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Resonant worlds:

Cultivating proximal encounters in planetary science

ABSTRACT
Planetary scientists are adept at producing knowledge about objects that are far removed from their lived experience of place and time. Sometimes, they overcome this distance by positioning Earth as a planet that can stand for other worlds. Encountering Earth becomes an encounter with another planet. When scientists experience the Earthly as otherworldly, they sometimes feel an excitement here described as "resonance." Fully felt resonance is rare, but scientists devote much time and effort to preparing for it so as not to miss its fleeting instances. Just as resonance affords scientists the possibility of experiencing the distant, it also describes moments when the anthropologist is in harmony with what had previously been strange. Thus, resonance is a mode of cognitive and affective reasoning that collapses distance and transforms the similar into the same. [*analogy*, *planetary science*, *resonance*, *anthropology of science*, *outer space*]

The Utah desert in November is dusty, gray, and chilly. According to some, it is also otherworldly. I am here with three NASA scientists to consider the accuracy of that claim—for research purposes, would studying the geology of this region provide insight for understanding the geology of Mars? This is the third day of our trip, based out of the Mars Desert Research Station, and we have spent our time traveling between landscapes, traversing red-tinted, Mars-like rocks, and now collecting soil samples in a grayer, more lunar setting. Most of the conversation concerns whether this soil is fine enough for the drill the NASA team is developing to burrow down several meters. Carol Stoker, the principal investigator, takes a soil core sample while a graduate student, Julia, and I assist.[1] At previous sites, we had perfected the collection protocol, and the three of us now methodically bag and label samples as Stoker digs deeper into the ground. Her chief engineer, Devon, wanders over to the foot of a nearby butte to see if the soil is looser at a slightly higher elevation. Satisfied that we have properly assessed the merits of this area, Stoker asks us to begin packing up the equipment. I blow into my frigid hands and eagerly begin carrying the gear cases back to the van parked on the nearby dirt road.

I am halfway to the van when the mood behind me changes. Stoker, Julia, and Devon are suddenly excited and animated. I hear shouts of delight and return to see what is going on. They are engrossed with a large field of spherical gray rocks a few meters from where we had been collecting. I watch as they frantically bag these rocks, disregarding the collection protocol we had spent the day perfecting. They are laughing and smiling, thrilled by these little rocks that to me seem insignificant. I try to join in the excitement, but all I see is a monotonous landscape. When they calm down enough to explain why they are excited, Stoker briefly answers, "These are like the blueberries on Mars." I realize that though I am standing in Utah, my interlocutors have the excitement of explorers who have made their first steps on Mars.

The thrill experienced by these scientists in this moment of recognizing the alien in the familiar, seeing Mars in something on Earth, was unlike any other moment of our trip. As I will explain, Stoker called the formations "blueberries" as a shorthand for a peculiar formation on Mars (called concretions on Earth) photographed by the *Opportunity* rover. Though she used the language of analogy,

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stating that rocks on Earth are "like" blueberries on Mars, the affect of my interlocutors when they stumbled on these formations—their excitement and laughter—indicates that there was a different relationship at work among themselves, these rocks on Earth, and the blueberries of Mars. More than just observing similarity, Stoker and her crew conflated the proximal and the remote. They substituted what is "here" for what is "there." This allowed where we stood on Earth to become grounds for knowing Mars. In studying Earth, scientists are studying other worlds.

How do we come to know the distant? How do places here come to stand for places there, and through what mechanisms are these connections forged? My answer comes in the form of *resonance*, a concept that describes how the knowing and sensing subject detects and amplifies connections between discrete, distant objects and worlds. In acoustics, resonance describes a vibrational excitement. As an analytic, resonance retains this attribute of physical excitement, exemplified by the enthusiasm of Stoker, Julia, and Devon. But as used here, resonance also signals a cognitive shaking up of a scientist's object of inquiry. In tracing these resonances, one can understand how the nearby object comes to stand for, perhaps even becomes, the distant. Resonance is not simply the acknowledgment that the near object is *similar* to the one belonging to a different place; rather, for the scientist experiencing a moment of resonance, the two objects *are* each other for however fleeting a moment. This is one way that it becomes possible to know worlds removed in time and space.

Contemporary practice in the planetary sciences depends on making and trusting knowledge claims concerning the distant.[2] Analogical reasoning is deeply important for this training and practice. The blueberry example illustrates a rare, thrilling moment when researchers transcended analogy and encountered the illusive and distant thing they studied. There was no other moment in my fieldwork quite like this. And yet, several other times I became aware of how scientists were configuring Earth as Other in the service of studying planets even more distant than Mars. I will present an example of this drawn from exoplanet astronomers, who study planets orbiting other stars. Lacking the kinetic excitement of the blueberry discovery, this example will instead illustrate a community preparing for and desiring a moment of resonance. It will also show the time and training needed to become sensitive to distant, if powerful, resonances.

From 2009 to 2011, I conducted ethnographic fieldwork both with NASA researchers studying Mars and university astronomers searching for and analyzing exoplanets. These scientists were forever striving to make remote planets knowable. Unlike Mars, exoplanets are invisible to today's telescopes. Many of the astronomers whom I worked with or spoke to were focused on finding not just any exoplanet but one that they could consider Earthlike. For these astronomers, it is an informative exercise to study our own planet as an exoplanet. Unlike the discovery of blueberries described above, in which the scientists unexpectedly encountered resonance, theorizing the study of another Earth practices for and anticipates resonance. Both the Mars scientists and these exoplanet astronomers argue that knowing Earth can be a way of knowing other worlds.

Whereas knowing the cosmically distant is perhaps a unique challenge for the space sciences, much of contemporary science depends on comprehending the intangible. Phenomena at the nanoscale, activities deep within cells, and invisible movements of the atmosphere are all beyond human experience in the same way that planets are. Anthropologists of science experiment with how to discuss and find meaning in scientific practices that strive to overcome these distances, such as visualizations and embodiments. As tools, visualizations powerfully give shape to the unseen, as with the nanoscale (De Ridder-Vignone and Lynch 2012) and the immaterial, when, for example, scientists use brain scans to represent otherwise amorphous concepts like depression or insanity (Dumit 2004; see also Alač 2014 for an analysis of the embodied interaction that scientists establish with brain scans). Anthropologists have also been interested in the role of human bodies as tools for connecting with the inaccessible. Scientists move and contort themselves to make microscopic processes, like protein folding, macroscopic and material (Myers 2008, 2015). In addition to overcoming such scalar divides, the scientist's body also serves as a generative medium when overcoming a spatial divide. Mars rover operators understand their malfunctioning robots through a "rover dance" (Vertesi 2015), and astronomers at mountaintop observatories imagine their bodies as detectors, absorbing the starlight like the detectors on the telescopes they use (Hoeppe 2012).

For the scientists in my study, visualizations are important when depicting Earth as an exoplanet, and embodiment is foundational to analog fieldwork. Yet, I center the analysis on resonance and its pursuit. Resonance speaks to the bigger problem that embodiment, visualization, and other techniques seek to address. It emphasizes the common challenge across many contemporary sciences of knowing that which is removed from human experience. We can also reframe this in language more familiar to the anthropologist: this is a challenge of knowing the Other. Scientists and anthropologists both make worlds resonate as a way of knowing, whether these worlds are different planets or different social practices. Resonance brings into harmony the familiar and the strange and captures that breathless moment when the alien is intimate, recognizable, and knowable.

I consider two examples drawn from my ethnographic work with planetary scientists who are searching for close encounters with remote, even unknown, planets. Whereas Stoker and her crew experienced resonance when finding Martian blueberries in Utah, exoplanet astronomers searching for an Earthlike planet might desire resonance but remain removed from such worlds. Instead, by imagining Earth as an exoplanet, they practice attunement and prepare for resonance. Resonance confuses the familiar and the alien while Earth is made other and the distant is brought closer. Resonance is not exclusive to the realm of science. It also reflects those rare but important moments of fieldwork when ethnographers find themselves in tune with what they have sought to understand. While I am not the first to describe an ethnographic encounter as resonant, I develop it as a tool of both the social scientist and the natural scientist, explicating a powerful aspect of resonance: it enables the distant to become fleetingly present.

Thinking through resonance

My use of *resonance* is built on its meaning in physics. When studying vibrations, both acoustic and electromagnetic, physicists describe resonant interactions as those in which a vibration in one object engages with and excites a previously still object if it has the same natural frequency (a property of all materials). In astronomy, *orbital resonance* describes the interaction of celestial bodies in such a way that they come to move in relation to one another. Resonant objects act over a distance, exerting pulls on one another, making objects in different states move in the same way while remaining physically separated. When objects achieve resonance, they fall in sync. This configuration is fragile, and resonant orbits can quickly fall out of sync. *Resonance*, as an analytic term, relies on a third party—the scientist or the anthropologist—to manifest the relationship. This is a cognitive and affective experience, simultaneously the extension of reasoning about a relationship among objects but also the excitement of transcendence and finding new harmonies.

Although my use of resonance keys in to the concept's dynamic quality, resonance is often employed in other scholarship in its acoustic sense.[3] Yet even the ocular qualities of resonance are inherently linked to motion. While resonance textures the sound of the violin, it also describes how a plucked string induces movement in a neighboring, untouched string. Denis Diderot once extended this physical description of resonance to an epistemological analogy: philosophers generate ideas not in isolation but in concert with other resonant thinkers and concepts (Erlmann 2010, 9–10).

If two strings resonate and have thus acquired certain identical properties, is studying one string the same as studying the other? When placed in resonance, do things that were previously similar become, for the scientist experiencing resonance, the same even as they remain distant?[4] If, rather than two strings, we have two planets, and if a scientist feels Earth resonating with another world, does this allow the scientist not only to study that other world but also to encounter it? The resonance of objects is a shift from difference (differing states of motion) to sameness (taking on another's precise attributes). In describing planetary scientists' experience and pursuit of resonance, I am drawing inspiration from this physical relation to explain how these researchers themselves become an excited element of this configuration. I am also examining the epistemological consequences of resonance to understand how a scientist comes to see a sameness not previously there and thus to experience the proximal (Earth) as the distant (another planet). Just as anthropologists of science have shown how visualizations make invisible phenomena visible and bodily movements facilitate the scientific understanding of molecular movements, resonance allows scientists to both mentally and physically engage with the remote.

Attempting this interplanetary (and interstellar) engagement is a thrilling endeavor. Scientists are excited by resonance because it enables an impossible immediacy.[5] Scientists know that they are not on Mars and that Earth is not an exoplanet, but the impossibility of visiting other worlds is precisely why configuring Earth as Other is so exciting. The prospect of sending humans to Mars or discovering Earth's planetary twin are theorized futures but unlikely to be realized during these scientists' lifetimes. Creating or anticipating resonance, then, is a way to not only experience distant planets but also to enact temporally distant professional aspirations.

Knowing distant Others—be they remote (Ardener 2012) or temporally removed (Fabian 1983)—is a foundational, if much critiqued, aspect of anthropological inquiry. Even as it is no longer necessary to travel great distances to do ethnographic work, finding remoteness in what is near and overcoming this sociological distance remains central (Harms et al. 2014). Anthropologists have employed the concept of resonance to show how finding the empathic vibrations between different social worlds can lead to deeper ethnographic understanding. Unni Wikan's (1992, 2013) theory of resonance pushes the analyst to go "beyond the words" and incorporate not simply context but *feeling* within ethnography to create a resonance between the anthropologist and his or her interlocutors, as well as between the ethnographic text and its reader. Similarly, resonance as an analytic guide compels deeper study of what otherwise might be dismissed as superficial similarities (Lepselter 2012). Resonance pushes the analyst beyond words and patterns and toward structures of feeling and affect (Massumi 2002; Mazzarella 2009; Stewart 2007; see also Le Blanc 1994 for a slightly different invocation of resonance).

Resonance allows humans to know one another, and scientists can employ it in a similarly powerful way to overcome physical, rather than social, distance.[6] Trained as analogical thinkers, scientists often compare objects and processes. Resonance, however, works less like this analogical reasoning, which maintains cognitive distance, and more like metaphor, extending beyond connection to substitution.[7] Metaphors, as conceptual constructs that shape how we think and act, allow us to understand "one kind of thing in terms of another" (Lakoff and Johnson 1980, 5). Resonance, as a way of knowing across distance, is not a substitution of kind for kind (planets, after all, are being compared to planets) but a substitution of "here" for "there." Whereas some thinkers have been unsettled by substitutive and mimetic practices, wondering if they dilute our comprehension of the original and the real (Baudrillard 1983; Schwartz 1996), the following examples illustrate that it is precisely this destabilization of signification that excites scientists, enables them to see the familiar as alien, and allows for the proximal study of another world.

Encountering Mars on Earth

What was it that allowed Stoker to so readily call a rock on Earth a "Martian blueberry"? She immediately recognized a similarity and fluidly switched to treating this rock here as a stand-in for Mars. Although this alien encounter was unexpected, it immediately made sense to everyone except the anthropologist. After the fact, through further research and conversations with Stoker, I made sense of these actions and recognized the resonance between Earth and Mars. Stoker's professional training tuned her in to this resonance, and in that moment, Stoker was studying and walking around Mars, not Earth. Resonance allowed the distant to be present.

The Mars Desert Research Station (MDRS) presupposes a kinship between Mars and Earth that makes this site fertile ground for these planets to become intertwined and indistinguishable. MDRS was established in 2002 by the Mars Society, a nonprofit that advocates human settlement of Mars. It is located in the San Rafael Swell in Utah, a region with very little vegetation and miles of exposed, red-tinted sandstone and shale. Wind and water erosion has carved out canyons and buttes, leaving behind a varied landscape. MDRS is situated there to capitalize on a landscape that evokes another planet. Visiting scientists and enthusiast crew members treat the environs as an "analog" site.[8] Since the 1960s, planetary scientists have used the term *analog* to describe terrestrial work applicable to other planets (for an early example, see Hinze et al. 1967). It is common practice for planetary scientists to travel to sites on Earth (including the Arctic, Mojave Desert, and others), examine the local terrain, and claim to learn something applicable to a distant planet.

Many planetary scientists at NASA Ames, where Stoker and her team were coming from, take part in analog fieldwork. I interviewed a few of these scientists to understand how such work figures into studying other planets. These conversations help distinguish conventional analog work from a resonant encounter. One woman, Victoria, early in her career at NASA, specializes in Martian dunes. Most of her research comes from studying aerial images of Mars, but like most planetary scientists she participated in field trips while in graduate school to experience the relationship between remote sensing (how Mars data are gathered) and emplaced exploration (common to traditional geology). While Victoria laments not having done much fieldwork since her graduate training, she does make sure that the students who work with her have at least seen dunes firsthand. When I interviewed her, she was preparing to take two students into the Mojave "just to show them [dunes]," she said. "There's nothing like seeing them and walking on them." During such an excursion, Victoria wants her fellow researchers to achieve a visceral feel for tall dunes and what ripples and other wind processes look like.

The importance Victoria places on such an experience is unsurprising given the origin of planetary science in geology (Messeri 2014), a discipline centered on fieldwork that values the experience of "being there." In lieu of being on Mars, Victoria and other planetary scientists do their best to find an epistemological place for fieldwork methods. This terrestrial work is important since, as Victoria explained, she can draw on it to better understand photographs of Mars. But this work remains analogical, not resonant, because Victoria maintains the distance between the two planets. Further, this mode of sensing is an important way of cultivating expertise, as Jessica O'Reilly (2016) has also shown in her ethnography of how scientists working in the Antarctic come to know ice through daily, lived experience. How does this reasoning prepare the scientist for a moment of "intimate sensing" (Helmreich 2009b) when, in the scientist's experience, Earth becomes Mars?

MDRS operates in this lively fieldwork tradition of planetary science, challenging visitors not only to draw connections between our planet and another but also to push beyond analogy and indeed experience the site and its environs as Mars. Each year, the Mars Society selects about 10 crews, each composed of six enthusiasts and scientists, to live in the MDRS habitat and simulate the scientific, engineering, and daily activities that participants imagine would constitute life on the first human settlement on Mars. The habitat, or "hab," is of a slightly futuristic build, and the crews opt to turn off their cell phones, ignore the conveniences of the nearby town, and even wear simulated space suits when leaving the hab (see Figure 1). These elements combine to heighten the feeling of isolation and danger necessary when imagining oneself on Mars. An early MDRS inhabitant described the experience of "being on Mars" in a crew report, posted and archived on the Mars Society's website:

> Sure, our suits were only simulated, with the bulbous lids of trash cans making up half of each helmet, but

Figure 1. Dressed in simulated spacesuits, Stoker, Julia, and Devon return home to the Mars Desert Research Station after testing soil samples in the San Rafael Swell in Utah. (Lisa Messeri)

> suited up—stepping out of the airlock for the first time in no way felt like playing pretend—It was stepping out onto the surface of another world.... From a science perspective, everything came alive—It wasn't just another chunk of Utah, but a virgin alienscape where every rock held the potential to rewrite what we know about the Universe. (Shannon 2002)

In other words, Earth became Mars.

Stoker, who has spent her career at NASA Ames and worked on several high-profile robotic Mars missions, has also been heavily involved in the Mars Society since it was established in 1998. She is both a professional planetary scientist and an advocate of human space exploration. Our trip to MDRS was the first in a series she was leading to test drilling equipment that would potentially be flown to Mars. Stoker also wished to call on NASA to support this site, arguing that it could produce good science. To substantiate this claim, she decided to eschew the features of MDRS that did not build on her research goals. Having met her at Ames, I was invited to join her and her colleagues on a two-week mission during which, though we lived in the hab, we did not wear the mock space suits (except for fun) and happily took advantage of the convenience store in the nearby town. In other words, the intention of this trip was not like most MDRS missions. We were not actively imagining ourselves on Mars but were conducting activities similar to more conventional analog work.

In contrast to the excitement of exploring the blueberry field, the mission objectives and daily work were relatively mundane. To ensure that drill testing would occur in conditions as similar to those of Mars as possible, our assignment was to characterize different geologic features of the area surrounding MDRS. Our primary task was to collect soil and rock samples that, following the mission, were sent off to various laboratories for analysis, and findings were eventually published in journals such as the *International Journal of Astrobiology*. Several goals motivated this collection and analysis, relating to near-term and future Mars exploration. During our mission in 2009, NASA was preparing the Mars Science Lab, later named the *Curiosity* rover, for launch. One of the instruments used to analyze our samples was similar to what would be aboard *Curiosity*. Thus, the analyzed soil samples offered terrestrial benchmarks and comparisons for what *Curiosity* would eventually return. Since all missions to Mars include a life-detecting laboratory, a second goal of the work at MDRS was to find traces of life in the soil samples, especially those located several feet under the surface. Our collections therefore included "soil cores" that provided lateral characterization of organic and mineral compositions. Finally, Stoker was interested in documenting the very process of sample collection to illustrate how productive human explorers are and bolster support for human missions to Mars.

The geomorphology at MDRS is such that several different geologic formations are accessible for sampling. Stoker's objective for our mission was to collect viable samples of formations from the Cretaceous and Jurassic periods (which have high concentrations of phyllosilicate, a mineral that has been detected on Mars and indicates the presence of water in the past). The first phase of our mission, then, was spent surveying different potential collecting sites. For the second phase, we returned to these sites, collected samples, and made other measurements that would later help characterize the region and bolster (or temper) the analog status of MDRS in regard to its geology.

On one typical day during the first phase, I surveyed different potential collection sites with Stoker, Julia, Natalie (a geologist), and Jon (an engineer). Over breakfast, Natalie, Julia, Stoker, and I devised a collection protocol that dictated how, upon arriving at a site, we would decide where to collect. We divided up documentation tasks so that Stoker, Julia, and I would be responsible for collecting samples while Jon wrote down a physical description of the site and Natalie recorded geologic information. Julia, an astrobiologist who was in charge of measurements to detect organics, insisted that we meticulously record precisely where each sample came from so follow-up tests could be performed if needed.

With lunches packed, we piled into an SUV, and Stoker playfully declared that we were "launching at 10 a.m." Jon joined in on her space-faring joke, confirming that he had completed the "preflight check." Although we were not wearing the space suits, we were still having fun with the idea that MDRS is a Mars simulation. Yet, Mars still felt very far away from where we sat in the SUV.

We drove between several sites that day. Each excursion followed a similar pattern. We got out, evaluated the land, sometimes joked about the surrealism of simulating Mars on Earth (Julia, upon finding a fossilized shell, exclaimed with a wry smile, "There's life!"), collected a soil sample, and drove on to the next site. This work was tedious, or at least routine. We enjoyed beautiful vistas throughout the day, but the sample collection had our heads down and focused while we recorded pertinent information. Stoker, Natalie, and Jon, with a certain level of dispassion, frequently compared the site to Mars. At one point, Stoker identified a spot near a coal seam as a "dream analog spot." She did not mean that it was a dream because it was a perfect Mars analog; rather, she meant that it would be a dream to find such a feature on Mars. She explained that the robot would start drilling on the soft sandstone (which, she noted, is not known to exist on Mars), and after a meter it would discover coal and the associated organics. To discover such a configuration on Mars would confirm that the planet once had life.

This day was representative of the work and conversation that occurred during our time at MDRS. The discovery of the blueberries occurred only a few days later. What was so striking about that encounter was the excitement I witnessed in my interlocutors' exclamations and actions. There was a different imagination at work, one that required a different analytic to make sense of. This resonant encounter reconfigured the relationship between scientific knower, their object of study (Mars), and their place of study (Earth). I became aware of this shift when the fieldwork activities being performed by the scientists I was with, which I had spent the previous days becoming familiar with, suddenly appeared strange. Stoker and Julia moved more quickly, smiling and laughing with each other, as they found more and more blueberries and placed them in unmarked collection bags. The purpose shifted, since these samples were no longer meant for analysis. Instead, the scientists were reasoning with the samples differently—enjoying holding the blueberries and walking through the field they were scattered in. It was only after the excitement died down, after the resonance faded, that Stoker could describe what had happened, reverting back to the language of analogy that otherwise predicated how we discussed the relationship between the here on Earth and the there of Mars.

To fully understand the resonant connection my crewmates delighted in, one needs to know about a high-profile discovery made by NASA's Mars Exploration Rovers in 2004. Shortly after the rover *Opportunity* landed on Mars, it set its electronic gaze on an outcrop of rock near the rim of a crater. Sticking out of this rock were tiny globules, described by chief scientist Steve Squyres as resembling blueberries in a muffin.[9] The description stuck, and the mystery of these blueberries occupied the science team for some time. Ultimately, they concluded that these spheres were hematite-rich concretions, which form when minerals settle in rock after being carried by water through softer rocks. Precipitates eventually form in layers around the deposit, replacing the softer sediment with hard concretions. As wind erodes the softer material, the concretions end up littering the surface. Finding concretions on Mars was an exciting discovery indeed: the place where *Opportunity* landed must once have been flowing with life-sustaining water (Squyres 2005).

Finding concretions in Utah was exciting not because they were a symbol of water but because they were a portal to Mars. The NASA scientists, in spotting these concretions and excitedly proclaiming them blueberries, induced a resonance between Mars and where they were on Earth. This did more than simply reinforce the analog status of the site. Instead of observing how Earth *is like* Mars (as is common in analog fieldwork), a small piece of Mars physically manifested on Earth. In this moment of resonance, Stoker and Julia breathlessly collected and examined Martian blueberries, not terrestrial concretions. Physical similarity provoked a cognitive shift, further amplifying this similarity and, indeed, leading to a substitution of the object here (concretion) for the one elsewhere (blueberry).

This manifested in their excitement as Mars became proximal and unexpectedly experienceable.

When Stoker stopped to explain to me their excitement, she let go of the resonant relationship between Mars and Earth. Stoker reverted to the language of analogy (these are *like* the blueberries on Mars) to translate for me what she had just experienced. Stoker, catching her breath from the excitement of this discovery, rejoined me in seeing Utah, not Mars, before her. Analogy maintains the impossibility of Earth being Mars, whereas the resonant moment that occurred just before brought forth precisely this impossible immediacy that led to my crew's great excitement. Just as vibrations propagate across space, invisibly inducing change at a distance, scientists can tune in to and amplify the resonance of planets, leading to the reconfiguration of a terrestrial object and making the distant present.

Calling the concretions "blueberries" inverts the traditional pattern of signification often used by planetary scientists. On Mars, scientists discovered a phenomenon and temporarily referred to it as blueberries (a thing belonging to Earth). After additional tests and much conversation, the team accepted that these blueberries were examples of a phenomenon on Earth called concretions. Earth was (re)established as the signified. Yet, when we stumbled on the concretions in the area surrounding MDRS, they were referred to as blueberries. A switch had occurred, and Mars became the signified. Alien Mars replaced familiar Earth, and Stoker and her crew felt more connected to the Martian blueberries than the terrestrial concretions.

Further, the blueberry was something proximally encountered that could be used by Stoker to better understand the distant. The resonant relationship between concretion and blueberry delighted the scientists, but it also provided a meaningful, hands-on experience with a much-discussed phenomenon on Mars. My crew felt the familiar and strange resonate with each other and become the same. In this moment, studying and collecting rocks on Earth was a way Stoker, Julia, and Devon could interact with Mars. Resonance allowed them to take what, to me, seemed an insignificant rock and understand it as a way to know, even experience, another world.

Anticipating resonance: Making Earth alien

Stoker and her crew felt a resonance between the world they inhabited and a distant world because of their deep knowledge of Mars. The experience of conducting analog fieldwork, years of studying Mars, and a keen interest in recent discoveries primed them to sense a resonance with the concretions and to comprehend them as Martian blueberries. The second example from planetary science also involves Earth being made other by scientific workers, but the world they desire Earth to resonate with is not yet known to exist. Rather than an example of fully realized resonance, this discussion will unpack the preparation—the attunement—that researchers undertake so that, at the right moment, they will be ready to experience a powerful and meaningful resonance. Conversations and scientific papers signal this anticipated discovery and suggest how part of this work, as with the blueberry example, involves playing with Earth as alien even if the researcher cannot (yet) experience a true substitution.

For exoplanet astronomers, scientists looking for and studying planets around other stars, the Earthlike, habitable planet is the holy grail of their profession (Messeri and Vertesi 2015). Such a planet would be the same mass and volume as Earth, and it would orbit its star at a distance such that its surface could support liquid water. Many thousands of exoplanets have been detected, and several are thought to be only slightly larger than Earth. Some of them orbit their star at such a close distance that only molten iron could exist on the planetary surface. Others are farther out and colder than Pluto. Exoplanets larger than Earth have been recorded within a planet's "habitable zone," but their density makes them unlikely hosts for life as we know it. While a truly Earthlike planet remains undetected, it is this world that astronomers most desire to know.[10]

My fieldwork with exoplanet astronomers centered around a research group at MIT run by Sara Seager, who was recognized for her professional work in 2013 by the MacArthur Foundation. Although much of Seager's research focuses on the modeling of exoplanet atmospheres, she, along with many of her colleagues, is convinced that finding an Earthlike planet will be a discovery on the scale of the Copernican revolution (Lunine et al. 2008, 876). In 2011 she convened a small conference at MIT, invited the leading exoplanet astronomers and her graduate students, and curated a discussion about the future of the field. There were about 50 of us present for "The Next 40 Years of Exoplanets." Seager's opening remarks set the tone for the meeting. "We will be remembered for finding the first Earthlike worlds," she said enthusiastically. But it will not happen "naturally," she added. "We have to make it happen."

Later in the day, Geoff Marcy, who co-led the first US team to detect an exoplanet, gave an impassioned talk.[11] Dressed in khaki pants, a green shirt, and black blazer and speaking from a script, he was more purposeful in both dress and message that the previous speakers. "I am feeling unhappy, and I am also feeling ecstatic," Marcy began. He was ecstatic about the success of the Kepler mission (a satellite dedicated to searching for Earth-size exoplanets) but unhappy about the lack of long-term commitment to developing additional satellites to further study an Earthlike planet. Marcy made a direct plea to President Obama (not present), asking that he deliver his version of Kennedy's moon-shot speech and direct NASA to launch an interstellar probe by the end of the century to search for planets around our nearest star.

The entire conference was an exercise in articulating a destiny. Seager asserted the collective mission of finding an Earthlike world, and Marcy projected a century out what such a finding should lead to. Although Marcy expressed unhappiness that missions to find another Earth were not further along, others in the room were unrelentingly optimistic. This optimism is apparent beyond this meeting, expressed in white papers that set out scientific goals. In the 2010 decadal report for astronomy and astrophysics, a paper written for the National Academies that prioritizes research programs for the discipline, the search for a habitable world received top billing:

> Can we find another planet like Earth orbiting a nearby star? To find such a planet would complete the revolution, started by Copernicus nearly 500 years ago, that displaced Earth as the center of the universe.... The challenge is great, but armed with new technologies and advances in understanding the architecture of nearby planetary systems, astronomers are poised to rise to it. (Blandford et al. 2010, 11–12)

This anticipation is not so different from the activities at MDRS, where a potential future is being prepared for through simulation. And, like Mars exploration, exoplanet astronomy uses Earth as a conduit for knowing other worlds.

Scientists are so eager to find an Earthlike, habitable planet that even before one has been discovered they are already practicing how to study it. The best example we have of an Earthlike exoplanet is our own Earth. Several different projects have asked what would *Earth* look like through a distant telescope. If more precisely understood, scientists would then better know what to look for. It has thus become a common trope in the exoplanet literature to conduct thought experiments and empirical studies in which Earth plays the role of an exoplanet. Instead of considering how other planets might be like Earth, theorists invert this relationship and ask how Earth is like an exoplanet. In playing with the relationship between the proximal and the distant, these scientists are preparing themselves for a discovery that might one day induce the resonant excitement that came from stumbling upon the blueberries. Studying Earth in this manner is preparing them for the instantaneous elation promised by Seager and Marcy when they recognize the signal of a distant world as familiar.

The search for another Earth is hubristic, but it also challenges the singularity of our own planet. The astronomers I encountered saw the detection of a habitable exoplanet as the biggest discovery that their field could make—one that would simultaneously complete the Copernican revolution and make famous this moment in humanity's history. As Marcy told me during an interview several months after Seager's conference, when his ecstasy had come to outweigh his unhappiness, "It really is an exciting time. At the risk of sounding hyperbolic, it's a momentous achievement, and the Kepler results will go down in the history books for a long, long time. You can only find Earthlike planets once as a civilization, and we're about to do it." Popular science books have been written about this quest (Billings 2013; Lemonick 2012), and progress in finding such a world is frequently in the news. While this sought-after discovery does not seem, by astronomers' accounts, to estrange us from Earth, it does implicitly question claims of Earth's uniqueness. Scientists fluctuate between positioning Earth as the exemplary planet or just one planet among many of the thousands they have recently discovered around other stars. Yet drawing connections between Earth and other worlds is not meant to make Earth less important; rather, it provides a way to make sense of worlds we can never physically experience. Just as the blueberries in Utah offered a close encounter with Mars, fashioning the imagination of exoplanets after Earth breathes familiarity into the search for other worlds.

Preparing for the discovery of an Earthlike exoplanet occurs not only in conversations but also in scientific articles. One example is found in a well-regarded research article, "Alien Maps of an Ocean-Bearing World" (Cowan et al. 2009), published in a top astrophysics journal. In the article the authors, a group of NASA and university astronomers (including Seager), use Earth data from a satellite to see if it is possible to distinguish oceans from landmasses.[12] In other words, is the habitability of our planet something detectable from a great distance? In the article's title, the "Ocean-Bearing World" refers to Earth, and the "Alien Maps" are abstracted representations of Earth. Since the data set offered higher spatial resolution than typical exoplanet data, the team first reduced images of Earth to a single pixel. Then the authors took the position of a naive observer, assuming "no prior knowledge of the different surface types of the unresolved planet" (917). After examining the spectra, the team "discovered" that at times the planet appeared optically blue and at other times optically red, suggesting two surface types. The final step of the analysis was to construct an alien map of this ocean-land planet. In so doing, they extrapolated the data from a single pixel back into a more complex image. Figure 2 appears in the paper as a comparison between an actual map of Earth and the alien map reconstructed from spatially unresolved data.

The alien map suggests we are viewing something "other," but in fact we are viewing a representation of ourselves. Representing the self as the Other, according to Michael Taussig in *Mimesis and Alterity*, crosses a destabilizing line: "What does such a compulsion to become Other imply for the sense of Self? Is it conceivable that a person could break boundaries like this, slipping into Otherness, trying it on for size? What sort of world would this be?" (1993, 33). These questions launch Taussig into an

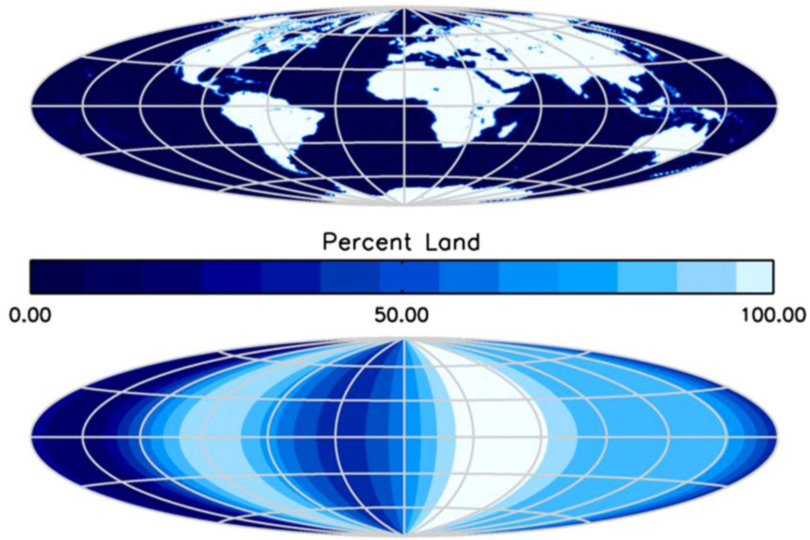

Figure 2. A map of a cloudless Earth is juxtaposed with a second map of Earth reconstructed from reduced satellite data. The bottom map is meant to mimic the kind of image that astronomers might one day capture of faraway exoplanets. The map thus suggests that we are viewing something "other," but in fact we are viewing a representation of ourselves. (Reproduced by permission from Nicholas B. Cowan et al., "Alien Maps of an Ocean-Bearing World," *Astrophysical Journal* 700 [2]: 915–23. © 2009 American Astronomical Society)

analysis of a 1935 surrealist essay by Roger Caillois. Caillois diagnoses mimesis of the self as "being tempted by space," tempted by an unboundedness in which the self is but one of many. Caillois warningly writes that the mimed self "tries to look at himself from any point whatever in space. He feels himself becoming space. . . . He is similar, not similar to something, but just similar" (Caillois 1984, 30). For Caillois the mimetic Earth, the portraying of the planetary self as the planetary Other, the alien map, leads to alienation.

Yet the aspiration fueling this scientific paper indicates the opposite—far from alienation, it is connection that these scientists long for. Although the "Alien Maps" article does confuse and abstract—digital manipulation morphs Earth from the familiar to the alien—it tries to forge a new understanding of how Earthlike planets might appear. In the article, at Seager's conference, and in other projects of finding a habitable planet, the astronomers involved are searching for solid footings elsewhere in the galaxy. This search is for the moment incomplete, but that does not keep the scientists from imagining what the signature of a planet that would resonate with Earth might look like. In preparing for such a moment, they also experiment with the extent to which Earth itself can be studied as this Other.

Imagining the Earth as an exoplanet is a cerebral activity. Though excitement accompanies discussions about the possibility of significant discoveries, exoplanet astronomy lacks the embodied and affective aspects of resonance illustrated in the blueberry example. This case emphasizes that training and work underpin resonance and reasserts the inherent challenge of studying other planets. It reestablishes the distance that the blueberry example collapsed. Considering these two instances together illustrates how resonance momentarily erases mediation. The blueberries offered an unmediated (and therefore exciting) experience of Mars. But when placed alongside the mediating instruments of exoplanet astronomy—the telescopes and satellites—blueberries can similarly be described as a lens through which a scientist studies the cosmos. And if the instrumentality of the blueberry can be erased in a moment of resonance, perhaps the mediating role of the telescope will briefly fade, and scientists will excitedly experience Earth as an exoplanet or an exoplanet as Earth.

Before this can happen, resonance is prepared for and practiced. The exhilaration that brings the scientist's mind and body into vibrational excitement when "here" and "there," the familiar and the alien, become indistinguishable has not yet occurred for astronomers in search of an Earthlike planet. But exoplanet astronomers continue to explore ways of knowing the distant by studying the immediate.

Conclusion: Resonant fields

It is a rare occurrence when researchers experience complete resonance—a profound connection to what they have encountered, one that facilitates a deeper understanding of something that might not actually be present. It is also much desired, especially by scientists who are constantly striving to know distant worlds. The examples offered here, of a resonant encounter and a set of practices that serve as preparation for such a sought-after moment, show how planetary scientists use resonance as a means to overcome physical distance. They use it, moreover, to substitute the experience of being here for being there such that they can more intimately understand and know another world.

Anthropologists are not necessarily separated from the worlds we seek to know by physical distance, but we struggle with social distance. In my own fieldwork, tracing methodological resonances allowed me to catch glimpses of ways that my work was the same as that of those whom I studied. For example, when I asked a planetary geologist about his research methods, he casually tossed a notebook on the table to corroborate his claim that he just "returned from the field." As I scribbled this gesture in my own field notebook, I felt an excited awareness that our practices were somehow the same.

As anthropologists of science leave the laboratory and follow scientists into the field, we reencounter activities that share an earlier, common origin (Kuklick 1997, 2011; Stocking 1984; Wax 1971).[13] At the same time that we are constructing a field to be studied (Amit 1999; Candea 2007), so too are our interlocutors. This begins to explain why, during the moment of excitement that my crew experienced when seeing not terrestrial concretions but Martian blueberries, I found myself lost. I did not understand what was happening even though moments earlier I had a strong grasp of the work we were doing. This confusion stemmed from my failure to feel the resonance that my interlocutors did, and thus I was unable to recognize that they were redefining their field. Whereas my field remained the Utah desert, Stoker and her crew's field became that of another world.

In anthropology, *world* is often used as a metaphor to describe different cultures. For Unni Wikan, resonance "demands a willingness to *engage* with another world, life, or idea" (1992, 463; emphasis in original). Importantly, Wikan also remarks that resonance is orthogonal to culture as the former implies similarity and the latter difference (476). Resonance brings closer the conceptually distant worlds that culture tends to reify. To be sure, thinking about the resonance between fieldwork methods evokes this sense of "world" as a difference I had to overcome to understand scientific practice. But when planetary scientists use *world*, it is, like resonance, about similarity. It is a shorthand way to say that planets are not merely scientific objects; they are *like Earth*. They, too, are worlds.

Resonance is a powerful term because it captures scientific and social-scientific ways of knowing. It can describe either ethnographers in the field or scientists' configuration of their objects of study. It combines reasoning with affect, imagination, and embodiment. Working to explicitly define what resonance is and how it works invites the incorporation of otherwise outlandish claims of "being on Mars" and the impossibility of abolishing interplanetary distance into the scientific process.

The planetary scientists discussed here want to find not the alien but the recognizable. They work to produce resonance in order to make the strange familiar and thus knowable. Sensing these vibrations focuses analysis on how distances and differences are overcome. Indeed, resonance provides a guide for understanding how scientists and social scientists navigate spatial and cognitive impossibilities through reason, experience, and affect.

Notes

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1. Single first names are pseudonyms. Full names are real names, used with permission or because they are part of the public record.
2. Studying outer space has recently become positioned as a generative way for opening up and reconfiguring ethnographic themes (Valentine, Olson, and Battaglia 2009, 2012). See also Battaglia 2006; Dean 1998; Denning 2011; Gorman 2016; Helmreich 2009a; Lepselter 1997; Messeri 2016; Mirmalek 2008; Olson 2010; Redfield 2000; Valentine 2016; Vaughan 1996; Vertesi 2015; Young 1987.
3. Focusing on the physical aspects of resonance takes me in a different direction from those using this term in sound studies. For an example of that work, see the website of a symposium held in 2014 at MIT's Center for Arts, Science, and Technology, titled "Seeing/Sounding/Sensing," in which "Sounding—Resonance" was a track: accessed October 27, 2016, http://arts.mit.edu/events-visit/cast-symposium.
4. This raises the important question of whether resonance, in celebrating sameness, obscures difference. Karen Barad (2007), following Donna Haraway (1997), recasts the physics concept of diffraction as an analytic for highlighting differences that matter. The purpose of this article is to rethink ideas of similarity, but a future analysis could quite interestingly use ideas of resonance and diffraction in tandem.
5. My thanks to China Scherz for this turn of phrase.
6. Anthropologists have attended to several ways that scientists collapse distance and connect with their objects of study (Ochs, Jacoby, and Gonzales 1994). For example, when embodying a protein fold, "modeler and model oddly come to resonate with and resemble one another" (Myers 2015, 101). This merging of subject and object is slightly different from the phenomenon addressed in this paper. Here, the boundary between subject and object remains; what is blurred is the relation between two scientific objects (two planets). This destabilization allows, in the case of the blueberries, for an embodied interaction with an otherwise distant object of study.
7. That analogy maintains distance can be illustrated in an example. When scientists draw analogies between the atomic model and the solar system, the intention is not to say that the atom is the solar system. Rather, they draw systematic similarities while retaining the integrity of each distinct concept (Gentner and Jeziorski 1993). For more on the role of analogy in science, see Hallyn 2000; Hesse 1963; Holyoak and Thagard 1995; Ortony 1993; Park, Daston, and Galison 1984; Shea 2000.
8. Such analog environments are both simulations of and arguments for human exploration of space, as Valerie Olson (2010)

argues in her analysis of the NEEMO 9 program, a NASA underwater analog station. This is true for MDRS as well, the difference being that MDRS and the Mars Society have significantly fewer resources to pursue human exploration.

9. The metaphor "blueberries in a muffin" reflects the hegemony of US cultures and norms in space exploration. Even as other countries launch and manage space missions, the United States and NASA continue to produce many of the significant findings and therefore often dictate the language (regional colloquialisms and all) used to describe extraterrestrial phenomenon. That the MDRS is located in the US West further ties the mythology of the US frontier to space exploration. Although many MDRS crews are international (including my own), space remains disproportionately shaped by US contexts.

10. In August 2016, astronomers announced that they had found an Earth-size planet orbiting in the habitable zone around our nearest star, Proxima Centauri. While this was an exciting discovery, the stark differences between this star and our sun has tempered claims that this is the truly Earthlike planet that astronomers anticipate finding.

11. In the fall of 2015, the University of California, Berkeley, found that Marcy had violated the school's sexual-harassment policies following a Title IX investigation. The outcome of this investigation was widely covered in the news. On social media the hashtag "#astroSH" (*SH* for "sexual harassment") brought attention to Marcy's actions and prompted a larger conversation about the challenges that women face in astronomy. Ultimately, the Title IX investigation's findings were less condemning than the public reaction, which led Marcy to announce his intention to retire.

12. Another example of a scientific article in this genre is Oakley and Cash (2009).

13. Ethnography inevitably changes when anthropologists study communities with similar expertise and epistemologies as themselves, a practice that Douglas Holmes and George Marcus (2005) call "para-ethnography." This requires reflexive practice by the analyst, as Stefan Helmreich (2009a, 21) illustrates when describing how he became aware that his trip to sea on an oceanographic vessel was fieldwork for both him and the marine scientists he accompanied. And yet, at the same moment, *fieldwork* became an unsatisfying descriptor because it failed to capture the distributed essence of his *and* his scientists' work.

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