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Mars, a Stepping-stone World, Macro-engineered

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Introduction

Geoscience is a never-ending pursuit of rock-related ultimates. There are three kinds of imperfections in humankind's knowledge of Mars: (1) intrinsic—spationauts cannot actually explore to Mars's center of mass; (2) unlinked theoretical idealizations—a planet with a closed Rock Cycle has no isolated systems; (3) "ground truth"—Geoscience lacks useful knowledge of all operationally relevant planetary constants for all Solar System planets. Future direct examination of Mars can cure two of these imperfections through practical data acquisition.

Acquisition of such data will involve pioneering humans in Macro-engineering event-processes seemingly encompassing a whole planet; actually, terraformers will demarcate the upper-lower boundaries of Mars's environmentally relevant crust based on the vertical range of their investigational instrumentalities of reconnaissance their mechanical means of surface travel and, as well, their ability to mobilize materials. Measurements of the Mars-crust, made from movable platforms conveying air-filled sealed homes and offices, will survey depth domains of particular interest. Exploitive macro-projects can then follow at sites deemed worthwhile for resource excavation, ore and fluid processing, industrial and residential use and final waste disposal. Every artful product of this far-distant human social group will be built on, in, or with these resources (topping an unfractured mantle), except those products that fly, float, or collapse, and these last three must start or end with some contact with Mars's soil-like surface material.

Nowadays, it is possible to imitate experimentally all temperature and pressure conditions that might exist inside Mars; subsequently, tentative conclusions derived from such experiments will be revised by extensive and intensive geological fieldwork at many places. The Martian's chief concern is Active Tectonics, which officially codifies all results from scientific observations of tectonic movements of parts of the Mars-crust that are occurring, or are expected to occur, within a period of vital concern to a particular human social group. A period of ~10,000 years or less, since that is a timeframe adopted by prudent Terran macro-engineers to ensure the natural total isolation of industry-generated radioactive wastes from the Earth-biosphere, seems most appropriate and the period selected permits Martian Macro-engineering's use of the tectonic "undulation theory" of planet-crust motion during a planet-specific Geological Time, a gravitational explanation first proposed by Reinout W. van Bemmelen (1904-83).[1] For this report, Active Tectonics encompasses all future Mars landscapes and seascapes resulting from the interplay of artificial climate and anthropogeomorphology *versus* natural and induced magmatism and unnatural crust tectonics.

Mars-crust as Kinetic Architecture

Mars probably consists of a number of concentric zones of different physical and chemical properties; with increasing depth the topmost zone—soon to become *Homo sapiens'* domain—becomes more and more complex, or simpler! Van Bemmelen identified planetary structural zones as "Stockwerke", and envisioned their vertical and horizontal movements following great inputs energy. Large bolide impacts,

causing extra-Mars energy to be shot into the planet's "Stockwerke", can heat the sub-aerial crust everywhere to its melting point, and energetic rocky ejecta (including rock vapor) can escape to space while, at the same moment, less energetic ejecta are globally distributed. Small surface-impacting bolides can affect the future domain of humankind, the "Stockwerke", by (1) disturbing CO_2 reservoirs consisting of dry ice, clathrate, and liquid carbon dioxide and by (2) rapidly injecting extra-Mars minerals and energy into the Mars-crust. Additionally, vaporized small bolides classed as ice/volatiles—"iceteroids"—can produce rapid changes in Mars's atmospheric composition and condition.[2]

Undoubtedly this has already happened, and it could again. If humans equipped with anti-bolide technology were actively present, and had a vital interest to prevent a normal event-process, then such cataclysms may not occur after settlement, ameliorated at reasonable cost. In that case, Mars's crust holds the long-term status of a protected and exploited lithotechnical system of rock formations influenced—ultimately to be controlled as a catastatic structure—by an ever-migratory *Homo sapiens*. Monitoring of the lithotechnical system and, perhaps, prediction of its state in the nearest and distant future will be one of the most important stages in the induced change from ecological expansion (imposed by Martian Terraforming) to ecological co-existence of biologically established people with Mars's solid and fluid material components. Our species' Earth-biosphere activities are remarkable: "The total earth moved in the past 5000 yr would be sufficient to build a 4000-m-high mountain range, 40 km wide and 100 km long".[3] Located at a single place, this is enough material—thicker and heavier than an Ice Age remnant—to activate a

localized (purely isostatic) vertical tectonic movement of the lithosphere. Martians may challenge that record for digging and piling!

Mars appears inimical to superficial Earth-life, and absent a closed Rock Cycle, the planetary crust must be intelligently altered and sensitively adjusted by any long-term future settlers by the bridled use of a truly comprehensive technology. The equivalent of "iceteroids" are thermo-nuclear explosives—huge subsurface explosions that create magma chambers and craters. The highest yield thermo-nuclear explosive so far exploded (in the Earth-atmosphere above Novaya Zemlya on 20 October 1961) liberated ~2.4 x 10^{17} joules by the annihilation of ~2.7 kg of matter. Some terraformers have opted to harness thermo-nuclear explosives in the complicated task of transforming Mars; it's an unnecessarily compromising way to proceed. Since it creates destabilizing and costly geotechnical macro-problems that must then be carefully considered and somewhat mitigated where necessary, violently fracturing the planet's crust is a counter-productive global Nature alterative technique.

A Crust-Infrastructure Mixture

"Infrastructure" is a broad term that refers to the overall system of services and physical facilities (involving transportation systems, freshwater supplies, energy distribution networks, waste treatment and disposal systems, and telecommunications networks) that are provided through public and privately financed activities. Ecology's popular "balance of Nature" propaganda line, established in 1779 by Jan Ingen-Housz (1730-99) when he discovered photosynthesis and conceptualized a

harmonious Earth-biosphere effective equivalence of animal and plant life, is a geophysical falsehood; its public denial ought to have come in 1879 after O.R. Lummer (1860-1925) and E. Pringsheim (1859-1917) proved experimentally that two objects anywhere in the Universe will mutually affect each other's motions and temperatures—any object at >0 K emits a continuous spectrum of electromagnetic radiation.

As living inhabitants of Earth, our ambitious species has endured technology's many vital breakthroughs and excitingly frequent breakdowns. To build an unbalanced artificial global Nature requires skills as yet unperfected and untested. Molecular nanotechnology's idealized machines, imagined by Micro-engineering's practitioners who don't yet fathom the full effect of Gremlins, may convey humankind to a planet-wide named Geological Time period and geophysical-state called "The End of Technology and the Beginning of Pure Art"! More concretely, John Heaver Fremlin (1913-95) during 1964 conceptualized a nightmarish future warehousing of $10^{16\text{-}18}$ humans held within a ~4.427 x 10^9 km^3 crust-enveloping building, a monumental ultra-computer regulated epidermis—a single shell-shaped geological formation made and typified by our species—covering Earth's surface at a distance determined by its present-day crust's highest elevation.[4] Fremlin's building would cause a closed Rock Cycle by capping. Atmospheric heating (forced by a near-Red Giant stage Sun)[5] will cause all lateral tectonic plate movement to naturally cease in ~2.5 x 10^9 years—the equal of a man-made cap. When that happens the primary magmas will equilibrate with the ambient phases at successively greater depths in the Earth-mantle accompanied by regular composition shifts (sub-

alkaline>mid-alkaline>alkaline).[6] During the same year, and in the same weekly popular publication that exposed Fremlin's bad dream, "Macro-engineering" first appeared—on 12 March 1964 in a New Scientist column at page 685 by "Geminus", entitled "It seems to me". Thus, it seems entirely permissible to think Mars's obvious hazards and ecological inadequacies eventually can be overcome economically; one result of the effort to transform Mars will be to embed various networked items of infrastructure within the Mars-crust, and to mix Martian life-support facilities through imbrications with planetary surficial features.

Advocates of "Footprints", a novel public relations idea that living standards and personal choices in life-style can be used to measure humanity's impact in the Earth-biosphere espoused by scientists such as William Rees and Donella Meadows, allege that if all humans lived like North Americans, it would require 2-3 planets exactly like Earth to support our present-day home-world's human population. Practically speaking, a Mars improved by *Homo sapiens* can only be ~25% of the volume of an Earth-biosphere. Today's Science leaders typically shun proponents of both Geoengineering and Terraforming because Macro-engineering, a practical umbrella term of art for both, empowers technology's managers and because they wish to clearly dissociate themselves in the public's mind from "oneiric macroprojects".

In 1848, John Stuart Mill (1806-73) had this to say about property rights to air: "If it became customary to sojourn long in places where the air does not naturally penetrate, as in diving-bells sunk in the sea, a supply of air artificially furnished would, like water conveyed to houses, bear a price: and if from any revolution in nature the atmosphere became too scanty for the [sic] consumption, or could be

monopolized, air might acquire a very high marketable value."[7] To forestall high-prices on a human necessity of life (in the private-sector economy or owing to confiscatory taxation in the public-sector economy), Mars must be terraformed by oneiric Macro-engineering so that its future trekking settlers need not wear spacesuits supplied with bottled air. Completion of such a macroproject—actually, an exercise in creative metabolism (from the Greek word meaning "alteration", "variation", "revolution" and "cyclic transformation")—will concretize the post-1972 vogue word "environment" and combine it with R.W. van Bemmelen's "Stockwerke" perspective. Theoretical terraformers attempt by speculative means, prognostic if not prophetic, to outline what *Homo sapiens'* next efforts ought to be.

Modern architect Rem Koolhaas (b. 1944) revealed one of the biggest philosophical problems nagging 21st Century oneiric Macro-engineering: "Beyond a certain scale, architecture acquires the properties of Bigness…. Bigness is ultimate architecture…. [Only] Bigness instigates the *regime of complexity* that mobilizes the full intelligence of [Hyper]-architecture and its related fields…. The absence of a theory of Bigness—what is the maximum architecture can do?—is architecture's most debilitating weakness….Big mistakes are our only connection to Bigness…. [The] attraction of Bigness is its potential to reconstruct the Whole…. Bigness destroys, but it is also a new beginning…. Bigness…is the one architecture that can survive, even exploit, the now-global condition of the *tabula rasa*: …it gravitates opportunistically to locations of maximum infrastructural promise, it is, finally, its own *raison d'etre*."[8] Koolhaas's "Hyper-architecture" is synonymous with "Macro-engineering"; but, more importantly, Koolhaasian "Bigness" correctly indicates

Macro-engineering's near-future scale, the scope of its prospective cost-benefit analysis/synthesis work, construction and demolition. In a word, Mars's crust, its future infrastructure, when it becomes a humanly useful mixture of natural and artificial components, a colossal composition that will be a new kind of global Nature, will be a Global Gizmo.

Infrastructure and Life-styles

By whatever means the new Martians first set foot on the planet—possibly by *circa* AD 2025—they will most likely dwell in inflatable composite habitats.[9] Balloons have been utilized in space (Echo 1 and 2 satellites during 1960-64), in the atmosphere of Venus (Vega 1 and 2 probes during 1985) and pneumatic buildings successfully function within the Earth-biosphere in multi-year "missions". Richard Buckminster Fuller's 1962 dome enclosing a large area of Manhattan Island, New York, is one of the really marvelous proposals in Macro-engineering. Graham A. Stevens, in 1967, designed and constructed his "Wavetube", a long self-supporting plastic tube stabilized by air over-pressuring, that provided a pedestrian river or lake crossing. However, these planned and tested buildings have several important negatives: a series of connected balloons constructed of membranes, which are sheets of material incapable for all practical purposes of resisting compression, bending, or shear but only tension, cannot be secure homesteads when the ground upon which they are set shakes violently (Earthquakes or Marsquakes). A better solution is Frei

Otto and Ewald Bubner's "Arctic City" of 1970-71, which is a pneumatically stabilized climate-regulating structural shell with a diameter of 2 km.

Still, considering *Homo sapiens'* profound ignorance of Mars Active Tectonics and the risks imposed by destructive cosmic radiation, it might be safest to lodge and shield all explorers and settlers in movable (*via* telescoping mechanical legs and by hover-crafting), 3 km-long tension-structure buildings like Archigram's "Walking City" (1964)[10] designed by Ron Herron (1930-94). It is possible to build such vehicle-cities because there are actually buildings that move at the USA's Cape Kennedy—the Vertical Assembly Building (VAB) on Merritt Island that first served the Advanced Saturn C-5 Launch Complex 39 and now is used to service the Space Shuttle. The VAB has a volume of 3.765×10^6 m^3. A platoon of "Walking City" urban regions, with the characteristics of artificial armadillos, are meant to house a large population of world traveler-workers, moving on to wherever the Martian economy and society dictates. Moving under their own volition, "Walking City"-type buildings will insert their extractive mechanical tubes into the underlying Mars terrain from which they shall draw raw materials and energy. "Walking City" is not that far removed from the no-need-for-mobility supposedly imposed on Earth's Macro-engineering by the microchip's mid-20^{th} Century invention.[11]

Previously I have opted to quickly terraform Mars using US Patent 4,795,113, issued in 1989 to Michael A. Minovitch. Such use, it was contended, would release fluids and gas—especially CO_2—from Mars's crust, causing the build-up of an atmosphere in which non-spacesuited spationauts might walk and talk with comfort.[12] While I don't disavow that macroproject, it now appears that building a Minovitch-

style facility in Mars will be too challenging technically. So, to cure the Mars settler's macro-problem relating to their need to place objects in orbit of Mars and to ship things to Earth, I propose they opt for US Patent 3,131,597, issued to Jules Gram and Charles Smith in 1964. Both expired patents legally protected a means to launch spaceships—Minovitch wanted an electromagnetic method while Gram-Smith chose a hydraulic steam-hydrogen method—that are unique, but site-specific. The chief difference between the two spaceship acceleration schemes (to Mars orbit and to Mars escape) is that Gram-Smith cannot launch living passengers, only freight, due to its high-G capsule take-off. A unique spin-off of the Gram-Smith machine is its post-discharge causation of a large-scale, widespread precipitation of freshwater onto the surrounding countryside; a fallout sure to instigate site drainage difficulties, a local water table rise and other undesirable hydraulic macro-problems following its first controlled blast issuing from the steam-hydrogen cannon. That's another good reason why off-the-ground surface facilities are best.

Atmosphere enhancements for Mars

Nick Hoffman, Senior Research Fellow in the Department of Earth Sciences at the Victorian Institute of Earth and Planetary Science associated with La Trobe University in Australia, proposes that a large amount of CO_2 is present below Mars's reddish-colored surface rocks, stones and soil-like materials in the forms of dry ice, a mixture of frozen carbon dioxide and water (clathrate) and even as a very cold liquid. Though some NASA officials consider his "White Mars" theoretical viewpoint geologically quite bizarre, I've adopted his perspective because I wish to impose a

maximally unfavorable landscape change scenario upon future Martians. Hoffman's "White Mars" theory has drastic implications for any Mars terraforming attempt: "On the plus side there is probably more [water] ice on Mars than a conventional Blue [Mars] model would predict. On the minus side, there is no 'former state' of the planet to which we can return. We would be [Macro] –engineering Mars *de novo*. The conditions that may be created in a newly terraformed world will render large tracts of the subsurface…unstable. One could…kick off massive CO_2 outbursts which would not be as tidy and survivable as the [water] floods in Kim Stanley Robinson's…descriptions of a terraformed conventional Mars."[13] Topographical instability promotes adoption of "Walking City"; highly mobile housing and work exploration-exploitation platforms, with the capability to rapidly self-elevate should conditions demand, is a promising technically sweet solution, responding to any and all of the threats vividly elaborated by Hoffman.

Homo sapiens and its industries are usually assumed to be a large source of CO_2 gas emissions into the Earth-atmosphere, an injection alleged in the public media to be causing a warming of the planet's climate system that will impact terrestrial and oceanic ecosystems.[14] After 3 July 1909, it became technically possible to convert atmospheric nitrogen into ammonia and then into fertilizer. That chemical processing enriched Earth's earth, and subtracted nitrogen gas from a planetary atmosphere that is still ~79% nitrogen. Fertilizer can be made on Mars by "Walking City"-style factories, drawing from the present-day atmosphere consisting of ~2.7% nitrogen gas. However, it is the emission of carbon dioxide gas by mankind that seems to be adversely affecting the Earth-biosphere. One of Macro-engineering's proposed

counter-actions is carbon dioxide sequestration; much R&D remains to be done during this century to discover ways to capture and store CO_2 cost-effectively.[15] But, like so many Geoscience facts, there's a macro-problem: if atmospheric CO_2 were removed at once, then the subsequent ~3% decrease in today's Greenhouse Effect would lead to a mere 1^0 C reduction in Earth-normal global air temperature and, as well, most green plants will die. If all that carbon dioxide gas were solidified it should form a ~2.5 mm-thick friable global stratum of Anthropic Rock.[16] (By contrast, the infamous natural global K-T Boundary—that is, the clay layer dividing the more recent Tertiary and the earlier Cretaceous—is only ~12 mm thick.)

For millennia mankind has dug and piled rocks. Contemporary vertical tectonics give evidence of humanity's vigorous satisfaction of its Earthly material needs and wants.[17] The same is bound to be true for future Martians. Making Anthropic Rocks from a surplus atmospheric gas seems doable and okay, especially in order to properly maintain the Earth-biosphere. It also gives Terraforming a tested stylization model. Quite aside from the theoretical pecuniary costs imposed by "global warming", big international insurance corporations, who have a vested financial interest in promoting horrific "global warming" propaganda, already impose hefty real monetary costs on the consumer for the mere threat of a catastrophic Earth-atmosphere warming.[18] "Save Our Planet", today's weird general fossilized subjunctive radical Green slogan ultimately will be forgotten, made irrelevant by dynamic event-processes undertaken by Macro-engineers working diligently on Mars's terraformation. Mars or Earth-based insurance company rip-offs will be disallowed!

The highest elevation on the Eastern Seaboard of the USA (~165 m ASL) exists on Staten Island, New York. It is the world's largest landfill, Fresh Kills, accumulated from 1948 until 2001.[19] Before any material can be a waste, it must be discarded. When they are extant, each "Walking City" will recycle its harvested resources as much as practicable, thereby adding few "wild card" elements to Mars's changing atmosphere. However, defining a suitable level of durability—the ability of a building to perform its required function over time in spite of degrading sub-aerial forces that act upon it—for any "Walking City" means first defining the service life of a proto-machine. Like Earth-connected cities, a "Walking City" ought to be sturdy, with a long design service lifetime, and not to become obsolescent because of a change in Martian requirements or expectations regarding their use. Only a few popular experts, among them Chiles[20], Perry[21], Spinney[22] and Zalasiewicz[23] have even hypothesized about the durability of Earth-normal cities or NASA's VAB and so, as yet, there is no helpful data permitting a credible durability assessment of Mars's first "Walking City".

Nevertheless, it is possible to foresee a planet development scenario focused on the geological effects of Martian vehicular-cities on the Mars-crust and its enveloping unmodified atmosphere. A rock-like glassy material resulting from *in situ* plasma vitrification of non-recycled "Walking City" wastes will emit various gases along with the processes used to make ceramics for assorted fixed facilities.[24] The "Glass Ocean"[25] macroproject plan, a Japanese originated concept that uses heated soil-like materials or molten basalt to store solar energy that is later recovered *via* mechanical and/or electronic means, if applied to Mars would greatly stimulate gasification of

impacted carbon dioxide deposits inherent in Nick Hoffman's "White Mars" theory. All these portend a CO_2 atmospheric build-up, stimulated by pioneer humans removed from Earth, connected only by an interruptible lifeline (spacecraft fleet).

Waste Element Liquefying Devices (WELD)[26] used to repair dangerous Mars-crust cracks or to intentionally liberate dangerous pockets of sub-surface carbon dioxide may also change the planet "forever". Heat generated by nuclear fission waste products is capable of melting the ground beneath a high-density capsule; a container will sink for decades at an initial daily rate of the order of tens of meters. Necessary WELD capsule cooling is automatically provided by melting of the rock through which it passes, and sealing of its vertical or sloped trail occurs because of the melt's rapid solidification above the descending capsule.[27] Solidification of artificially melted soil-like materials and recycled Sedimentary, Igneous, Anthropic, and Metamorphic rocks creates a new Anthropic Rock no less, and no more, competent than any unfractured plutonic rock. Earth's Rock Cycle takes hundreds of millions of years, but it eventually renews the face of the Earth because it is closed, as R.W. van Bemmelen assumed. Mars probably has an open Rock Cycle.[28] It is conceivable that WELD can function as a catalyst commencing a cylinder of rising magma, a Mars-crust plume, something akin to the mantle plume under Iceland. Wherever a plume breaks the Mars-crust, encountering the atmosphere, volcanism and an outflow of lava will take place; since rising magma and extruded lava move very sluggishly, both could be classed as a convecting fluid with a crystalline structure! As soon as Mars probe-landers gather samples for analysis, it will then become possible to discover their physical and chemical characteristics.

Probably the first modern attempt to describe an artificial Earth satellite was published during 1869-70 by Edward Everett Hale (1822-1909). In "The Brick Moon", and its sequel, "Life in the Brick Moon", both stories serialized in Atlantic magazine in the USA, he sketched in entrancing prose the accidental launch by gigantic flywheels of a manned satellite consisting of several hermetic spheres built with thousands of kiln-fired clay bricks. His synthetic rock satellite had been intended to function as a navigational aid for the Great Naval Powers and commercial shipping companies. Were one circling Mars like Phobos and Deimos, a baked brick satellite would finalize a Mars closed Anthropic Rock Cycle. In other words, new Martians may shoot a ceramic cannonball from Mars, an orbiting sphere or cylinder-shaped Time Capsule used to demarcate the Martian territory geodetically like Earth's LAGEOS.[29] If terraformers emplace an ocean on Mars, the Time Capsule will also serve to help ship captains find their latitude and longitude during daytime and clear nights!

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