Article

Science, Technology, & Human Values
2019, Vol. 44(5) 762-785

DOI: 10.1177/0162243919858717
journals.sagepub.com/home/sth
SAGE

Touching with Light, or, How Texture Recasts the Sensing of Underground Water

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Abstract

This paper is an ethnographic examination of the early social life of a project to map Costa Rica's aquifers using LandSat imagery and a specialized algorithm. The project aims to make subterranean formations accessible for public agencies mediating recent environmental conflicts over underground water, which have been diagnosed as the country's first "water war." I analyze the presentation to the public of this project and the technology it uses to show how vision and touch are conceptual resources that people use to describe the technicalities of satellite imagery. Attending to the semiotic and technical power of vision and touch requires a nonessentialist understanding of the senses. It requires moving away from a narrow understanding of sensing as embodied, phenomenological practice. Focusing on the role of texture as that which operates in the interstices of vision and touch, I propose going beyond panoptic imaginaries in order to grasp the diverse social lives that technologies such as satellite imaging have.

Keywords

water, subterranean, remote sensing, underground, touch, verticality

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Introduction

In most people's everyday life, subterranean space is present only implicitly until the subsurface irrupts as a "resource," as the home for hidden infrastructures, or as a resting place for the afterlife. But emergencies of all sorts, many tied to the perils of planetary crises, are changing that. The underground is slowly becoming more present in everyday conversations to remind us of the vast worlds that literally undergird our lives. In Costa Rica, many of the emergencies that bring subterranean worlds above the surface are tied to the recognition that the country is approaching a threshold, a moment when the quality and quantity of its subterranean water is reaching a point of no return.

Globally, there is hundred times more freshwater in the subsurface than there is available in rivers, lakes, and swamps combined. The age of that underground water ranges from a few days to hundreds of years, making aquifers types of water bodies with wide-ranging temporalities. Like most other regions around the world, Costa Rica depends largely on underground water for human consumption and industry. Many of the aquifers that supply water to the population are under severe threat of contamination, others have been made unusable due to saline intrusion, and a third group is exploited without systematic monitoring or evaluation. In the last twenty years, conflicts over subterranean water have been the main drivers of environmental struggles. One well-known case involved the 2004 contamination with benzene of one of the deep wells that supplies water for a large section of San José, Costa Rica's capital city. This emergency reminded the public, if only temporarily, of the fragility of urban aquifers. Another conflict first exploded in 2003, and then again in 2008, between residents of the coastal town of Sardinal and tourism developers in northwest Costa Rica. In this case, the conflict crystalized a legacy of inequality and institutional inertia that resulted in a radical questioning by local communities of the legitimacy of the scientific information state agencies produced about the aquifer (Ballestero 2019b). That conflict is still unfolding and is an important precursor to the project I analyze here. More generally, conflicts such as these have effectively brought to the surface the aqueous subterranean worlds that for most of Costa Rica's republican history remained within the exclusive purview of specialized government bodies and well-drilling companies. Today, underground water is a topic of conversation in supermarkets, in waiting rooms and, of course, in the media.

But how are these subterranean water worlds brought above the surface? What kinds of cross-modal forms of sensemaking are necessary to turn them

into public objects of concern? This paper uses the introduction into public life of a project designed to map "all of Costa Rica's aquifers" as an opportunity to explore these questions. The project is a collaboration between Costa Rican environmental authorities, academics, and a US governmental agency. As I write this article, the project is still in its planning phase, so I do not report on its implementation. Rather, I am interested in how the project is presented to the public as a solution to water struggles. More specifically, what kind of sense do the remote sensing (RS) technologies on which the project is based bring to a situation where the distinct subterranean quality of water is at stake? Here, I build on Yusoff's (2013, 213) observation that enhancing our forms of attention to new spaces "entails asking how sense is enrolled into our habits of thought and theories of materiality."

To explore these questions, I focus on an early event, a particular performance of expertise that turns embodied sensing into conceptual resource. This form of making sense of RS is announced at a public meeting (Alexander 2017) where the expert leading the project explains its technical uniqueness and management potential. Generally, RS technology involving satellite imagery is conceptualized as an extension of the visual register (Harris 2011). By paying careful attention to this public event, I identify a more diverse set of sensing modalities. Specifically, I will show how the overlap between sight and touch becomes a critical cross-modal medium for understanding how satellite imagery relies on texture to reveal subterranean water worlds. This cross-modal overlap requires that we calibrate our analytic habits to attend to sensorial combinations rather than continuing to reproduce essentialized notions of the senses where vision is only vision and touch only touch.

But there is a twist. My argument about sensing will not be a phenomenological one (Gabrys 2016), nor will I focus on the embodied articulation of the senses as if they were unmediated affective and epistemic resources. Rather, I am interested in how experts turn sensing into a conceptual resource, into an abstraction. My interest is in how vision and touch are articulated to make sense of what RS is, how it is used, and what it yields as a form of knowing. In other words, I show how sensorial articulations are mobilized as cognitive resources to conceptualize spatial formations that are impossible to inhabit. This analytic move extends the reach of the senses, turning them into conceptual resources that blur any radical separation between abstract and embodied knowing.

I organize these explorations by beginning with a brief reflection on how scholarship on RS technologies and satellite imagery has privileged vision

and the securitization of vertical space. I then turn to two alternative conceptual inspirations to think about underground sensing. One is scholarship on cave exploration that powerfully shows how grasping underground space is inseparable from the practices and histories that occur above the ground. The second source of conceptual inspiration comes from the work of scholars of disability who theorize sensing as an always already mediated and cross-modal process. With these ideas in place, I shift from conceptual background to historical context. That context includes one of Costa Rica's most severe water conflicts in the last decade, the Sardinal case. With this history in place, I turn to the public presentation of the RS project that occupies me and track how the project leader invites his audience to think about underground water exploration as a practice of *touching with light*, a process of thinking with texture, something that sits in the overlap between vision and touch. I take this presentation as an opportunity to meditate, somewhat speculatively, on what is at stake in the notion of touching with light. Finally, I return to how formations that cannot be directly sensed are brought into being as political objects. I highlight the sensorial articulations and conceptual resources necessary to do so and emphasize the need to attend to the rich repertoires, beyond essentialized forms of vision, that scientists use to explain what sensing remotely via satellite images entails.

Sensing the Subterranean

In recent years, interest in underground issues among STS scholars has expanded in part because of the intensification of mining endeavors around the world and given the increasing impact of extractive industries in local worlds and global climate change (Ureta 2016; Kinchy, Phadke, and Smith 2018; Kroepsch 2018). Something similar is occurring in the public sphere where people are attending more and more to the subterranean formations that undergird their lives. As they redirect their attention, people shift from an emphasis on horizontal forms of dwelling and wayfaring to vertical forms of sensemaking. This shift becomes necessary as analytic tropes such as landscapes and routes of movement cannot grasp the impossibility of dwelling in subsurface formations such as aquifers. Those formations require a form of volumetric thinking that is only possible by articulating horizontality and verticality, a shift scholars are exploring in a variety of historical and geographic contexts (Elden 2013; Braun 2000; Buys and Farber 2011; Pike 2005; Ballestero 2018). The move to think about aquifers volumetrically necessitates considering depth and distance as enveloping and surrounding spatial forms, not as measurable units in a flat plane cut by

a horizon. Making this conceptual shift is not automatic. It is not enough just to add a vertical dimension to horizontal conceptualizations. Rather, we need to ponder how thinking volumetrically reshapes our recognition that "[t]he subterranean environment is a technological one—but it is also a mental landscape, a social terrain, and an ideological map" (Williams 2008, 21). This recognition can only result from questioning the conceptual and ontological legacies imbued in technical forms of knowing subterranean environments.

The underground is not new to scholars studying space, governance, and knowledge production (Melo Zurita, Munro, and Houston 2018; Simonetti 2013; Bennett 2011; Lesser 1987; Buys and Farber 2011). Political ecologists, for example, have noted how access and distribution of "subsurface resources" reflects broader structures of dispossession, environmental injustice, and harm (Dundon 2002; Nash 1993). This scholarship has focused for the most part on mineral extraction and on water as a resource that is subjected to extractivist schemes (Bebbington 2012; de Rijke, Munro, and Zurita 2016). In recent years, another group of scholars has turned to the underground by theorizing its verticality using resources from critical urbanism, security, and military studies (Bridge 2013; Elden 2013; Benton-Short 2007). This scholarship has attended more explicitly to how technologies produce specific ideas of what the subsurface is and how it can be governed.

The work of Eyal Weizman (2002) on the Palestinian/Israeli conflict is a well-known example of this scholarship. Weizman attends to tunnels, transport infrastructures, and aerial surveying to conceptualize what he and others call "the politics of verticality." This body of scholarship proposes vertical analyses of securitization and practices of control in a visual register. Authors in this lineage argue that making subterranean things visible—tracking the movement of people and materials—is a tool for disciplining and repressing social and material worlds. By pairing government and the conduct of conduct with practices of vertical surveillance and panopticism, these authors give a literal meaning to the idea of seeing like a State (Scott 1998).

And yet, as generative as this literature has been, it tends to work with an essentialized notion of visuality and a singular understanding of power as securitization. As a result, we are left with an analytic repertoire that takes vision for granted and extrapolates militarized logics across unequal and diverse contexts (Harris 2015). In addition, this approach pays little attention to how socially situated those habits of observation are, not only for those being observed but also for those performing the act of professional

observation (Goodwin 1994; Wilke 2017; Amoore 2009). To transcend those limitations, we need theorizations that entail more than visual-centric forms of analysis and that think about forms of governance beyond militarized ones. Doing so requires attending not only to the horizontal and the vertical together, as Elden (2013) and others have called for. It also requires troubling the radical separation between above and below the surface because of its tendency to engender a certain fetishizing of subterranean spaces. A richer understanding of how surface and subsurface bleed into each other helps keep in mind that making sense of this continuum is a practice that is distributed between humans and nonhumans.

To avoid replicating any strict geological separations or essentialized forms of sensing, I draw inspiration from two areas of scholarship: analyses of cave exploration and disability studies. I build on their call to transcend any essentialization of the senses, on their invitation to think of sensing as a cross-modal form of analytic elucidation, and on their insistence on blurring boundaries that attempt to set the surface and the subsurface in opposition to each other.

Speleologists and cavers are enthusiastically drawn to search for new formations to explore and map. As a community of individuals with different backgrounds, they hold different understanding of their practices. Some embody an "explorer" imaginary while others see themselves as "scientists" producing fundamental knowledge (Pérez 2015; Powell 2018). Across their differences, these groups hold conceptual, sensorial, and historically specific ideas of verticality that grow from the encounter between scientific imaginaries, the bodily requirements of cave exploration, and their intimate understandings of the purpose of knowing and mapping subterranean spaces (Cant 2006).

As cavers explore these spaces, their capacity to translate geological formations into cartographic images depends on the collective work of articulating visualizations and existing scientific records with ways of touching, patting, and pressing against the surfaces through which they move. At the same time, they are deeply aware of the harm their presence can cause in delicate geological formations so they often retreat, avoiding contact, and even closing off spaces to avoid their decay. Creating physical distance is thus as crucial as reducing it. All of these analytic decisions and forms of affective restraint are constitutive elements that are also irreducible to underground spaces (Pérez 2013). They depend on myriad epistemic and material infrastructures—including funding sources, organizational histories, and the charisma of leading figures—that sit above the surface and are integral to the process by which a cave becomes a geologic entity and an

object of attention. Put more concretely, the fact that knowing the underground depends on travel, preparation, training, and archiving practices that happen above the surface is not a minor detail (Pérez 2015; Cant 2006). It inflects the emergence of a cave as a cartographic site with temporalities, ideas of materiality, and political and interpersonal struggles that bleed from above the surface. Consequently, no hard boundary can be drawn between what happens below and above the surface. The histories, materials, and knowledges that make the work of cavers and speleologists possible puts them in constant vertical movement and should prevent us from fetishizing subterranean space (Pérez 2015). Despite romantic legacies that conceive of the underground as a mysterious site detached from human worlds and waiting to be explored (Shortland 1994), the underground is far from that.

A similar disruption of borders, this time sensorial, and a similar refusal of fetishizing, this time of the body, are called for by scholars of disability working on questions of sensing. Already in the eighteenth century, Diderot (1999) reflected on how a blind person attunes to different forms of sensory experience by judging their "proximity to the fire by the degrees of heat; of the fullness of vessels by the sound made by liquids which he pours into them; of the proximity of bodies by the action of the air on his face" (p. 134). Since then, an important thread of scholarship on disability has argued against the assumption that the senses are functionally independent from each other. Thanks to that work we have learned, for example, that hearing and nonhearing are about much more than the perception of sound by the ear (Friedner and Helmreich 2012; Mills 2015). We have begun to think about sensorial articulations such as feeling by reference (Wool and Dupree 2014). We have realized that rather than defining blindness as a lack of sight, we might think of it as a form of tactile, olfactory, and aural perception (Paterson 2006; Candlin 2008), a form of cross-modal sensing. There is an important underlying, antifetishistic gesture here. Disability scholars emphasize how this sensorial integration is a cultivated, technologically and linguistically mediated accomplishment (Paterson 2006). That is, there is nothing primal or intrinsic in any form of cross-modal sensing (Macpherson 2009). Sensing is always a historically and technologically mediated process.

I borrow resources from these areas of scholarship to explore, somewhat speculatively, new ways of analyzing the aquifer mapping project that I follow. To do so, I combine ideas of cross-modal sensing along with what studies of caving show us about the nonseparability of the surface and the subsurface. I ask what kinds of cross-modal forms of sensing are necessary to adjust one's thinking, use RS technology, and access the underground

from above the surface. This question allows us to track how forms of embodied sensing become abstractions and help shape technoscientific objects such as aquifers.

Mapping Aquifers

The origin of Costa Rica's project to map all of its aquifers was serendipitous. In 2016, Mohammed, a public official from a US government agency, met Costa Rica's ambassador at a reception in Washington, DC. After pleasantries, Mohammed told the ambassador about his job at the agency, to which the ambassador immediately followed with an explanation of what he called "the Sardinal conflict." Sardinal is a small town in northwestern Costa Rica that is located near one of the most popular tourist regions for international visitors to the country. Since the early 2000s, the community has been involved in a conflict that has grown over the years. Today, people in Costa Rica speak about the Sardinal water conflict as the country's first "water war." If seen in comparative perspective, the qualification of a war might seem overstated, and yet nationally it is one of the first conflicts over water that has resulted in mass mobilizations and confrontations between protesters, community members, and state representatives. Elsewhere I have examined the knowledge politics of the Sardinal conflict, noting how courts diagnosed the absence of a "conceptual hydrological model" as the source of the problems (Ballestero 2018, 2019b). Here, I provide some of its background, as the conflict was an important factor sparking the idea that connected a diplomat and a technocrat in Washington, DC.

The town of Sardinal supplies water to its approximately 16,000 residents through an aqueduct originally built by the State in coordination with the local community in the 1960s. In 2006, AyA, Costa Rica's largest water utility, signed a memorandum of understanding with a newly formed company called Coco Water S.A. Constituted by twenty-two developers, the company was created to secure water access for a series of new projects in the area. The memorandum established that those two entities would expand the existing aqueduct to service new developments. Once finished, the infrastructure would be transferred back to the utility for public ownership and would be managed according to the principle of service not for profit, a regulatory principle that outlaws profiting from public services such as water and electricity (Ballestero 2015, 2019a).

While AyA and CocoWater promoted their project as an antiprivatization effort, activists unearthed a series of procedural illegalities that they saw as evidence of privatizing motivations. Additionally, they feared that

extracting water at the rate the developers wanted would deplete the aquifer. In April 2008, people from Sardinal, nearby towns, and other parts of the country took to the streets, marching to demand a halt to the project. They drew enough national attention to paralyze construction. Ultimately, courts settled the conflict, at least temporarily, by issuing a decision that determined no construction could happen until a comprehensive hydrogeological study defined the aquifer's capacity to provide water for all the uses developers and the utility had in mind. In March 2017, many years after the initial decision and after an interinstitutional scientific commission conducted the studies courts required, machinery started working again to complete the project.

In 2016, before construction resumed, Costa Rica's ambassador in Washington, DC, recounted the Sardinal conflict to Mohammed at the reception where they met. The ambassador explained how the conflict would remain unresolved until more "scientific information" was produced. Mohammed recognized the conflict as something he was familiar with. He believed he had the science necessary to help appease not only the Sardinal conflict but also the growing unease around underground water issues in the country. In a classic modernist reading of the situation, Mohamed suggested that with the right information in hand, authorities could make better decisions and settle conflicts. Out of that conversation emerged the idea of bringing Mohammed to Costa Rica for a series of meetings that, if things worked out, would result in a map of all existing aquifers in the country's subsurface.

A few months later, Mohamed arrived in Costa Rica to hold the first of many planning meetings and present the project to the public. The visit was hosted by the Water Directorate of the Environment Ministry and included a public event at a University auditorium. Public officials from the Environment Ministry were happy to announce that finally the country would have an improved technical foundation to decide on water extraction permits. After a brief set of introductory remarks, they distributed a fact sheet that described the project. The leaflet noted, among other things, that the country's historic lack of scientific information regarding underground water sources was the reason government agencies could not avoid conflicts and guarantee the sustainable management of water.

Other public servants at the event, particularly geologists form the University of Costa Rica and the underground water agency, were clearly irritated by this portrayal of the country's situation. As one of them told me, "these people [the officials from the Environment Ministry] think that we [have] no scientific capacity, it is outrageous that they can talk about

their own country in this way." This comment signaled their irritation with a neocolonial politics of knowledge production enacted through the distribution of epistemological labor: US scientists would design the research program, Costa Rican's would implement it. This epistemic politics was also powerfully embodied in the finances of the project. Structured as part international cooperation under the figure of aid, and part contract that the Costa Rican state would pay for, the total cost of the project was never clearly communicated to the public. Regardless of that, a number of the attendees suggested they knew the project would cost US$1.4 million out of which more than US$1 million was being paid to foreign scientists rather than invested in local science, which they had more than enough capacity to conduct. Mohammed had arrived in Costa Rica to present his RS methodology and introduce the project to the public in this charged institutional, social, and (geo)political context.

Reaching into the Ground

Mohammed became don Mohammed on May 5, 2017, during his trip to Costa Rica. He was not knighted or granted a royal title. His transformation happened inadvertently, through car conversations, planning meetings, and shared meals. Unceremoniously, his hosts turned Mohammed, PhD, into don Mohammed. As soon as I met him, I saw why he was quickly renamed with a prefix that shows respect and appreciation. Don Mohammed is charming. He speaks with a calming and pleasant pace. His personal history is fascinating. He was recently inducted into the US's Space Hall of Fame due to his vast experience working with LandSat imagery in environmental initiatives. LandSat is a space program managed jointly by the US Geological Service (USGS) and NASA. It holds the longest existing record of earth images taken from space. In the 1960s, the program took technologies previously restricted to military use and repackaged them for civilian efforts. By the 1990s, the program made the data available for a fee. More recently, after automating data retrieval mechanisms using the Internet, LandSat data became freely available to any Internet user (excepting data related to "national security" issues). Today, the USGS and NASA define LandSat data as "a public good similar to GPS and weather data" (USGS 2018).

Don Mohammed moved to the United States in 1973. After receiving his PhD in the early 1990s, he worked in academia for a while and then started working at NASA where he produced images and maps out of data collected by a series of satellites the US government had launched. Then he moved to

the USGS to work as scientific liaison to NASA. There his role consisted of, as he put it, providing "the scientific point of view" to the engineers developing the sensors that were later attached to satellites. During his public talk, don Mohammed told us jokingly that engineers are different from scientists. Engineers get infatuated with devices, while scientists always have their eyes on research questions and the data they need to collect.

The aquifer mapping technology he was presenting that afternoon processes LandSat data with an algorithm that captures information from a very narrow window within the light spectrum. This use of satellite imagery read through a specialized algorithm and combined with radar information is called the "WATEX^{TM} methodology." WATEX^{TM} was developed by Alain Gachet, a French geologist who worked in oil and gas exploration for decades. At the turn of the millennium, Gachet discovered that the algorithm he had invented to map precious minerals and oil in middle eastern deserts had the capacity to pick up traces of underground moisture. Using this algorithm, he unexpectedly located a major leak in an underground water pipe system in Libya. Gachet quickly repurposed the algorithm and contacted the US agency where don Mohammed worked to request that they evaluate the accuracy of the inferences his system was making. Don Mohammed was involved in that process of evaluation, and the rest is history.

As a result of their successful experiences using WATEX^{TM} to sense aquifers, Gachet and don Mohammed passed the methodology to USAID, which most famously used it to locate water sources in Darfur during the "humanitarian" emergency of the early 2000s. As all of the promotion materials note, WATEX^{TM} allowed aid workers in Darfur to increase the success of water drilling from 33 percent to 95 percent, securing water sources for a large number of displaced people. Gachet and don Mohammed present WATEX^{TM} as an unprecedented accomplishment for hydrogeology, a field that has struggled with practical and affordable uses of RS technologies in everyday decision-making.

Since at least the 1970s, hydrogeology, hydrology, and groundwater scientific journals regularly publish essays addressing the unrealized potential of RS for groundwater investigation and management (Jha et al. 2007; Becker 2006; Brunner et al. 2007; Byron Winn 1972). There have been multiple advances, though. Those include the use of computer models to simulate hydrological dynamics based on remotely sensed data, the incorporation of satellite imagery in water management decisions, and experiments on how artificial intelligence might transform the field altogether. But despite these innovations, many in the field continue to suggest that

"ground water is the last component of the hydrologic cycle to realize the benefits of remote sensing" (Becker 2006, 306).

That sense of lag can perhaps be explained by the physical challenges that underground features create for RS based on satellite imagery. One of those challenges is financial. Any data gathered through remote sensors have to be triangulated with field data gathered via well drilling. A robust data triangulation plan that includes a comprehensive well grid is extremely expensive. The number of wells necessary to generate enough data points for a robust triangulation grid is prohibitive to most public agencies responsible for water management around the world. The promise of the WATEX™ algorithm is that its accuracy drastically reduces the need for such drilling. Don Mohammed and Gachet argue this will transform the field, allowing countries to use RS technologies to map their subterranean watery worlds in an affordable and timely manner.

Touching with Light

At the University auditorium in Costa Rica where don Mohammed was introducing WATEX™ to the public, he peppered technical explanations about RS with anecdotes from his work in the Middle East and North Africa. He also mentioned how he often collaborates with "Department of Defense" and how that collaboration has taken him to many regions of the world. I had heard don Mohammed talk for about fifteen minutes and I was already disconcerted by how smoothly the American military apparatus and the oil industry became the backdrop against which the audience was invited to see aquifers.

The audience that afternoon included public servants, researchers, university professors, consultants, and several students. The talk was announced to the public as a general introduction to how *teledetección*, as RS is called in Spanish, can help better manage underground water. The cadence of the Spanish word teledetección resonates with science fiction terms. *Teletransportación*, for instance, is the word used for the dream of moving bodies across discontinuous space. Any word that begins with the prefix tele, with the exception of television, carries futuristic overtones. It signals the ability to accomplish a task at a distance, a somewhat fantastic capacity to grasp the world in one location while your body sits at another (Figure 1).

As his presentation progressed, don Mohammed quickly disabused his audience of any futuristic references. He did so by radically normalizing RS and squarely emplacing it in the human sensorium. He explained, "We are

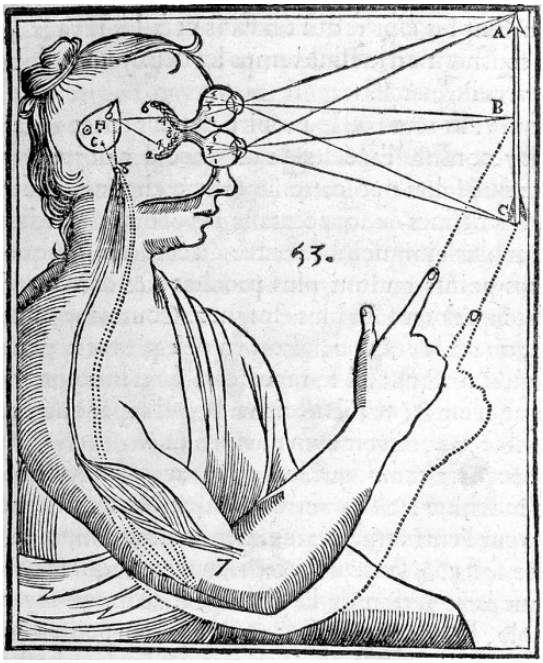

Figure 1. Rene Descartes's seventeenth-century rendition of vision whereby light rays impressed subtle particles into the eyes, stamping images that then moved to the pineal gland.

all remote sensors, our bodies are sensors. Anytime you are unable to touch an object but can sense its presence you are sensing remotely." With this statement, he was suggesting that vision and touch were different registers of perception that operate in a subsidiary manner—if touch fails, vision steps in and fills the gap. He was also making the (im)possibility to touch an object at a distance the conceptual hinge that determines "remoteness." This was a normative Western contrast between the haptic as proximate and vision as detached (de la Bellacasa 2017, 95; see image 2). Here, touch resembles contact, the sensation of full bodies, an idea that builds upon notions of matter and distance drawn from classical physics (Barad 2012).[1] He continued, "Remote sensing is nothing more than studying something without touching it, maybe by only seeing it."

Up to that point, his explanation was somewhat predictable. Don Mohammed was emphasizing sight as the privileged medium for

knowledge generation in a situation where observer and observed are separated. He was delineating a generalized "technoscientific gaze" from nowhere (Haraway 1991). His words were also evoking RS as a "technology of distanced, elevated image capture" (McCormack 2010, 641) that exhibits spatial affinities with guards and military operators observing distant objects that have been made controllable and repressible by virtue of their visibility. Seemingly, don Mohammed was providing evidence to the well-established idea that with modernity, and its taste for empiricisms of different sorts, comes an emphasis on sight that replaces the preeminence of other senses and forms of perception. His rendering of vision was transparent, as if seeing was not a cultivated, theoretically and culturally laden practice (Haraway 2004; Lynch 1988; Vertesi 2012).

If I were committed to a panoptic analytic, at this point, I would have hit a core. I could argue that don Mohammed had split apart vision and touch, privileging the former at the expense of the latter. His talk would provide more evidence of the Western, enlightened occularcentrism that scholars have extensively critiqued. On that basis, I could also produce a solid critique of visuality, its politics, and its imperial aspirations. But it is precisely at this point that I wish to pause and ask whether this response is warranted. What if, rather than reading for panoptic logics of observation, we reassessed what don Mohamed asserted by attending to the other sensorial articulations he invoked. After all, touch, or its lack, is the condition of possibility for RS to emerge as a solution to lack of proximity between bodies. To chart this undercurrent in his rendering of RS, we need to attend to the more-than-visual clues he also provided; particularly, his explanation of how LandSat sensors produce data.

Don Mohamed's incursion into cross-modal sensing was organized around the issue of texture and its significance for LandSat images. The most detailed part of his talk, for example, explained how every object on earth has its own unique light signature, a combination of reflection, emission, and absorption of light. This is the basic premise behind LandSat imagery that "the earth's features and landscapes can be discriminated, identified, categorized, and mapped on the basis of their spectral reflectances and emissions" (National Research Council 1998, 39). He described how as the light emitted by those objects touches satellite sensors it does not yield predetermined forms, as if these were ready and available for observation. Instead, sensors in LandSat satellites record textures. As different wavelengths of the light spectrum touch upon the surfaces of sensors, they inscribe different textures on them. Each object manifests itself as a pattern of surfaces, a distinct grouping and topography. Don Mohamed showed on

the screen a series of images where textures were visible, but objects were not recognizable. Some textural patterns were tightly woven, others were spread out in space. But most of the silhouettes were unrecognizable for untrained eyes. To emphasize their unintelligibility, he asked his audience to identify the different textures on the screen. He gave us time to think by speaking of smoothness, coarseness, tightness, and spread.

As Sedgwick notes, texture sits at the overlap between sight and touch. Texture requires a pattern, "it comprises an array of perceptual data that includes repetition, but whose degree of organization hovers just below the level of a shape or structure" (Sedgwick 2003, 16).[2] While initially one might associate it exclusively with touch, texture "is not coextensive with any single sense" (p. 15). Rather, texture is liminally registered "on the border of properties of touch and vision" (Bora 1997, 101). Moreover, its cross-modal character can be defined as "the sensory and functional manifestation of the structural, mechanical and surface properties . . . detected through the senses of vision, hearing, touch and kinesthetics" (Szczesniak 2002, 215). Texture is more and less than an object. It is less because it fails to reach the boundaries that allow us to recognize something as a figure, and it is more because it exceeds those boundaries, challenging separations, and creating unexpected continuities across space. In dealing with texture, what our eyes see is always supplemented by the memories and insights that other senses accumulate. The operation of elucidating texture posits a demand; a need for inference emerges after being presented with texture. One more act of interpretation is required if we want to turn what we perceive into a recognizable entity. That subsequent act of interpretation draws on haptic histories and theories, as much as it depends on technically cultivated forms of vision. In this case, that interpretive act is performed jointly by the WATEX^{TM} algorithm, its computing infrastructure, and the humans who specialize in RS. Together, with institutions and social structures behind them, they constitute a distributed network of visual-haptic meaning-making that turns wave lengths inscribed as numerical data into textures and later into visual forms of representation (maps).

This need for one more act of interpretation intrinsic to textural elucidation has an unexpected effect. It denaturalizes vision as an automatic source of clarity and knowledge. When you see the textures that satellite sensors capture, for example, you are far from seeing what you had hoped to see. This was most clear at the moment don Mohammed asked his audience to identify the images he presented and only silence followed. Noting this conundrum, don Mohammed brought up another of his main points. He explained that it was misguided to think of the peculiarities of remotely

sensed textures and assume that because our eyes react to light, they grasp objects by way of ocular recognition. This was even more problematic when thinking of underground formations. As he put it, "light is good for many more things than just seeing," particularly in relation to aquifers, which are entities that can never be seen. Narrating the inherent impossibility of seeing the underground, he noted that the point is not to use remote sensors to produce enough magnification nor to bring close what is far away in order to produce a better image. Aquifers have a different epistemic relation with RS. As he said, "The light spectrum cannot do the impossible, it cannot penetrate deep into the subsurface." Unlike other forms of observation, RS of aquifers is limited to launching "a process of inference." The light spectrum is only a tool from which to infer, to gather information as underground water remains, at the end of the day, unobservable.

Having recuperated this textural dimension, the critical place of touch in conceptualizing RS, and the uncharacteristic description of failed vision as critical points in don Mohammed's presentation, we can now realize how what is at stake is not merely a form of panoptic visualization. Rather, it is the articulation of sedimented senses of touch and vision—forms of processing light and texture—resulting from the contact of light waves with sensors and their subsequent interpretation. I see this as a cross-modal form of touching with light. On the one hand, light waves touching the surface of sensors. On the other hand, tactile meaning-making capacities that take that which light creates, a textural record, into an interpretive process that eventually yields a recognizable object. Touching with light captures surfaces, depths, and forms but stops short of automatically turning those into transparent objects. The process of touching with light constitutes a distributed network of humans and nonhumans that face the need for one additional act of inference, one additional interpretive step.

The dominant technoscientific knowledge of the subsurface that we have inherited is tied to geology, the field that blossomed in the eighteenth century hand in hand with the mining industry. Geology combined the romantics' vision of underground formations as dark spaces of reclusion and the mining industry's vision of the underground as a hidden resource waiting for excavation and extraction. Not surprisingly, many descriptions of subterranean formations present them as dark spaces to be conquered via illumination, by bringing light to overcome their inhospitable conditions. This combination of metaphors is sedimented in popular ideas of the subterranean. Don Mohammed's explanation of how light is used to generate textures that an algorithm interprets to infer what lies in the subsurface plays with a different kind of illumination. This form does not automatically

produce the self-evident objects that enlightened forms of vision seek. His take on light, vision, and texture goes beyond the assumption that things are sitting there, waiting to be seen. Instead, it uses light to think about the process of rendering textures meaningful, even if the objects one attempts to observe remain invisible, as aquifers inherently are.

WATEX^{TM} relies on light signatures that touch sensors, are transformed into digital languages, and then become records of texture. I have suggested these textural objects are different from self-evident images of landscapes or territories. This form of visualizing, even if it ends up producing a map, is never a realist image. It always carries with itself the marks of its technological production in a way that challenges any claim to transparent observation. This form of sensing is a complex historical arrangement that involves satellites, sensors, and algorithms but that also fundamentally needs subjects making sense of all of that media. Together, they accomplish a textural form of knowing made possible by touching the subsurface with light. This procedure depends on the intense entanglement of our notions of the subterranean, the tools we use to sense it, and the concepts people use to make sense of those tools. That dynamic articulation requires attending to their cross-modal sensorial integration, even when they are abstracted as concepts. Once we pay ethnographic attention to this form of sensing, we see how visual centrism is just one part of the story. There is much more going on.

Despite my fascination with don Mohammed's introduction to RS, the technical details of the project were only available to a very small group of people, namely, those immediately in touch with him. A few days after his public presentation, the country's largest newspaper published an article announcing that "Costa Rica was going to explore its subterranean water" (see Figure 2). The piece noted how the project filled a crucial knowledge gap and would allow for better planning and monitoring. The implication was that existing water conflicts were due to a lack of scientific data, an equivocal, but widespread, premise that erased the economic and environmental histories structuring such conflicts. The article also praised the government's investment in the initiative. Neither don Mohammed nor the ambassador made it into the photo. The tourism developers that Sardinal residents opposed didn't make it either. Instead, those following public discussions over underground water issues saw a man, probably not a very wealthy one, pulling water out of a dark artisanal well; a deserving subject performing what many people in Costa Rica consider a chore that belongs to a different era in the country's history.

8A | EL PAÍS | JUEVES 11 DE MAYO DEL 2017 / LA NACIÓN

En Guanacaste es donde se ha afrontado la mayor crisis por falta de agua. Elías Contreras bombea agua de un pozo en Sardinal. ALBERT MARÍN

INICIATIVA DEL MINAE, EN CONJUNTO CON EL SERVICIO GEOLÓGICO DE ESTADOS UNIDOS

Costa Rica explorará sus aguas subterráneas

Estudio utilizará información de satélites, así como datos de campo

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Con mapas e imágenes de alta resolución, Costa Rica comenzará a evaluar el estado y el potencial de las aguas subterráneas, en otra vía para asegurar el recurso hídrico del futuro.

Para lograrlo, el Ministerio de Ambiente y Energía (Minae) anunció el lanzamiento para julio de un proyecto, conjuntamente con el Servicio Geológico de Estados Unidos (USGS, por sus siglas en inglés), con el cual trabajan desde diciembre del 2015.

El objetivo es que los mapas y las imágenes en alta resolución permitan localizar acuíferos y zonas de recarga, lo que haría posible planificar mejor el uso del líquido.

Actualmente, en el país no existen estudios previos, a escala nacional, sobre el potencial de las aguas subterráneas. En consecuencia, tampoco hay programas de planificación de recursos hídricos ni planes para afrontar el cambio

"Hay mucha información sobre el tema, muy dispersa y alguna incluso escondida, por lo cual estamos tratando de reunir las voluntades de distintas instituciones", afirmó José Miguel Zeledón, encargado de la Dirección de Aguas del Minae.

El estudio, valorado en $1,4 millones, comenzaría en julio y concluiría 14 meses después. Se financiaría con recursos del Ministerio.

Más precisión. El estudio combinará datos de detección remota recogidos por varios satélites, propiedad del USGS, con datos de campo e información sobre aguas subterráneas ya existente en el país. Esto supone la participación de varias entidades ligadas al agua.

Entre esas instituciones están el Ministerio de Salud, el Instituto Costarricense de Electricidad (ICE), el Instituto Costarricense de Acueductos y Alcantarillados (AyA), el Servicio Nacional de Aguas Subterráneas, Riego y Avenamiento (Senara), la Universidad de Costa Rica (UCR), el Instituto Meteorológico Nacional y el Instituto Geográfico Nacional.

La utilidad y el alcance de los mapas basados en teledetección (se aplicará una tecnología llamada WATEX, desarrollada por el USGS) permitirá contar con datos sobre distribución espacial del agua, direcciones de flujo, condiciones confinantes del líquido y áreas de recarga.

Solo este conocimiento, recordó Zeledón, podría ahorrar tiempo y dinero, al elevar la tasa de éxito de perforación en sitio al momento de explotar pozos. Asimismo, las investigaciones podrían guiar planes reguladores en distintas municipalidades sobre dónde se puede o no construir.

Otro objetivo del plan es establecer un sistema de monitoreo de las condiciones del recurso hídrico en el ámbito nacional.

La realización del trabajo de campo incluirá dos equipos completos con sistemas de navegación y exploración de aguas subterráneas. Este equipamiento permitirá caracterizar, en tiempo real, las áreas analizadas, en relación con su potencial hídrico subterráneo.

Los datos recolectados serían un insumo importante para el Estado a la hora de decidir si otorga autorización para nuevas perforaciones, o en la creación de políticas para la adecuada protección y el correcto aprovechamiento del recurso hídrico subterráneo. ■

Figure 2. Newspaper article presenting the mapping project.

Conclusion: The Difference Texture Could Make

I began this paper with one straightforward question: how is the subsurface brought to the surface? To explore possible answers, I excavated a relatively ephemeral occurrence, the public presentation of a RS project designed to

map all of Costa Rica's aquifers. I traced the meaning of sensing in this project, looking for cues of the kinds of unexpected articulations that such sensing rests upon. Following a feminist science studies approach, I began from the premise that the act of sensing is not about connecting separate subjects and objects but about their co-becoming. The public presentation of this project called forth a form of sensing that is not visual centric. People were invited to think about and with textures, not with given visual forms or identifiable objects. The metaphors, visuals, and technological descriptions used by don Mohammed revealed an interesting twist: the need for non-phenomenological and cross-modal sensing. That is, making sense of RS required turning embodied senses into abstract conceptual resources. This abstraction process circled around the notion of texture as a semiotic artifact that pulled data, wavelengths, light emission and reflectance, satellite sensors, images, and interpretations together. Texture activates our thinking about touch and vision, eliciting a cross-modal form of sensing. While panoptic understandings take vision as the act of surveilling objects that can be observed, sensing aquifers with satellites offers information on texture first, and only sequentially can visions of a unit or object emerge. Thus, my argument that grasping the underground through RS technologies is a practice of making texture meaningful akin to "touching with light."

WATEX^{TM} makes possible the collection of textures to render a world that can never be seen. This is where limiting touch to embodied contact reveals more about our analytic habits than about touch itself. Don Mohammed mobilizes touch as a sensemaking resource, as a concept that builds on our embodied capacity, but deploys it in a space that is utterly out of reach for any human body. Here, the haptic is much more than the embodied, and any radical separation between the phenomenological and the abstract becomes an inadequate convention. It is apparent now how an argument centered on vision exclusively would flatten the rich and cross-modal interpretive moves used to infer objects that can never be approached physically.

Another important reason for taking this analytic route is to trouble the dominance of securitized and militaristic analyses of the politics of verticality. My point is that while that is part of the story, there is much more going on, and thus, we need broader analytic repertoires to capture the diversity of vertical sociotechnical projects and sensing modalities occurring across distinct political, environmental, and social contexts. Even if based on a single event, and if of a somewhat exploratory character, my analysis offers nonorthodox avenues for thinking about what sensing subterranean spaces entails. At a time when all sorts of environmental

instabilities and cataclysmic conditions demand action, it is important to find fresh resources to engage with technoscience. Turning to areas of scholarship that are not usually connected to studies of RS, such as theorizations of caving and disability studies, expands our analytic repertoires, opening new ways for making sense of our responsibility for the worlds we encounter.

Author's Note

As usual, Robert Werth provided fundamental critiques and suggestions that have made this project better.

Acknowledgment

I want to thank Mel Ford, Katie Ulrich, and Charlie Lotterman for their feedback on an earlier version of this paper.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Funding for this research was provided by the National Science Foundation, the Wenner-Gren Foundation and by fellowships from Rice University, Arizona State University, and the University of California-Irvine.

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Notes

1. As Barad (2012) explains, when you touch "what you are actually sensing is the electromagnetic repulsion between the electrons of the atoms that make up your fingers and those that make up the [substance you touch]" (p. 209).
2. Here, I diverge from Sedgwick's assertion that texture and affect are irreducibly phenomenological, if we take that assertion to invoke a direct embodiment of the act of touching (p. 21).

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