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A Cartography of the Unknowable: Technology, Territory and Subterranean Agencies in Israel's Management of the Gaza Tunnels

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ABSTRACT
This article evaluates the potential for agency exercised by the subterranean volume in geopolitical conflict. Joining recent geographical conceptualisations of territory as a volumetric assemblage with calls for an elemental geopolitics, it argues that the density of the underground layer creates a convoluted techno-political problem that obfuscates the state's means of directly observing, visualising and knowing the topological space of territory. To illustrate this, a methodological approach based on the relational ontologies of actor-network-theory (ANT) and assemblage theory is applied to an empirical study of the geophysical sensing techniques used by Israeli engineers, scientists and military to manage cross-border tunnels built by the Palestinian militant group Hamas before and after the 2014 Gaza war. The soil conditions, settlement patterns and infrastructures in the Gaza-Western Negev region have necessitated experimentation with complex and multiple forms of scientific and political expertise in attempts to locate the invisible tunnels, alongside a shift towards increasingly oblique techniques of cartographic representation of the subsurface. The contingency of these efforts has unsettled the State of Israel's confidence in its ability to manage geopolitical risks through techniques of territorial control. This case raises poignant questions about the extent of the capacities and limitations of technological solutions and geopolitical practices to secure territory when confronted with the geophysical agency of the underground.

Introduction: Material Agency and Geopolitics

The elemental properties of the Earth in a particular place exert influence on the strategic efficacy of the military, and by extension the political agency of the state. Put differently, the materialities and processes of the physical environment play an active role in shaping geopolitical processes (Adey and Anderson 2011; Barry 2013a, 1–2). Shaw notes that the "relationship between violence and the environment has persisted since the dawn of humanity... all that has changed is the scale, intensity, and technical

complexity of this relationship" (2016, 692). Explicating the complex entanglement of political organisations with the hybrid earthly–technological volume of the space through which they operate can provide a more nuanced understanding of the dynamics and limitations of geopolitical power enacted through the logic of territory. This article will address how the subterranean dimension specifically affects the complex relationship between territory, techno-scientific risk management practices and geophysical material agency. To do so, it will use as a case study Israel's efforts to detect cross-border tunnelling from Gaza by the Palestinian political party-cum-militant group Hamas[1] around the 2014 Gaza war.

The Israel Defense Forces (IDF) declared Operation Protective Edge on 8 July 2014 with the stated aim of halting persistent rocket fire into civilian areas in the Negev from Hamas in Gaza (State of Israel 2015, x; UN Human Rights Council 2015, 18). However, 10 days into the conflict the Israeli operation's primary objectives suddenly shifted to detecting and neutralising a series of newly discovered clandestine attack tunnels from Gaza, which had taken the IDF by surprise. Furthermore, this new goal necessitated a ground incursion by IDF into Gaza, as opposed to their preferred strategy of intense aerial bombardment demonstrated in the 2009 and 2012 Gaza wars. Such a ground battle is a politically undesirable strategy for the appointed Israeli security cabinet due to public casualty aversion in relation to Israel's conscript military.

According to Israel's count, thirty-two cross-border tunnels were destroyed during the conflict, eighteen of which had actually penetrated into Israeli territory while the other fourteen were incomplete (State of Israel 2015, 47). However, it is unclear whether all of Hamas' cross-border tunnels were actually discovered. Since the end of the 2014 Gaza war, Hamas has started to build new tunnels into Israeli territory in preparation for a stand-alone attack or use in the next round of conflict. Several tunnels have been discovered and destroyed by the Israel Defense Forces (IDF) between the end of the 2014 Gaza war and 2016 (Harel 2016a). The unusual and sudden circumstances of a state apparatus shifting the stated goals of a military operation mid-campaign, as well as taking the politically unpopular decision to put "boots on the ground," begs the question of why tunnels were considered such a severe threat as to initiate this uncharacteristic set of actions by Israel's political echelon?

This article argues that the tunnels are perceived as a serious threat by Israel's strategic decision-makers because they are a technology of occlusion that makes use of the material properties of the earth to subvert the Israeli state's apparatuses of surveillance and calculation to secure against danger. The tunnels are unpredictable vectors from which Hamas militants could evade Israel's strong regime of border fences, visual and communications monitoring, and human intelligence gathering (HUMINT) to carry out

surface attacks within Israel. In this way, the tunnels attack the core premise of territorial sovereignty through which the state derives and articulates its power. The Hamas tunnels harness the elemental agency of the sub-surface to undermine the surfical power of the state. In doing so, this tunnelling disrupts the way that "space is 'geo-coded' through mapping... to know, control, and govern territories" by state security agents (Crampton 2011, 94). This undermining of cartographic representation unsettles the territorial knowledge through which the state asserts its perceived sovereignty.

However, this materialist analysis does not imply that the Hamas tunnels, or the conflict between Gaza and Israel is a purely technical issue. Rather, the tunnels are problematic for Israel's security organs due to the complex convergence of politics, geopolitical organisation, socio-economic factors, material practices and geology endemic to the Gaza-Western Negev region within the broader context of the Israel-Palestine conflict and the turbulent geopolitical circumstances of the Middle East at present. It is precisely the entanglement of these converging vectors that make the problem so complicated, as their totality transcends the capacity to deal with each aspect individually.

To explicate how a subterranean geopolitics can enhance a critical understanding of the how political violence operates, this article will link the technological management and the manipulation of territory for political ends to the spatial production and rupturing of state sovereignty. The following section will provide a theoretical context for locating the subterranean within recent debates on the spatialisation of state power. In doing so, it will reconcile contending positions that have emerged in the recent literature on the volumetric nature of territory that treat volumetric space either as a vector through which political-rational calculations are spatialised (Elden 2013a, 2013b; Graham and Hewitt 2013; Weizman, 2007), or alternately as an elemental volume made up of a materiality that exceeds and constrains actors' agencies to manipulate the earthly volume (Adey 2010, 2015; Peters 2012; Squire 2016; Steinberg and Peters 2015). The methodology section will set out how a materialist epistemology based on actor-network-theory (ANT) and assemblage theory provides a useful set of tools for excavating a subterranean geopolitics, as well offering a brief discussion of the politics of research in a conflict zone. The fourth section "'Two Gazas': Locating the Tunnels in a Space of Conflict" will historicise the present case study within the regional context and in terms of Israel's territorial logic regarding Gaza. The two sections that come after will form the empirical core of the article. "Subsurface Complexity and Political Agency" attends to the ways in which local material agencies manifest and how this frustrates scientific attempts to know the underground layer. "A Cartography of the Unknowable" deals with the issue of representing the subterranean, a space whose dense volume negates the primacy of visual perception, and its implications for the state's ability to technologically manage risk through data analysis. The article concludes by relating the Gaza tunnels case study back to a broader theoretical discussion of how the

subterranean destabilises state power by interfering with the calculative rationality of the state, and how this alters the ways in which geopolitics can be understood.

Securing the Elemental Volume

The recent paradigm of a volumetric political geography offers a powerful means to theorise the relationship of state-space with the physicality of the earth and how spatialised assemblages of humans, matter and technological innovation work to both negotiate and negate the supposedly inviolate border of the sovereign state (Elden 2013b). Territory is not a flat surface with demarcated and fixed boundaries. Rather, geopolitical processes are in constant flux through the three dimensions of space, i.e. above ground, at the surface and below ground, as well as horizontally and diagonally (Elden 2013a, 17). Arguments from the emerging elemental geographies literature extend the concept of volumetric geopolitics as a dynamic and full physical environment by drawing attention to how the elemental richness and affective capacities of volumetric space can exceed political rationality, rather than treating the maintenance of territory as an instrumental political process. In other words, politics do not just operate through the volume, they are "immersed" in the volume (Adey 2015, 57).

The elemental geographies literature documents how general categories of earthly elements, such as rock, air and water have influenced sites and processes of geopolitical significance in a way that exceeds the abstraction of a juridical notion of territory (Adey 2010, 2015; Peters 2012; Squire 2016; Steinberg and Peters 2015). In keeping with Boyce's recent work on the pitfalls of the SBInet surveillance sensor network at the US-Mexico border, an elemental perspective can further "a post-humanist theory of 'terrain'" that attends to "the ways that the quality of certain forces, spaces, and conditions may impede or disrupt a state's vision, navigation, or administrative practice" (2016, 246). This concept of the political inertia of material agencies can be pushed further to add greater depth and breadth to the political geography of terrain by focusing on the peculiarities that constitute its subterranean aspect. Building on McCormack's critique of the emerging elemental thinking, more attention should be paid to "the particular capacities and properties" of "classes of matter" (2015, 86) as they converge in a unique location. As political geographers, we can develop even more sophisticated accounts of geopolitical events by correlating the elemental notion of volumetric space with the rational-political understanding of territory through which state actors themselves articulate sovereignty. Considering the convergence of distinct elemental properties with other specific aspects of a place will produce better theorisation of the ambivalences between the sameness that make general classes of elemental matter analogous and their place-specific localisations that generate difference to provide more sophisticated accounts of geopolitical situations. In the present case of the Gaza tunnels, the region's historical trajectory alongside the particular patterns of bordering, fortification and surveillance, have coalesced with

the endemic soil conditions to challenge the state's approach to managing security through territorial ordering.

Such a theorisation of security as working through territorial assemblages necessitates consideration of how security is understood and operationalised both by practitioners and scholars. In contrast to a constructivist definition of security as a conceptual discourse of threat identification through "speech acts," (eg. Waever 1998), security is treated in this article as a materialisation of people, technologies, practices and knowledge that coalesces in response to "some form of dangerous supplement to the present that threatens to bring disappearance, damage or loss to a valued life (Anderson 2010, 229). Existential security defends life through the "social technology" of risk 'by means of which the uncertain future, be it of a catastrophic nature, is rendered knowable and actionable" (Aradau, Lobo-Guerrero, and Van Munster 2008, 150). By using an array of cartographic technologies including aerial and satellite imagery in concert with a constant stream of signals intelligence (SIGINT), HUMINT and sensor data being disseminated from the Gaza border, the IDF is engaged in a labour regime to monitor and anticipate any breaches of its security, rather than reacting responsively to an emergent threat. The key importance of cartographic techniques within military technological practices to "render space 'visible'" underscores that "the power of the visual always exceeds the simple matter of representation" in a way that is "central to the ability of the state to enact geopolitical power" (Graham 2010, 202).

In order to unpack how Israel's techno-territorial assemblage works to manage risk in a dialectic with Hamas' competing assemblage working to destabilise Israel's territorial control, a methodological approach based on ANT and assemblage theory is particularly useful. These two related approaches are valuable because they explicitly deal with the co-constitutive relationship between society, materialities and technologies in a sophisticated way that is neither deterministic nor deconstructionist.

Methodology

The present research works from a materialist epistemology that borrows from ANT and assemblage theory. These related, but different, approaches treat politics as a web of socio-technical relations in which agency is distributed between humans, objects and the physical environment. The capacities and relations of these actors coproduce ontology in a way that exceeds a purely human agentive capacity. By tracing how the interaction between humans and nonhumans, and among non-humans "creates… geopolitical risks" (Ek 2000, 866), an ANT approach can lead to novel insights about how political conflicts occur. Barry develops this notion by suggesting that scholars ought to engage with the specificities of techno-scientific knowledges and

material processes to produce more multifaceted and nuanced narratives of political situations (2013b, 420). This methodological approach demands that the researcher focus on the unique dynamics of the situation at hand to alter existing theory, rather than rigidly applying a normative theory to a particular case.

Assemblage theory is a useful supplement to ANT for considering how military groups organise in the context of their environments. It views a political organisation as constituted by a heterogeneous network i.e. assemblage comprised of both human and non-human elements that can be manipulated or interfered with to enact social or political change (De Landa 2006). Müller argues that "critical geopolitics all too often just assumes organisations as given actors without looking at what exactly fashions them with agency" while in actuality "organisations are precarious entities" that require constant work through bureaucratic processes and the enrolment of technologies "to maintain their actorness" (2012, 379). Borrowing from ANT's terminology, assemblage theory provides a way to dissect the *"black box"* of military organisations, to expose their composition and inner workings. Incorporating the elemental properties of the physical environment itself into the military assemblage/counter-assemblage, can explicate how the earth is simultaneously both an agent that furthers an actor's agenda, and an inertial force that works against an entity's strategic goal.

In order to explicate the relationship between the socio-technical assemblage of the IDF in their efforts to locate the Hamas tunnels from Gaza and the material properties of the soil, this research has relied on a mixed method approach that combines field research with documentary analysis. The field research was conducted in Israel in 2016 and consisted primarily of semi-structured elite interviews with reserve or retired military personnel, academic experts, earth scientists and engineers. An especially rich vein for this ANT-based enquiry came from an engagement with the scientific and engineering experts. They provided an explanation of the technical specificities, capabilities and limitations of geo-physical detection that is at the core of this argument. It is only by grappling with the physics and mathematics of frequency ranges, magnetic fields, electrical conductivity and reflection coefficients, that the material agency of soil becomes apparent.

Supplementing these "elite" perspectives are ethnographic site visits and interviews with residents and activists in the Western Negev region bordering Gaza. Additionally, documentary sources were used to supplement the interview data, and to provide a wider political context for the case study. These sources included Israeli and foreign newspapers, government reports and media outputs, and reports by both Israeli and foreign NGOs, IGOs and think tanks.

Unsurprisingly, conducting a military "technography" (Woolgar 1998, 441) in an arena of active conflict is fraught with sensitivities and impediments to access that must to be carefully negotiated. As a deliberate response

to the often contentious discourse about the Israel-Palestine conflict, care has been taken in this article to moderate against a strongly agonistic characterisation of the Gaza case, and instead focus on its value as a medium to think through theoretical concerns about the political significance of subterranean materialities. However, it is important to acknowledge the deeply entangled and mutually reinforcing "dialectics of space/violence" (Yiftachel 2009, 146) in the conflict between multiple sets of actors that goes beyond a simple binary of Israeli/Palestinian. I have conscientiously avoided fetishising the subalternity of Hamas and other Palestinian militant factions to excuse their violence, nor uncritically accept the legitimacy of the frequently draconian violence of Israeli military action in Gaza. That said, this article does not pretend to provide an "objective" or even-handed account of the role of tunnels in the Gaza-Israel conflict.

The present account focuses almost exclusively on Israel's experience with the Gaza tunnels as an ongoing exercise of risk management. Reasons for this include the focus of enquiry on technology and the state, and the researcher's own positionality within the research, which opened certain pathways of access and participation that might have been restricted to other researchers, whilst simultaneously making other lines of investigation problematic. Other considerations included the sensitivity of negotiating access to elite participants in Israel, travel restrictions on entering Gaza, and the deliberate secrecy of Hamas regarding the tactics and strategy of their tunnel-building. As a result, Palestinian perspectives on the matter are unfortunately absent. However, since the emphasis of this article is on how the subterranean affects hegemonic state security, the absence of Palestinian voices in the present research does not detract significantly from its substance or purpose.

Additional considerations included taking care to respect both legal requirements regarding state secrecy and participants' personal boundaries in what they were willing to discuss. These sensitivities necessitated avoiding the use of audio recording in certain interviews. As a researcher, I also needed to be aware of how my own acts of information gathering and knowledge production could make me an active agent in the geopolitical conflict. In one instance, I was interviewing a scientific expert about tunnel detection and asked a question about whether different materials used by Hamas to reinforce the tunnels made them harder to detect. At this point, the participant said he didn't want to answer that question because if I published that information it could "help the enemy." [2]

"Two Gazas": Locating the Tunnels in a Space of Conflict

The Israeli journalist Shlomi Eldar observed that the tunnels "suddenly revealed that there are two Gazas: One is the crowded, impoverished and faltering Gaza, but there is also an 'underground Gaza,' buried deep below

the surface" (2014). This sub-surfical dimension of the Gaza situation is not without antecedents or parallels within the broader context of the Israel-Palestine conflict. Weizman notably describes the "bewildering and impossible Escher-like territorial arrangement" created by Israel's construction of "underground tunnels" and "infrastructure" in the occupied West Bank as a set of volumetric techniques to enable Israeli territorial control to occur above- and below-ground simultaneously with Palestinian political control on the "surface" (2007, 180). Furthermore, issues around the sovereign rights and distribution of subterranean resources have caused significant disagreements impeding a negotiated peace agreement. For some time, there have been disputes over shared aquafers concerning water allocation by volume, the digging and control of land for wells and pollution from agriculture and sewage (Tal and Rabbo 2010, 103–123; Zeitoun 2008, 47–53). More recently, the exploration and potential discoveries of fossil fuel deposits located both off-shore between Israel and Gaza, and sites in the West Bank have become another locus for resource conflict (Oil in Palestine 2014; Hatuqa 2014; Schwartz 2015). However, it is necessary to look beyond geo-strategic approaches to underground territoriality that treat the ground or what lies within it as an inert vessel for human political power, to reappraise the constitution of territory and its significance within the Israel-Palestine conflict.

To understand how the subterranean mediates the existence of "two Gazas," at present and what makes the Gaza tunnels a "matter of concern" for Israel (Latour 2004, 231), it is important to locate their position within the regional geopolitical arrangements that produce Gaza as a territory. Following this, it is necessary to provide an account of Hamas' and other Palestinians' agentive roles within this space of conflict, whilst considering the extent to which the tunnels themselves can begin to exercise their own capacity for agency in ways that go beyond the instrumental functions anticipated by human actors. A caveat should be noted that while this section works to provide a historical, political and social context for the tunnels, there will inevitably be lacunae due to the intentionally secretive nature of the tunnelling and detection enterprises, and the impossibility of engaging with some of the actors involved in the complex network that is responsible for the tunnels' construction and destruction.

The State of Israel derives its authority through a malleable application of the Westphalian conception the state's absolute territorial sovereignty as a means of asserting its claim to economic resources and existential security within and without its borders. This use of territory has historically metamorphosed over a series of spatial shifts starting from the 1948 Arab-Israeli War in which The State of Israel was founded. The IDF captured the Sinai Peninsula and Gaza from Egypt in the 1967 Six-Day War. The Sinai was returned to Egypt in 1982 as part of what the State of Israel has coined a

"land for peace" strategy in accordance with 1979 Begin-Sadat peace agreement, although Egypt revoked its claim to Gaza. Little changed in terms of the territorial condition of Gaza as part of the Israeli state following the creation of the Palestinian National Authority (PNA) and the rezoning of the West Bank into areas of Palestinian, Israeli and joint control resulting from the 1993 Oslo Accords. In response to the violence of the Second Intifada that started in 2000, Israel began to tightly restrict the movements of Palestinians in and out of Gaza. In 2004 the Israeli Knesset decided to support the controversial plan of right-wing prime minister Arial Sharon to unilaterally "disengage" from Gaza. Multiple reasons have been presented for Israel's decision to withdraw. These included the high costs in resources and blood to defend the Jewish settlements in Gaza, how disavowing the predominantly Palestinian territory would alter the state's demographic balance in favour of a Jewish majority to preserve Israel's "democratic character," and to assuage Palestinian and international criticism of Israel's ongoing occupation of the future Palestinian state in contravention of the Oslo roadmap (Byman 2011, 174–176). Following Israel's completion of the withdrawal in autumn 2005, Hamas won the majority of parliamentary seats in both the West Bank and Gaza in the 2006 Palestinian legislative elections. These results were not accepted by their rival, the secular Fatah party, leading to a violent internal struggle within Palestine. By the end of this conflict in 2007, the Palestinian Authority was spatially divided between the two factions, with Fatah controlling the PNA in the West Bank and Hamas gaining full control of Gaza.

Paradoxical to its application of the Westphalian concept of sovereignty as the underlying source of political legitimacy, the State of Israel also extends its *de facto* partial sovereignty over Gaza's borders and atmosphere. The preexisting movement restrictions continued following the 2005 withdrawal, against the backdrop of increasing Palestinian rocket attacks. Human Rights Watch reported that approximately 2,700 rockets were fired from Gaza into Israel between September 2005 and May 2007 (2007, 31). Since the Hamas takeover in mid-2007, Israel and Egypt have intensified, and in some limited circumstances de-intensified, a blockade regime against Gaza. In doing so, Israel has maintained its application of control over Gaza's boundaries to counteract Hamas' political control within the strip that Israel perceives as a threat to its own territorial security. This partial sovereignty is expressed in the multiple and convoluted logics that administrate the interior and exterior of Gaza's territory. Hamas governs inside the territory and is primarily responsible for aspects of routine governance like infrastructure, policing, social welfare, tax collection, broadcast media, and hospitals and schools. Simultaneously, Israel and Egypt both control and limit the movement of people and goods outside of Gaza through their respective land borders to constrain Hamas' military capacity and to produce

stressful socio-economic conditions to stimulate popular antipathy against Hamas (Donnison 2010). Likewise, Israel controls Gaza's maritime zone through a naval blockade (Steinberg 2011, 13) that has been in continuous operation from 2007 and maintains control of Gaza's airspace. Gaza is also heavily dependent on Israeli and Egyptian infrastructure for its telecommunications and the importation of both generated electricity and the fuel needed to power the enclave's inadequate power plant, private generators and vehicles.[3]

This grey area in sovereignty has led to heated debates in international law over whether Gaza is still an occupied territory by Israel following the 2005 withdrawal. These debates have centred around the legal test of "effective control" of an occupying power based on Regulation 42 of the 1907 Hague Convention on the laws of war, which states that a territory is occupied "when it is placed under the authority of the hostile army" and that the occupying force's authority "has been established and can be exercised" (Dinstein 2009, 42–44). Some academics and human rights organisations contend that the Gaza is still occupied since Israel maintains "a broad scope of … control in the Gaza Strip" (B'tselem 2017; Maurer 2012). An opposing position argues that the IDF lacks the "potential" to maintain a stable military presence inside Gaza due to Hamas' military control of the territory's interior, nor does Israel control Gaza's civil governance or legal regime (with the caveat of the Palestinian government's responsibility under the Oslo Agreement to report updates to its population registry to Israel) (Cuyckens 2016; Milanovic 2009). Ultimately, whether Gaza is still an Israeli occupied territory is a question of scholarship in international law that is outside the purview of this article. However, in both practical and legal terms the Israeli state treats Gaza as a "*sui generis*" non-state territory that is external to Israel due to Hamas' internal control of the enclave (State of Israel 2009, 11).

In contrast to the malleability of spatial boundaries in the Israeli occupation in the West Bank and East Jerusalem, Gaza's terrestrial territorial dimensions are now well-defined in map terms based on the borderline established in the 1949 armistice agreement between Egypt and Israel.[4] Following the 2005 withdrawal, Israel disavowed any claim to inhabit Gaza. This is evidenced by the permanent moves to dismantle Jewish settlements during the withdrawal, including burying synagogues and relocating Jewish grave sites inside Israel. Furthermore, Israeli politicians have also sought to shift responsibility for maintaining Gaza's infrastructure and trade flows to Egypt in order to abrogate Israeli responsibility for Gaza's welfare and economic conditions (McCarthy 2009).

Israel and Egypt have been able to assert their security interests by means of applying superior military force to override the norm of sovereign inviolability. This is in keeping with the phenomenon that Elden has termed

"contingent sovereignty" (2009, 168–169). Israel's use of political violence to maintain its security regime over Gaza has included pervasive UAV and electronic surveillance over Gaza's atmosphere, carrying out targeted assassinations by missile-strike on Palestinian militants, and shooting at Gazans who approach maritime boundaries and the border fence inside Gaza. Likewise, Gazan militant factions including the Al-Qassam Brigades, Hamas' military wing, and Islamic Jihad have carried out frequent rocket and mortar attacks against Israeli towns and settlements in the Western Negev, and have made several infiltrations into Israel's pre-1967 borders by both sea and tunnels to carry out attacks. Both sets of examples illustrate that while Gaza's territorial contents appear fixed in two dimensions, when expanded to a three-dimensional volumetric conception of territory, the ordering of space becomes far more permeable and precarious than the Westphalian model can allow for.

For several decades, networks of tunnels branching underneath Gaza have been the veins that have vitally sustained the enclave's economic survival, as well as its self-styled armed "resistance" to Israel. These tunnels can be divided into three broad categories: cross-border smuggling tunnels from Egypt, tactical tunnels within Gaza, and cross-border strategic attack tunnels into Israel. However, as Cowen observes, "the distinction between 'civilian' and 'military'" is highly precarious in the contemporary world, particularly in relation to the violence implicit in the military origins and continuities of the logistical techniques that enable the "pipelines of flow" through which goods and bodies can elide the boundaries of the nation-state (2014, 4). Hamas' tunnelling practices have evolved from the experience gained through the earliest building of smuggling tunnels across the Philadelphia Corridor, a 14km long narrow buffer zone between southern Gaza and the Egyptian border near Rafah, that has been ongoing for several years prior to Hamas' establishment in 1987 (Pelham 2012, 7). These early tunnels were built to smuggle cheap goods and to facilitate movement between the previously contiguous community after the physical partition of the Sinai border in 1982. These tunnels continued to be used to counter movement restrictions on people and goods through the 1990s and early 2000s. However, the nature and roles of these tunnels have evolved significantly in the aftermath of Israel's 2005 withdrawal from Gaza.

In response to Hamas taking power in Gaza in 2007, Israel and Egypt both imposed a comprehensive blockade restricting the movement of goods and people entering or leaving the territory. Banned goods have included many categories of food, clothing, household goods, cars and building materials (BBC News 2010). Israel argues that the blockade is necessary to prevent weapons being transferred to Hamas and other militant organisations operating in the strip from Syria and the Lebanese Shia movement Hezbollah in the context of increased rocket attacks emanating from Gaza (Haaretz 2008).

Egypt for its part has maintained the blockade because it views the Fatah-led government as the legitimate Palestinian authority to control Gaza's borders alongside monitoring by European Union observers (Haaretz Service and News Agencies 2014). However, the UN and human rights NGOs have called the blockade "collective punishment" against Gaza's population for supporting Hamas which they argue is a violation of international law in war (UN News Centre 2012; Amnesty International 2010, 7). The blockade has variably eased and tightened over time in correlation with changing regional dynamics. However, it has continued to remain in effect as a long-term militarised governmental technique for managing security (Winter 2014, 316) despite the concerns raised by human rights advocates about its proportionality, and indeed some Israeli security practitioners' questioning of its efficacy (Eiland 2017; Harel 2016b).

Since 2007, the Rafah tunnels have become an essential conduit for importing food and banned goods into Gaza against the backdrop of worsening humanitarian conditions (McCarthy 2009) Hamas has consolidated authority over the cross-border tunnels, which are privately operated by Palestinian families who pay a license fee to the regime. Hamas uses its oversight of the tunnels to raise revenue by levying taxes on goods imported through the tunnels, import fuel supplies, as well as to clandestinely transport weapons into Gaza (Pelham 2012; Piven 2014; Verini 2014). This dual-use arrangement has made the tunnels a crucial infrastructure in maintaining Hamas' viability as the political hegemon inside Gaza, both financially as a source of income to sustain its government, and militarily as a logistical conduit. However, in early 2013 the Egyptian military launched a crackdown to seal the smuggling tunnels. This process intensified following the *coup d'état* that overthrew the Muslim Brotherhood government of Mohammed Morsi.[5] The Egyptian efforts to destroy the tunnels were in part designed to quell the growing instability being perpetuated by Islamic State-affiliated militant groups operating in the Sinai, which had instrumental links to the Al-Qassam Brigades in Gaza at the time (Eldar 2015). In addition to the environmental contamination of Gaza's water supplies from the sewage and seawater being pumped from the Egyptian side to collapse the tunnels, this destruction had severe effects on Gaza's economy (State of Palestine 2016, 20) and Hamas' revenue stream.

Hamas has also used cross-border tunnels into Israel for both tactical and strategic ends in several incidents prior to the 2014 war. These tunnels specifically are the focus of this article's empirical discussion. The most significant cross-border tunnelling operation by Hamas was the 2006 kidnapping of IDF sergeant Gilad Shalit from a border post near the Kerem Shalom crossing. Shalit was used as a hostage with which to negotiate the release of Palestinian prisoners from Israeli incarceration in 2011. This tactic of tunnelling mobilises the elemental properties of subsurface soil to disrupt the

contiguity of sovereign terrestrial space defined through the assemblage of practices and infrastructures that delimit the state's borders, such as patrols, fences, walls and border-crossing installations. According to one Israeli (res.) Major-General who was involved in strategic planning during the 2014 war: "the attack tunnels [were] one of the most important challenges that we are faced with because it threatens most military camps and of course civilian ... and near the borders [and] we don't evacuate not military, not civilians from the war area."[6]

Hamas' more recent military tunnels into Israel that played a role in the 2014 Gaza war were far more sophisticated than earlier tunnels, which were quite shallow and crudely built. To thwart detection by Israeli forces Hamas engineers started to build the tunnels at greater depths. To do so, they reinforced these tunnels with concrete, a scarce commodity in Gaza due to Israeli import restrictions. The IDF claim that approximately 800 tons of concrete were used in the construction of the tunnels that it had discovered (McCoy 2014). This material has either been diverted by Hamas from documented building projects, was smuggled from Egypt via the Rafah tunnels prior to 2013, or possibly stockpiled from a combination of sources (Barnard and Rudoren 2014). Either way, clandestinely accumulating, storing and deploying such a massive supply of concrete for the attack tunnels was an onerous, expensive and well-coordinated enterprise. According to one media report the "cost of excavating, reinforcing and maintaining each tunnel [was] approximately $1 million" (Eldar 2014), which was a significant expenditure for the cash-strapped Hamas government in the midst of a humanitarian crisis. Following the 2014 conflict, there is evidence that Hamas has been using concrete purchased through the black market at above-market prices from supplies intended to rebuild Gaza's heavily damaged residential and public infrastructure (Khoury 2015).

The extensive resources directed towards building the tunnels indicates that they are not built *ad hoc* for short-term tactical advantage, but are long-term strategic assets to further Hamas' political goals. The tunnels are an attempt by Hamas to "level the playing field" by strategically flanking the Israeli state's security assemblages, and by extension the Israeli state's claim to sovereign control. The tunnels' immanent potential for facilitating a surprise attack requires Israel to take seriously Hamas' interests and demands to avoid the domestic and international political consequences of an infiltration, or renewed conflict to incapacitate the tunnels. In this sense, the tunnels destabilise an understanding of territory in which state security apparatuses can protect their citizenry within the state's territorial confines by pre-empting vectors of existential danger through holistic territorial knowledge and techniques. In practical terms, this weakens the confidence of Israel's political echelons and security agents in their own abilities to exclude threats from without

(Elden 2013b, 327–328), and in turn the Israeli citizenry's faith in the state's ability to provide security.

This strategic purpose is reflected in the deliberate internal construction of the tunnels' infrastructure. These tunnels are on average approximately two metres high by one metre across. These dimensions allow the movement of people and munitions with relative ease. They contain lights, electricity and in some cases tracks for transporting materiel, and are booby trapped with improvised explosive devices (IEDs) to hinder penetration. Furthermore, their entrances and exits are camouflaged by brush, trapdoors inside buildings such as mosques and private homes, or are positioned within *wadis* to evade detection. In keeping with the well-documented geographical critique of the "gods-eye" view of aerial surveillance (Graham and Hewitt 2013; Gregory 2011; Saint-Amour 2011; Shaw and Akhter 2012), these camouflaged tunnel openings are virtually impossible to detect by conventional aerial imaging techniques, thus making ineffectual the UAVs used extensively by the IDF to maintain surveillance over Gaza. Hamas' deliberate practices to evade surficial detection require that the IDF turn to complicated and precarious geophysical sensing techniques to locate sub-surface incursions.

Subsurface Complexity and Political Agency

An elemental geopolitics requires a reconfiguring of our understanding of war as a spatial phenomenon by accounting for the agentive role of the materialities of rock and soil, and the military engineering practices that either harness or are confounded by their properties. The Gaza tunnels have become a political danger for Israel due to the convergence of a unique set of human and physical factors becoming enrolled together in a specific place to become a salient military assemblage. To produce the tunnels, both the digging practices of Hamas and the earthly conditions of Gaza and the Western Negev have become agents in the messy three-way political conflict between Hamas, the PNA and Israel. Likewise, the area's heterogeneous soil types and chemical composition in conjunction with the specific depths at which the tunnels transect, and the border practices and settlement patterns of the area have made finding the tunnels a challenging techno-scientific problem for Israel's scientists, engineers and soldiers. It is precisely Hamas' ability to capitalise on these limits of the scientific ability to know the density of subterranean space that make the tunnels a political "matter of concern."

In order understand the material relationship between soil composition and the political-strategic issue of tunnel detection, or failure thereof, it is first necessary to have an appreciation of the geophysics of seismic sensing and electro-magnetic sensing techniques (Daniels 2004; Kearey, Brooks, and Hill 2002; Ruffell and McKinley 2008, chapter 3). Several geophysical sensing techniques are being experimented with for detection of the Gaza tunnels

including classical seismic techniques using acoustic waves generated by a sound source, ground penetrating RADAR (GPR) that uses radio waves and frequency domain electro-magnetic mapping (FDEM) that measures the variance in electromagnetic conductivity of different materials. Seismic techniques and GPR are both similar in their basic principles. Waves, either sonic or electro-magnetic, are projected from a source into the underground. The waves then reflect off the subsurface materials. Data is collected by measuring the time it takes a signal to bounce back from the source to the proximate sensor at the surface level at a given point. Different surfaces reflect a frequency back at different rates depending on their material properties. This time/distance data is then converted and manipulated into a legible representation of a cross-section of the earth.

A signal will be able to penetrate deeper, or will reflect more easily, based on the density of a given sub-surface material. However, a trade-off must be made between the depth of penetration and the resolution of the data collected. Lower frequency wavelengths can penetrate more deeply beneath the surface, but resolution decreases drastically at lower frequencies.[7] FDEM is somewhat different in that it uses a large and powerful electromagnet to produce a signal and a sensor located on the apparatus measures disturbances in the sub-surface magnetic field.

In contrast to the earlier smuggling tunnels into Rafah from Egypt that were typically from 10 to 12m deep, the more recent attack tunnels into Israel at 20–30m depth are far more problematic. They exist below the depth of approximately 10m that the high frequency electromagnetic waves used in GPR are most effective, but well above the several kilometres of depth that seismic techniques are typically used to detect large geological features. Also, as previously mentioned, since the resolution decreases at greater depths, lower frequency waves struggle to detect objects the size of the tunnels, which are less than six feet tall by three feet wide. While FDEM can in some cases produce resulting images of up to 50m depth, it is particularly susceptible to interference from magnetic anomalies.[8]

Another source of frustration for tunnel detection experts is the heterogeneity in soil types, compositions and strata. Different techniques are better suited to specific soil types, and each soil type presents its own set of challenges for geo-sensing (Kuloglu and Chen 2010, 4314). As shown in Figure 1, beneath Gaza are variegated layers of sand, clay, loess and rock both laterally and across, as well as harder rocks imbedded in the soil which waves reflect back at different times, complicating the process of gathering geophysical data. Compounding this problem, the endemic soil contains a high saline content.[9] As salt is hygroscopic, the soil contains numerous pockets of liquefied salt which reflect electromagnetic waves back to the surface, often at oblique angles from the signal source, producing anomalies that are detrimental to obtaining a clear subterranean image. Yet another layer of frustration for rendering the
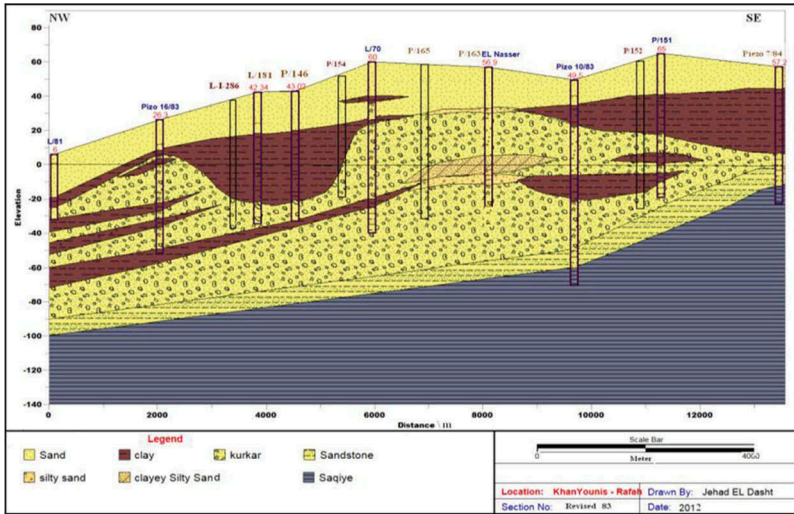
Figure 1. Cross-section of soil layers in Rafah District, Southern Gaza.
Source: Zaineldeen et al. 2014, 4352.

subterranean expanse knowable is the amalgamation of discrete strata. Several of the experts that I interviewed described the soil conditions at the Gaza border as "disturbed."[10] This "disturbance" can be attributed to the historical conditions of the area as a settlement hotspot for several millennia. The intensive agricultural activity endemic to the area has contributed significantly to blending the natural soil layers, which disorients the locations of objects in the geophysical images.

Sub-surface detection is further complicated by unwanted interference. These artefacts occur largely as a result of patterns of settlement and human activity in the border area. Vibrations from road traffic and heavy farming equipment interfere with small-scale seismic techniques that can best target the 20–30m depth range of the tunnels. Likewise, GPR and FDEM are affected by fences and detritus in the ground that produce anomalies due to electromagnetic conductivity. Paradoxically, the interference generated by the extensive military activity and material security infrastructure of fences, walls and communications posts along the border in fact mitigates security from tunnels by interfering with the capacities of detection technologies.

As this section demonstrates, technological efforts to render subterranean territory knowable will remain for the foreseeable future a fraught, contingent and inevitably incomplete project constrained by the material agencies of local geological and geopolitical conditions. The elemental qualities of the earth in concert with the patterns of human activity, and even the security assemblages of the state itself, collectively generate a more-than-human agency that has an inertial force against the security aims of the state to

defend its self-defined territorial integrity. Following on from the technical challenges of merely gathering accurate and useable geophysical sensor data, there is a second problematique of how to cartographically represent this data in a legible way. Since the opacity and density of soil requires sensing outside of direct visual experience, novel forms of visualisation become necessary that are dissociated from the intuitiveness of direct visual perception.

A Cartography of the Unknowable

Collating and representing the data gathered from geophysical sensing will always rely on multiple, contingent and incomplete ways of knowing and visualising the subterranean volume. Once raw data is acquired it must be processed into an image that is suitable for analysis. This time-consuming process necessitates enhancing particular aspects of the data and organising it as a diagrammatic output useable for analysis. Even at the final stage, analysis of the processed data requires highly specialised expertise to make sense of the underground cartography and to find relevant anomalies. Unlike a photograph, which is a familiar and naturalised visual form that enables quick interpretation, subterranean geophysical exploration requires highly abstract forms of imaging. These techniques require knowing what object is being sought in advance (for example, a fossil fuel deposit, an archaeological site, or a tunnel), as well as specialist knowledge of what an anomaly will look like when represented.[11]

At present, the specialist training and intensive computer-aided post-processing that are necessary to make geophysical scans legible preclude the possibility of a simple solution for tunnel detection that could be easily and quickly operated by soldiers in the field. See for example the GPR scan shown in Figure 2, used to investigate a suspected escape tunnel leading from a prison in Northern Ireland, near the border with the Republic of Ireland, following subsidence on a road adjacent to the facility.[12]

It would be very difficult to identify the features labeled in Figure 2(b) extrapolated from the scan shown in Figure 2(a) without a high level of training and expertise. Furthermore, even with this expertise, the representation such a scan can provide will always be incomplete and imperfect. Near the bottom of the cross-section, below 5m depth, the image becomes noticeably distorted, due to the high-frequency radio waves' inability to penetrate at greater depth. It should be noted that the target depth for this investigation was from the 0m to 8m range, which is far shallower than the cross-border tunnels from Gaza into Israel.

The endemic conditions of a particular area in conjunction with the strengths and drawbacks of each exploratory technique necessitates the use of a combination of methods to obtain a heuristically viable model of a
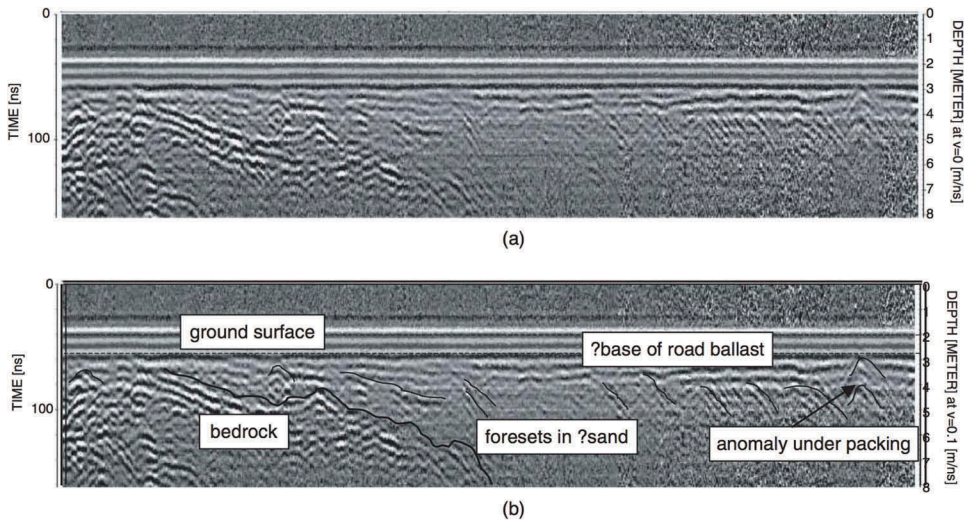
Figure 2. (a) GPR scan used in investigation of suspected prisoner escape tunnel in Northern Ireland. (b) Expert interpretation of the above scan.
Source: Ruffell and McKinley 2008, 82.

location's underground terrain. Several research participants suggested that there is no simple "one-size fits all" solution to the tunnel problem that could be easily applied without highly specialised scientific education. Rather, successful detection in each place will require an *ad hoc* solution that combines several geophysical techniques with other forms of knowledge such as human and signals intelligence.[13] Recently, Israeli forces have interrogated several captured Hamas militants, including a 17-year-old, in order to obtain intelligence on how the tunnels are being built and concealed (Cohen 2016; Cohen and Ben Zikri 2016).

The subterranean layer presents a significant challenge for a totalising political knowledge of territory by the state through cartographic representation. As expert 1 put it, finding these tunnels is "like searching for a needle in a haystack [where] you need to separate valuable data from background noise." Instead of being able to directly visualise what lies below the surface through intuitive forms of perception, the underground must be indirectly sensed through technological means calibrated by an arduous process of trial and error. The intensive time and resource allocation required for such a project is at odds with a temporal and economic logic of security based on the quick and efficient identification and targeting of threats. Whatever useable sensory data that is eventually gathered must then be represented diagrammatically and interpreted using knowledge that is contingent on highly specialised forms of scientific expertise. Even then, successful tunnel identification is contingent on the limitations imposed by the rules of physics and the actual capacities of

technologies at present. These limitations necessitate a shift towards abstract forms of topological representation that are increasingly divorced from the immediacy of direct visual perception of a phenomenon. Such knowledge is not always accurate because it is predicated on reasonable conjecture from pre-existing expectations about what should be found beneath the ground.[14] This opacity and reliance on supposition destabilises the confidence of state security actors to identify with any certainty the potential security threats concealed within the soil of the territory they are tasked with managing.

This uncertainty has profound implications for the calculation and anticipation of risk by the military. Despite expectations of politicians and the public that technological solutions can provide anticipatory evidence of threats, the present techniques of scanning, data modelling and mapping cannot give the definite locations of cross-border tunnels. All of the scanning techniques discussed in this article require "boots on the ground" to operate large and unwieldy apparatuses in exposed areas in a conflict zone, making the operators highly susceptible to attacks from infantry, snipers or ranged munitions. Even then such efforts might not produce any actionable data, despite the risks involved. Additionally, the amount of guesswork required by experts in tunnel detection requires definitive action to be taken by combat forces based on information that invariably comes with an increased probability of inaccuracy. Expert 2 explained the problem of neutralising the tunnels in the 2014 war:

> We don't see where the objective starts, where it ends... this is the basic reference you cannot make distinctions where the military objectives are so ... this is something that should change all the concepts that you ... because you cannot work without the basic layer of understanding [of] the enemy and you cannot understand the enemy not by the objectives, the specific objective, and also not by the intention, what he's going to do... If we had a system that can take all the relevant military camps and move them and also some people from the community and move them for few weeks, it could have achieved much better results than using very expensive measurements in order to detect where the [tunnels are].

The concealed nature of the tunnels makes it impossible for military planners to even identify a basic space from which a threat will emanate. This makes it difficult to ascertain the intended target or temporal frame of a threatening action. This knowledge gap makes it near impossible to effectively direct force towards a military objective. Complicating this matter is an understanding of the border area as a spatial container for people and objects that must be protected. To create a calculable space in which targets can be identified and military action can be effected, the sources/objects of risk protection must be removed completely. Such a move would be an admission of failure in the state's ability to be able anticipate and secure its population and resources from danger. This undercuts the very foundations of risk management underlying contemporary state security practices.

Amoore uses the case of the aftermath of another geo-physically imbricated crisis, Italy's 2009 L'Aquila earthquake, to argue that contemporary risk logic demands that "nothing is incalculable" and that for experts and politicians "to have available data – even if they are tangentially related, partial or fragmentary – and to fail to infer across the gaps" is tantamount to negligence (2014, 424). Such perceived negligence is likely to have severe political repercussions. A commission of enquiry was carried out by the Israeli State Comptroller's office in response to criticism in the Knesset of the security cabinet and military brass' handling of the tunnels in the 2014 war (The State Comptroller of Israel 2017). The report excoriated Prime Minister Benyamin Netenyahu and former defense minister Moshe Ya'alon for failing to act on intelligence about the immediacy of the threat posed by the tunnels and for failing to share relevant information with the full security cabinet (Jerusalem Post Staff 2016). It points to a previous report on the potential for tunnel attacks from 2007 to demonstrate the availability of adequate intelligence to allow decisive action and to show that warnings about 'the necessity of oversight and even intervention by the political leadership' had been made clear prior to 2014 (Bob 2016). According to one former defense industry executive who consulted on the 2007 report, possible pathways for technological solutions were proposed including a 'sensor net' several kilometres in area that could detect and locate underground vibrations from the digging of tunnels. However, he believed that no action was taken at the time due to "political decisions" and competing budgetary priorities within Israel's Ministry of Defense.[15] While the risk for a tunnel attack was conceivable based on available intelligence and conjecture from Hamas' past use of tunnels, the occlusive properties of the subsurface interfered with the presentation of directly verifiable and incontrovertible evidence of an imminent threat. This uncertainty gave the political leadership the option to ignore the tunnels risk to pursue other avenues of political interest, until that risk has materialised and rebounded, leading to accusations of negligence or even wilful manipulation at the expense of Israel's national security. Put simply, this example illustrates how the materiality of the subterranean make the technical political, and vice-versa.

Conclusions

The Israeli response to the Gaza tunnels is a particularly illustrative case of how human political activity is inextricable from the vicissitudes of the materialities and physical properties of the environment. This hybrid agency comes from the endemic convergence of the material practices of bordering and tunnelling, discourses of security and danger and the elemental processes of the subterranean. Whilst it would be an overstatement to suggest that the following are causes of the Gaza-Israel conflict, the soil

composition, settlement patterns, architectural practices and infrastructure of Gaza-Western Negev all contribute in intricate and entangled ways to the tactical, strategic and geopolitical dynamics of the ongoing Gaza-Israel conflict. This complex amalgamation suggests that to better understand the geopolitical as a material-earthly process, geographers need to grapple with the unique vectors of difference endemic to the subsurface volume in a given place. These vectors might include local conditions of elemental chemistry, material practices and human political contexts, alongside broader categorical conceptualisations of elemental materialities in terms of air, sea, rock, soil.

The dynamics of the relations between human activities that alter the geophysical and the elemental forces of the underground make palpable the limits of techno-scientific capacities to obtain certain cartographic knowledge of the subterranean. The contingent nature of state sovereignty in relation to an elemental inertia of a dense and heterogeneous soil that defies attempts to bring it "to account" (Adey 2015, 55) necessitates constant work by state scientific, military and intelligence actors to secure sub-surface territory through increasingly complex and fractional materialities, practices and discourses. This provokes a "cartographic anxiety" over "the desire to make geographical space legible" and thus calculable. The subterranean "unknown" must be drawn "into the ambit of Reason" otherwise it will aggravate an epistemological crisis that threatens the intrinsic logical foundation of territory as the geographical manifestation of state power (Painter 2008, 346). To assuage this crisis, the cartographic inscrutability of the subsurface must be overcome by the state. This necessitates innovating new ways of obtaining geographical knowledge that are tailored to the specific conditions of the terrain, and can synthesise fragments of partial knowledge to produce at least a crude epistemology of underground space. However, the limited adequacy of these spatial knowledge, and the increasingly indirect forms of representation being generated to visualise them, greatly diminishes the abilities of state authorities to accurately forecast and manage security risks. The soil's ability to obfuscate techniques through which data can be gathered, analysed and used to predict future threats profoundly alters the calculus through which the political logic of risk operates in a fundamental way. An inability to anticipate risk at the foundational level of territory undermines the authority of the state in the eyes of both its citizens and its adversaries, and thus destabilises its legitimacy as the sole provider of existential security. This unsettling of political order begs the question of to what extent can technological solutions effectively manage the epistemic lacuna precipitated by the enrolment of the material agency of the earth by contending forces? Answering this question requires a critical evaluation of how techno-scientific knowledge, practices and tools are enrolled in the project of securing territory when confronted with the ambivalent elemental agencies of the subsurface.

Notes

1. Hamas is an Arabic acronym for *Harakat al-Muqawwma al-Islamiyya*, which translates in English as Islamic Resistance Movement (Caridi 2012, 36).
2. Expert Interview 1, Geographer specialising in remote sensing at an Israeli university, March 2016.
3. For criticism of the power relations of Israeli infrastructural control from radical Palestinian perspectives see Salamanca (2011) and Tawil-Souri (2012).
4. Further to my explanation in the previous paragraph, the present article deliberately does not address the territorial disputes over Jerusalem, the West Bank and the Golan Heights in any detail. This is because each of these locations has a distinct spatio-political logic that goes beyond the localised focus of the present research on the Gaza-Israel border region.
5. The Muslim Brotherhood is an ideological sibling organisation to Hamas, which was founded as the Palestinian branch of the Muslim Brotherhood, although more recently they have severed formal ties.
6. Expert interview 2, IDF Maj. General (res.) involved in strategic planning of 2014 Gaza war, March 2016.
7. Expert Interview 3, Engineer specialising in seismic detection at Geophysical Institute of Israel, April 2016; Expert Interview 4, Engineer specialising in GPR and FDEM at an Israeli university, April 2016; Expert Interview 5, Engineer specialising in seismic detection at an Israeli university, April 2016.
8. Expert Interview 4.
9. Expert interview 4.
10. Expert interviews 3 and 4.
11. Expert interviews 1, 4 and 5.
12. I was unable to obtain actual scans of the Israel-Gaza border for inclusion in this publication due to issues with participant confidentiality and state secrecy requirements. However, the scan in Figure 2 is comparable in type to test scans that were shown to me by expert interviewee 5. Further investigation of the anomaly identified in Figure 2(b) determined that a rotting tree stump caused the road to subside, and that the suspected tunnel did not exist (Ruffel and McKinley 2008, 81–83).
13. Expert interview 1; see also Kuloglu and Chen (2010, 4314).
14. Expert interview 5.
15. Expert interview 6, retired executive from a prominent Israeli defense company, March 2016.

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