There is ample evidence that the magnetic variations of the sunspot cycle have an effect on processes here on Earth, from the migration of the magnetic poles to the manifestation of the weather.[20] It has been determined from rock samples and tree rings that rainfall patterns over the world display a cycle of highs and lows correlating to the 22-year sunspot cycle. However, it is not as simple as a sunspot maximum equating to a rainfall minimum. What has been observed is that a specific location's response to the cycle is highly individualistic, so that a sunspot maximum in one area may predict heavy rainfall, while two thousand kilometres away the land experiences drought. Evidence of this dynamic supports the theory that weather on Earth has responded to the sunspot cycle for several thousand years, and suggests that it has likely always been affected by it.[21]

All ancient civilizations recognized some variation of a solar deity, and there is striking similarity in the ideas formed by different cultures when they considered the genesis and objectification/personification of the Sun. From Africa to Scandinavia, the Americas to Asia, the Sun was conceptualized according to several common themes: as animal,

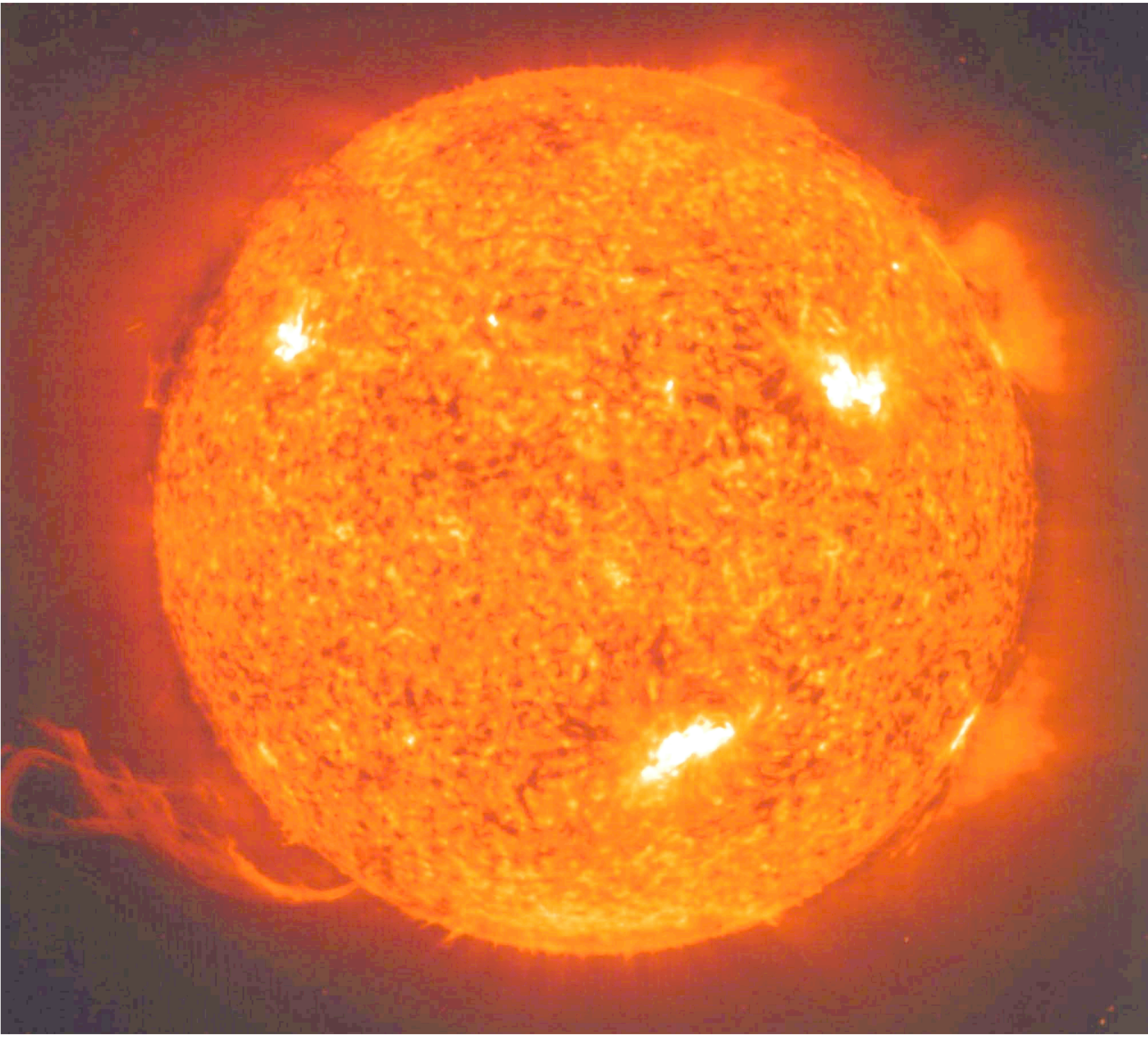


fig. 7.4- The solar chromosphere with numerous ultravoilet bright spots. Eruptive prominences can also be seen, particularly at the bottom left.

fig. 7.5- Limestone relief showing the Pharaoh Ikhnaton
making a sacrifice to the Sun God, circa 1350 BCE

as sailing ship, as spinning wheel among others.[22] One of the most popular of these themes was the Sun as omniscient eye,[23] as observant god who witnessed all things visible by the light of day. It was the eye of Ra that watched over ancient Egypt, and the eye of Odin that looked over Norse lands and colonies. However, the most consistent theme amongst solar myths may be that of the Sun's place in the history of darkness and light.[24] In many historic and contemporary belief systems, both in the East and West, the Sun was preexisted by a phase of darkness or semi-darkness, occupied by the gods and in some cases by men as well. In the Abrahamic religions of Judaism, Christianity and Islam, for example, it was light that was brought into being on the first day of creation. The setting of the Sun was often regarded as engagement in a quotidian battle between the forces of good and evil, a solar deity's voluntary entry into war with the underworld, vanquishing them to rise each day.[25] Such an example can be found the Hindu faith, where the Sun god Indra battles with Vritra, the serpent of the night, between each dusk and dawn.[26] For all of its associations, it is inevitable that representations of the Sun would take on both genders; however, it is the male depictions that have been the most prevalent around the globe. Gender is but one polarity in solar myth; there is also that of the Sun's own benevolence and malice. While a life-giving and sustaining force to many cultures, particularly in Northern latitudes, those living under its harshest fire, such as the peoples of sub-Saharan Africa, regarded the Sun as a dangerous and harmful entity.[27] Here the rising Sun is a curse, and not the positive force represented in other mythologies.

The Sun is linked to the sign Leo and the zodiac's fifth house. Traditionally the fifth house was known as the House of Children, and Sir George Wharton mentions the house as one of posterity.[28] Creation is a major focus of the fifth house, as are its related aspects of recreation and procreation. In the latter can be seen a connection with the Baroque association of the fifth house with children. It should be noted that the products of the creative process, as they are tied to fifth house expression, are of personal interest and investment,[29] for this is still within the realm of the private houses where the individual's own fulfillment (and sometimes indulgence) trumps their motivation to benefit society. The fifth house is one of emotional response, and the humanist astrologer Dane Rudhyar makes a distinction here between feelings and emotions, with the former considered as spontaneous reactions, and the latter as the outward expression of those feelings.[30] Love relationships of the fast-burning kind may be found through the fifth house, as the purpose of these unions is to satisfy the need for emotional and sexual release, more so than long-term relationships indicated by other houses such as the seventh.[31]

The glyph for the sun is the same as that used for gold by alchemists: a circle with a point at its centre, shown as ʘ. Variations on this symbol abound across all parts of the world, from the ancient Egyptian hieroglyph to the Chinese character, although the most widely represented icon of the sun displays the solar disc surrounded by licks of flame.[32]

gold : to endure

The metaphorical connections between gold and the Sun were first drawn together thousands of years ago. The yellowed hue of gold's surface is emulative of the colour of the midday Sun; its incorrodible lustre, likewise, captures light more vibrantly than the other metals and does not tarnish over time. It can also be evidenced that elements of the mythology and symbolism of one is often shared with the other. Some of the more prevalent of these correlations include the symbolism of light, connection with figures of power (whether man or god) and the position of prominence that both hold over the other classical metals and planets in terms of importance and influence. How these symbolisms might be viewed through the lens of astrology, and in particular the zodiac's fifth house of creation, helps to develop an idea of the gold imperative.

It is evident through the research on gold and the Sun that the phenomenon of polarities is intrinsic to both. The beauty, lustre and rarity of gold have made it a thing of value and prestige, but alongside the benevolent uses of the metal is its potential to provoke greed. The power of the Sun to create and nurture life by its warmth and light is also expressed through an excess of fire that destroys the life it creates. These polarities find expression at a cultural scale within the lessons of morality that are a part of world religions and mythologies.

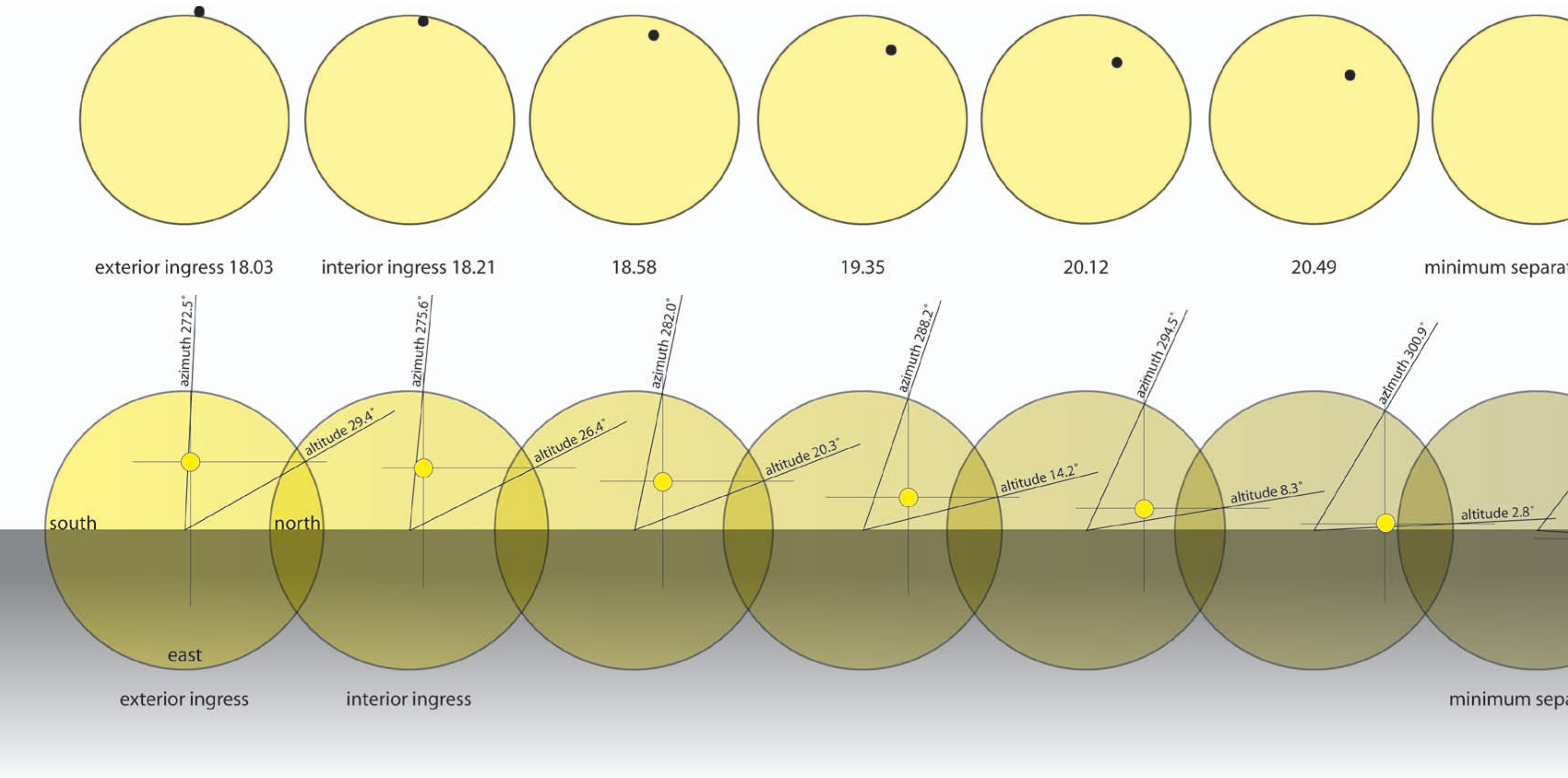
Some of these lessons of humility stem from a character's desire for traits beyond the human reality, such as immortality, omniscience or omnipotence. The aspiration of Phaethon, son of Apollo, to drive the golden chariot of the Sun across the sky expressed his desire to assume great power - more power than could be handled by a mortal. This lesson suggests that there is something very human in the aspiration to the divine. It is only through such ambitions that the individual can step outside of himself to stand in the realm of the gods, as the man who drives the chariot of Apollo, if ultimately to mass destruction.

If, then, man is to aspire to some iota of godliness, he must emulate that most godly of acts: the ability to create, and, in particular, to create *life*. Only a human being can create life in their own image. It is through the ability to create - and only through this - that man is able

figs. 7.6, 7.7 and 7.8- Representations of solar deities: Indian, 2nd century BCE; Etruscan, 7th century BCE; Peruvian, 800 BCE-200 CE

to aspire to immortality. Man's mortal flesh endures through his children, not only in the continuation of his bloodline but as a matter of passing on his wisdom and legacy. The symbolism of eternity is similarly expressed through gold and the sun: the constancy of the sun, rising and setting with unceasing regularity; the timelessness of gold, never losing its lustre or beauty. It is proposed that the imperative *to endure* is the most true expression of gold.

If gold's spirit is to endure, then light is the means by which it does so. The effect of light on gold is not absorptive; the metal casts the light on in a multitude of different directions. A similar dynamic is in effect with the light of the universe's multitude of stars, including our own Sun. A gaze into the night sky shows the stars as bright points, as pinpricks marking where the source of that light is generated. Shifting perspective, it can be understood that each star casts out light in all directions; it is only our distant vantage point that makes them seem as single spots, rather than as spheres of light extending out indefinitely. The light that we interpret as stars can be hundreds, thousands, even millions of years old, traveling tremendous distances towards our planet. It continues on, in every direction, long after it has passed by the Earth. To consider a universe full of such light, some so ancient it traces back to the very moment of the creation, is to consider a concept of endurance that surely surpasses any other.



gold space : the platform

Several million years ago, the Coniston area was compressed under a prehistoric mountain range. More recently, during the ice age that ended approximately ten thousand years ago, the site was buried under a mile-thick glacier. Given these changing dynamics, the idea of endurance in the context of landscape seems to resist taking a single physical form. The rock will not endure; it will erode, and new rock will be forced up from under the earth's crust by tectonic movement. The water will not endure; it will freeze and thaw, cycling between the air, land and oceans. Even the winds will change as the profile of land and ocean transform. Truly, the only characteristic of the site that resists change, and the only one that can be expected to endure in the same form that we know today, is the light of the Sun in its constant daily and yearly cycle. To the points of latitude and longitude of the site, the Sun will appear at the same place in the sky a million years from now, just as it did a million years past.

The area of the site slopes to the south, towards Baby Lake, so that the entire site turns its face towards the midday sun. Along the site there are a few elevated platforms, some of them relatively near the water's edge. One of these points lies close to the marsh separating Baby and Alice Lakes, and is notable as a marker that differentiates it from other high points along the path: in a landscape that is characterized by barrenness, here a single, hardy pine tree reaches upwards from a crack in the rock. This lonely tree, bent and twisted from a life spent battling the winds, is a strong symbol on a landscape that has seen much of its life burned away in the past century.

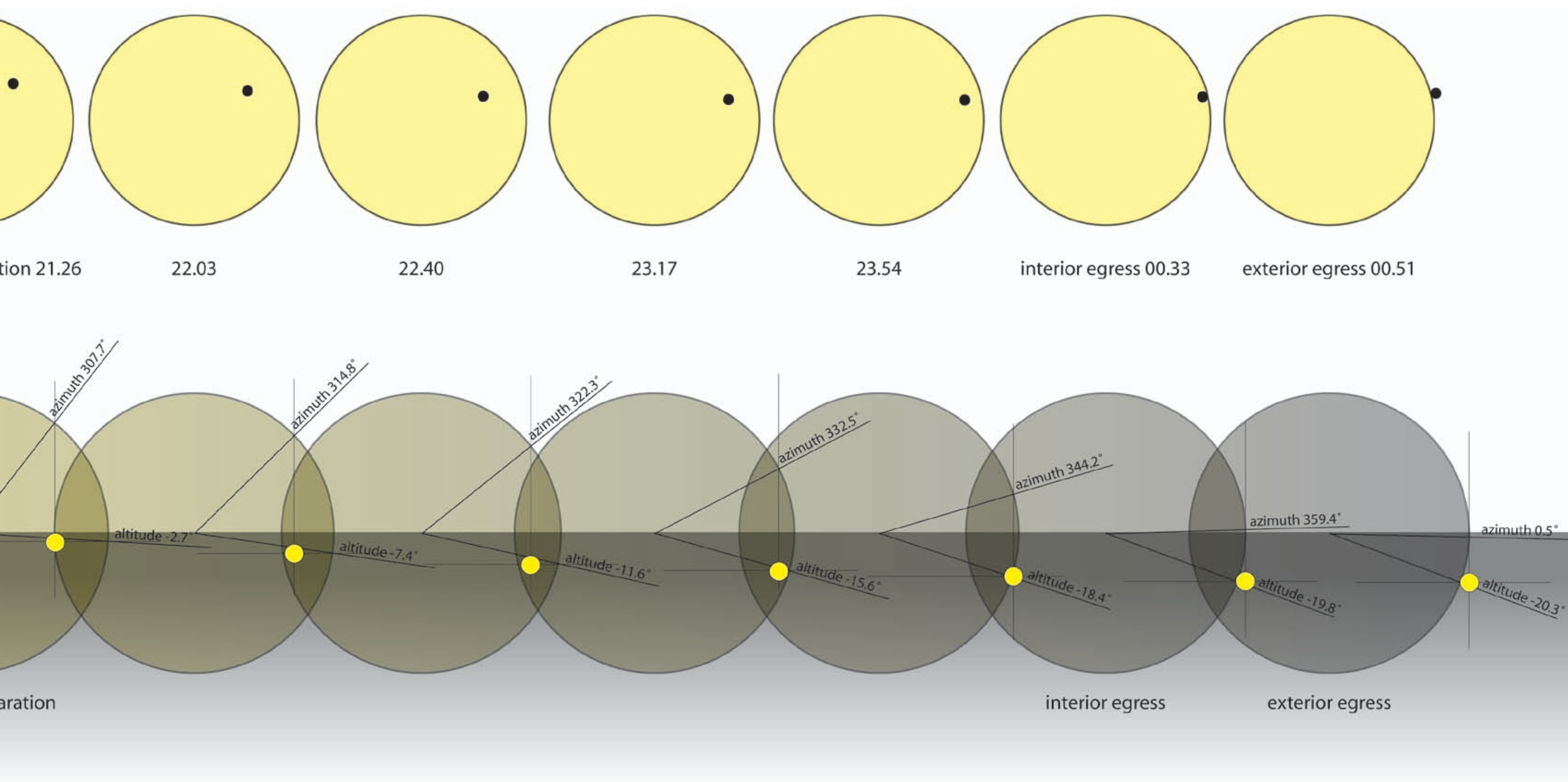


fig. 7.9- phases of Venus transit, 05-06 June 2012

The gold space is situated in proximity to this iconic symbol. A cylindrical void is cut directly downwards into the rock to a depth of 2m. Into this void is fitted a column of glass 50mm thick and 750mm in diameter, which allows light to be cast downwards into the void while also illuminating the alabaster slab of the platform from the underside. This alabaster slab, with its glowing translucence, is incised and inlaid with a series of trajectory lines indicating constants of the site's solar dynamics: locations of the rising and setting sun at solstices and on the first of each month of the year. This provides an expression of the imperative of gold *to endure* through the timeless cycling of the sun across the sky, taking the iconic element of light as the embodiment of the metal and focussing it towards a single point in the landscape.

The gold space also directs the viewer towards one specific event as it will be observed from Coniston: the Venus transit of 2012. The incisions on the alabaster platform direct the viewer's gaze towards the Sun at critical intervals during the transit: ingress, during which time the planet Venus moves into the Sun's orb; maximum separation, which marks the midpoint of the transit; and egress, as Venus passes out of the glow of the Sun. Not all of these moments can be observed from Coniston; the end of the transit occurs after the sun sets at this location. However, the directional indications marked on the platform remind the viewer that, beneath the horizon, this spectacular event will continue to unfold - for the last time during their lifetime.

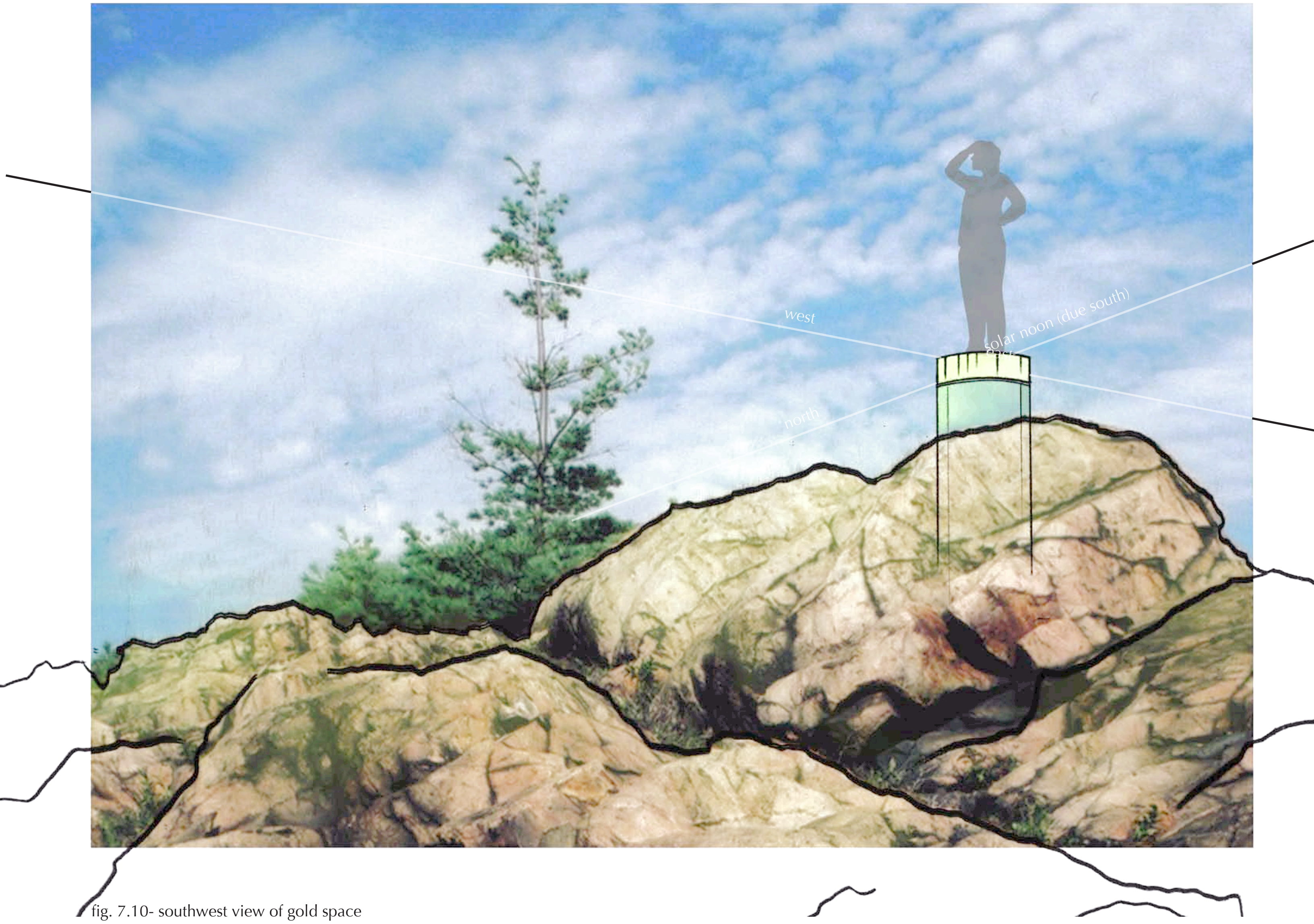


fig. 7.10- southwest view of gold space

Cylinder construction: two-piece bent glass cylinder, capped with alabaster slab inlaid with copper and lead markings. Glass conforming to ASTM C1464, Standard Specification for Bent Glass: two-piece glass cylinder, exterior diameter 750mm and height 2000mm, installed to a depth of 1500mm, double-walled 25mm thickness, clear with minimum visible transmittance of 70%. Stone: Calcite alabaster, minimum Mohs hardness 3, inlayed with copper and lead as per design drawings, finished with shop-applied protective resin coat. Stone slab supported on underside by aluminum frame attached to top of glass cylinder.

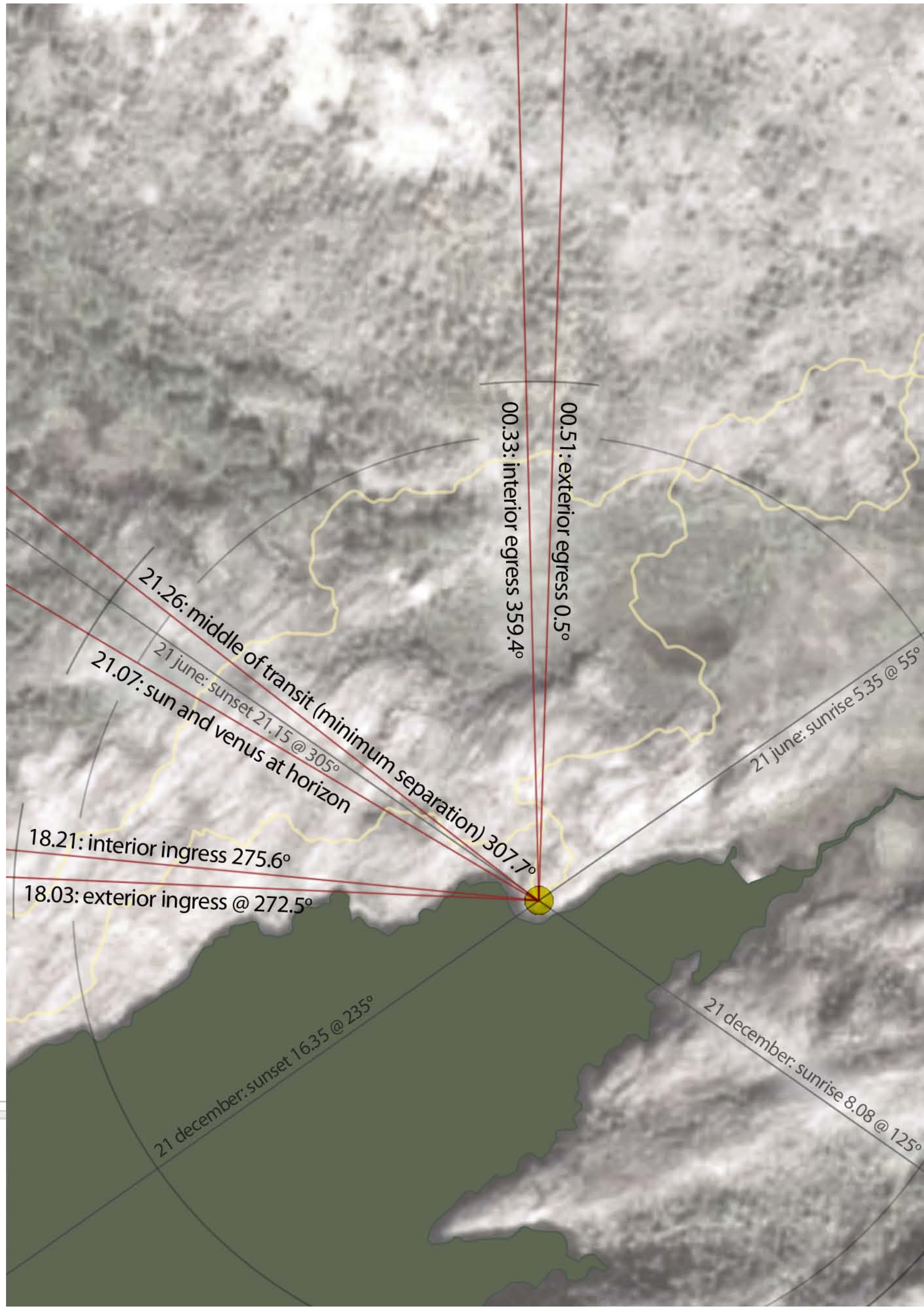


fig. 7.11- site map, showing solar constants and Venus transit phases

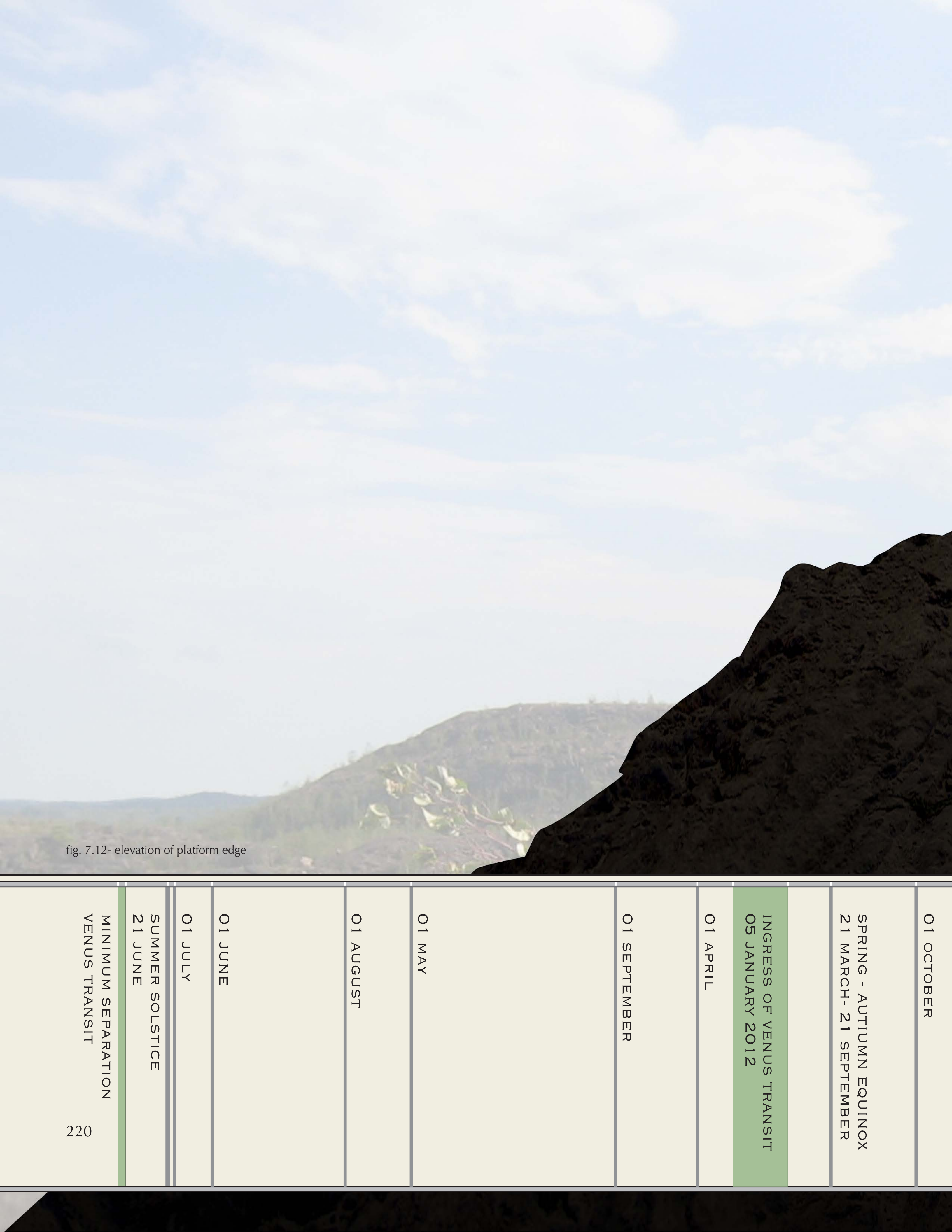


fig. 7.12- elevation of platform edge

fig. 7.13- ascent to gold platform

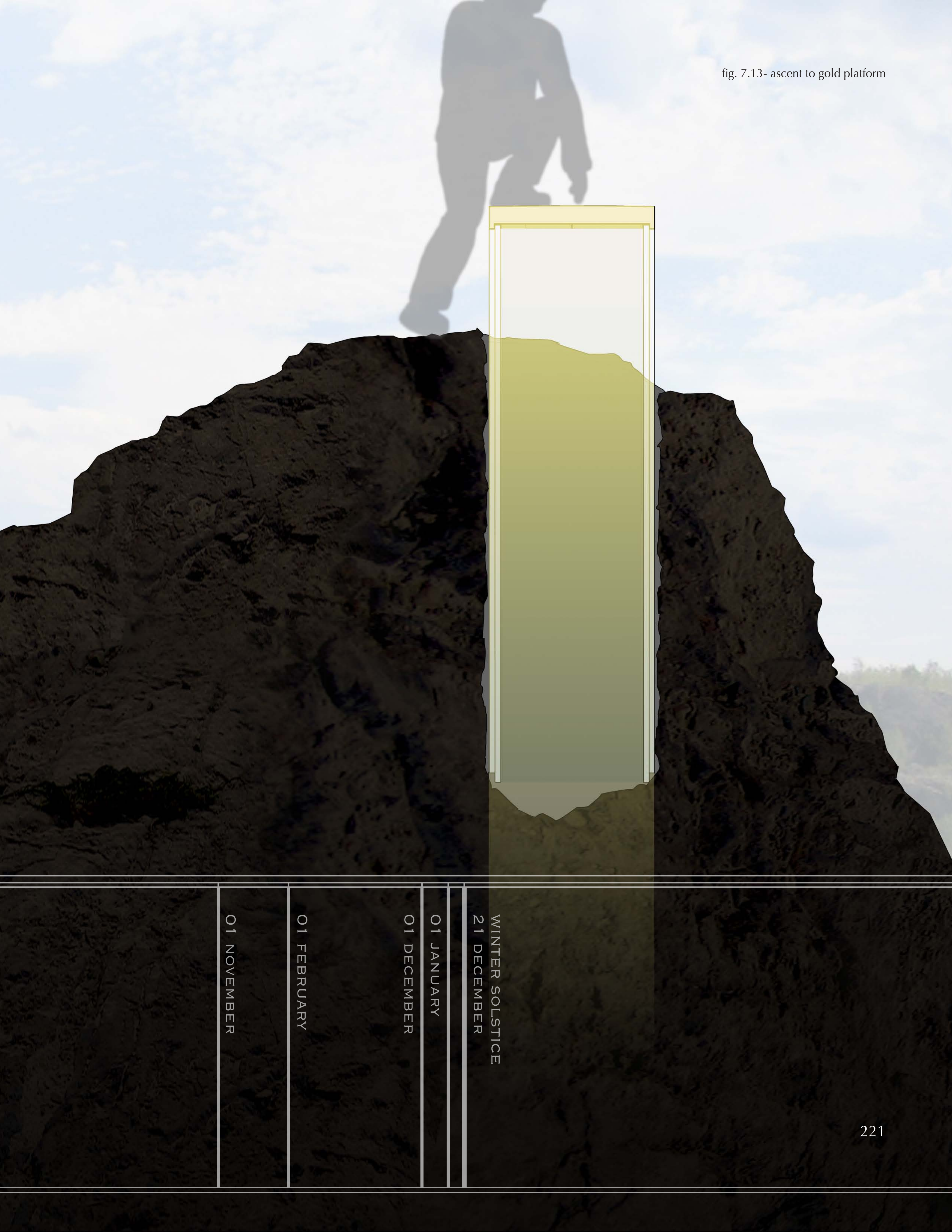


fig. 7.14-
platform markings 1:2

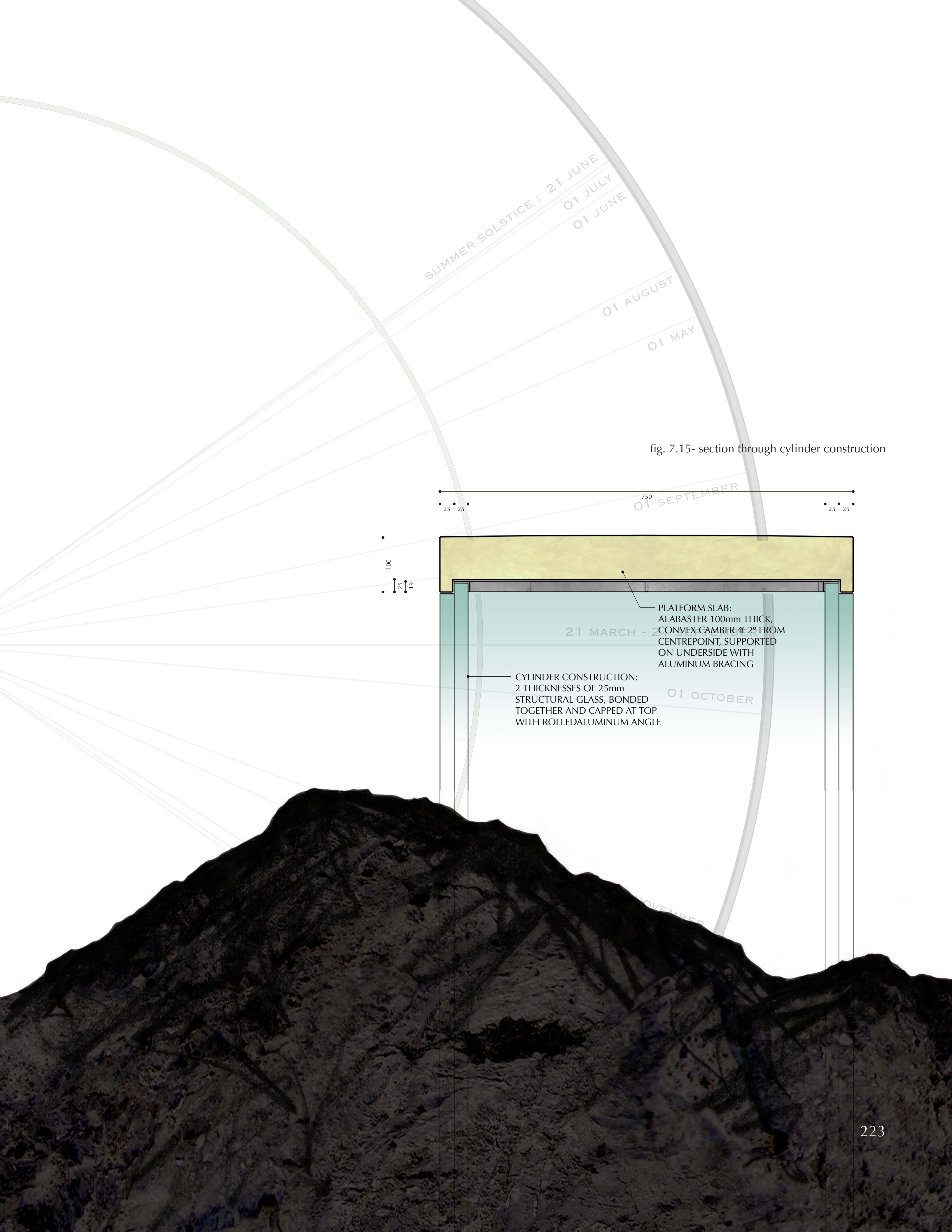


fig. 7.15- section through cylinder construction

Book VIII : stannum

♃ Sn 50

the fable of summanus

A dark, moonless and cloudless night:
Summanus takes an infrequent moment
Of repose, laying down
His heavy thunderbolt to observe
The great expanse of stars above him.

His journeys have carried him long over the globe,
Shaking his thunder-crash on
The heels of the setting sun,
Never catching more than a glimpse
Of twilight, or dusk.
His world is lit instead by the glow
Of the face of the Moon, and the
Flashes of light that explode
From his rumbling song.

But tonight he rests.
The world can sleep without
The sound of storm, as
The many guises of Summanus, with his many names
And instruments of sound
Are laid down for a single, rare peaceful night.

The lands of the East rest easy
Under the closed lids of Indra,
His copper mace loosely held in his sleeping hand.
Lei Gong tucks his mallet away:
No thunder will punish evil spirits
This night, nor
Mortals warned of temptations.

In Western worlds, the four corners
Of the sky, each held up by the mighty Bacabs,
Chaac, spirited brother of the East,
Robed in red as if alert,
His thunder axe at the ready,

Stands sleeping at his post.

To the frigid North, where gods and men
Alike might freeze to death
In the long winter's cold,
Thor lays down in his marriage bed with
Golden-haired Sif.
His war-hammer forgotten amidst
Their conjugal embrace.

This night, the world rests without storm.

Summanus, reclined on a pillow
Of stone, looks up to the heavens
Revolving around that lynch-pin, the
Immovable Polaris.
He looks for those omnipresent members
Of northern skies:
Cassiopeia, the queen, and her king
Cepheus. Also
The body of the great beast
Ladon, slewn by Hercules as he protected
The golden apples
In the garden of the Hesperides.
Lastly, the animal forms
Of Callisto and her son Arcas,
Cast into the skies, the two bears.

To the south, the great band
Of constellations: the Zodiac,
Through which move
All of the planets, and the Sun included.
Here Mars, present in the
Scorpion's den,
And beside him: Jupiter,
Weighing the Libran scales.
Saturn, nearer the horizon, lies
With the Fishes, preparing to move
Into the daylight.

Behind him, hidden in the light of the Sun
Mercury lies at home
With the Twins, but Mercury,
Always steadfast, stuck next to the Sun,
He rarely sees.
Venus too- only when she is caught
In evening, dragged along with the Sun
But lagging behind, as if longing
To observe a nocturnal Earth.
Or before dawn, racing ahead of the Sun,
Anticipating his path across the sky
Before his light overcomes her.

How marvelous, then, the wandering stars
Through these myriad posts,
Aligning with each other, or in opposition
Across the sky-
How marvelous that each moment should be
So unique, so unrepeatable.
And at each moment, a new life,
An infant taking their first chestful of air
Takes with them, like a fingerprint,
Theirs alone, an imprint of the stars.
Their celestial birthright.

Summanus takes his finger, pointing it
To the North Star,
His body tethered to the rock,
And slowly he spins the great bowl of stars:
His ancestors, siblings, the characters
Of ancient myth,
Set to motion, with his bare hands.

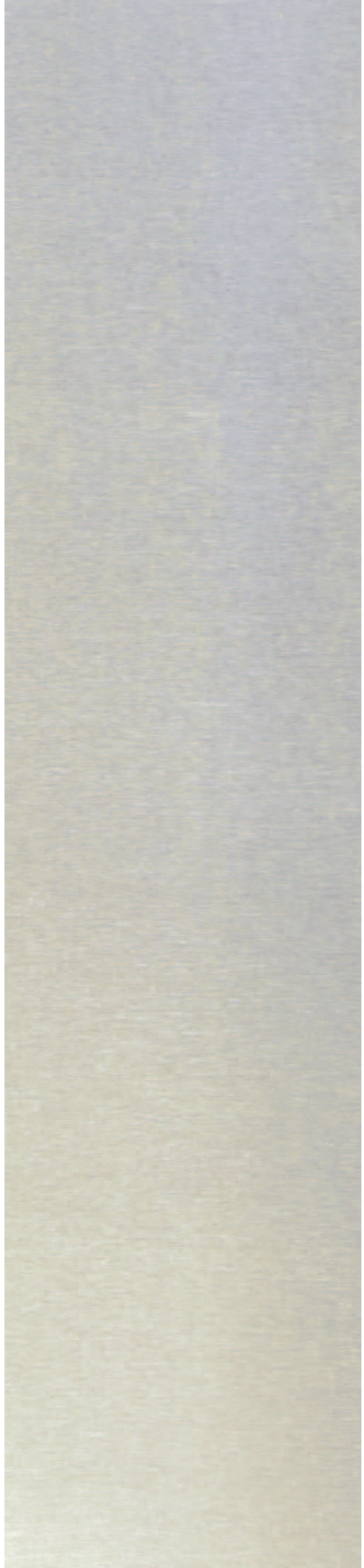


fig. 8.1- Tin

Even a tin knocker will shine on a dirty door.

- Irish proverb

Sn from the latin *stannum,*
possibly from *stan,*
the Celtic root of the English *stone*

Having made its grand entry into civilization hidden within the alloy bronze, tin has a ubiquity that belies its seeming inconspicuousness. Most likely the fifth classical metal to be procured from terrestrial sources, after gold, silver, copper and lead, tin may have been overlooked for some time as another form of lead,[1] for it shares its characteristics of weakness and low melting point*. The malleable, silver-white metal has a unique set of physical qualities. While quite heavy, tin is structurally weak and, like lead, is not suitable on its own for toolmaking. Tin changes states in a manner rather unlike the other classical metals: it melts at the relatively low temperature of 232˚C, but from 161˚-232˚C it pulverizes into powder, and while it does not boil until almost 2400˚C, it vapourizes significantly from 1200˚C.[2] It is highly resistant to corrosion, for which it is often used as a protective coating for other metals such as steel or copper. It can be polished to a soft lustre, and its malleability allows it to be rolled into extremely thin sheets, similar to gold leaf. Like gold, it is highly resistant to tarnishing. For this, it was often used in illuminated manuscripts to represent silver, as true silver quickly turned to black on the pages.[3]

A significant part of tin's mythology is tied to its mining history. In Malayan mining culture there is reference to tin as a living thing, and most importantly as a creature possessing cleverness.[4] For this reason, Malayan tin miners followed a somewhat unusual protocol: the delicate removal of the ore without the tin's knowledge, for it was believed that the metal would retreat into the rock should it discover it was being removed. Another superstition associated with tin was shared by Asian mining cultures and Cornish tin miners alike: that the presence of the metal was indicated by a will-o'-the-wisp. Both groups connected tin with the occurrence of these quick flashes of light, caused by an emanation of phosphine-containing gases released from decaying organic matter.[5] While the applicability of the connection is dubious, it is still interesting to note that two cultures, half a world away from each other, made the same association between tin and these ephemeral, luminous flashes.

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* There are historical references to "white lead" and "black lead" in ancient texts; these are believed to indicate tin and lead respectively[7].

fig. 8.2 and 8.3- Japanese tin toys: *Aikoku*, 1930s; Motorbike, 1950s.

As with many of the classical metals, the initial use of tin was for personal ornamentation, as evidenced by a bangle of almost pure tin found on the Greek island of Lesbos dating from around 2600 BCE.[6] However, tin's most prolific historical usage was within two alloys: bronze and pewter. Bronze, with its hardness and strength, was to inspire an age marked by technological progress in toolmaking and weaponry. Bronze was to remain a preferred metal for armour,[8] even with the development of iron, for the malevolent associations of the latter* prescribed its use only for offensive weapons, such as spears and knives. Most of the seven classical metals were used in some way to manufacture mirrors, and in antiquity, a high-tin variation of bronze known as speculum was a preferred material.[9] Mirrors of speculum, while not as reflective as silver, were not subject to the same rapid tarnishing, and because of this quality they were to figure prominently in the development of astronomical telescopes to peer ever deeper into space, such as that used by Sir Isaac Newton in the first reflecting telescope, built in 1871.[10] Tin is a major constituent of pewter, being combined with lead (traditional) or antimony (modern).[11] Pewter was used extensively in common tableware such as plates and cups, and it was also specified for chalices, alms dishes and other ceremonial items in the Christian Church.[12]

Tin's connection with sound is one of its more unique qualities among the classical metals. The structure of tin is crystalline in nature, so that when a piece of tin is bent, these crystals grind against each other to make a cracking sound known as 'tin cry'.[13] The sound of crying tin is quite surprising, as though the metal is being harmed by this manipulation. Tin has a further connection to sound through its extensive use in musical instruments. The bright, clear, crisp ringing of cymbals can be attributed to the metal's acoustic properties. As a component of bronze, tin is used extensively in the large bells of churches and clocktowers, the resonance of which carry far beyond the church itself. Tin is one of the main metals, along with lead, to be manufactured into organ pipes, and is

* see Iron, page 91.

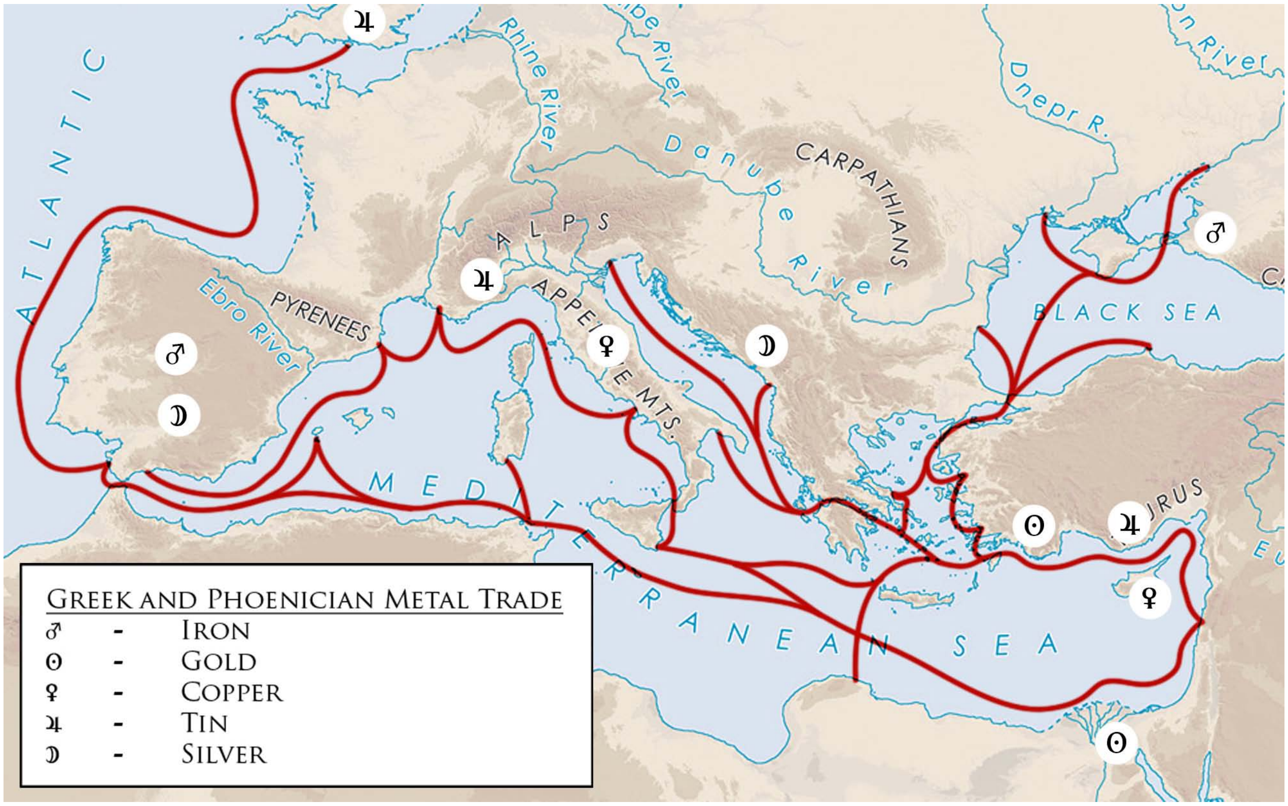

fig. 8.4- early European trade in five of the classical metals, including tin

particularly useful where a bright tone is desired, or if the sound of string instruments is to be emulated.[14] Ironically, a colloquial reference to tone deafness - the inability to interpret pitch - is known as having a "tin ear".

An image of tin as a gleaming, untarnished and vocal metal does not reveal one of the most intriguing aspects of its history, for the most significant cultural contribution of tin was its impact on the development of international trade.[15] The desire for tin in the ancient world was comparable to that for salt: both were resources needed by many, but immediately available to few. With the discovery of bronze, the demand for tin grew exponentially. However, unlike copper, tin was not available in many locations across the known world. One of the largest resources of ancient tin in the West came from the Cornish mines of Great Britain, located at some distance from the Mediterranean cultures of Greece, Phoenicia and Rome that sought the metal. These populations established routes over land and sea that continue to be used today,[16] pathways that transferred knowledge, technology and culture as well as the ores of the clever metal.

The first association between tin and the classical planets linked it to Mercury, as described by Origen in the 2nd century. By the 6th century, Olympiodorus the Younger had tied the metal to the planet Venus. It was not until the 7th century Byzantine astrologer Stephanos that the connection between tin and Jupiter was definitively made.[17]

What do I care for Zeus? Justice is matter between men, and I need no god to teach me it.

- Jean-Paul Sartre, *The Flies (Les Mouches)*

jupiter

The largest and most massive planet in the solar system, Jupiter's fantastic properties stretch the imagination. This gas giant can hold within its volume all of the other planets combined, and from Earth this immensity appears in the night sky even more brightly than Mars, despite being ten times as distant.[18] Up close, the surface of Jupiter is a mass of multi-coloured swirls, dominated by the planet's most famous and recognizable feature: the Great Red Spot, a huge storm vortex that has been raging for centuries. A year on Jupiter lasts for twelve years on Earth, but a day is a brief 9 hours 55 minutes, and the velocity with which its bulk spins causes a distortion of the planet that flattens it visibly at the poles.[19] Holding some 63 (recorded) moons in orbit, Jupiter's tremendous gravitational pull also maintains a faint set of rings that appear more like a halo[20] when compared to the prominent rings of its neighboring planet, Saturn. While all matter in the solar system shares a gravitational attraction with the Sun, it is massive Jupiter alone that exerts a force strong enough to actually draw on the Sun in kind.[21]

The planet Jupiter figures prominently in one of the greatest discoveries in the history of astronomy, made by Galileo Galilei in the earliest telescopic observations into space. In the seventeenth century, Galileo conclusively determined the existence of the four largest moons around Jupiter: Ganymede, Callisto, Europa and Io, still referred to as the Galilean moons. It was decisive proof that not all things in the universe rotated around the Earth, a discovery that supported the heliocentric system that placed the Sun at the centre of the planets.[22] At the time this posed a significant threat to geocentrism, upheld by the Christian Church on the basis of scripture that referenced the Earth as the centre of the universe. So revolutionary was the concept that Galileo never saw it accepted in his lifetime.

It is telling that the ancient Greeks and Romans ascribed a principal deity to the giant planet. Considered the ruler of the gods after deposing his father, Saturn, from the post, Jupiter was possessed of a great power and revered for his virtuous judgement.[23] Sharing many of the same characteristics as the Greek Zeus, Rome's Jupiter was considered the god of the skies and of light, and his connection with weather

Opposite page:
fig. 8.5- The Jovian surface. Jupiter's Great Red Spot is along the top of the image.

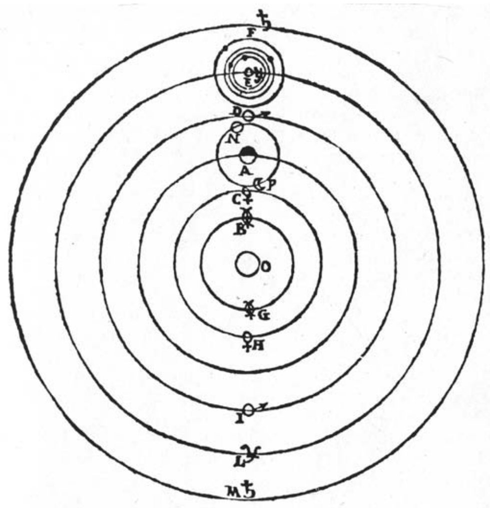

fig. 8.6- Galileo's sketch of the solar system, with the Sun central and Jupiter's four moons

(particularly with storm) was shared in other cultural pantheons (the Norse Thor, for example,[24] whose swinging hammer brought thunder from the skies). The wise Jupiter was responsible for the orders of the state and was the protector of laws that governed cities.[25] It is interesting that mythology would link the planet Jupiter with the god that protects the world, for it has been discovered by modern astronomers that the gas giant plays a crucial role in deflecting cosmic debris, such as comets and asteroids, away from Earth through the influence of its strong gravitational pull.[26] While it is true that Jupiter casts approximately as much material towards the Earth as it deflects away from it, if a smaller planet were placed in its position- even a planet with the mass of Saturn- the resulting decrease in pull on the asteroid belt would result in a constant bombardment of the Earth's surface with objects from space,[27] possibly rendering our planet uninhabitable.

Beyond these properties, what truly sets Jupiter apart from the rest of the planets is that, in of itself, it can be imagined to constitute a world of its own: as its own sun, with its own planets (moons), and possibly even its own forms of life. The composition of Jupiter is 90% hydrogen and 10% helium, with trace amounts of several other gases; this ratio is highly similar to that of the Sun, which is 92% hydrogen and 8% helium.[28] For many years scientists theorized that Jupiter could be an unrealized star, or a transitional phase between planet and star, but that its size would have been too small to engage the processes of nuclear fusion required to classify it as such. Nevertheless, it does generate a good deal of its own heat, approximately twice as much as it receives from the Sun.[29] The possibility that Jupiter might harbour forms of life was first proposed by the esteemed astrophysicists Carl Sagan and Edwin Salpeter: not carbon-based life, as we are familiar with on Earth, but an ammonia-based form of life.[30] Comparing the Jovian atmosphere with the oceans of Earth, Sagan and Salpeter suggested that there could be life occupying different strata and interacting in much the same way as takes place in terrestrial seas: "sinkers" at the top, comparable to plankton; "floaters" living below the sinkers and feeding on them; and "hunters" occupying the lowest reaches and preying on the floaters. Certainly the prospect that other forms of life, so different from ours, share the solar system requires a broad reimagining of the phenomenon of life as we understand it. In a sense, this recalls the lessons of Galileo, whose observations of the moons of Jupiter challenged longstanding cosmic beliefs and provoked a rethinking of astronomical theory.

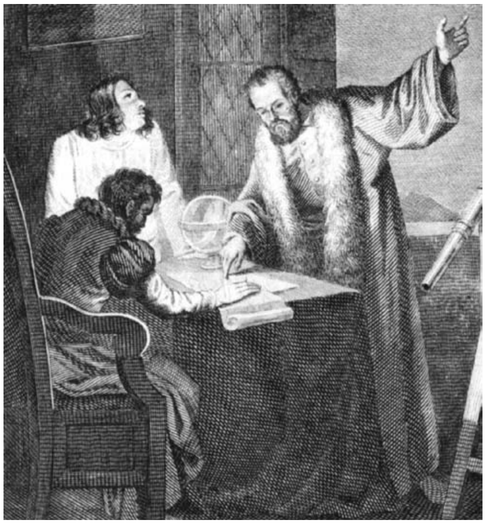

fig. 8.7- Galileo shows Cosimo de Medici his observations of the four moons of Jupiter, which he calls the Medicean stars

The planet Jupiter is astrologically connected with the sign Sagittarius and the zodiac's ninth house. Known during the Baroque as the House of Religion, Sir George Wharton presents the ninth house as where the "Life of God" resides.[31] This house is focused on the types of experience that foster the individual's broader learning: higher education, travel and cultural interactions (as well as the traditional theme of religion) which serve to expand one's understanding of the world.[32] The ninth house encourages curiousity in the larger scale of human civilization, across cultural divides, religions, languages and geographies. While education and learning are promoted through the ninth house, more important to these experiences is the ability to analyze, synthesize and abstract the new information and concepts, and draw the connections between individual things and the greater systems of which they are part.[33] The capacity to think abstractly allows for a more comprehensive understanding that incorporates a range of information, whether recently learned or part of one's own personal back story. As an extension of the concept of abstraction, symbols are also connected to the ninth house.[34]

The astrological symbol for Jupiter, ♃, is the same as that for tin in alchemy, and is composed of a crescent above a cross. The crescent symbolizes the soul, and the cross the body, so that the two together communicate the balance between the aspirations of the spirit and the limitations of the flesh.[35]

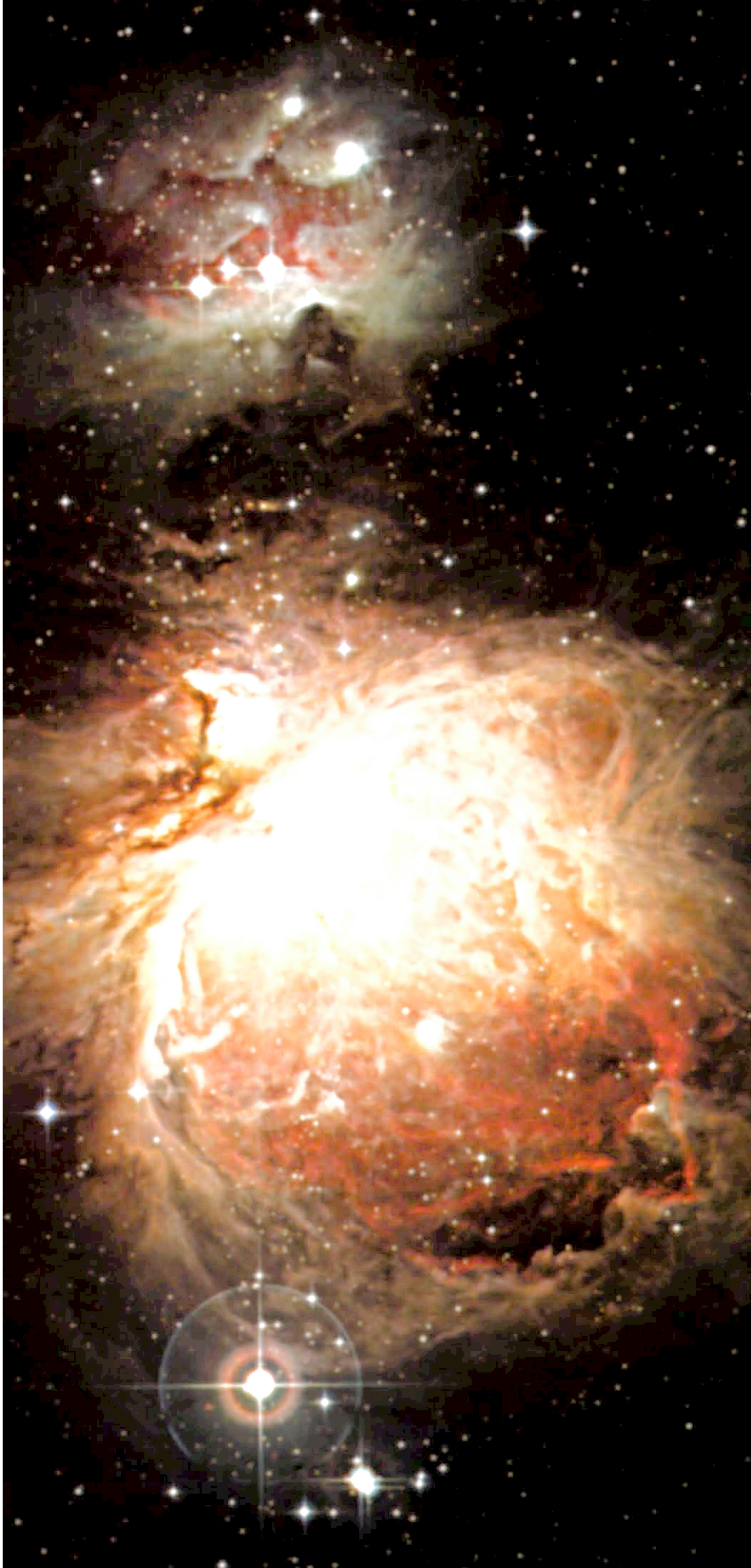

fig. 8.8- The Orion Nebula, a stellar "nursery" from which new stars are generating

A synthesis of the physical, cultural and mythological concepts that connect tin and Jupiter follows several threads. The early linking of tin with the planet Jupiter may have had to do with sound: the cracking heard when bending a bar of tin is quietly emulative of the sound of thunder made by the ancient god of the skies. There is also a common theme of protection: not only was the planet Jupiter named for the god who protected the world, but modern astronomical science has revealed that the planet's tremendous gravitational pull has a role in deflecting earth-bound projectiles. The protective qualities of tin have long been employed as a coating on other metals to guard against corrosion, but as a constituent of bronze, tin was also a preferred metal for protective armour in the ancient world. One of the more compelling connections between Jupiter and the zodiac's ninth house, that of philosophy, religion and higher learning, is the idea of imagination. The discoveries made of Jupiter by Galileo, which were revolutionary for his time, stand as a lesson when new and similar belief-challenging proposals are made about the giant planet, such as the potential that it houses different forms of life. The ninth house of the astrological chart fosters flexibility of the mind as the individual's factual knowledge is confronted by alternative ideas and views which prompt the individual to consider the basis of his or her own beliefs. Certainly the theme of knowledge permeates the research into the metal, planet and house, from the wisdom of the principal deity of ancient Greece and Rome, to the clever metal hiding in the mines of Malaysia.

The idea of knowledge, of learning and wisdom is the starting point for developing the imperative of tin. Astrologers associate the planet Jupiter with expansion: the physical immensity of the planet and its even larger sphere of influence are metaphor for intellectual and spiritual growth indicated by the planet's astrological associations. Expansiveness might also be considered through the metal's role in the development of global trade. Networks to transport tin between distant places were well established by 1000 BCE, and along these paths were distributed knowledge, technologies, religions and cultural customs. Populations still existing in the Stone Age were transported into the Age of Bronze by its technologies, tools and implements. The development of civilization as we know it was shaped by the trade of tin in the ancient world, and even today the location of cities, the path of roads and the movement of goods in certain parts of the world can be traced back to these early networks. While it is true of all classical metals that they held influence over the development of human society, the great impact of tin was through this act of expansion. Therefore, the physical, intellectual, and spiritual expansion interpreted through the metal and the planet can be established as the imperative of tin.

expansion and order

The imperative of expansion necessitates a period of integration, as a response to the intrinsic human need for order. This impulse can be demonstrated in as simple an example as the tendency of the eye to pick out patterns in a jumbled image: searching out similarities in colour and repetitions in form is something the brain does innately. While the mind may deduce an existing order, it can also impose an external order. For example, in looking at a piece of classical sculpture, a doctor may look at the musculature, a historian at composition, and a stonemason at the qualities of the marble: all are different lenses of order through which the individual interprets the world. The overlaying of a known structure onto an unknown system may allow the individual to access the new information through an understanding they already possess. It can also distort that information by attempting to interpret it through a potentially incongruous set of principles.

Disorder is commonly understood as a lack of order, but it is not in fact a condition of randomness and chaos; rather, it is the presence of multiple orders that manifests as conflict.[36] To consider the true nature of disorder is to realize that what seems a disturbance may simply be one's incapacity to see or understand the true order that exists. The neurologist Oliver Sacks captured this dynamic in his book *The Man Who Mistook His Wife for a Hat,* a chronicle of the conditions of several patients suffering from different mental afflictions. What is common to all patients in this collection of stories is the sense that their own existence is normal: the man who wakes each day with the belief that it is still forty years past; the man who walks with his body tilted at an angle yet feels himself entirely upright*. With the revelation that the order of one is as valid as the order of another - for both find either somatic or intellectual confirmation of their beliefs - the concept of disorder brings with it the opportunity to develop an understanding of where the conflict between orders lies.

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* In a chapter called *The Lost Mariner*, a patient suffering from Korsakoff's Syndrome has not been able to create new memories for several decades, and is effectively trapped in a time when he was a much younger man, even maintaining a high-school level of intellectual development[37]. A patient suffering from a lost sense of balance in *On The Level* is likewise faced with an arresting realization of himself, as his physical sense of being upright conflicts with the bent body he sees in the mirror[38].

Language provides one of the most meaningful ways in which mankind has developed order through seeming chaos. Human beings around the world have attempted to capture the same essential range of needs, desires and emotions in sound. Through the construct of language, cultures make symbols of sounds; these symbols were captured in form as alphabets, and, just as the laws of a people are symbolic of their cultural values, so too are their words. The First Nations poet Greg Scofield writes in his two languages, English and Cree, but does not translate verses from one to the other, feeling the essence of the sentiment would be lost. Rather, he believes that the shape and alliteration of the words, their sequence and the manner in which they are spoken, will communicate the message regardless of one's ability to speak the language. Certainly the capacity to grasp meaning through a mesh of unfamiliar words is a romantic proposition, but is it so fantastic to imagine that one might intuit the message through some deeper sense of attunement - one akin to that which first associated such sounds with meaning?

According to the ancient Greeks, such subtle connections were part of a grand cosmic harmony that united all things, however seemingly divergent: plants to animals, humans to gods, in a vast, universal order. In this vein, the idea that an underlying spirit or essence may exist between metals and planets through science, symbolism and myth thus seems entirely plausible. It becomes possible that an inert piece of metal, pulled from the ground or dropped from the sky might possess certain physical qualities, be interpreted culturally in distinct ways, become associated with a planet millions of kilometres away, and be drawn together with elements of the astrological chart. It lends weight to the notion that these disparate things have a common quality, a property that transcends scientific explanation to resonate with a deeper sense of understanding. The prospect that a metal may truly embody an imperative that captures its spirit is to bring the study back to the ancient sensibilities that ascribed life to all things. What was spoken by lead that has caused it to represent death since ancient Egypt? What more than force has made iron the metal of war? Perhaps these imperatives are buried deep in cultural memory, but not so deep that we do not still marvel at gold, or play with mercury, or connect with copper.

fig. 8.9- panorama as viewed from the observatory

tin space : the observatory

The very nature of the Coniston site seems to embody the imperative of tin *to expand*. Characterized by expansiveness across the ground plane, the site has the additional effect of opening up to the sky. Without trees, buildings or overhead wires to block the view, and without urban light polluting the night sky, the view of the stars in such a removed location is spectacular. The opportunity to set up a point from which to view the night sky was to establish the tin space as *the observatory*.

The observatory situates itself on a promontory north of Alice Lake. Situated on a line with the striations in the rock, this promontory features a small, flat, open space of black stone. There is a curious change in the type of rock observed on the promontory as compared to that over the rest of the site: the common, striated rock covering most of the area is sandy brown, whereas the rock on approaching the observatory is black and crystalline. Where broken, it has cracked in a single, clean line. In some places, the black rock was split and the line of the crack filled with white quartzite. The site of the tin space, distinct from the surroundings due to its rock type, flatness and altitude made it ideal for the tin space. While these conditions offered a broad panorama of the surrounding landscape by the light of day, the true purpose of the observatory would be revealed after dark, once the sky filled with stars.

The intervention proposed at the promontory is a disc of polished black granite surrounded by a band of bushhammered granite, 3.75 metres in diameter. Into the surface of the platform is inscribed a reveal running north-south, with a shallow curved hollow towards the North end of the platform. Placing the head at this hollow and aligning the body along the reveal, the viewer is placed in alignment with Polaris, the North Star. The surface of the platform is not perfectly flat, but is very slightly, yet noticeably, convex. This detail serves to heighten the corporeal sensation of feeling one's body set on the surface of a sphere as a pronouncement of the curvature of the Earth. The altitude of the promontory is such that the line of the horizon appears below it, so that when one lies supine on the platform, the horizon seems to fall away,

leaving nothing but the bowl of stars above.

One's vantage point on the stars is linked implicitly to the latitude of the viewing location. Those in Earth's Northern hemisphere are able to orient themselves to true North by way of Polaris, which is located almost exactly at the point around which the heavens spin. Easily found at the end of the handle of the Little Dipper, Polaris can be used to deduce not only the direction of North, but also one's latitude, for the altitude of the North star is equivalent to the latitude of the viewing point. Coniston is located at a latitude of 46°30' North, which places Polaris approximately halfway between the horizon and the zenith. From the site, there are a small number of constellations that, due to the Earth's rotation, never dip below the horizon and thus are visible all year long. These constellations include Cepheus and Casseiopeia, the King and Queen of Aethiopia as immortalized by the ancient Greeks, as well as Draco, the dragon. Also visible year-round are Ursa Major and Ursa Minor, the Big Bear and Little Bear, so named after the nymph Callisto and her son, Arcas. The beauty of Callisto, one of the virginal followers of the hunter-goddess Artemis, caught the eye of Zeus, who descended from Olympus to seduce and rape her. After becoming pregnant with Arcas, Callisto faced the wrath not only of Artemis, to whom she had sworn her chastity, but of Hera, the wife of her seducer. As she secluded herself in the woods to bear her child alone, Hera cast a spell that transformed Callisto into a bear. In a twist of irony, Arcas, as a youth and a hunter himself, came face to face with his mother and, seeing only an animal, meant to take her down. It was at this point that Zeus rescued poor Callisto by placing her, as Ursa Major, high in the sky. Arcas would later take his place alongside his mother as Ursa Minor. However, Hera's wrath was not to be so easily satisfied, and she condemned the two to spin eternally in the night sky, never able to descend low enough to touch their lips to water on the horizon.

fig. 8.10- procession to the observatory

fig. 8.11- location of tin site

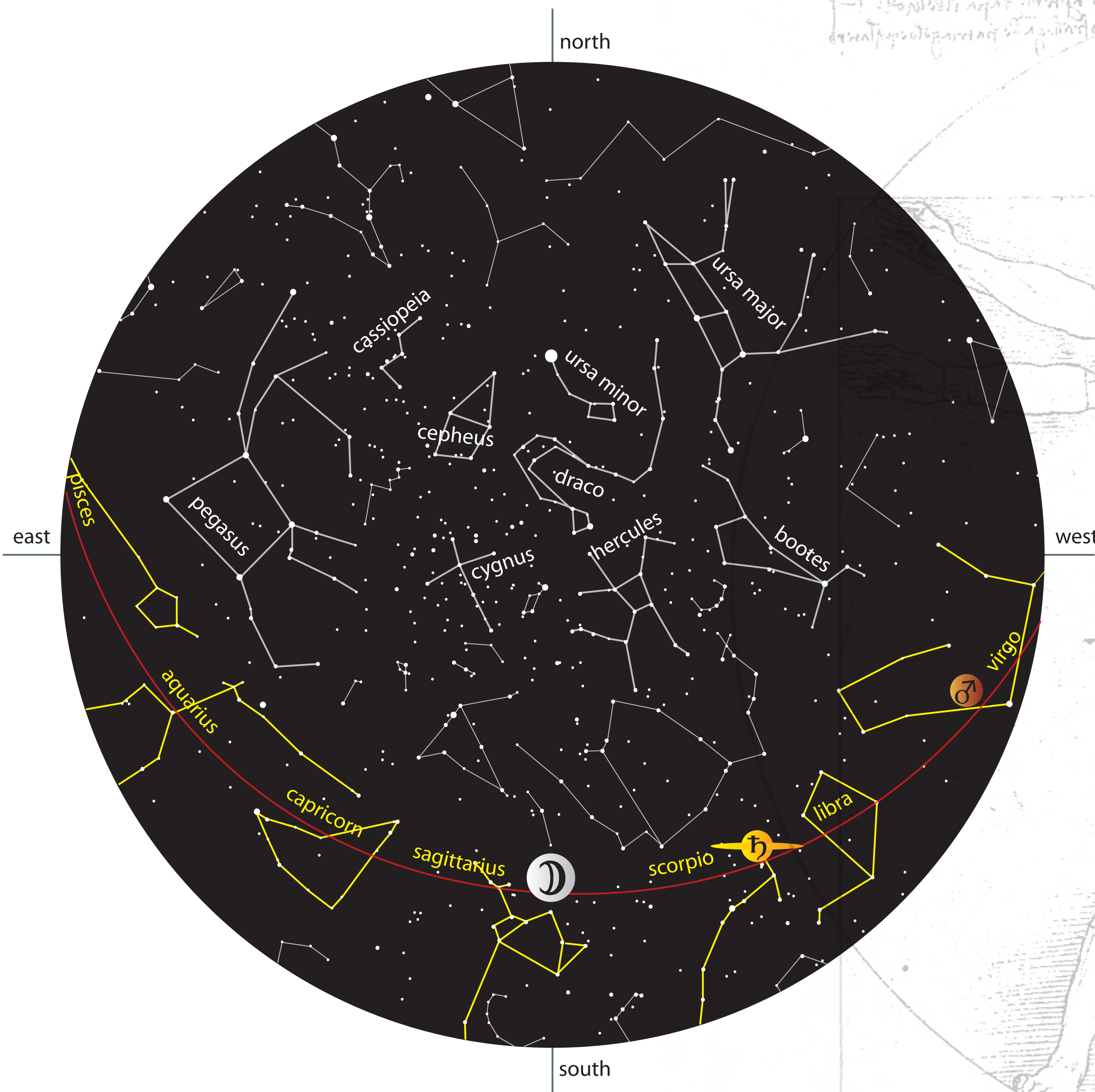


fig. 8.12- sky view at interior egress,
conclusion of Venus transit
06 June 2012 00.51h

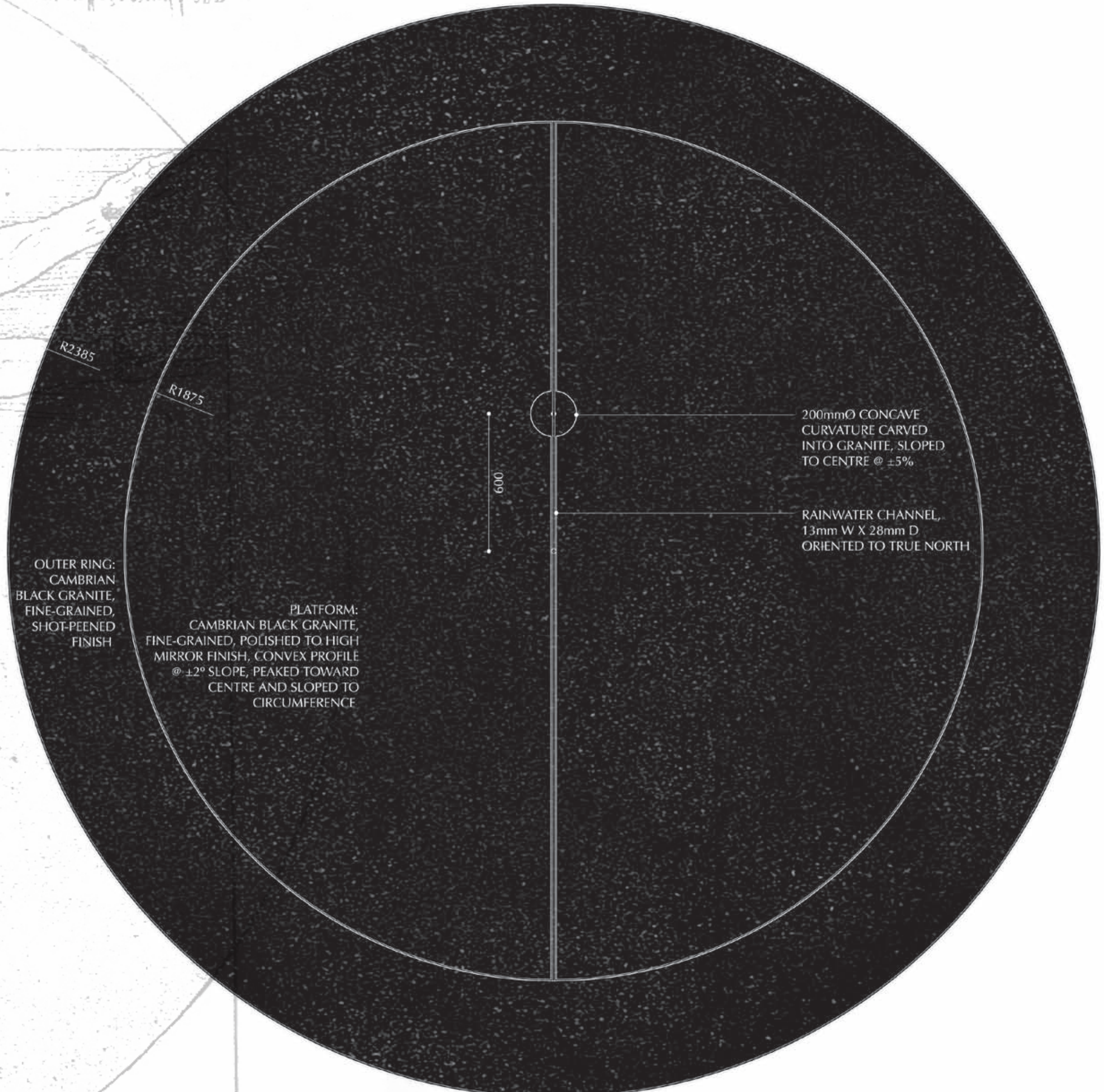
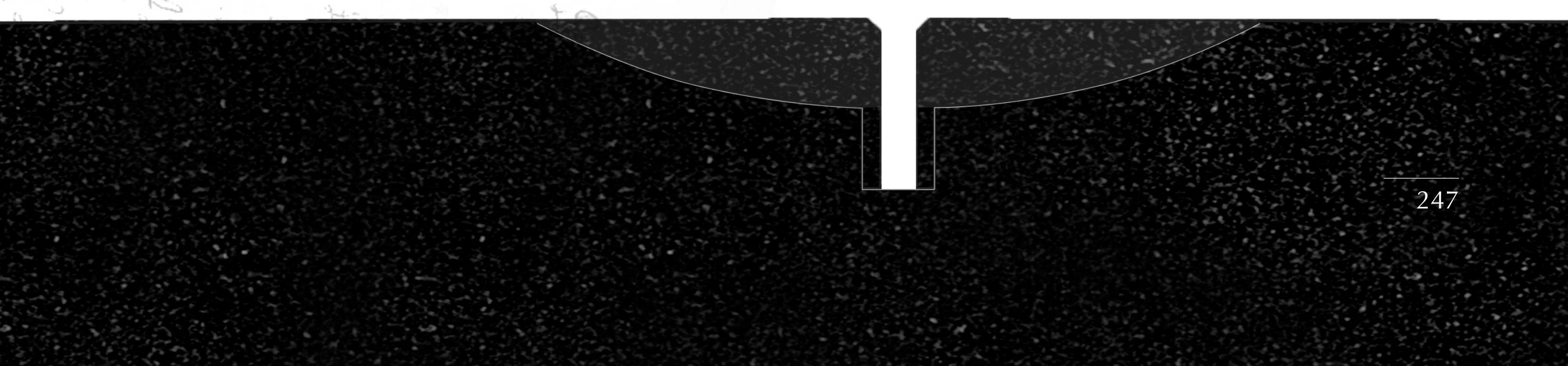
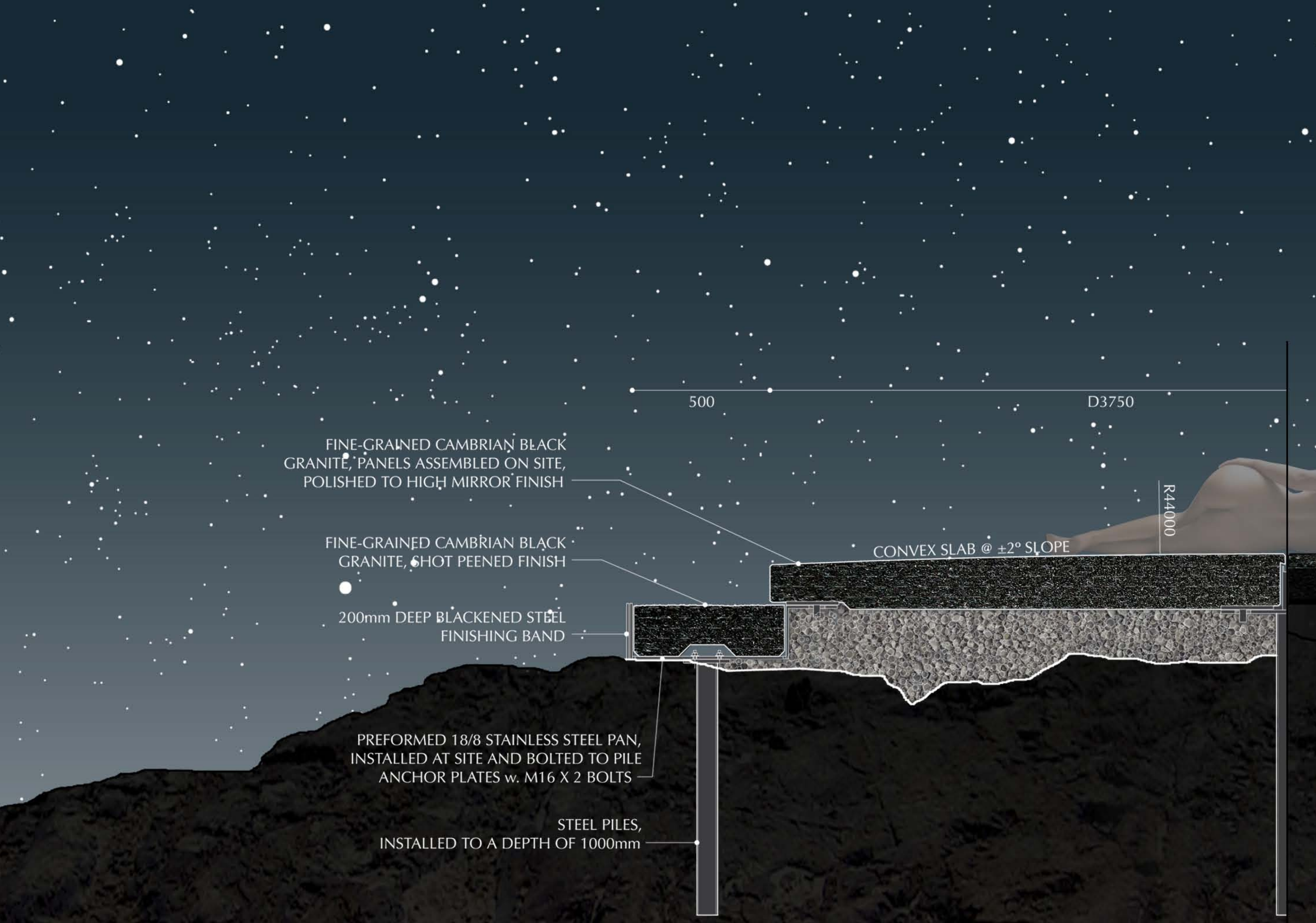


fig. 8.13- observatory slab,
plan view 1:30

fig. 8.14- observatory slab,
headrest section 1:2





Slab construction: two-piece granite slab installed on grade, granite perimeter slabs installed on grade and wrapped with steel band. Stone to ASTM C615-03 Standard Specification for Granite Dimension Stone: Cambrian Black granite, quarried in St. Nazaire, Quebec. Centre slabs: polished high-mirror finish, shaped to convex slope @ ± 1% with high point at centre of circle, 200mmø concave profile carved at 600mm from centrepoint of slabs and sloped to centre @ ± 5% as per design drawings. Perimeter slab: shot-peened finish, outer edge finished with blackened steel band 200mm wide.

fig. 8.15- observatory platform
sectional and elevation views
1:20

Book IX : cosmographia metallica

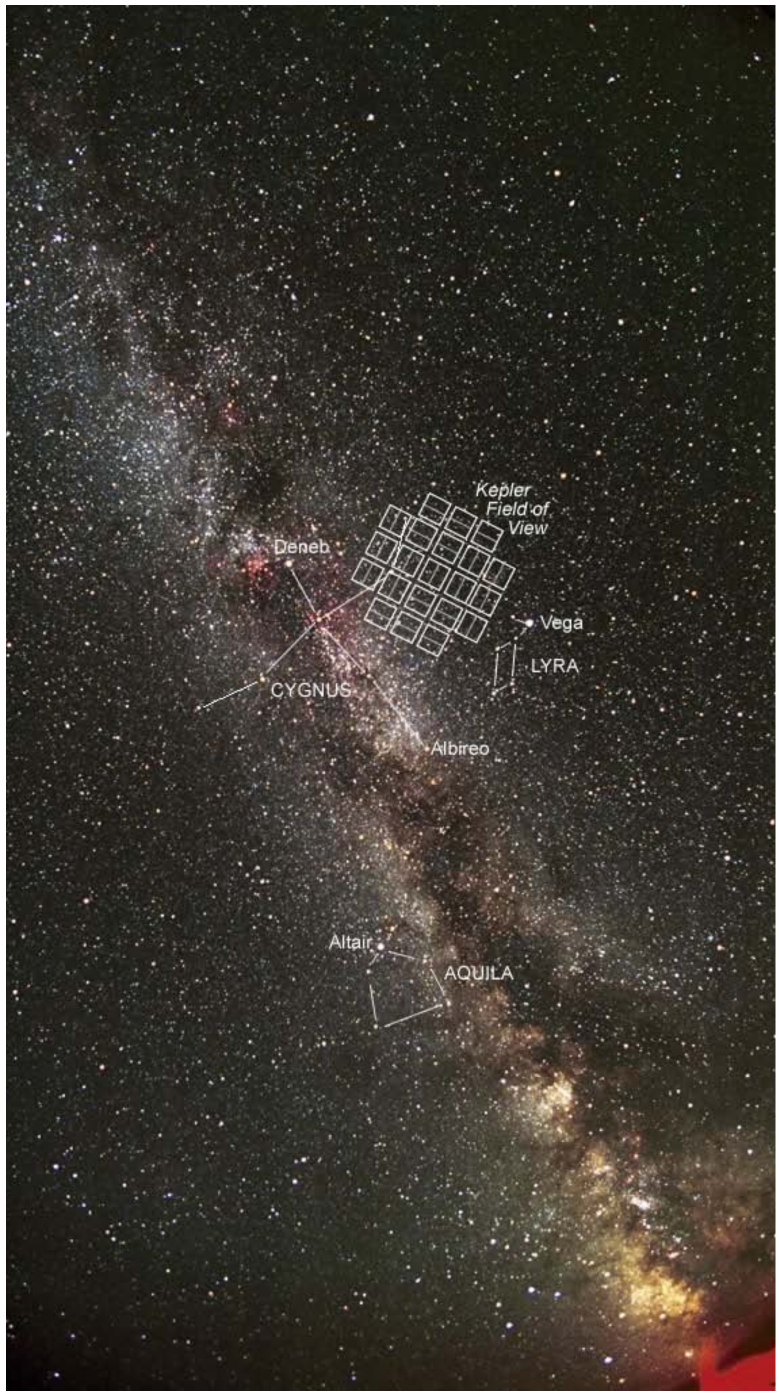


fig. 9.1- Kepler telescope field of view, in relation to constellations Cygnus and Lyra

On Friday, 06 March 2009, The National Aeronautics and Space Administration (NASA) launched a telescope into space to initiate the Kepler mission, so named for the famed 17th century German astronomer Johannes Kepler. Like many missions before it, Kepler will cast its gaze into deep space in search of cosmic phenomena. Arrayed with a 95-megapixel camera, Kepler's telescope will focus on a small area of sky in the vicinity of the constellations Cygnus and Lyra, an area of focus comparable to the size of an adult hand, held at arm's length. In this small piece of sky, Kepler will document approximately 100 000 stars,[1] although stars are not the specific focus of the mission. What Kepler seeks are planets, and in particular, planets of a similar size to Earth, orbiting the narrow zones of their stars where the existence of liquid water may be possible.

Determining the presence of planets orbiting other stars was first done via the wobble method: large planets capable of exerting a strong gravitational force would tug at their stars, causing them to move back and forth in their position as viewed from Earth.[2] This method of observation was initially relegated to truly large planets, several times the size of Jupiter, which caused a measurable shift in the placement of their stars. By comparison, Kepler measures not the movement of a star but its brightness, and any miniscule diminution of that brightness caused by a planet passing across its face as observed from Earth. Effectively, Kepler is looking for transits, the same event that we see when Mercury or Venus moves between us and the Sun.

The degree of a star's diminished brightness as caused by a transit allows the calculation of two critical facts about the planet in question: its size, and the size of its orbit. The reduced brightness of the star indicates the size of the planet, even if the planet is quite small: Kepler is capable of recording a change of only 0.01% in a star's brightness, comparable to a fruit fly moving across a lit car headlight.[3] As for the size of the planet's orbit, the frequency of the "blips" in brightness, applied to Kepler's third law of planetary motion (the square of the orbital period of a planet being directly proportional to the cube of the semi-major axis of its orbit)[4] provides an indication of the orbit's size. An assessment of the star's size and colour allows scientists to determine the vicinity of its habitable zone. With this information, it can be established if the planet is within this small band informally called the Goldilocks zone - neither too hot, nor too cold. Needless to say, at this early point in the mission it is impossible to guess how many extrasolar planets Kepler will discover, for it must also be taken into account that the orbital planes of planets may not allow for transits to be viewed from Earth. In reality, the planets of only 0.5% of stars will be expected to transit from Kepler's perspective.[5] It is exciting to consider that Kepler may discover dozens or even hundreds of planets of a similar size to ours, in a comparable proximity to their stars, where life as we know it - relying on the presence of water - might thrive. However, Kepler may also conclude that our terrestrial world is amazingly rare, should it not be able to determine the existence of planets in a similar dynamic to ours.

Ultimately, the likelihood boils down to statistics. There is a statistical chance that the stars in Kepler's view have planets in their habitable zones. Of these planets, there is a statistical chance that one houses life. There is a statistical chance, however remote, that the life aboard that planet is intelligent. And, if there is intelligent life on that distant satellite, this much is certain: the iron on that planet is our iron, our lead their lead, the tin they use the same as our tin. Their gold will have 79 protons spinning around a nucleus, and their mercury 80, exactly the same as ours, for these are not just metals: they are *elements*, the building blocks of the universe. In my mind, it raises the question: does this distant civilization seek their reflections in silver? do they send messages across copper? dominate their landscapes- and each other- with iron? adorn themselves with gold to emulate their sun? If they do - if there is even *a chance* that they do - then perhaps each of the seven classical metals does embody an imperative that informs their use not only across the cultures of our globe, but between civilizations many light years apart. It is a concept that transcends our science and mythology, and hearkens back to the ancient philosophy that all things in the universe truly are connected.

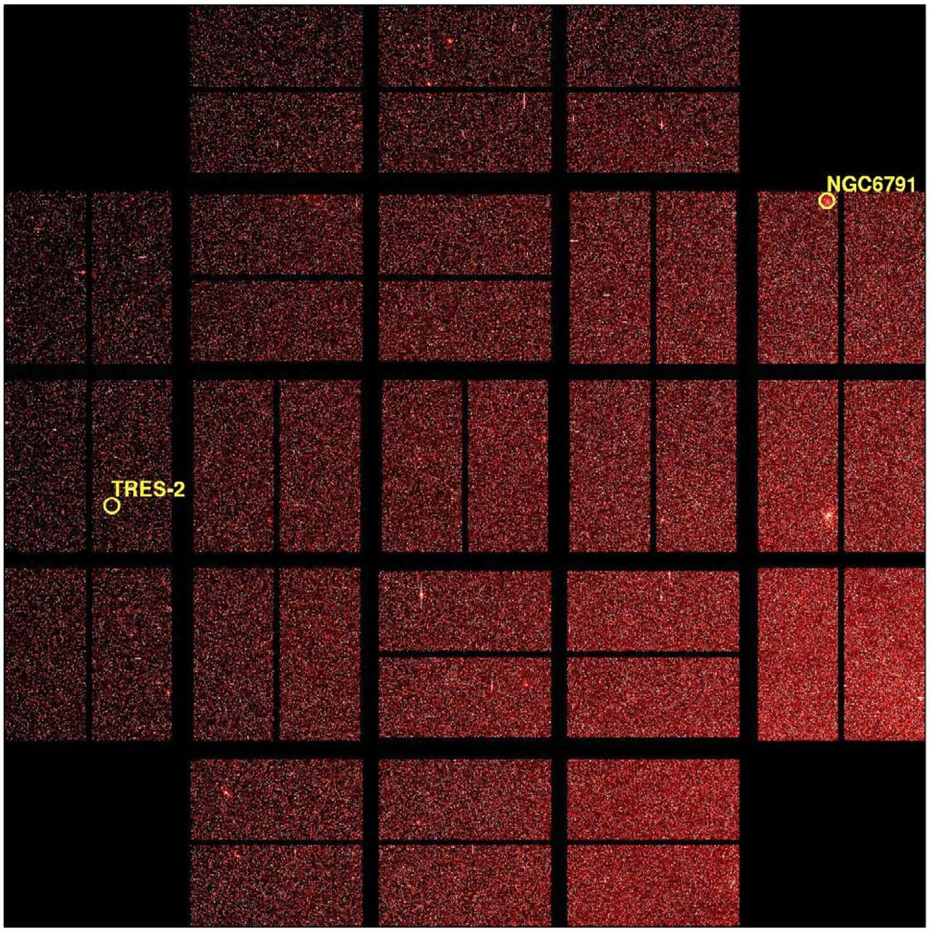


fig. 9.2- Kepler's "first light": first image of the stellar target area, 13 April 2009

Appendix A: houses

Four houses:

House of Fire: Aries
House of Earth: Taurus
House of Air: Libra
House of Water: Scorpio

But God, or Nature, while they thus contend,
To these intestine discords put an end:
Then earth from air, and seas from earth were driv'n,
And grosser air sunk from aetherial Heav'n.
Thus disembroil'd, they take their proper place;
The next of kin, contiguously embrace;
And foes are sunder'd, by a larger space.
The force of fire ascended first on high,
And took its dwelling in the vaulted sky:
Then air succeeds, in lightness next to fire;
Whose atoms from unactive earth retire.
Earth sinks beneath, and draws a num'rous throng
Of pondrous, thick, unwieldy seeds along.
About her coasts, unruly waters roar;
And rising, on a ridge, insult the shore.
Thus when the God, whatever God was he,
Had form'd the whole, and made the parts agree,
That no unequal portions might be found,
He moulded Earth into a spacious round:
Then with a breath, he gave the winds to blow;
And bad the congregated waters flow.
He adds the running springs, and standing lakes;
And bounding banks for winding rivers makes.
Some part, in Earth are swallow'd up, the most
In ample oceans, disembogu'd, are lost.
He shades the woods, the vallies he restrains
With rocky mountains, and extends the plains.

-Ovid, *Metamorphoses*

House of Fire: Aries

"Prometheus, you are glad that you have outwitted me and stolen fire... but I will give men as the price for fire an evil thing in which they may all be glad of heart while they embrace their own destruction."

-Zeus, to Prometheus
Hesiod, *Works and Days*

Rainscreen system: Cold rolled cor-ten weathering steel, fully killed and continuously cast with standard surface finish, minimum chromium content of 0.75%, minimum combined copper and nickel content of 0.50%, 1.5mm thickness and 1200mm width. Panels attached with stainless steel fasteners to 25mm profile vertically applied galvanized steel hat sections at 600mm o/c, bolted to 19mm exterior grade plywood c/w self-adhesive membrane.

His eyes peel open, responding to a chill washing over him. The fire has gone out. He rises and heads towards the front porch, grabs the newspaper and a handful of kindling, finds matches tucked into a cigarette package. Crouching down, he tears one section of the paper into strips, lays them crisscrossed with the kindling. He is about to crumple another sheet when he notices the unfinished crossword. Further down the page, Wednesday.

Aries: The stars are gently reminding you that there's more than one point of view, and you need to take a certain party's perspective into account before you move ahead. You're moving with brisk progress toward what you desire -- and you're about to get it, too -- but it's important that you don't trample or shove anyone out of the way, especially if you want them to stick around for the next phase of the journey. So stop and inquire about someone's feelings.
Taurus: Your best self is currently on display and drawing plenty of admirers, so make sure ... them ... donning a cool facade. The time is ripe to

He crumples the page, then two others, lights a match into their underbellies and watches the flames curl up and over. The paper, seeming to sublimate, reveals the edges of the kindling as they begin to glow. He waits for the fire to infuse itself, then lays two coarse logs gently alongside. The fire dances in his eyes, the light growing across his face as life springs from the dead wood. He stands up, satisfied, as the warmth fills the room.

He walks over to the window, puts a hand against the cool glass. The moon shines bright in the night sky behind heavy, pregnant clouds. There is a perceptible charge in the air that he senses like a tickle in his molars. He hopes for a storm, the crack of thunder, the hammering of rain on steel, the railing weather battering its way into his home. His control over this, the protection of the fire within.

Control. The greatest illusion of all.

He had grown up the golden son of admirable, unambitious parents, had filled them with pride by attending a good school, top of the class. Great prospects, our boy. Had lifted their hearts into their throats as he undertook the reckless life of a displaced traveler, checking in sporadically, reducing his mother to tears as he returned an emaciated willow of himself, but wiser, worldlier, in love. There was nothing he couldn't do, they would boast. And he knew they were right.

Ah, Giulia.

Undiagnosable, they had maintained. She spent her last days in bed, speaking in riddles, making nebulous promises. *soon. meet me.* Me thirty, she only twenty-four, not being ready, wanting desperately to believe such impossibilities. Her eyes full to bursting with the need to see her faith, reciprocated. *meet me, i will find you.* The brazenness of striking bargains for the next lifetime. *not yet, meet me. i will be red.* Grasping, red, then she was gone.

He looks back on those years and the free naïveté with which he believed that he was master of his own fate. Fate, now a constant reminder in every streetscape- a red scarf, envelopes slipping into red mailboxes, stop signs, red nails pulling a cigarette up to red lips. Once he looked for red he couldn't stop, its ubiquity his curse. He looks for her everywhere, for eyes to flash, *it's me*. If time isn't constant, perhaps she is here already, a doppelganger living in a parallel time frame, born into a concurrent existence. Perhaps this alter ego will rise up from a shadow and step into her life, occupy the aura that hangs, sticky, thick and palpable around him. He built the red house for her, the flat, grey steel turning slowly but surely into the burnished oxblood. He built it away from the city, banishing all other red from existence.

He returns to the fire, stokes the glowing embers, breaks open the logs to free the flames. Sitting as close as he can bear, he gazes into the roots of the fire, sees its life, its shifting forms, random and unpredictable. Amidst the oranges and yellows, a glimpse of red.

House of Earth: Taurus

Demeter did not refuse but straightaway made fruit to spring up from the rich lands, so that the whole wide earth was laden with leaves and flowers. Happy is he among men upon earth who has seen these mysteries.

-Homer, *Hymn to Demeter*

Structural system- steel construction, main members W250 columns 4500mm o/c to 3550mm high; structural roof joists 450mm deep welded open-web steel trusses @ 600mm o/c, floor joists 300mm deep open-web steel trusses @ 600mm o/c. Roof deck 38mm profile corrugated galvanized steel decking, floor 25mm profile corrugated galvanized steel decking with 50mm concrete topping.

Friday. Looking outside at ashen skies, she felt strangely optimistic. She opened the window a crack, leaned her nose into the gap, inhaled deeply of the smell of leaves in freefall, latening sunrises and perennials closing up shop. Best check the horoscope, though.

... Who kn... you might just make a co... out of them yet!
Taurus: Go out of your way to do something new, even in the smallest way. Take a different way to the office kitchen (who knew that there was a cute new hire in the east corner?) or go somewhere different for lunch (Greek food -- what a nice change from the usual burrito!). If you make an effort, there are a thousand different ways you could shed a little light and brighten up your day. It might just spill over into all kinds of unexpected areas, too.
...innings, but when it comes to seeing things through 'til th...

Maybe she would take another route to work then, go down Davies and drop off the drycleaning on her way. She wasn't averse to sponteneity. She just preferred routine. Teacup into the sink, paper into the recycling bin.

He left her the house, felt it reminded him only of failure. She never felt it. The house was no more of failure than it was of the two of them. His hand swung the hammer, hers the pencil, but the house was not of them. This, her house, was a response to a whispering felt through her feet, a vibration sensed on her tongue, a smell that made her hair stand on end. His house was an emblem of their union, their man-made forever. Her house was a forever, but never theirs.

She looked out at the panorama to the east, the mountains cutting ragged razor-edges into the chalky sky, their slow growth and decay imperceptible on a millenial scale. She imagined how this landscape would fall, the tectonics that shifted these monoliths into place driving the spires higher in a massive scream of rock on rock, great forces of wind and water shearing and buffing and soundlessly polishing the stone.

How it was that such forces of earth conspired to put this house here. She found the slab of metamorphic rock at the cusp of winter and spring, sucking up the energy of the sun while its surroundings languished in a hibernal trance. Putting her hand to its surface, warm, dry, alive, a surface she would cleave with steel like a modern-day haruspex, she divined the will of pagan gods. The auspiciousness of the site confirmed, the house as product of her will felt circumstantial. In staunch, yet instinctual, defiance of the rigour which had otherwise governed her life, she intuited that she must simply wait for the clues, that the place would tell its story in fragments, some fitting together seamlessly while others demanded a leap of faith. Like reconstructing a dream, she located walls, peeled open views. It was a process that would demand a phenomenal patience, there always being an elusive answer to coax out, like a sliver in the palm.

So it was that the house took shape, grew from the rock and contorted itself with its back to the wind, its face to the mountains. No, it was not of them. This place had called, had likely called others before who had camped, settled and rested here. Now, it called her. She placed her hand on a column, feeling it draw the warmth from her, pull her energy down its length and into the ground below. She imagined the landscape all around, a millions years from now, fallen, the mountains changed profile, the windows long since shattered, the wood consumed back into the earth and regrown again a hundred times over. She saw the column, bent but unbroken, pitched deep within the stone. Placing her forehead to it, then her ear, she listened.

House of Air: Libra

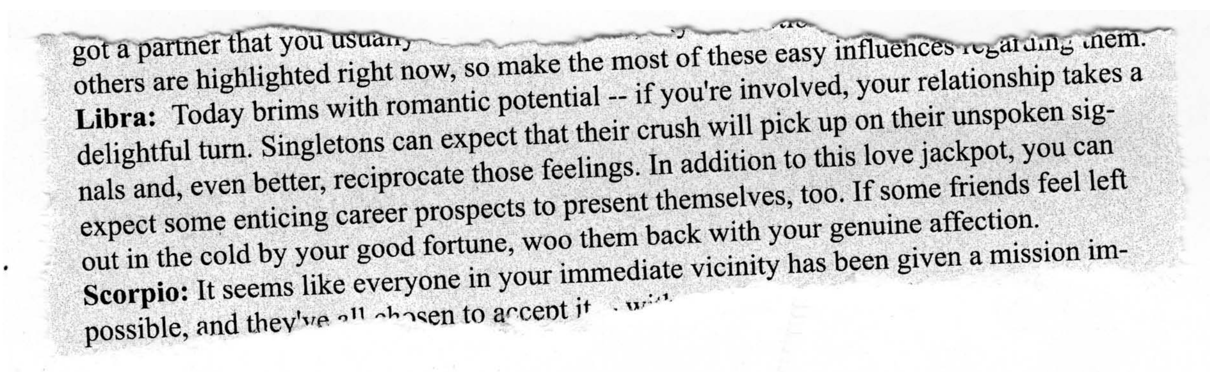
"Hippotades rules the Venti (Winds) of heaven, holding imprisoned all their stormy strength, soothing at will the anger of the seas. When once the Venti are loosed and seize the main, naught is forbidden them; the continents and oceans cower forsaken; in the sky they drive the clouds and with their wild collisions strike fiery lightnings crashing down the world."

- Ovid, *Metamorphoses*

Feature wall cladding system- 24-guage copper panels, bolted through building paper and 15lb asphalted felt to 19mm exterior grade plywood with stainless steel cleats and fasteners, standing seams formed to height of 16mm as per architect's design specifications.

Saturday. Emerging from a mid-morning nap with the business section, and feeling like a coffee is in order. Looking over to the kitchen, Daphne is perched on a stool, reading either the book reviews or the world news because she is reading the paper, and never reads anything else in it.

She senses movement, looks over, returns my smile. Libra! she says, purposefully flipping pages.


got a partner that you usua...
others are highlighted right now, so make the most of these easy influences regarding them.
Libra: Today brims with romantic potential -- if you're involved, your relationship takes a delightful turn. Singletons can expect that their crush will pick up on their unspoken signals and, even better, reciprocate those feelings. In addition to this love jackpot, you can expect some enticing career prospects to present themselves, too. If some friends feel left out in the cold by your good fortune, woo them back with your genuine affection.
Scorpio: It seems like everyone in your immediate vicinity has been given a mission impossible, and they've all chosen to accept it ...

That's exactly what it said last Saturday, I reply, when I was a Capricorn.

My coffee and I step outside. Daphne follows, wraps her arms around me from behind. Indulge me, she says. I just think it's a romantic idea, that there is something that draws us together, something bigger than us, some reason we found each other.

There's not, I remind her. You, me, us, this. We built it, not some ephemeral- some, *inequitable*- force that shines on some and not on others. Where's your inner humanitarian, ask her why you're here and not starving in Bangladesh. Besides, if there is such a thing as fate, why is the outcome totally, *fucking* bleak? We're on the doorstep of an apocalypse.

No more oil, no more clean water, species extinction. The only respite from that doom and gloom is to make the most of our situation, right? So we write, we build, we *love*, we *choose*. We do these things, we're not instructed by some other-worldly script. Besides, I found you in Grade 11 physics.

Take that, prophesied delightful turn.

She is frustrated. I have gone academic on her. Now she will look down, now spin, and I think that if there is fate in our relationship, it is a snapshot of her walking away. A snapshot carried in a wallet like a talisman, corners peeling.

I walk out the length of the dock, turn back and look at the house. A massive slanting wall shields it from the wind, the sun, the rain and the snow like a hand protecting a match's flame. The rest of the house hides under it, windows peeking out to check the weather before deciding how to dress. We covered the wall with copper, the seams creating a kaleidoscope of points tapering towards the ground. The early days of the copper saw it take on colours like an oil slick, iridescent pinks, purples, blues that would hold your fingerprints. The wall is six years old now, from a distance appearing reddish brown, deep and thick and matte as if extruded from the mud. When you get up close you can see, where the seams have collected water, a thin skin of green has begun to form, an acceleration of time. Rain and snow held in place by the metal, formed by a man's hand, created by force of will. When I am two hundred years old I will look upon the seams in this wall, the green grown over the entire face. I will drag my petrified fingernails over the surface, scratching deep into the patina, through to the unseasoned, virginal material. Begin again.

It's not that I don't believe in fate, it's that I don't believe in her version, passed down from the mystics to the misanthropes of organized religion. Hair shirts and self-flagellation, gullible young men in suits and ties twenty years their senior, selling elitism for a handful of change. Add two numbers together and you will get the same sum, try it a million times and it will always be the same. That is fate. Cemeteries. That is fate. The rest is choice, like turning my head now to look towards the windows, seeing Daphne gazing out. Winking. Her choice now to approach, to tilt her head up at me, to lay her cheek against my shoulder.

I run my hands through her hair, oxidized green shaved under my fingernails.

House of Water: Scorpio

Okeanos I call, whose nature ever flows,
from whom at first both Gods and men arose;
sire incorruptible, whose waves surround,
and earth's all-terminating circle bound:
hence every river, hence the spreading sea,
and earth's pure bubbling fountains spring from thee.
Hear, mighty sire, for boundless bliss is thine,
greatest cathartic of the powers divine:
earth's friendly limit, fountain of the pole,
whose waves wide spreading and circumfluent roll.
Approach benevolent, with placid mind,
and be forever to thy mystics kind.

- Orphic Hymn 83 to Okeanus

House for Clement

Roofing system- Recycled tin roofing shingles, 30 guage, individual units repaired as required and c/w approved elastomeric coating. Stainless steel cleats and fasteners connecting shingles to heavyweight building paper, ice shield and 19mm exterior grade plywood. Thermal protection- 100mm rigid polyisocyanurate board insulation tops 13mm cement board substrate, c/w two coats mopped-on vapour retarder.

Toora loora loora

Toora loora li

He sleeps.

There is a soft battering of raindrops on the tin roof, a sound so familiar to me that it went utterly without notice until I began listening with four ears. It is the first rain since I brought him home. Standing against the window, shielded by the roof overhang, I look beyond to the surface of the fountain at the back of the yard. The noise from above echoes the drops' collision and entry, a disproportionate soundtrack.

A month ago I had the roof painted, as I do every year before the rainy season starts. The tiles are antique and, although I probably don't need to do it every year, it marks the passing of time. I got married in the yellow year. Every year I choose a different colour, this year grey, like my eyes, all the while wondering if this colour would be reflected in the baby's eyes too. It is not; his eyes are blue, at least for now. They tell me his eyes can change even until he is two. I wonder if somewhere down the road his eyes will match mine, he and I and the roof like somber triplets.

Unsure if this is merely what constitutes maternal instinct, motherhood has thus far been a week-long déjà vu. In what seems now like his first moment of lucidity, he looked up at me in what I can only describe, my heart clenched, as a critique, a sizing up of who it is he has chosen as his guardian for the first, crucial years of his life. I returned his gaze, defiant yet questioning. My mind clearing cobwebs back to classical studies, I hunt down Plato's daemon, the spirit that is fully grown, fully developed yet congested, cramped, frustrated in a tangle of clumsy limbs and inarticulate speech: the oak inside the acorn. Plato's daemon, the governing force in the individual's character, their spirit guide whose duty it is to achieve the soul's calling, a calling that is latent, predating the first breath of mortal air. The guide that chooses the circumstances of birth, the very womb from which life will spring. I look down and feel charmed, flattered. Terrified.

He twists, rubs his eyes before opening them. Again, that look like a judge, waiting on a lapse in composure or a rogue bead of sweat. This child is an old soul. It seemed that I chose him, or chose to have a baby, it seemed that I was free to decide, but I feel that challenged, like the grinding wheels of fate have placed me squarely on this path, on a crash course with this being, my son. Every day he changes but is no less himself. Does he will himself to grow, or is it beyond him, outside of him? His mouth gapes, for now silent. He seems to have grown fussy with such ruminations.

Over in Killarney, many years ago

My mother sang this song to me in tones so sweet and low

Toora loora loora

Toora loora li

I take a seat on the rocker, continuing to sing. Another newspaper, unopened, sits on the table. I lean over, flipping to the horoscopes, divining what the fates have in store for this old little man. Monday.

that at the end of this day's hard work, you make sure that you both get the credit.
Scorpio: You're about to embark on an extraordinary opportunity or relationship. Be receptive and open to the influences that are intent on presenting you with experiences that will shape your mind, body and soul if only you are willing to relax your sense of control and deal with what comes your way. There's no need to decide one way or the other what your course of action will be. Instead, watch, wait and listen for your golden chance.
Sagittarius: When it comes to making sure you perform your best, what really counts is how much time you spend preparing.

I hear a soft squeak. His head back, he reaches his left arm up, his hand clenched in a determined fist. Character is Fate, my dear. Heraclitus.

Three houses:

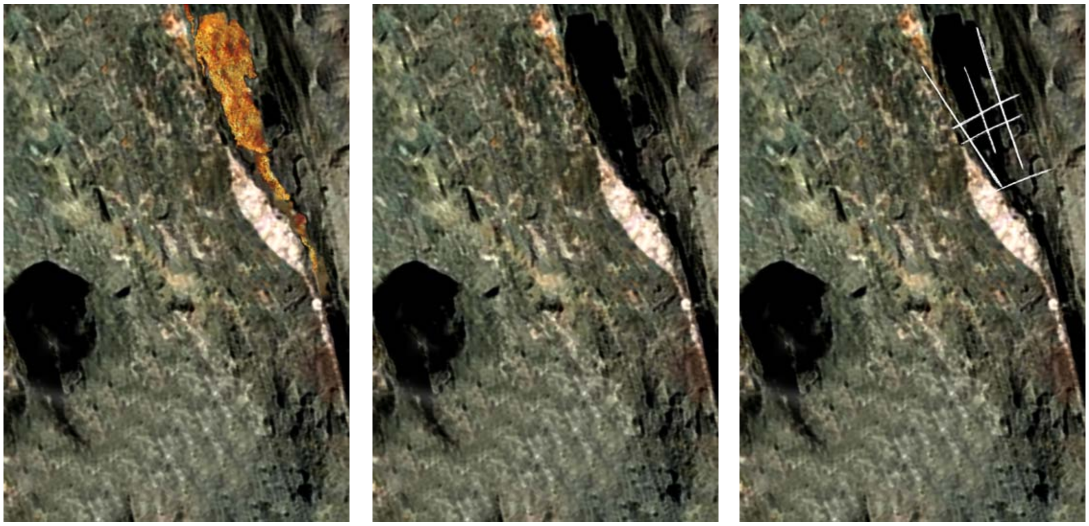
alchemical folly
cliff house
villa metallica

alchemical folly

alchemical folly : a house in seven metals was designed through a House As Thesis exercise. Most important to the "house" was an attempt to investigate, through various qualities of enclosure, the notion of myth and in particular the symbolism associated with the seven classical metals. The mythology of each metal, viewed through its related planet and astrological house, led to the first definition of a personality or spirit associated with each metal. This was to pave the way to the eventual description of an imperative attributed to the seven classical metals.

These personalities are viewed through an exploration of enclosure, characterized by barriers of varying permeability. The nature of a barrier that encloses yet is open to sound, or open to light, or completely opaque; the possibility of a barrier that is itself the occupiable space: these notions are considered through the lens of each of the classical metals. All seven metals come together in a series of spaces that together form the House As Thesis.

The siting for the house is the crevice, the break in the rock through which the veins of ore emerge. The search for metals within rock carries overtones of divining, of not just the hunt for the metal but of a more spiritual sensing of the element's qualities. In ancient philosophy, metals had two sources of provenance: either they came from the sky (in the case of meteoric iron), or they came forth from the earth. The latter supported the belief that metals were not a static, exhaustible resource, but that they grew within the earth in much the same manner as a fetus grows in the womb. The house occupies the crevice by fitting itself into a void in the rock created by a vein of metal. The first gesture is a steel box which braces open the gap. Compressed along its length on all sides, the back of the house finds a vertical break in the rock; this is reinforced with a polished concrete wall to bring light- specifically, nocturnal light- into the darkest spaces. A copper sliver cuts through the house, reflecting daylight down through the break in the rock.

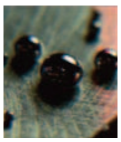


divination of the ore | procurement of the ore | reoccupation of the void

fig. a.1- investigations in forms of rock

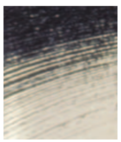
IRON : FORCE

Iron has long been associated with power; its earliest appearances in civilization came in the form of meteoric iron, believed to be cast to earth by the gods and therefore more precious (and rare) than gold. With the discovery of smelting iron became prolific in the fabrication of tools and weapons; iron is connected to the planet Mars, named for the Roman god of war. Iron in the human body is understood to impart strength and energy; likewise a deficiency in iron causes weakness and lethargy.



MERCURY : MOVEMENT

Mercury is distinct among metals for its liquidity at room temperature. It is also well known for its movement, ergo its nickaname: quicksilver. Because of the self-weight of the material (it is sixteen times that of water) it moves with great momentum and at times on an erratic path. This velocity- and virtuousity- of movement ties the metal to Mercury, the fleet-footed messenger god of ancient Rome, and to the planet of the same name- which makes the fastest orbit around the sun of all planets.

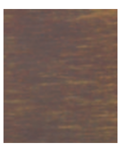


SILVER : RECORD

Whether used in mirrors or photography, silver has a particular quality among metals to record images- even if only for an instant. Whereas silver's lustre and colourlessness make it the optimal choice for mirrors, it is the metal's response to light that enables the photographic process. A silver surface, kept protected in darkness, will record an image from a brief exposure to light in a process akin to tarnishing of silver jewelry. Silver is associated with the Moon, an entity choosing the sanctity of night for her appearances.

GOLD : LIGHT

Whether symbolizing the bond of marriage, rewarding excellence in the arts and sport, or providing the basis for world monetary standards, gold is universally esteemed. Since antiquity it has been the most highly valued of the currency metals, inspiring ancient alchemists to attempt the transmutation of other metals into this most precious element. Gold is linked to the Sun and to the god Apollo, who drove the golden chariot across the sky- the sun being the chariot's bright gold wheels.



COPPER : NURTURE

The ubiquity of copper is due to its versatility both as a decorative metal and a utilitarian one. It has been used for millennia in jewelry and decorative artifacts, alone or as part of the alloy bronze. It is widely used in buildings to carry and distribute water, or to protect an exterior from the elements. While all humans have copper in their bloodstream, women have significantly higher quantities, particularly during pregnancy. The metal is linked to the goddess and the planet Venus, both recognized for their feminine beauty.

TIN : SOUND

Understood as the most tonally resonant of the metals, tin has associations with sound that venture into the mythological. Due to its crystalline structure, the bending of tin causes a distinctive crackling sound known as 'tin cry'. This sound is used to replicate thunder in stage productions, through the shaking of a tin sheet. The ancient Romans believed that thunder was created by the god Jupiter; this could be why classical alchemists associated Jupiter the planet with tin.

LEAD : TOMB

Lead has often been referred to as the basest of metals: the most simple, the most humble. It was used in ancient times as a plumbing metal and continues to be used as a roofing material, due to its softness and ability to be made watertight. Lead has long been known to deteriorate the physical and mental health, and exposure is ultimately fatal. The mental effects of lead poisoning are known informally as saturnism, in reference to the brooding darkness of the god Saturn; lead is the metal alchemically associated with Saturn.

fig. a.2- early investigation of metals and their mythico-symbolic attributes

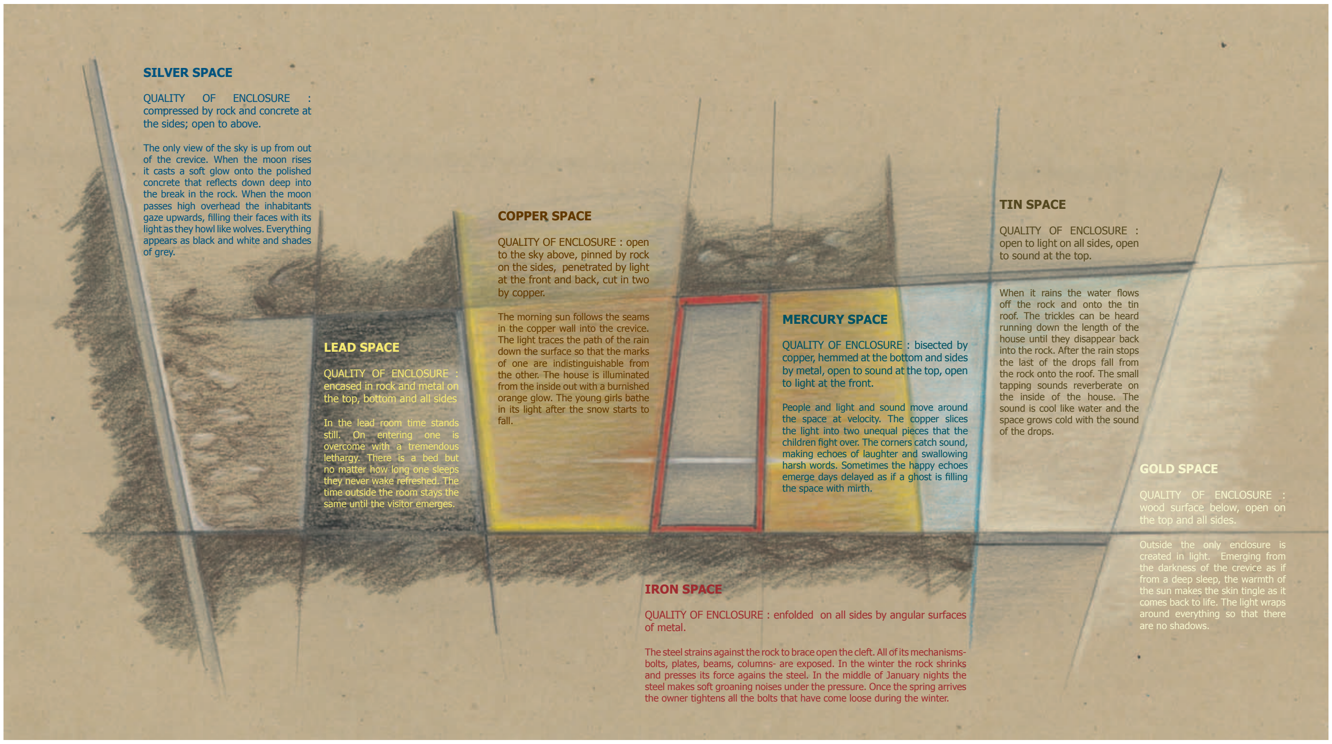


fig. a.3- conceptual section

cliff house

This iteration of the thesis investigated the possibility of incorporating the seven metals together into a single house, here situated on a rocky cliff on the coast of Labrador. The imperatives of each metal are conceptualized as seven spaces which are linked together in varying degrees of connectivity and separation. The lead spaces forms a core-like vault, connecting the levels of the house vertically; the mercury space is that of the circulation paths which form a woven connection through the other six metal spaces. The silver space, semi-exposed to the outdoors, collects rainwater in a pool, while the open-air tin space serves as an auditorium for watching, listening to, and making music with storms. Copper is interpreted through a central communal space for sharing foood and company, while the gold space is intended as a private and indulgent world for a couple. The final space, that of iron, is the hearth: it not only establishes the burning heart of the house but also marks the spot of a prehistoric meteor strike, one which split the rock in two, providing the ground into which the cliff house is enbedded.

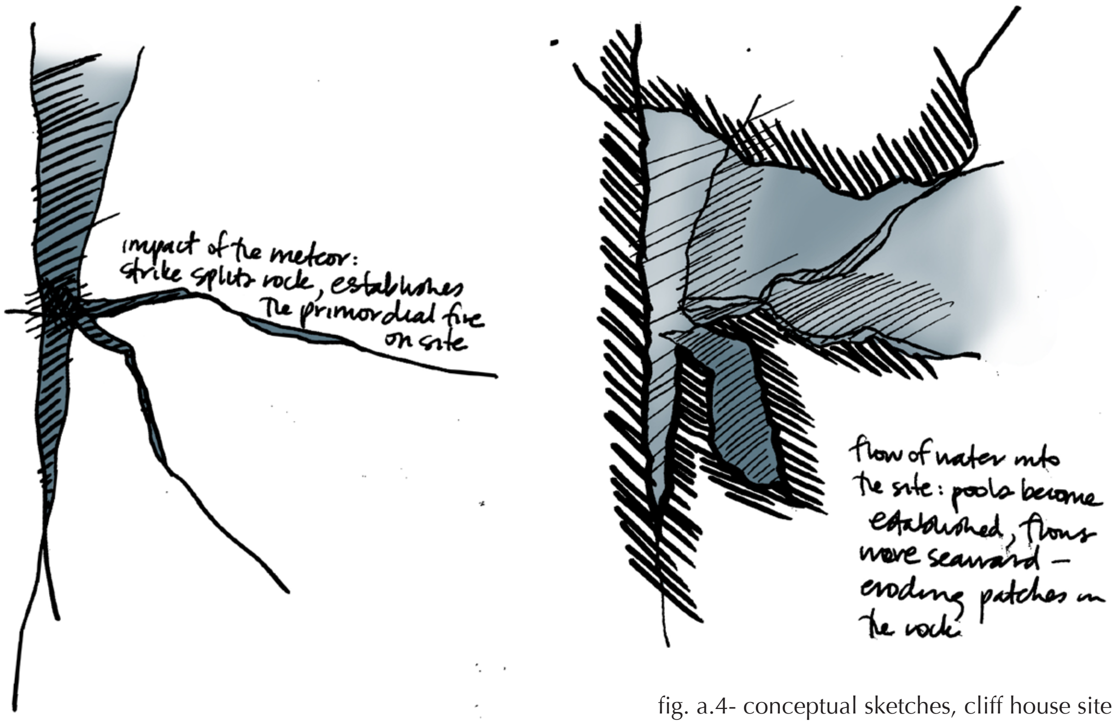


fig. a.4- conceptual sketches, cliff house site

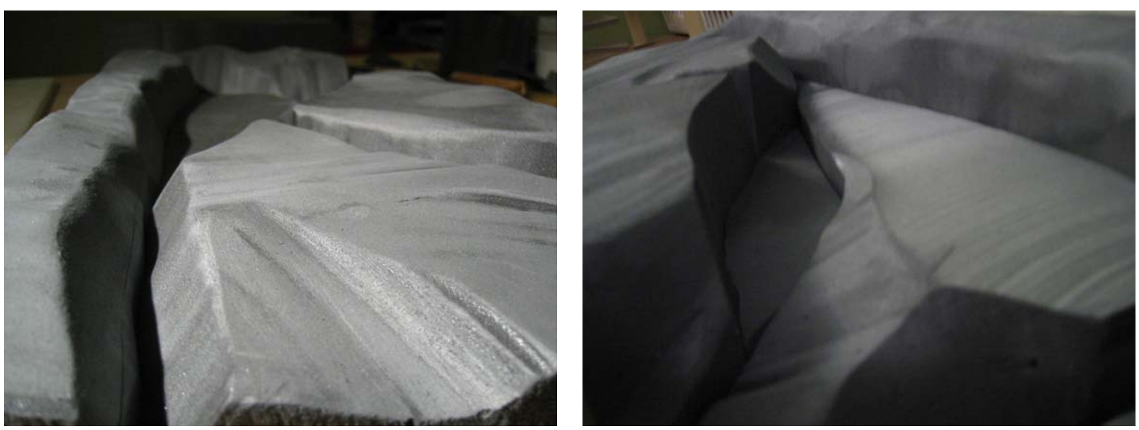


fig. a.5- conceptual site models

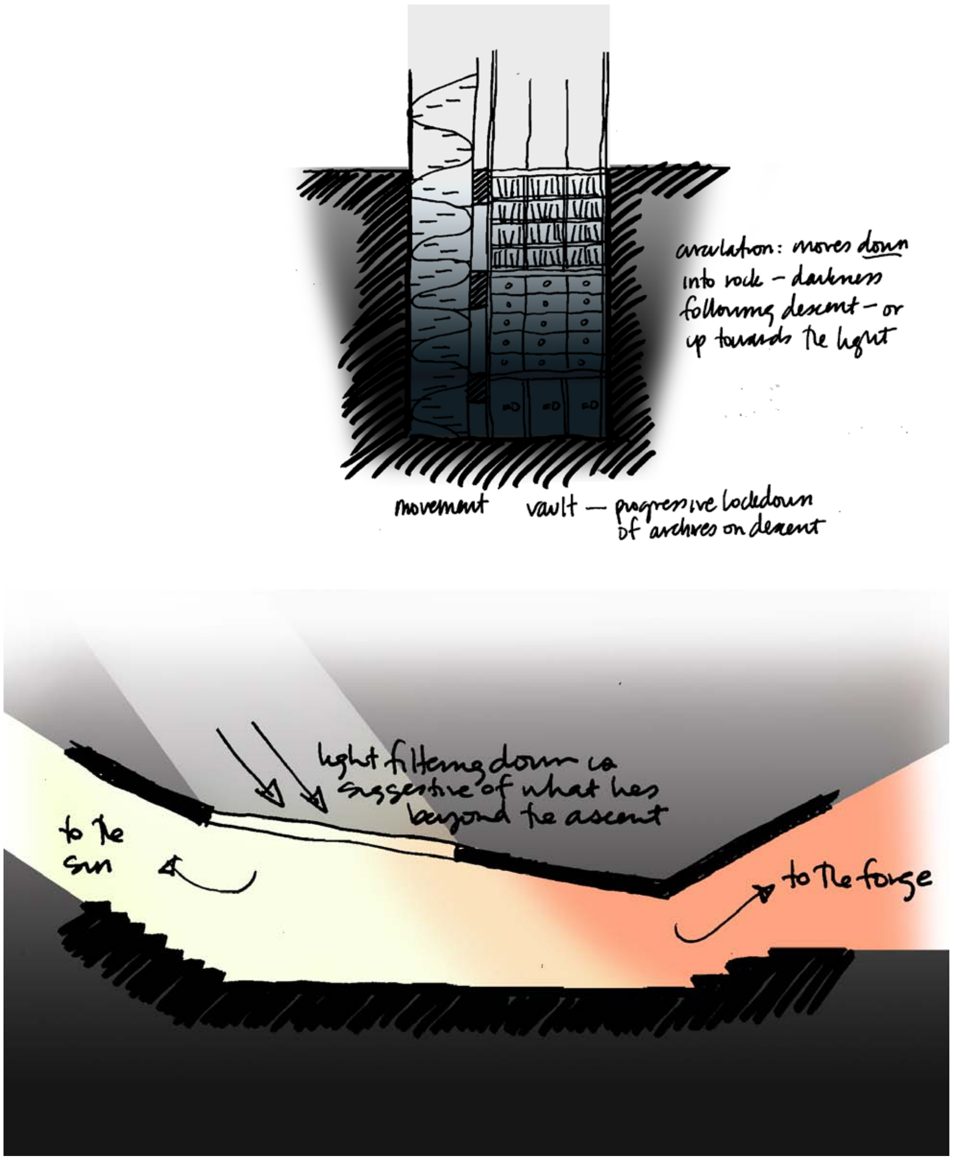


fig. a.6- conceptual sections, cliff house

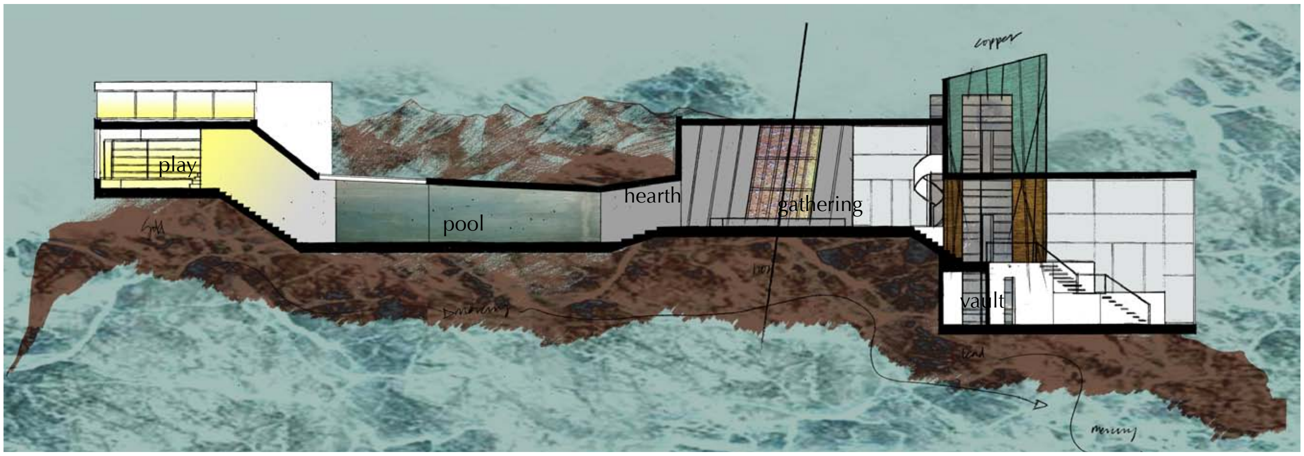


fig. a.7- house section: gold to silver to iron to copper to lead

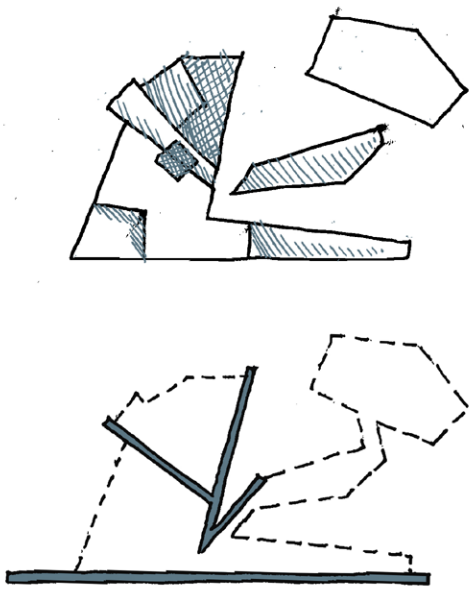


fig. a.8- cliff house surfaces and lines

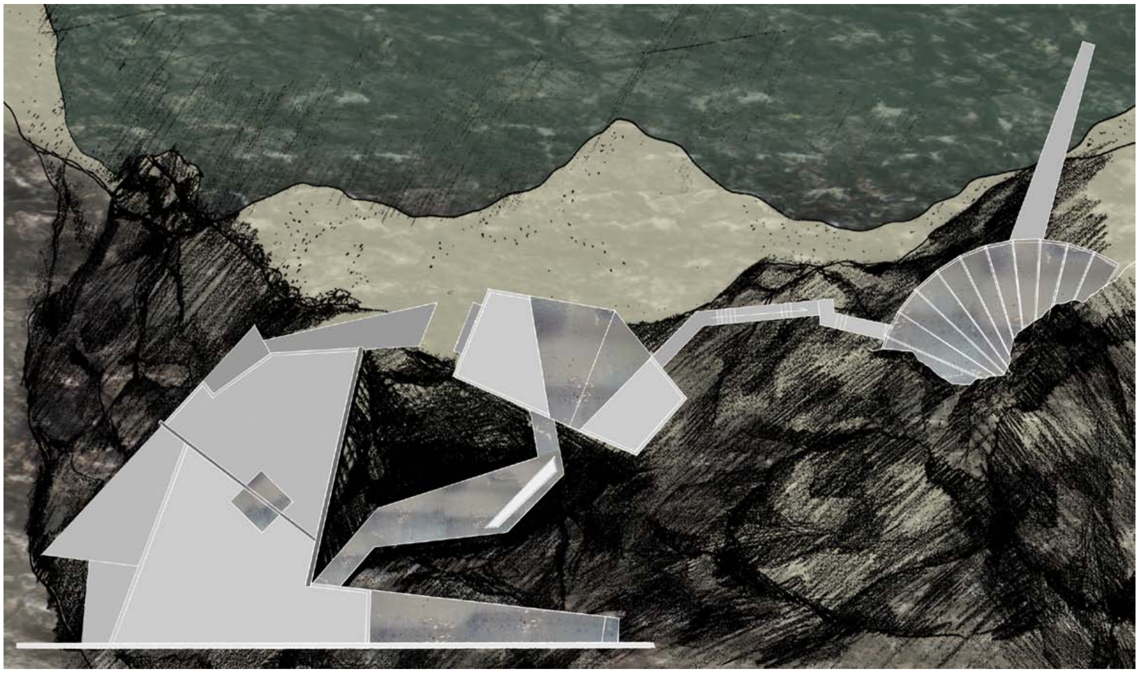
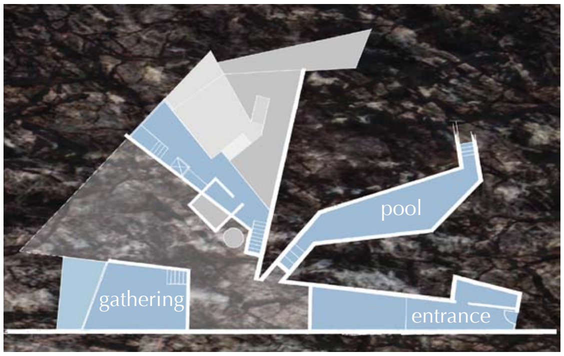
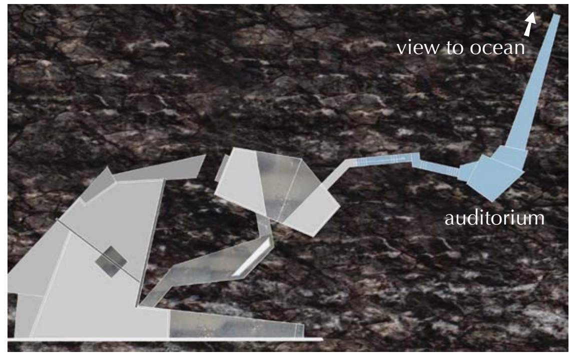


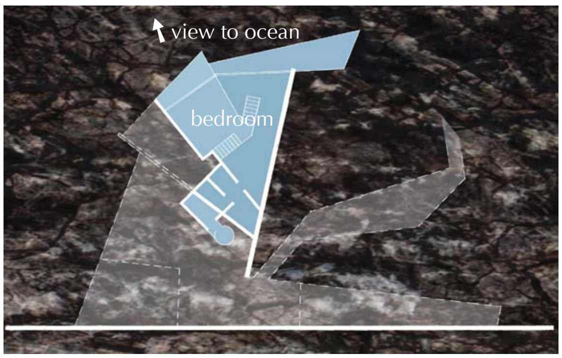
fig. a.9- plan of roofs



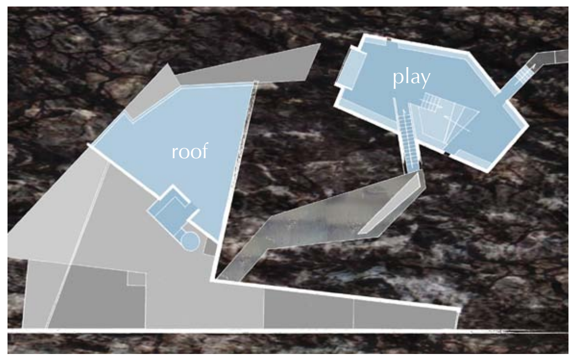
plan @ 4.6m



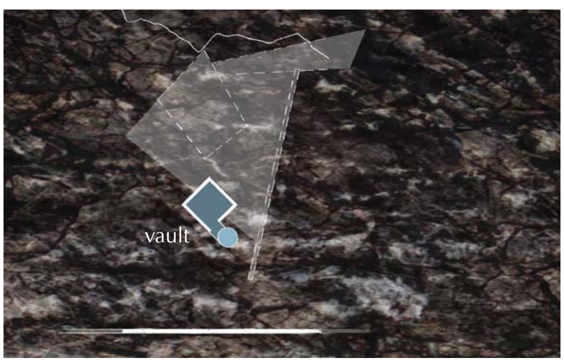
plan @ 10.0m



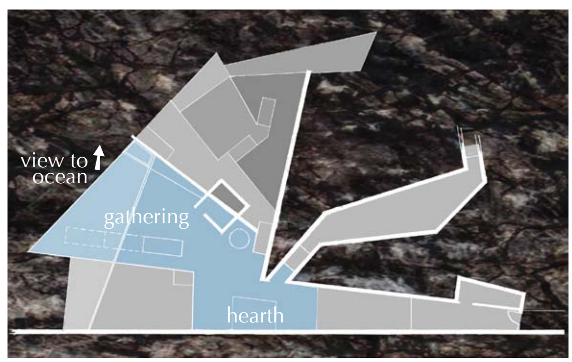
plan @ 3.0m



plan @ 6.8m



plan @ 1.5m



plan @ 5.4m

fig. a.10- floor plans

villa metallica

The second iteration of the house project diverted from the concept of one house for seven metals. By fracturing into several metal spaces, each one taking its location across a larger territory, more freedom was granted for the realization of the imperatives. The necessity of siting the silver space in proximity to water could be independently addressed, without needing to reconcile other imperatives to the same location. The resulting program saw a series of small pavilions dotting a landscape in northern coastal Labrador, some spaces linked together, some with trajectories to celestial bodies.

The impetus for a gradual development of metal spaces over the site was a chronology of characters that would discover the landscape and make their own mark on it. The first intervention comes by way of carving the rock by wind and water. The first nomads commemorate a lunar event on the site and thus establish the ground for the pool. A wanderer with compass in hand builds a shelter, directing his windbreak in the direction of magnetic north; his return decades later is marked by the building of a vault. The shelter is eventually rebuilt by his descendent, the wall partially reconstructed to reflect a new and updated magnetic north. His lover's arrival is commemorated through a morning garden and a westward observatory for the viewing of the 2012 Venus transit. The final intervention, that of the philosopher, establishes the line of true north by setting up an observatory platform pointing at Polaris, the North Star.

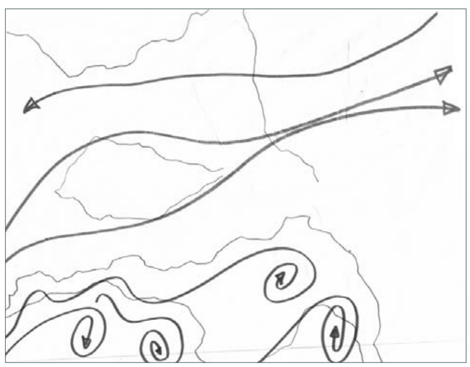
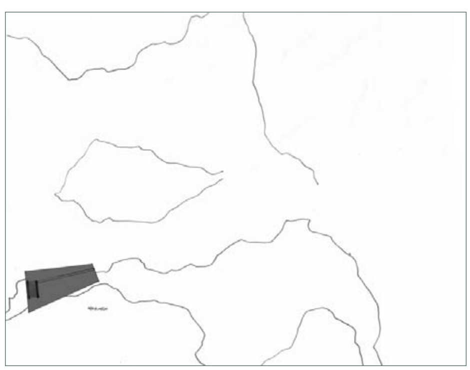


fig. a.11- prevailing winds



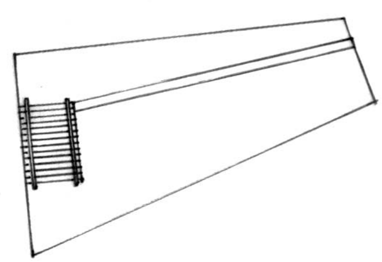


fig. a.12- silver space: reflective pool

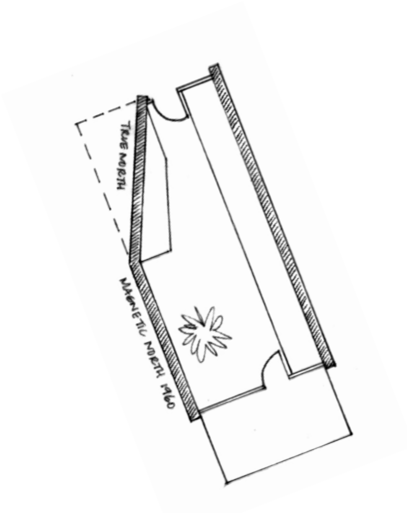
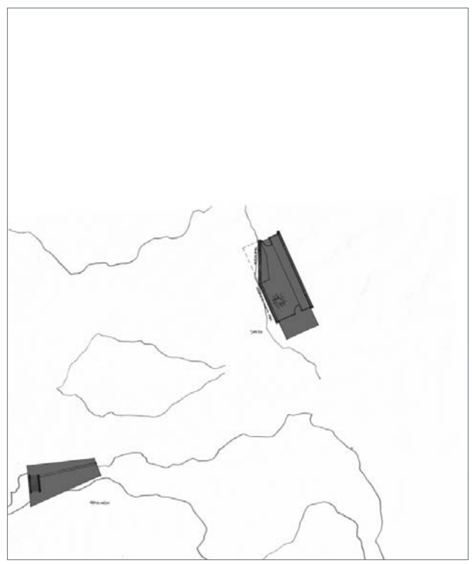


fig. a.13- iron space : wall/shelter



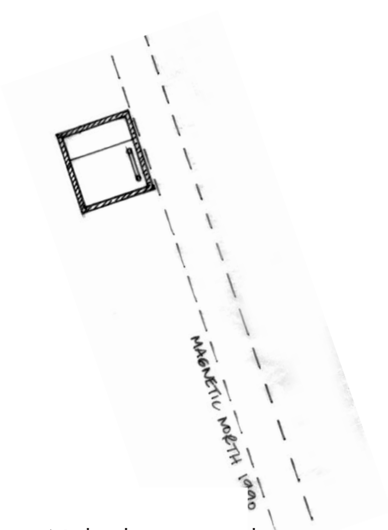
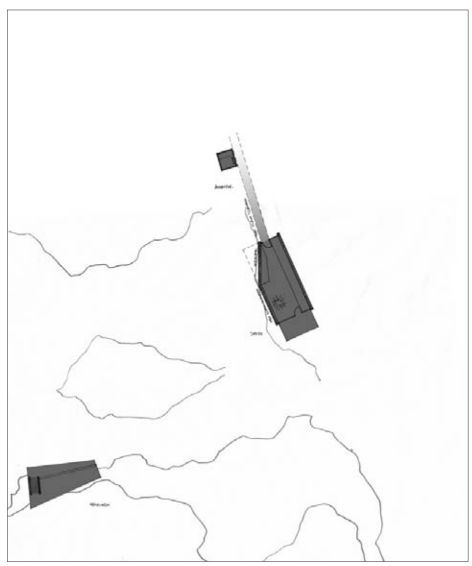
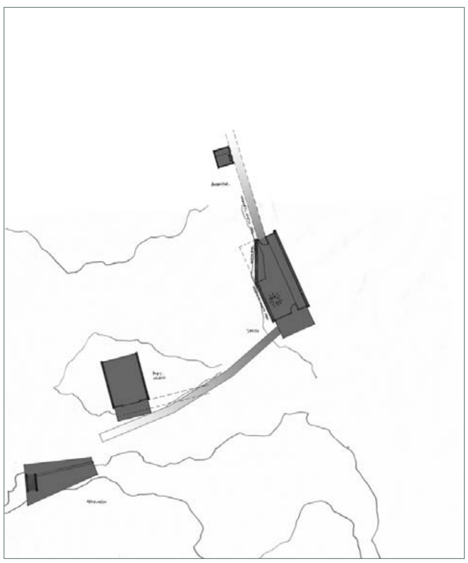


fig. a.14- lead space : vault





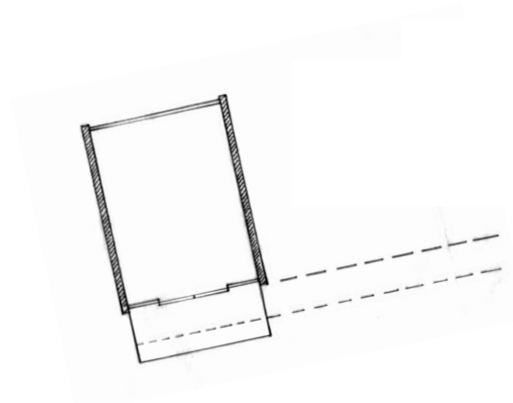
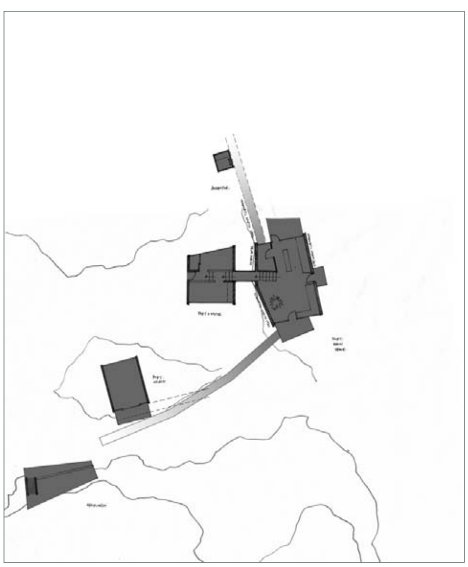


fig. a.15- gold space : studio



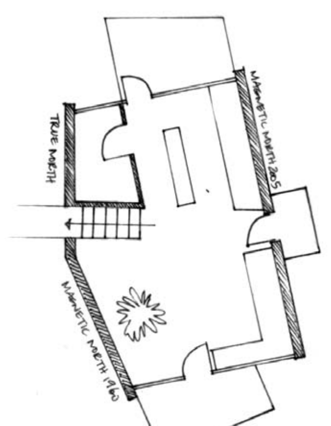


fig. a.16- the new shelter

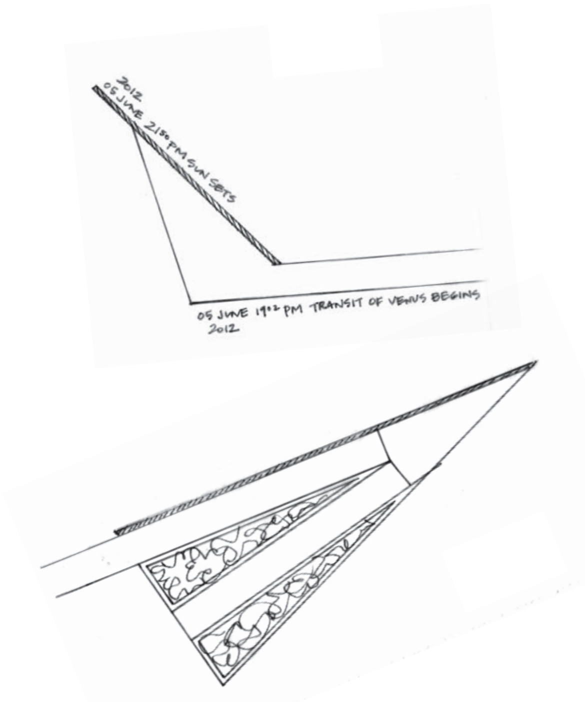


fig. a.17- copper spaces : transit observatory
and morning garden

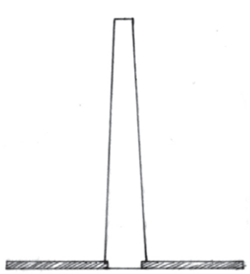
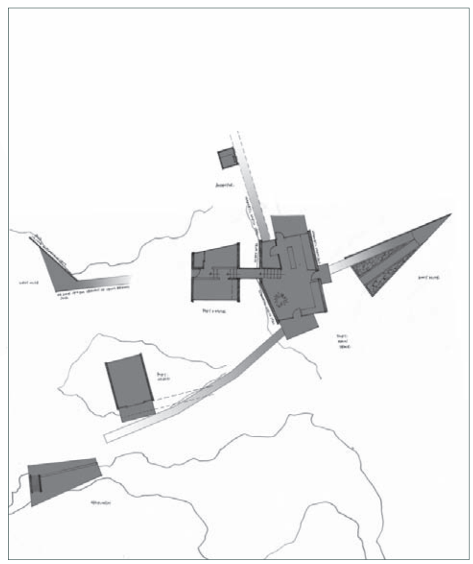
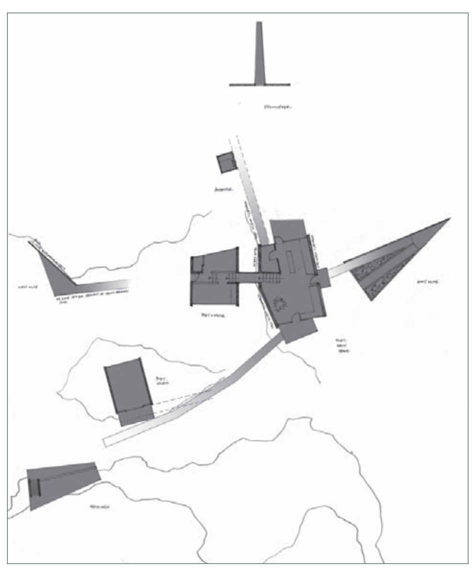


fig. a.18- tin space : polaris observatory





Opposite page:
fig. a.19- character development matrix

character development matrix

metal	planet	house	orientation	character	space
mercury Hg 80	mercury	3rd house: house of communications	prevalent winds: orientation to the prevalent winds is also orientation to the seasons: the fluctuation in temperature reflects mercury's common usage in society as a gauge of temperature. wind likewise expresses communication in that the air carries words, song and stories.	the child: the child appears on the site through the wind: moving unpredictably, joyfully, madly, scurrying into hiding places, carving out niches, smoothing planes like desire lines over the rock. the child has two guises: the good child/ east wind, bringing warmth and life, and the bad child/ north wind, scolded with cold, angrily ripping leaves from trees and bringing storms.	circulation, paths of movement: the movement of the wind creates two kinds of path: that which moves at velocity, and that which moves sensually. the velocity paths respond to acceleration to points of light, or to gravity; the sensual path find spaces and erodes them into smooth-faced refuges and hiding places from harsh weather. these paths are picked up by subsequent generations on the site.
movement	velocity	self-expression, most natural method of communication			
silver Ag 47	moon	4th house: house of home	lunar phenomena: we observe two lunar eclipses per year, as well as solar eclipses. however, only during lunar eclipses does the red or copper moon become visible. many ancient societies worshipped the moon and calculated occurrences of phenomena with great accuracy.	the matriarch: the matriarch comes to the site with the women of her tribe, to perform the ceremonial rites associated with the appearance of the red (eclipsed) moon. it is a passage for girls of a certain age, ushering them not only into womanhood but into the community of women that hold the tribe together.	the pool: the ceremony on the site takes place around a pool of water. this symbolizes several things: the responsiveness of water to the moon (pull of the tides); the reflection in the water and the moon acting as mirror to the earth; the equation of both the moon and water with the feminine: both are changeable, emotional, potent, and incomprehensible- and therefore fearful.
reflection	emotion	the idea and myth of home: what constitutes home?			
iron Fe 26	mars	1st house: house of self	magnetic north: magnetic north is a phenomena that moves- it moved marginally in the early/mid 20th c, but has started accellerating from the Canadian north towards Siberia. This is a repetitive pattern that occurs continuously- as does the shift in magnetic South.	the smith: the smith comes to the site led by the point of his compass. he is something of a reclusive genius, working the forge and making art in metal in sometimes unconventional ways. he attempts to reconcile the constant inconsistencies between true north- Polaris- and his north- the pull on his very body, the iron in his blood. this is ultimately the gap between his terrestrial and celestial selves.	the forge: the smith constructs an elemental shelter for the creation of his art; the centrepiece is his forge. he constructs a bent wall, angled at Polaris and at magnetic north: he is somewhat obsessed with their irreconcilability. after he abandons his house the only pieces that remain are the forge and the wall.
force	free will	the most elemental sense of the personality			
lead Pb 82	saturn	10th house: house of social status	gravity: the character of Saturn as spirit of death, and the similar association of lead, orient towards gravity: the pull downwards that will eventually affect all things, manmade or natural, living or inert. it is the expression of time on an infinitely long path.	the ancestor: after wandering free of the site and abandoning it for several decades, the smith returns as the ancestor. he has been made aware of the legacy he wishes to leave of his art, all the while railing against the terminal human nature that is pulling him slowly into the ground. he builds a vault amidst the semi-ruins of his former inhabitation, burying his most personal possessions.	the vault: the ancestor returns to the safest place he can think of- and sets up the vault to keep both his greatest treasures and his darkest secrets hidden away. he builds into a crack in the rock, the lead forming to the profile of the site, as he tucks pieces of himself into the crevices and folds. he seals the vault closed after it is filled, but forgets something. this he bequeaths to his nephew, the aesthete.
entombment	time	achievement, respect, formality			
gold Au 79	sun	5th house: house of pleasure	solar path: the orientation of the studio space maximizes the flow of light through clerestory windows during the summer months. these months are when the elliptic is at its highest point in the sky and its farthest points east and west.	the poet: the poet arrives at the site the unlikely inheritant of his uncle's ruinous inhabitation. his sensitivities draw on the energies imbued in the site and he begins to draw, paint, write and, eventually, build. he spends mostly summers there- he feels most alive in summer. he builds according to the cues inherent in the site. but eventually, he craves a human muse.	the studio: the building of the studio commences with the reestablishment of the original shelter: the wall and the forge. he builds on pieces every summer when he returns, gradually making the site more himself. he builds the studio first because that's what the site brings out of him.
light	creation	joy through all forms of creative enterprise, hedonism			
copper Cu 29	venus	7th house: house of relationships	path of venus: the path of venus follows the movement of the sun- it does not strictly adhere to the line of the elliptic but it does follow the sun. venus appears only in the morning and evening- therefore the views east and west are most important. in particular the view west- for the 2012 transit.	the muse: the muse is brought to the site by the poet; she is his love, his inspiration. she immediately brings new life to the outcrop of rock: she plants a garden and captures the sun in it, she reasserts the location of the lunar ceremony and calls forth its energy. it is as if she is now the sun around which the house revolves. she and the aesthete bear a child.	the garden: the poet builds much on the site but hasn't fully recaptured the energy that was established by the first two occupants. the muse starts to fill the hollows carved by the wind; the plants she nurtures then move with the wind. there is a nod to Mayan worship of Venus and their following of the Venutian calendar. she plans a western extension of the copper space for the 2012 transit of Venus across the sun.
nurture	beauty	ourselves through the eyes of others, bonding			
tin Sn 50	jupiter	9th house: house of philosophy	Polaris: while the earth moves, and everything on it constantly changes, while the pattern of the heavens spins around, the north star is the only steady point- like the centre of a vast wheel. in this way it is the most effective anchor point in the stars.	the philosopher: the philosopher is the child of the poet and the muse, and therefore the child of the site. like the original smith, he leaves the site to explore the world and learn more of himself. his reappearance at the site marks the assertion of his place in the terrestrial and celestial worlds.	the stage: the final form on the site is a platform for viewing the stars. the platform tethers the viewer at two points, one terrestrial and one celestial: the first anchors the feet to the ground, the second the head (eyes) to the only fixed point in the sky- Polaris- around which the entire great celestial performance navigates.
sound	expansion	knowledge of self through the knowledge of others			

Appendix B : tables

table b.1- elements and their architectural metal forms

element	metal form
classical metals	
lead	terne lead alloys
iron	cast iron steel stainless steel
copper	commercially pure copper brasses bronzes silicon bronzes monel (nickel-copper alloys)
tin	bronzes speculum tin alloys tin plate
gold	gold alloys
post-classical metals	
aluminum	aluminum alloys
nickel	nickel plating monel (nickel-copper alloys)
titanium	titanium alloys
zinc	brasses zinc alloys galvanizing zinc/tin alloy coatings

table b.2- colours of metals

colour	metal type
violet	anodized aluminum with metallic salt titanium with interference colouring stainless steel with interference colour titanium-coated stainless steel - interference copper - initial oxide interference
blue	anodized aluminum with metallic salt titanium with interference colouring stainless steel with interference colour titanium-coated stainless steel - interference zinc - slight bluish tint steel - oxide tinting
green	anodized aluminum with metallic salt titanium with interference colouring stainless steel with interference colour titanium-coated stainless steel - interference gold alloy - greenish yellow tint copper patina copper alloy patina
yellow	gold copper alloys - brass anodized aluminum with metallic salt titanium with interference colouring stainless steel with interference colour titanium-coated stainless steel - interference nickel silver - silver gold colour zinc patina - custom yellow-white oxide
orange	weathering steel copper alloys - high copper content copper patinas anodized aluminum with metallic salt
red	anodized aluminum with metallic salt titanium with interference colouring copper alloys - high copper content

table b.3- colours of copper alloys

common name	alloying elements - nominal	colour
copper - 99.9% pure	none	salmon red
gilding metal	5% Zn	reddish-orange
commercial bronze	10% Zn	salmon red with gold tint
red brass	15% Zn	golden red
cartridge brass	30% Zn	yellow
yellow brass	35% Zn	yellow
muntz metal	40% Zn	golden yellow
architectural bronze	40% Zn, 3% Pb	golden yellow
nickel silver	25% Zn, 10% Ni	silver with gold tint
nordic Brass	5% Al, 1% Zn	yellow with slight green tint
aluminum bronze	8-10% Al	light yellow color
silicon bronze	3% Si	red color
phosphor bronze	3-9% Sn, 0.03-0.35% P	dirty yellow color
manganese brass	1.2% Mn, 29% Zn	golden brown

table b.4- alloying constituents for various metals

base metal	alloying element	attribute
aluminum	copper	improve strength
aluminum	manganese	improve ductility
aluminum	silicon	lower melting point
aluminum	magnesium	improve finish
copper	tin	colour, lower melting point
copper	zinc	colour, strength
gold	silver	colour, strength
gold	copper	colour, strength
iron	carbon	improved ductility and strength
iron	chromium	improved corrosion resistance
iron	nickel	improved corrosion resistance and hardness
lead	tin	hardness, colour
nickel	copper	workability, colour
tin	antimony	workability
zinc	titanium	workability

table b.5- changes in metal surface from typical exposures

metal	initial oxidation	prolonged oxidation
aluminum	small fuzzy gray patches	uniform gray with some darker patches
copper	brown oxide; streaky gold	brown uniform colour with green tint
copper alloys - commercial bronze, red brasses	brown to yellow-brown; streaky surface	deep dark brown colour
copper alloys - architectural bronze, muntz brass	brown to dark brown streaks and spots	deep dark brown with blackish streaks
gold	little change	loss of reflectivity around edges
lead	streaky surface with interference colours	dark even gray with some white streaks; sometimes red stains
monel	loss of reflectivity	green-brown or gray-green patina
nickel	gray spotty tarnish	gray-green patina
weathering steel	orange-brown streaky patina	dark reddish brown colour over the surface
stainless steel	small reddish spots if exposed to contaminants	very light, transparent reddish haze
tin	light tarnish spots	even tarnish over surface
titanium	indiscernible	formation of titanium carbide below oxide in acid rain environments
zinc	darkened tarnish; initially spotty oxide	even zinc carbonate or chlorinated hydroxide; dark gray colour

table b.6- patinas on various metals

metal	patinas	colour
aluminum	aluminum selinide	black
	aluminum oxide, aluminum selinide	gray
copper	copper oxide	brown
	copper oxide	black
	copper chloride	green-blue
	copper sulfate	green
	copper ferrite	golden brown
lead	lead oxide	dark brown
	lead oxide	red (usually not desired)
	lead carbonate	whitish gray (usually not desired)
monel	copper oxide, nickel oxide	brownish green
weathering steel	ferrous hydroxide	orange-brown
zinc	zinc carbonate	blue-gray

table b.7- various metals and expected time until surface oxides become visible

metal	surface finish	arid environment	moist environment
aluminum	alclad	5 to 10 years	2 to 5 years
	specular	5 years	6 to 12 months
	coarse	2 to 5 years	3 to 6 months
	anodized - clear	10 to 15 years	7 to 10 years
	color - mineral	10 to 15 years	7 to 10 years
copper	cold rolled	12 to 18 months	3 to 6 months
	prepatinated	very little change	very little change
	predarkened	10 to 15 years	5 to 10 years
	blackened	unknown	15 to 20 years
brass	mirror polished	3 to 6 months	1 to 3 months
lead	mill	1 to 2 years	6 to 12 months
monel	specular	5 to 10 years	1 to 2 years
steel	mill	3 to 6 months	several days
stainless steel - 300 series	mirror	100 years plus	50 to 70 years
stainless steel - 400 series	mirror	10 years plus	1 to 2 years
steel	mill	3 to 6 months	several days
tin	mill specular	2 to 5 years	6 to 12 months
titanium	mill	unknown	unknown
zinc	mill specular	5 to 10 years	2 to 5 years
	preweathered	15 to 20 years	10 to 15 years
zinc coating	galvanized	5 to 10 years	2 to 5 years

table b.8- light reflected from metal

metal	visible light reflected from a polished surface
silver	95%
aluminum	90%
tin	70%
gold	61%
chromium	61%
iron	58%
nickel	50%
stainless steel	49%

table b.9- finish designations

sheet form of metal	mill finishes	secondary finishes
aluminum	unspecified nonspecular specular	mirror finish satin finish- directional; fine, medium, coarse glass bead angle hair- nondirectional embossed anodized blackened
copper	unspecified cold rolled prepatinated predarkened	mirror finish satin finish - directional; fine, medium coarse glass bead angel hair - nondirectional embossed blackened
copper alloys	unspecified specular	mirror finish satin finish - directional glass bead angel hair - nondirectional embossed
gold	foil leaf	not applicable
iron	hot rolled cold rolled	not applicable
lead	mill finish	not applicable
steel	hot rolled cold rolled	satin finish - directional glass bead steel shot angel hair - nondirectional

sheet form of metal	mill finishes	secondary finishes
stainless steel	hot rolled and pickled no. 2D no. 2B no. 2BA shadow coined	no. 9 mirror no. 8 mirror no. 7 no. 6 - directional no. 4 - directional no. 3 - directional angel hair - nondirectional glass bead embossed interference-coloured
tin	cold rolled	specular fine satin angel hair
titanium	cold rolled on smooth finishing rolls cold rolled on rough finishing rolls shot blast and acid cleaned	interference-coloured
zinc	cold rolled preweathered preweathered, blackened preweathered gray	satin finish- fine, medium, coarse angel hair- nondirectional

table b.10- expansion coefficient of metals

metal/alloy	coefficient of thermal expansion μ-in/in C°	expected expansion (inches) of a 120″ metal segment	expected expansion (mm) of a 3-meter metal segment
lead	29.3	0.13	3.30
zinc	24.9	0.11	2.79
aluminum	23.2	0.11	2.79
tin	23.0	0.10	2.54
architectural bronze	20.9	0.10	2.54
yellow brass	20.3	0.09	2.29
red brass	18.7	0.09	2.29
commercial bronze	18.4	0.08	2.03
copper	16.8	0.08	2.03
stainless steel	16.5	0.08	2.03
nickel silver	16.2	0.07	1.78
gold	14.2	0.05	1.27
monel	14.0	0.06	1.52
iron	11.7	0.05	1.27
steel	11.7	0.05	1.27
titanium	8.4	0.04	1.02

table b.11- comparable hardness of different metals and alloys

metal	alloy and temper	hardness (Rockwell B-Scale)	yield strength ksi	MPa	ductility degree (1- very ductile, 5- stiff)
aluminum	A93003-H14	20 to 25	21	145	1
	A93004-H34	35 to 40	29	200	1
	A95005-H34	20 to 25	20	138	1
	A96061-T6	60	40	275	4
copper	1/8 hard (cold roll)	10	28	193	1
gilding metal	1/4 hard	32	32	221	1
commercial bronze	1/4 hard	42	35	241	2
red brass	1/4 hard	65	49	338	2
cartridge brass	1/4 hard	55	40	276	1
yellow brass	1/4 hard	55	40	276	2
architectural bronze	As extruded	65	20	138	4
nickel silver	1/8 hard	60	35	241	3
steel - low carbon	Cold rolled	60	25	170	2
cast iron	As cast	86	50	344	5
304 stainless steel	Temper pass	88	30	207	2
lead	Sheet lead	5	0.81	5	1
monel	Temper pass	60	27	172	3
zinc alloy	Rolled	40	14	97	1
titanium	Annealed	80	37	255	3

table b.12- electromotive scale of various metals

voltage potential		metal
least noble	-1.03	zinc
	-0.79	aluminum
	-0.61	cast iron
	-0.53	active stainless steel
	-0.36	copper
	-0.31	bronze
	-0.29	brass
	-0.28	tin
	-0.27	lead
	-0.25	monel
	-0.15	400 series stainless - passive
	-0.10	titanium
	-0.08	300 series stainless - passive
most noble	1.29	gold

table b.13- relative cost of metals

metal	cost by weight alone	cost by surface area-thin form	cost by surface area-thick form	cost by cast form
steel	1	1	1	1
iron	1	1	1	1
aluminum	2	1	2	2
lead	2	2	4	4
stainless steel	2	2	3	5
copper	3	2	3	3
zinc	3	3	5	4
brass	3	3	3	2
bronze	3	3	4	2
tin	4	4	6	-
titanium	5	3	6	6
monel	5	4	6	-
gold	6	5	-	-
1 is the lowest relative cost, 6 is highest relative cost, dash denotes not applicable				

table b.14- standard and maximum widths of sheet metal

metal	standard width inches	standard width mm	maximum width inches	maximum width mm
aluminum	48	1220	120	3050
	60	1525		
	72	1830		
copper	36	915	48	1220
	39	990		
	48	1220		
copper alloys	48	1220	48	1220
copper alloys - nickel silver	36	915	36	915
lead	48	1220	48	1220
monel	48	1220	48	1220
steel	24	610	120	3050
	36	915		
	48	1220		
	60	1525		
	72	1830		
	96	2440		
	120	3050		
stainless steel	36	915	96	2440
	48	1220		
	60	1525		
tin	36	915	36	915
titanium	48	1220	48	1220
zinc	39	990	39	990

table b.15- comparative sheet metal thicknesses

thickness inches	thickness mm	steels (gauge)	aluminum (nominal thickness)	lead (lbs/sf)	copper (oz/sf)
0.188	4.78		0.188	12	
0.172	4.37	8			
0.156	3.97	9		10	
0.141	3.57	10			
0.125	3.18	11	0.125	8	
0.109	2.78	12			80
0.100	2.54		0.100		
0.097	2.47				72
0.094	2.38	13		6	
0.090	2.29		0.090		
0.086	2.19				64
0.080	2.03		0.080		
0.078	1.98	14		5	
0.075	1.91				56
0.070	1.79	15	0.070		
0.065	1.64				48
0.063	1.59	16	0.063	4	
0.056	1.43	17			
0.055	1.40			3.5	
0.054	1.37				40
0.050	1.27	18	0.050		
0.049	1.23				36
0.047	1.19			3	
0.044	1.11	19			
0.043	1.09				32
0.040	1.02		0.040		
0.039	0.99			2.5	
0.038	0.95	20			28
0.034	0.87	21			
0.032	0.81		0.032		24
0.031	0.80	22		2	
0.028	0.71	23			
0.027	0.69				20
0.025	0.64	24	0.025		

thickness		steels	aluminum	lead	copper
inches	mm	(gauge)	(nominal thickness)	(lbs/sf)	(oz/sf)
0.024	0.61			1.5	
0.022	0.56	25			16
0.020	0.51		0.020		
0.019	0.48	26			
0.016	0.41			1	12
0.010	0.25		0.010	1	8

table b.16- maximum thicknesses to consider field forming

metal	maximum thicknesses to be formed using hand equipment
aluminum	.032″ | 0.081mm
copper	.024″ | 0.61mm | 16 oz
copper alloys	.024″ | 0.61mm
iron/ steels	.024″ | 0.61mm | 24 ga
monel	.024″ | 0.061mm
stainless steel	.019″ | 0.48mm | 26 gauge
titanium	.016″ | 0.41mm

Endnotes

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