On the Fringe of Science

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Extreme environments are steeped in a mythology of the frontier. Even in an increasingly interconnected and homogenized world, these places, located at the edges of known geography, retain an air of mystery left over from an earlier age. Writer Sarah Wheeler describes Antarctica, for example, as a place that "exist[s] most vividly in the mind...a metaphorical landscape, and in an increasingly grubby world it ha[s] been romanticized to fulfill a human need."[1] There is, perhaps, no other site comparable to the moon in this respect. Staunchly positioned in the Final Frontier, the moon is one of the most extreme places that humans have experienced directly; it is a site that, for a majority of people, is only accessible indirectly, through scientific representation and legendary tales of exploration.

Designing architecture for extreme environments is appealing, in part, because of the challenge of dealing with so many constraints. Climatic conditions are impossible to ignore, logistical realities must be confronted, issues of efficiency and environmental impact drive decision-making. There is an underlying sense of science in the design methodology: an alluring pretense of universal rules…and a feeling that somehow, architectural decisions can made in a way that is less arbitrary. Overwhelming functional challenges overshadow less pragmatic criteria and, ironically, seem to simplify the design process by mechanizing it.

Perhaps this shift towards a more "scientific" architecture is part of a larger trend that Ulrich Beck calls the "complete scientization" of knowledge in the current age of "ecological enlightenment."[2] Beck argues that contemporary society, which he calls Risk Society, is characterized by the awareness, avoidance, and production of risks, many of which are ecological in nature. Global climate change, environmental destruction, and chemical toxicity, are problems which are global in scale, represent irreversible harm, and cannot be discerned through casual observation. Navigating these risks requires the employment of scientific methods to measure increasing complicated (and otherwise imperceptible) environmental phenomena. Data must be gathered and decoded by "experts." Scientific knowledge becomes a prerequisite for action. Extreme environments, one might argue, are places in which this contemporary condition – of ecological risk and the perceived need for science – is exaggerated.

Then again, maybe the extreme-environment-trend is just a way of infusing an artificial edginess into architectural discourse; if the building itself doesn't offer anything radical, there is, at least, an interesting place to talk about.

This article examines two extreme sites: the polar wasteland of Antarctica, and the contentious Negev Desert in Southern Israel. In Antarctica, the notion of science (and scientific research) has been used to justify large scale territorial claims and the reorganization of a continent. The Negev Desert example, in contrast, zooms-in to the comparatively tiny scale of a single architectural intervention, examining the role of science in a particular design process. While these two case studies are vastly different in scale and scope, they offer two points of entry into the Piranesian space that is the intersection of science, design, politics, and "ecological enlightenment".

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[1] Wheeler, Sara. *Terra Incognita*. London: Jonathan Cape. 1996. Page 3.

[2] Beck, Ulrich. *Ecological Enlightenment: Essays on the Politics of the Risk Society.* Translated by Mark Ritter. Atlantic Highlands, New Jersey: Humanities Press, 1995. Page 3. Originally published as Politik in der *Risikogesellschaft* by Suhrkamp Verlag Frankfurt am Main 1991. Page 59.

In extreme environments a scientific approach to building seems appropriate, even inevitable. Yet, architecture that rejoices in its own scientific-ness should be approached with skepticism. Measuring success in terms that are purely technical or "scientific" can obscure social and cultural aspects of a project, creating the illusion that architecture can exist outside of the complexities of a political situation. In extreme cases, feigned objectivity dominates, fabricated statistics abound, and critical thinking is thrown out the double-pane low-e window.

Antarctica: Lessons Learned

Despite their opposite temperatures and vastly different physical scales, Antarctica and the Negev actually share a surprising number of commonalities – remote location, extreme desert climate, limited access to building materials, and unstable territorial status. In both places, boundaries remain unclear, sovereignty is contested, and local happenings are inseparable from global politics. There are few places on earth besides Antarctica and Israel where territorial sovereignty is still a matter of debate, where architecture has been used so overtly as a mechanism for controlling space, or where the notion of "frontier" still looms so large.

The Antarctic Treaty, ratified by the governments of 12 signatory nations in 1961, and legally designating Antarctica as a Global Commons[3], is often touted as a radical example of global cooperation. John Vogler, perhaps over dramatizing slightly, calls it "the closest thing to a 'world order miracle' that the world has known."[4] Governments set aside their conflicting territorial claims to declare that "in the interest of all mankind…Antarctica shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord."[5] Publicly, this agreement was made in an effort to extend the scientific cooperation initiated during the International Geophysical Year. In reality, however, it was a bit more complicated.

Between the turn of the century and the 1950s, seven nations (The UK, New Zealand, Australia, France, Norway, Argentina, Chile) made formal land claims to Antarctica. The results of abstract cartography, these claims were defined only by longitudinal boundaries and share the bizarre feature of converging at the South Pole. Several claims also overlapped. In the late 1950s, despite disagreement over land claims and mounting Cold War tensions, thousands of scientific researchers descended on Antarctica under the auspices of the International Geophysical Year (IGY), perhaps the most complex international scientific event ever undertaken. It was an unprecedented success.

It was also an opportunity for national governments to increase their presence in Antarctica without taking part in the land claim controversy. For example, despite significant investment in this frontier of modern science, the US government had yet to make a formal land claim to Antarctica. Historian Kieran Mulvaney surmises that "the view steadily evolved in Washington that the country's desired aims [i.e. control over the largest practicable area possible] could be achieved just as easily, or even more so, without claiming territory."[6] At a 1955 IGY planning meeting, when the USSR announced its plans to build a station at the South Pole, committee

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[3] A term used to refer to "areas or resources that do not or cannot by their very nature fall under sovereign jurisdiction." See Vogler, John. *The Global Commons: Environmental and Technological Governance*. New York: John Wiley & Sons: 2000. Page 1.

[4] Vogler quoting Falk, 78.

[5] As stated in the preamble to the Treaty. National Science Foundation Office of Polar Programs (OPP) website. www.nsf.gov/od/opp/antarct/anttrty.jsp

[6] Mulvaney, Kieran. *At the Ends of the Earth: A History of the Polar Regions*. Washington: Island Press, 2001. Page 135.

chairman Georges Laclavére countered that the US had already begun working at that site, and that, since all resources would be shared, two bases there would be repetitive. In reality, it wasn't until the following year that the Eisenhower administration agreed to allocate funds for the project.[7] Construction of the Amundsen-Scott South Pole Station began in 1956, under the direction of Navy Admiral George Dufek, who also happened to be the tactical leader of the US Navy's "Operation Deepfreeze." Thus, in the name of research and cooperation, and with the blessing of the international scientific community, the US government built a building at the Pole and occupied the Southern end of the earth with American armed forces.[8]

The IGY's precedent of international cooperation in the name of science was an inspiration at the US-initiated talks that followed over the next few years. In 1961, representatives from the 12 nations whose governments had built facilities in Antarctica ratified the Antarctic Treaty System, freezing all existing land claims and awarding the signatory nations "complete freedom of access at any time to any or all areas" on the continent.[9] Other governments could become involved in Antarctica by demonstrating "significant interest" in the continent, which meant, by constructing a scientific research facility on the ice.[10] With that, architecture became the buy-in price for a seat at the Antarctic table.

The elitism of this "Antarctic Club" was challenged in the 1980s, as visible public debate erupted. New evidence suggested a vast array of mineral riches lay trapped beneath Antarctic ice caps and other nations[11] wanted access. Meanwhile, researchers at the British Antarctic Survey base at Halley Bay discovered a large "hole" in the ozone layer above the continent. World CFC pollution was, they argued, being registered above Antarctica; the earth's atmospheric systems were interconnected and Antarctica needed help. The continent's image was made-over; a once foreboding frontier suddenly became a precarious fragile ecosystem. A UN-sponsored report, *Our Common Future*, better known as the Brundtland Report, addressed long-term strategies for sustainable development of the global commons: Antarctica, the moon, the high seas, and the geosynchronous orbit. The report declared Antarctica an invaluable scientific archive and initiated a preservation effort that would eventually lead to the adoption of the 1991 Environmental Protocol, which designated Antarctica a "natural reserve, devoted to peace and science."[12]

Yet, like 30 years prior, underneath the positive rhetoric of scientific research lurked a reality of state-centered, self-interested, Antarctic activity. The US expanded its polar operations, building an "ice highway" half way across the continent, despite disapproval from other governing parties. And the jury is still out on the efficacy of the Protocol's mining ban, especially after Mr. Qu Tanzhou, director of the Chinese Arctic and Antarctic Administration, made a public statement

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[7] Mulvaney 140.
[8] The military occupation of Antarctica was supported by anti-communist propaganda back in the US. A 1959 article in *Missile and Rockets* published the following sentiment: "At the frozen bottom of the earth Russia is moving into a position from which its missile squadrons could outflank the free world. Half of Antarctica is rapidly turning from white to red…" (Mulvaney 143).
[9] www.nsf.gov/od/opp/antarct/anttrty.jsp
[10] See The Antarctic Treaty (1961). Article IX, Section 2.
[11] In a 1982 address to the UN General Assembly, Malaysian prime minister Dr. Mahathir Bin Mohamad likened the Consultative Parties' control over Antarctica to colonialism, proclaiming "the days when the rich nations of the world can take for themselves whatever territory and resources that they have access to are over." (Suter, Keith. *Antarctica: Private Property or Public Heritage?* Leichhardt: Pluto Press Australia, 1991. Page 77.) The governments of India and Brazil were also instrumental in expanding the ranks of consultative party nations.
[12] Protocol on Environmental Protection to the Antarctic Treaty (1991). Article 2.

earlier this year concerning China's intentions to investigate possibilities for Antarctic mineral extraction.

In Antarctica, the rhetoric of science has been used to advocate for territorial control. While individual polar scientists may not have an explicit political agenda vis a vis Antarctic sovereignty, their research is still embroiled in a global political context. The next example, concerning an individual building project in the Negev, addresses how scientific rhetoric can have the unintended consequence of obfuscating the relationship between a building and its political context.

The Negev: a design problem.

Lotan is a Reform Kibbutz established in the early 1980s in the Arava Valley, a sub-region of the Negev Desert occupying a thin strip along the Eastern border of Israel. The kibbutz is home to the Center for Creative Ecology, a hub for environmental education offering classes and workshops on permaculture and alternative building methods. "Eco-volunteers" live in "domes" built from mud and strawbale, recycle their wastewater, cook in a solar oven, and use composing toilets. The CCE has had a major impact on the kibbutz, which is now working to develop its image as an eco-tourism destination.

The project at hand was to design a new library for the CCE that would have a minimal energy footprint.[13] The plan was to follow the basic tenants of bioclimatic design, a methodology for translating climate data into architecture, and to use quantitative energy data (gathered through thermal simulations and embodied energy calculations) iteratively throughout the design process.

However, despite the utility of bioclimatic design, its methodology proved to be surprisingly un-adaptable. Following its rules required making assumptions about the validity of the data on which design decisions were predicated and its technical vocabulary precluded a discussion of site conditions that were not, specifically, climate-related. When "success" is strictly quantified in terms of energy use, "value" is measured only in terms of technical performance: "good" architecture functions efficiently and the importance (or relevance) of non-quantifiable factors – aesthetics, social issues, cultural readings, symbolism, meaning – is downplayed. Carbon is more than a universal currency, it is a metaphysical metric.

A Technical Approach: Pragmatic issues.

When it comes to reducing energy use in buildings, there are basically two camps. The proponents of "operational energy analysis" argue, as John Straube does on buildingscience.com, that "scientific life-cycle energy analyses have repeatedly found that the energy used in the operation and maintenance of buildings dwarf the so called 'embodied' energy of the materials."[14] The opposing argument is that in order to truly understand a building's environmental impact, one must consider the full range of energy consumed across all phases of production, maintenance, and eventual disposal of building materials. This systemic approach advocates for a "life-cycle assessment" of the energy "embodied" in building materials. A range of digital tools and strategies help architects simulate the operational energy use of the buildings they design and calculate the embodied energy of materials and construction methods. These

[13] The project was a collaboration between myself, Alex Cicelsky, and Nora Huberman-Meraiot, advised by David Pearlmutter and Isaac Meir.

[14] Straube, predictably, offers a statistic to prove his point: "Cole and Kernan (1996) and Reepe and Blanchard (1998) for example found that the energy of operation was between 83 to 94% of the 50-year life cycle energy use." http://www.buildingscience.com/documents/insights/bsi-012-why-energy-matters/

tools share an underlying assumption that making good architecture requires quantifying not only site conditions, but also most aspects of the building design.

With the Negev project, the plan was to use a newly-developed “energy optimization framework”[15] that combines a thermal simulator (Quick) with embedded embodied energy data, making both types of analyses available via a single interface. However, a number of problems arose in practice. Much of the data was, I felt, of questionable accuracy (despite its impressive precision!) Simulating a building’s thermal performance often requires producing a digital model that is simplified to such a degree that its relationship to the actual design is debatable. And when calculating embodied energy, industry precedent seems to mean disregarding margin of error, and glossing over frequently made approximations.

A number of attributes of the building were impossible or extremely difficult to model using the thermal simulation software. These included a vaulted roof, a layered wall system that was alterable throughout the day, and a wall section with complex geometry (designed to shade inset windows and minimize glare reflected from the ground). The software permitted only a flat or inclined roof and wall systems were assumed to be static, perpendicular to the ground plane, of consistent width, and made of conventional materials. Part of the problem could have been mitigated by using more sophisticated software, but the fact remains that it is only possible to model something which can be described using the presets in a pull down menu (running counter to innovation, a core impulse of design.) If the model used in energy simulations is a simplified/abstracted version of the building designed (which is, often not equivalent to the building which will eventually be built), then shouldn’t data be accompanied by an indication of the margin of error inherent in the calculation process?

When calculating embodied energy, the margin-of-error problem was compounded. First of all, it is theoretically impossible to compute an actual, absolute value for an object’s embodied energy -- the sum total of all the energy that went into producing that object and transporting it to where it is right now. Embodied energy can only be calculated relative to a limiting “system boundary,” the placement of which is somewhat subjective and often ignored. In practice, calculating embodied energy more often involves adding up the total volume of a particular material used and multiplying that by the material’s “embodied energy constant.” (A Wikipedia search will quickly reveal the “EE values” of various common materials.) These “constants” are empirically derived averages, calculated via opaque methods. Given the hyper-specific factors impacting embodied energy (how many miles was the material transported, what transportation method was used, etc.) the very idea of a universal constant is paradoxical.

Even though the EE values we used were specifically derived for the Negev Desert region,[16] there was still a substantial amount of personal discretion, approximation, and subjective decision-making embedded in the data. The inherent fuzziness of the calculation methods raises questions about accuracy: can we realistically expect more precision than simply an order of magnitude? If not, do these calculations tell us anything that we didn’t already know? For even without data, it’s fairly intuitive that mud bricks will have a lower embodied energy than steal beams.

As if these were not problems enough, there were also, obviously, aspects of the design that defied measurement altogether. For example, in Lotan, the benefits of mud as a building material

[15] This energy accounting tool is currently being developed by Nora Huberman-Meraiot as part of her doctoral work at Ben Gurion University.

[16] By Huberman-Meraiot, as part of the research done during her Master’s program. Despite obvious variation across the Negev, these numbers were used as there was no EE data for the Arava Valley or Lotan, specifically.

extend beyond low cost and negligible embodied energy. Mud offers an aesthetic quality that is unmistakably associated with the Natural Building movement's ethic of holistic, organic, down-to-earth responsibility; the assumption on Lotan is that a mud building is a building you can feel good about living in. Though impossible to quantify, this benefit is significant.

Energy data, though fallible, imperfect, and incomplete, is often viewed as objectively generated scientific evidence, which is then presented with the positivist power of fact. Numbers, despite a lack of transparency concerning their creation, have a powerful rhetorical value.

Defining the Desert: Is climate enough?

Energy Aspects of Design in Arid Zones, a primer for bioclimatic design in the desert, begins with a section called "The Desert – What is it?" that contains the following definition:

> Empirically, it is possible to define the desert as an arid area, wherein the quantity of precipitation is small and irregularly distributed…there is a basic difficulty in defining 'the desert' because of the great variety of characteristics in different areas. An exact definition needs to be multi-disciplinary.[17]

The "multi-disciplinary" definition offered in the text incorporates thresholds for "moisture index," "quotient of variation for rainfall," and "deflation" (transport of sand and dust by wind). Ironically, even after acknowledging the need for a "multi-disciplinary" understanding, this picture of the desert is purely technical – a landscape of statistical averages.

As far as the bioclimatic design methodology is concerned, a desert is a desert. It is unimportant that Lotan is located 2km from the Jordanian border; or that Negev Desert lies just south of the oldest continually inhabited city on the planet (either Jericho or Damascus, depending on who you ask). It is unimportant that semi-nomadic Bedouin have inhabited the Negev Desert for at least 4,000 years[18] or that any building on a kibbutz in the Negev is somehow embroiled in Zionist frontier mythology, summarized in Ben Gurion's famous pronouncement to "bloom the desolate land and convert the spacious Negev into a source of force and power, a blessing to the state of Israel."

Alice Gray writes about two paradigms that have driven Israeli development in the Negev: the idea of "redemption of the land" and the "concept of ethnocracy," which she defines as allocating resources primarily for Jewish use, to the disadvantage/disenfranchisement of other ethnic populations, the Bedouin, in this case.[19] Eyal Weizman, in his article "Principles of Frontier Geography"[20] addresses the insidious role that the Negev plays in contemporary politics in the region. Weizman argues that it is the very idea of the frontier – a territory that is, by definition, understood as being peripheral, indistinct, and indeterminate – that allows for a suspension of civil and international legal conventions, and a perpetuation of violence. Weizman writes: "frontiers offer a variety of zones of legal exception where crime and murder are possible…a

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[17] Page 1-2.
[18] And perhaps as much as 7,000. See Martin Ira Glassner (January, 1974). "The Bedouin of Southern Sinai under Israeli Administration." *Geographical Review* 64 (1): 31-60.
[19] Gray, Alice. *Babylon Journal on the Middle East and North Africa*, Volume 5, September 2007. See http://www.bustanqaraaqa.org/al2/web/page/display/id/19.html. A more in depth explanation of the concept of "Ethnocracy" can be found in Oren Yiftachel's " 'Ethnocracy': The Politics of Judaizing Israel/Palestine."
[20] In *City of Collision*, by Birkhauser in 2006.

shifting legal geography of exception positioned outside the conditions of modernity and progress."[21]

No matter, though. A desert is a desert.

Bioclimatic design feels like Modernist functionalism, updated for a post-energy crisis world. It may be hyper-contextual in terms of climate, but it is anti-context with regards to everything else. Ironically, despite its technical language, it is not without an underlying sense of morality. Another excerpt from *Energy Aspects of Design in Arid Zones* reads:

> Different species of flora and fauna have successfully adapted themselves to desert conditions. Through these adaptation processes, a dynamic balance was achieved…this is a delicate balance and an uncalculated (and uncaring) interference could disrupt it, causing irreversible changes in the entire system.[22]

The desert is a fragile ecosystem and to upset its "natural balance" would be "uncaring."

Bioclimatic design doesn't claim to have a political agenda, but its refusal to engage the socio-political context of architecture is, itself, a political act. Taking a position that the numerical is the only "value" necessary, is still taking a position -- all the more dangerous because of the way it feigns objectivity, neutrality, impartiality…indifference.

In *Risk Society: Towards a New Modernity*, Ulrich Beck describes how, in classical Industrial Society, people were concerned "exclusively with making nature useful, or with releasing mankind from traditional constraints,"[23] whereas members of contemporary "Risk Society" have the additional burden of trying to forestall the problems imposed by modernization itself. These problems, according to Beck, can only be understood through science, and yet, they are also caused by science.

As science is increasingly viewed not only as a means of solving problems, but also as a potential cause of problems, Beck argues that science's monopoly on the production of truth is eroded. Beck specifically sites the emergence of environmental research in the United States in the 1970s as an example of this, arguing that as biologists demonstrated the destructive ecological outcomes of industrialized progress, one version of scientific "truth" was poised against another.[24]

Risk management depends upon scientific descriptions and data – simulated scenarios and calculations of probabilities of future occurrences. However, Beck warns, this type of information is not enough; decisions must take into account a social context. How else can one weigh potential scenarios to determine which risks are acceptable and which are too great? For Beck, this risk-oriented social rationality – necessitated by relentlessly conflicting information and competing viewpoints – challenges the scientific "monopoly on rationality."[25] Yet ironically, just as universal claims of scientific knowledge are deteriorated, social circumstances validate their

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[21] Weizman Page 91.
[22] Page 1-2.
[23] Beck, Ulrich. *Risk Society: Towards a New Modernity*. Translated by mark Ritter. London: Sage Publications, 1992. Page 33.
[24] Beck (*Risk*) 162. Ironically, this challenging of science's claims to objectivity results not in a dismissal of scientific knowledge, but rather in a tendency to try to discredit one scientific claim by arguing "even more scientifically" (Beck (*EE*) 80).

[25] Beck 29.

necessity: “scientific rationality without social rationality remains empty, but social rationality without scientific rationality remains blind.”[26]

Architects and building scientists should heed his warning. Energy metrics are here to stay, but the reality they feign – where a building can exist outside of a cultural context, where science is separate from politics, where architecture is “technical” and devoid of meaning – is an illusion.

[26] Beck 30.