Cultures of Forecasting: Volatile and Vulnerable Nature, Knowledge, and the Future of Uncertainty

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Summary
This dissertation is a cultural history and ethnography of volatile nature forecasting. It looks at the ways that the future of nature is known in highly unpredictable contexts through a broad history of modernist nature forecasting and an ethnography of state scientists, shamans, and a sultans retinue on the active volcano, Mount Merapi, Indonesia. The project aims to understand how practices of forecasting generate futures, mobilize, and organise anticipation, how time is known, and populations governed. It looks at the way that publics emerge through forecasting technologies, and how futures and nature-culture relations are contested. It follows the practices of scientists in volcano and tsunami observatories, in planes tracking tropical storms, and bunkers dug into active volcanoes; at how instruments and technologies such as seismographs, windows, globes, speakers, and electrical tomography, mediate and transform relations with nature, the future, and governance. It considers too, the role of architecture, shamanism, and the state in appropriating and governing uncertainty. By following the fieldwork of geophysicists and volcanologists in observatories and the edge of the caldera of Mount Merapi, as well as spirit possession practices, and the ritual offerings of a sultan, I demonstrate how practices of forecasting are making contested futures lived in the present, and forging infrastructures and tools for their longevity. Forecasting, I demonstrate, is a cultural technique that negotiates the porous borders between the human, nature, and the future.

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Chapter 1
Volatile Nature and Uncertain Futures

Volatile Nature

This dissertation is about the future. It is not concerned so much with what the future will look like, its content, nor is it a study of the histories of utopias and dystopias. It is instead about how the future is lived and imagined in the present, how it is a fullness in the present, appears and disappears, is unevenly distributed, and how there is always, everywhere, more than one future. [1]

From another angle, it is about the future as hard and present as concrete and dirt, and as liquid as a landslide. It is about the future of nature, and nature as the source of the future.

Nature, here, is uncertain and on the move. The people who live with it can't quite make out where it is going. The question of where it is going is so powerful that it brings people together around it, forms communities in which ideas thrash out, conflicts emerge, and powers confront each other. Tools and instruments are vital to this future because they are created and used to make sense of it, to predict it and project from the present to tomorrow. Around these tools, too, people disagree and battles are waged.

The nature that I study here, then, is liquid. It is volatile and vulnerable, it is always going in another direction. It is a nature that is cultured, it is machines and representations, a nature that is watched from look-out towers, video cameras, sampled in glass bottles, carried over ridges and rocky outcrops. While it is intercalated with the lives of the people and instruments that try to understand it, it is also always retreating from their ability to know it.

The empirical basis of this dissertation is the volcano, Mount Merapi, in the centre of Java, where more than a million people live even though it often erupts. Towns circle its base and people live in villages as close as four kilometres from the caldera. When it erupted in 1930, thousands of people were killed; in 2010, over 100,000 people became refugees for three months, and more than fifty people were killed. It ejected enough material in one day to fill a space the size of the Empire State Building three times. In the 120 years between 1878

[1] Ben Anderson has used the phrase "the presence of the future". Anderson, 2011.

to 1998, there was a total of 17 years of quiescence.[2] Even still, in those 17 years, rocks fell from the summit into the deep river valleys and river banks continued to erode.[3] But this volcano has been a part of society at least since the 600 CE, and likely much earlier. The Borobudur temple complex was built at its base in the 8th century and the early modern Empires of Majapahit thrived in the plains between the 13th and 16th centuries until the emergence of Islamic polities, and then Dutch colonialism at the end of the 18th century.[4] A scientific observatory is currently stationed in the city of Yogyakarta (also known as Jogjakarta or Jogja) at its base, and four other cities circle it. Yogyakarta is the centre and contains the palace of the Yogyakarta Sultanate which has its roots in the 16th century. There is an airport at the base and the flanks are lined with infrastructure, sand mines, and a continuous network of villages and farms. Merapi is the central story of this dissertation because no one knows what it will do and everyone is watching it. It means living at the limit of predictability.

Merapi is also a vehicle to tell broader stories about today. Climate change, for example, is the acknowledgement that what nature is going to do in the future cannot be fully understood today because the climate system is made of so many moving parts that we can't know how it will unfold. Acknowledging the unforeseeable consequences of climate change is also, at the same time, often a recognition that nature is inextricable from society. When we express that we can't know what the future of climate change will be, we are also expressing that we can't know the future of society. Forecasting climate change, then, is a way of telling ourselves how we are entangled with that nature, even though the conjunction between nature and culture is something that is at stake in the very foretelling. Foretelling the future of nature is simultaneously a way to foretell the future of society.

The stories told here, then, about volatile natures do not separate the telling of the future of nature from defining what society is. That, I believe, is where more work needs to be done so that imagining other ways of making futures present, methods of future telling, and other kinds of societies and natures are made possible. Because the future isn't going away, what we need to understand is how it is lived, and how we and our world are shaped by it in the present. Cultures are formed through the stories they tell about the future, and how they make the future felt. Communities form around stories of the future, fear and loathing,

[2] Voight, et al., 2000. In Voight's terms, eruptions include the following: Volcanic deposits, dome eruptions, paroxysm, pyroclastic flow, lahars, vent clearing, rock-falls, lava effusion, dome collapse (partial and complete), lava tongue, plume, gas burst, accelerated seismic deformation, breakout, crater rim overtopped by lava, tilt.
[3] Voight, et al., 2000.
[4] Tarling, 1992.

panic and indifference, they contest, hate, and ravage other cultures' futures, and build institutions that govern, adjudicate, and distribute futures.

The reason to study forecasting, then, is to shift discourse away from the content of the future to how futures are made. To do this, I turn to a frequently misunderstood medium, the modern forecast: weather reports, tsunami warning systems, climate change forecasts, tornado warnings, volcano evacuations. The volatile nature forecast is a cultural phenomenon that is central to modern life that we haven't sufficiently understood from the vantage of its infrastructural, technical, and social dimensions. It is a genre of making the future of nature present, generating anticipation, and modes of action and practice, while being woven through contemporary local and international economies, spaces, and materials.

Modern Western society is defined by its anticipation and management of risk.[5] Modernity, according to Ulrich Beck and Anthony Giddens, emerged through the production of new risks from its own technological change and developed governance structures to manage them. Social structures, institutions, law and policy, and politics, are shaped by attempts to manage and make sensible the ever new emergence of unpredictable futures. Nature forecasting emerged within this context of risky and unpredictable futures and in this way, stories about nature forecasting need to be told as they interface with cultures of risk and uncertainty and broader cultural events of making unpredictable futures sensible. This is always a technical as much as a political story and telling it needs to consider the interfaces between the machines and tools that sense the future, the cultural practices that bring them into being and the material worlds and multiple natures that push back upon and transform them. It is, in short between nature, culture, and technologies that forecasts emerge and that the future is made sensible.

Aims of this Dissertation

What follows in this dissertation is structured by the following four aims:1) The first is to understand how cultures of forecasting generate futures and mobilize and organise anticipation. This is about how time is known. 2) The second aim is to understand how forecasting systems know, frame and shape nature. This is the epistemological dimension of this study, and it undertakes this by looking at multiple, often contradictory and contested ways of knowing the future and nature. 3) The third aim is to understand the liveliness and agency of the infrastructural and technical systems of forecasting. This is the soft

[5] See: Beck, 1992; Giddens, 1991.

technological determinist argument that I pursue in this dissertation. I argue that nature forecasting cannot be understood as a knowledge practice without understanding the technical and infrastructural systems it is composed of. 4) The fourth and final aim is to understand how forecasting systems shape nature-culture relations and renders them governable. This is the politics of forecasting.

In the rest of this chapter I break down these aims and add flesh to the conceptual approaches I pursue throughout the rest of these chapters.

Uncertain Futures

Turning to the future is not new in the social sciences and humanities. The study of past futures has long been a way to understand the underlying dynamics of a society through the ways that societies represent themselves to themselves. Utopias and dystopias are two ways of negotiating the present conditions of society by editing and amplifying the parts that stay or go in the future.[6] Walter Benjamin described utopian and dystopian wish images in terms of star like constellations wherein elements of the present are placed within a network of selected pasts and projected futures.[7] Societies at particular historical junctures are shot through with constellations of progress and decline, redemption and catastrophe. These divergent narratives of the future are ways of making sense of the present through cultural forms such as novels, theatre, or advertisements, but also new technologies and instruments, and as Benjamin notes, emancipatory futures governed by freedoms not experienced in the present are ways of loosening the grip of oppression and challenging domination.[8]

Benjamin's argument shared with the phenomenological tradition the argument that the relationship between imaginaries of the future, present, and past is one of constant revision in relation to each other in a non-linear, constant transformation and revising.[9] There is always more than one constellation of past, present, and future, and that many futures, sometimes contradictory, are lived at the same cultural moment. We see this today in the way that the future of the climate is contested as ecological collapse, economic ruination, the obsolescence of humanity at the whims of its technologies, the production of new markets, a hoax, and opportunities for space exploration.[10] This multiplicity of futures pressurizes how we act in the present by emphasizing priorities and giving meaning to action, decisions and

[6] Bloch, 1995; Benjamin ,1999; Castoriadis, 1987.
[7] Bloch, 1995; Benjamin, 1999, 2016.
[8] Benjamin, 1999, 2016.
[9] Heidegger, 1996; Gadamer, 1977; Ben Anderson, 2011, also notes this.
[10] Hulme, 2009; Jasanoff and Kim, 2015; Urry, 2016.

governance strategies and these acts can be endowed with value because they are in relation to staving off doom, are righteous, or because they are linked to bringing about particular futures.

Both Benjamin and the phenomenologists were responding to the way that Western modernity had been cast in terms of progress. Society was improving, its technologies advancing, and evolution was social, biological, technical, on an upward climb of adjustment and refinement. In this imaginary, nature was subjected to the domination of technology and control and modern society emerged through the harnessing of its power.[11] But how progress was lived in the present began to shift, Ulrich Beck argued, as modern society became reflexive towards its own destruction and to organise itself around managing, distributing and making sense of those risks.[12] It was not as if those risks were disappearing, instead the organisation of society around them was becoming the driver of governance and technological change. Progress was risky, and in order to achieve it Western modernisation required putting those risks at the centre of its governance strategies. The risks came from within modernization itself, its technological ingenuity to make life better was producing the conditions for its own destruction. As Paul Virilio put it, the invention of the airplane was the invention of the plane crash, the invention of the automobile was the invention of the high-way pile-up[13]. But risk was also coming from external contingencies: the urge to mine for resources was also producing collapsed mines and devastating landslides of tipped waste materials, the waste dumps of consumer society were killing fish stocks, atomic energy was producing hazardous waste that will outlast human life on the planet.[14] The effects of modernisation were becoming increasingly unpredictable and producing ever more unique and new conditions for its own destruction. With each new risk there needed to be a reckoning: what were its causes, how could it be managed, where was the expertise to do so, did it threaten the project of progress or was it only a momentary set-back?

The big picture of progress has been troubled as a metanarrative and the motive force of a future of infinite betterment has questioned. In its place, climate change and the Anthropocene have recast (Western) human history in terms of human impact on nature, and tells a story in which progress has delivered us a world of planetary and unthinkably long (deep-time) precarious, volatile and vulnerable natures in which we see our own history

[11] Horkheimer and Adorno, 2002. For more recent arguments in this vein in relation to risk see, Tsing, 2015.
[12] Beck, 1992.
[13] Virilio, 1999.
[14] On the Aberfan disaster, see Bishop, 1973.

reflected in ozone holes, rising oceans, blazing forest fires and mass extinctions.[15] Imaginaries of progress are accompanied by a permanent uncertainty and volatility, a maxed out reflexivity in both the sense of awareness and a state of constant reaction. Inaction and business as usual are also fallout imaginaries of a narrative of stalled progress and the endless expansion of the same. The insight of Beck remains true, though, that in the unpredictability and volatility of nature we see ourselves as the anthropogenic force of modernity.[16]

This is one reason to turn to a volcano in Indonesia. It has more than a few things to teach to people who are on the verge of escaping modernity. It is becoming increasingly apparent that turning to what was once considered the periphery, Third-World, and Global South, has much to teach those in the Global North because forecasters there have centuries long histories of highly contested forecasting in which the modern constitution – the ideology of the separation of nature from society– has never been total, and hybrids of religion, secular Western science, politics, sorcery, animism, sultanism, high and low-tech, authoritarianism and democracy, are creating different futures, registers of anticipation, and anxieties, negotiated and leveraged by nature forecasters.[17] Reading the future, making sense of it, broadcasting it to communities and populations, making cultures of the future, is also a way of negotiating these socio-natural-technical hybrids, political manoeuvring, and power plays.

How the future of nature is lived and made present in this hybrid space, again, cannot be untangled from the technical processes through which it is known and who claims to know it. The epistemology of the future is constituted through the morphology of its infrastructures and instruments and therefore its geography. This raises fundamental metaphysical problems about causation in nature and how we access it, how we can extrapolate from the present and project to the future, how we see the present order as changing, or remaining the same, and act with forewarning and foretelling through instruments and infrastructures. It is about seeing the future appearing in the present and the present facing multiple directions at once. To invert the geologist Charles Lyell's maxim, "the future is the key to the present".[18]

The future isn't only about time then. It bears upon the categories that make society, draw the limits of the human from nature, and tests them. The future comes to be present through the categories that demarcate it from present and past, but also thread them through

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[15] Beck, 1992. This argument is taken up to varying degrees also in Latour 2014, 2017, and "Agency at the Time of the Anthropocene", 2014. See: Kolbert, 2015, on mass extinction; Jussi Parikka, on media and the Anthropocene 2015; Paul Krutzen on the agency of Ozone holes in Schwägerl, 2013.
[16] Beck, 1992. Latour argues this as well in 2017 and in various places including *An Inquiry into Modes of Existence*, 2013 and *Reset Modernity!,* 2016.
[17] Latour, *We Have Never been Modern* 1993.
[18] Lyell, 2005.

each other. How we define what the human is or what nature is, is constituted through the way futures are lived and made present, and in this way, the future in the present is ontologically generative, bringing into being what is and how.

Cultural Techniques

I draw inspiration throughout these chapters from theories of cultural techniques invented by German media theorists influenced by post-structuralism. The aim was to stress the mediality of human subjectivity and locate the emergence of social categories and sense making within the manipulation and management of material and technological substrates. Initially, these theorists were intent on showing that the sphere of culture was not the product of artistic geniuses in advanced societies, but the work of alphabets, typewriters, megaphones, graphite pencils, film reels, fibre optic networks, telephone cables, and other, often mundane, technologies.[19] As Friedrich Kittler's first sentence from *Gramophone, Film, Typewriter,* reads: "Media determine our situation, which—in spite or because of it—deserves a description."[20] By this he didn't mean only mass media, and especially not its content, but the form of media, its machinations, and networking of machines and techniques. The ambition of this work, was to displace the transcendental categories which Kant had located in the mind of the human, those categories of time, space and causation which made the world intelligible and knowable and from which were derived the structures that distinguish the human from the animal, society from nature, the future from the past. Theorists of cultural techniques, such as Bernard Siegert, took this labour of categorisation and legibility and shifted it outwards into tools and devices, including such minor, over-looked works as plumbing, electricity and abacuses.[21] This classically critical project – in the sense of revealing the conditions of possibility of knowledge and being, exposed how techniques in the world were entangled with the production of social categories, and like much post-humanism, take the steam out of the exceptionalism of the human (and its valorisation of the mind) and puts it back within wider, more distributed ecologies of actors.[22]

To understand the future then means excavating the cultural techniques it is based in, from which emerge technologies, infrastructures and spaces in which the future comes to be legible and sensible in particular ways, its borders drawn, and the mechanisms that create it

[19] Siegert, 2015.
[20] Kittler, 1999, p. xxxix.
[21] Kittler 1999; Siegert 2015.
[22] In this way, it intersects with the geographical project of grounding and materializing knowledge of the world and social form.

set in place. It also means that communities are formed through the technological apparatuses that make particular futures legible. To anticipate the future in the present is more like the work of engineering and architecture, it is important to bear in mind that technologies are not instruments that we control, they shape how we know the world. If we do not order or control them, then they have to have an order and ordering capacity particular to them and of which human knowledge and being is an effect. Describing these orders requires a materialist eye for the junctures between conceptual and abstract categories and the material operations that make those categories sensible in the world, or which undermine them because of their own inhuman agency. Every form of future making and sensing that I analyse in this dissertation, I try to show is a future for particular groups, always for a someone or something: an animal, plant, human, volcano, or cloud. Cultural techniques produce these distinctions in action and *in situ* as the very process of making the future sensible.

The liveliness of the future-present that I depict here is not one of a sovereign human subjectivity located in a sovereign body or thought laden ego; it is distributed, already made of a community, and forged through complex interactions with non-human things. People appear often in these pages, and some of them I represent in terms of their complex biographies, I analyse their characters and decisions, but this is always in the service of putting them within a milieu of cultural techniques which is vitally active in and through the person. The future is their future but it is emergent across a highly differentiated socio-technical-nature field.

Forecasting

Today, the future is made present and lived through the crucial, powerful, and under studied social institution of forecasting. It includes the broad and diverse institutions that range from studying the futures of economies, societies, and nature. Some of these institutions are purpose built, some contain elements of forecasting within them, such as studying futures markets, investments, or the effects of climate change, or weather forecasting. They range from the specialised skills of consultancy firms that focus on emerging technological security threats to business, to political threats in “emerging” markets. Mass media play a crucial role as a forecasting institution as talking heads and experts regularly project where some present environmental, political, economic, or public health condition is going. Foucault, in his histories of liberalism and bio-politics examined how the emergence of institutions of forecasting became central to Western society in the

modern period in a shift in the notion of governance to one that operated in environments that were unpredictable.[23] Governance became a modulation of uncertain futures, the aleatory, and forecasting became ways of making those futures present through a diversity of techniques, new knowledge systems and forms of expertise.[24] These cultures of forecasting have created forms of preparedness, a diffuse anticipation, practicing and dry-runs for what may or may not happen. This includes the cultures of repetition that keep populations on the ready to negotiate the aleatory, such as the subterranean landscapes of bunkers and bomb shelters, air-raid sirens, and evacuation drills during the Cold War. More contemporary examples can be found on the peri-urban fringes of some large modern cities in warehouses where companies test the fragility and limits of contemporary consumer products. For example, on Randall's Island, in the Hudson River just off of Queens, New York there are 1:1 scale models of Brooklyn and Manhattan streetscapes including pizza shops and auto-repair mechanics. The New York Fire Department sets them on fire, plants fake bombs in them, and builds mock meth-labs in them. They also test the rate at which new composite building materials burn or melt so as to anticipate real fires in the city in new buildings. Similarly, while taxiing in an airplane on a runway it is, at some airports, possible to glimpse a burnt-out nose of an airplane with a ladder welded to the side for fire practice drills. In these cases, the aleatory is given its own dedicated spaces, as if it was on the periphery of the normal, with the goal of being in advance of the present, inside and outside the here and now at the same time. These are some of the ways that forecasting operates within a space of projected futures, in zones in which the unpredictable is played out and domesticated and partitioned from the norm. As Foucault understood, forecasting is a diffuse, distributed culture of future presencing that creates island like formations of possibilities within an archipelago of futures. On one island of this archipelago, for example, there is a fire drill, while on another there is a mass vaccination. Each is formed through the emergence of a particular future, its imaginary, anxieties, and the state is made sensible in the tip of a needle, or the civil service as a guarantor of safe futures.

Forecasting Nature

The main focus of these chapters is on how forecasting institutions relate to volatile nature. I am interested in volatile nature because it is in relation to it that the tools and infrastructures that forecast what nature will do (hurricanes, tsunamis or volcanic eruptions)

[23] See, Foucault, *Security, Territory, Population,* 2007, pp. 1-27.
[24] Foucault, 2007, pp. 1-27.

reach their limit and knowledge is highly uncertain though stressed for accuracy. In this context, the distinction between humans and nature are malleable, social boundaries become fragile because it is difficult to separate the human from nature, and the content of the future becomes radically uncertain. The relationships between infrastructures, tools and expertise, in these contexts, "become molten", as Sarah Whatmore describes it, meaning the status quo material relationships that make up environments no longer hold.[25] The "black boxes" that conventionally keep environments as passive backdrops for social life forcefully emerge into the foreground and it becomes difficult to separate the social from the natural as they become newly entangled.[26] Volatile nature loosens the structural categories that conventionally separate nature form culture in such a way that they can lead to fundamental controversies over how to re-establish black boxes, put the categories back into place, and rebuild the distinctions between nature and society, and return to the norm. In this process, we can often witness controversies over what the norm should look like, and how society should relate to nature.

I chose to undertake fieldwork on Mount Merapi because it exemplifies these issues of volatile nature forecasting. Volcanoes cannot be accurately predicted and the techniques for predicting them are inseparable from ideas about how society ought to relate to nature. Modern volcano forecasting is a cultural technique of arranging the unpredictable, volatile earth, with humans and understanding their futures together, of building and making sense of what humans are in relation to a ground that can destroy them, while they cannot be certain of what that ground will do. Merapi is a site in which these controversies are common and can offer broader lessons about how environmental uncertainty is lived.

In trying to understand forecasting and volatile nature, the arguments in these chapters diverge from other recent interpretations of volatile nature forecasting that can be divided into two camps: culturalist and technicist. Culturalist understanding of volatile nature often attempt to foreground the role of culture in the shaping of perceptions of risk and hazard.[27] In this framework, it is often argued that volatile nature is a result of specific cultural interpretations, there is no universal perception of risk, it is multicultural. It is a mononaturalist position that sees nature as one while culture projects its interpretations on top

[25] Whatmore, 2009; Landström, 2011; S. Whatmore, "Earthly Powers and Affective Environments: An Ontological Politics of Flood Risk," 2013.
[26] On black boxing, see Latour, *Pandora's Hope: Essays on the Reality of Science Studies* 1999, and *Science in Action: How to Follow Scientists and Engineers Through Society*, 1987.
[27] Belizal, 2014; Schlehe, 1996, 2008; A. Donovan, 2017; K. Donovan, 2010.

of it.[28] The intention of this critical work is often to take some of the steam out of the universalising tendencies of technicism, to celebrate multiple worldviews, and create a better understanding across cultural divides. This often results in an ethnographic project in which reporting on local traditions and perceptions is often seen as a solution.[29] Likewise, participatory projects of community hazard mapping and community based risk management are put forward.[30]

The technicists argue for standardizing risk and hazard strategies across the globe and the techniques of forecasting and managing volatile nature in relation to specific hazards. The technicist perception of volatile nature often assumes that the threat to life, property, and circulation are the key threats of volatile nature and that the betterment of observation and more efficient communication systems, and the centralization of expertise, are the keys to improved forecasting systems.[31] In this perspective, culture is subject to the forces of unpredictable nature, a conception that grows out of the natural hazards tradition exemplified by Gilbert White but also the processes of modernisation described by Beck and Giddens, as a technological project that tries to govern the effects of its own technology.

I argue though that the culturalist tradition is not technical enough and the technicist tradition is not culturalist enough. Neither sufficiently understands the co-production of culture and technology in the way that cultural techniques does.[32] It is a theory that explicitly entangles 'perspectives', 'mentalities', 'interpretations' with the material world and therefore goes to the heart of the problem that cultural interpretations of hazards are trying to resolve by dislodging culture from an ethereal space of the mind and putting it in the material world and technical practices. Cultures are embedded in material, infrastructural, and technical systems but also cannot be reduced to them. So both sides need to be played at the same time, that culture is determined by its technologies and infrastructures but never absolutely, those can be repurposed and modified, too.

Cultural techniques, in the way that I deploy it here, begins with acknowledging that there are multiple cultures and natures because there are multiple techniques. As Siegert says, this is not "in deference to politically correct notions of multiculterality; it also implies a post-humanist understanding of culture that no longer posits man as the only, exclusive

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[28] Descola, 2013; and Descola, *The Ecology of Others,* 2013.
[29] Schlehe, 1996, 2008; K. Donovan, 2010.
[30] Donovan, 2017; Gerlach, 2010, 2014.
[31] Gilbert White, 1978; Kates, 2011. This is a central debate in Hazard studies that dates back to Haroun Tazieff's debates with Soufriere, to the Italians prosecuted for misleading the public, see: Tazieff, 1977, 1979; and Cartlidge, 2015.
[32] Jasanoff, 2004.

subject of culture."[33] Cultures of forecasting need to be explained in terms of their emergence through a diversity of techniques, as geographically distributed, and multiple. And to understand cultures of forecasting is to understand something deeper than the perception of risk, it is the way that the future itself is made present, and how that process is itself material, technical, and corporeal. This means attending to intersections, like nature-cultures, co-production, socio-technics, and in particular, the linkages between unlike domains, and asking, how do they intersect? Perspectives of what is risky and what the future may be, are emergent properties of infrastructures while at the same time not simply determined by them in a unidirectional process. Entanglements and assemblages have been recent ways to conceptualise this thinking of the hyphen as complex relationships that stick together, of unlike properties and differences that nevertheless hold together.[34] Cultural techniques then is a method for asking how mentalities without shared cultures, technologies without complete determinism, and natures without universality, are enlisted at the site of a forecast, and emerge with a semi-stable presence in a culture. It is to ask how culture is emergent, on the way, and in process.

Nature forecasting is particularly important today because it has become increasingly ubiquitous as a culture, fused and inseparable from the creation of futures and social relations. It has become, it seems, more and more immaterial, a function of data transmission, wireless signals and transmission. One example of this is work in natural hazards research around the accessibility of real-time data to applications such as earthquake information, storm warnings, and tsunami warnings.[35] This dematerialisation promises a simultaneity that overcomes the future by knowing exactly what it will be before it arrives. It is a quest for the speed of knowledge transmission to be so fast that it overcomes the stubborn resistances of time, of not knowing the future. This kind of forecasting is part of the new cyberneticist romantic imaginary of an immaterial world in which the arrival of the future could be automated and societies relationships with volatile and unpredictable nature could be choreographed by technology and infrastructure.[36] In this world, infrastructure is capable of disseminating information faster than nature can move. I demonstrate throughout chapter 3 and 4 how these dreams are old modernist dreams that are still alive today. What they suggest

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[33] Siegert, 2015.
[34] See Anderson on assemblage and geography, 2011; Anderson, 2012 et. al. On entanglements, see: Barad 2007, and Haraway, 2016.
[35] Sobradelo, 2015; Haynes, 2008; W.J. McGuire, 2009; M.C.Solana, 2008.
[36] See John Durham Peters, on the collapse of nature and media technologies in contemporary society: *The Marvellous Clouds,* 2015. Also, on the materiality of so-called "new media," see Lisa Gitelman, *Paper Knowledge: Toward a Media History of Documents,* 2014; and, Jussi Parrika, *Geology of Media*, 2015.

is a deep, implicit recognition of the agency of infrastructure and technology in the shaping of society. Nature forecasting is one of those sites that have long understood that technology and infrastructure are actively choreographing society, while they in turn, are transformed. There is a misconception amongst critical social scientists and humanists that reaches back, perhaps, to Heidegger's critique of technology, that modern western technology has been anti-nature by making it static, and where its exertion of control has been to stabilize it.[37] Large dams, walls, foundations, are the types of technologies that keep nature out, aggressively blocking it, stopping its flows in order to create an orderly and controlled future and this tradition has associated the state with anti-movement and stability against becoming.[38] But the history of modern nature forecasting that I present in this dissertation has been about the development and refinement of an entirely different logic, one of flows, choreography, movements, and the anticipation of nature. It has been a drive towards movement and change as a form of governance itself. And it perhaps can be detected in the invisibility of its infrastructure and its spatial expansion. Nature forecasting relies on orbiting satellites and cables a few inches thick running along the bottom of the ocean for thousands of miles. It requires offices in different continents to send data packets to each other while they are working on the same computer programs. The politics of this condition is not one of monumental infrastructure in the early modern sense, but a new kind of monumentality characterised by vast thinness. It is the politics of translation and synchronisation between different parts, from the orbiting satellite to the computer screen and each movement between different parts along that long network there needs to be translation.[39] This is the contemporary politics of a nature forecasting which takes choreography, change, becoming, and adaptation for granted, in which the future is a perpetually uncertain atmosphere which we learn to automate our reactions to. It is a politics of how to assure that the networks can translate the signals between formats, and that the infrastructures don't wear out. It is a politics that operates at the scale of the planet and at the scale of the handheld device which was built in Jakarta but used in Japan. Untangling the implications of this is the purpose of this dissertation.

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[37] Heidegger, *The Question Concerning Technology,* 1977.

[38] I am thinking here of a tendency in the work of authors who privilege becoming in a way that can verge on a romantic affirmation of change and flows, such as Brian Massumi, 2015, 2017; Erin Manning, 2007; Pickering and Guzik, 2008; Deleuze, 1987; Bataille, in the *Accursed Share* 1991, and *Theory of Religion,* 1989. I do not mean to suggest that they do so in simple ways or that they are not necessarily aware of this potential, but there is a legacy of thought which has tended to position state power as one of blocking flows and where the flow can be positioned on the side of what is transgressive.

[39] On theories of translation and coordination, see: Mol, 2002, 2010; Law, 2002; Callon, 1984.

Practices

One way through this tangle is to understand that nature forecasting is a practice. This allows us to understand how knowledge is a process, incomplete, and partial as scientists, shamans, sultans, gatekeepers, and fortune tellers work with machines, infrastructures in spaces and buildings that shape them and they in turn transform. They work with instruments that break and need repairs, and they undertake long trips to field sites to take samples and make experiments. They travel along international routes, spend time preparing for their journeys, arranging equipment, booking rooms, and holding meetings. Considered as a practice, forecasting can be understood from the perspective of its labour.

When I began to visit the scientific volcano observatory in Yogyakarta, I was first of all surprised by its banality. I was in a city at the foot of one of the most dangerous volcanoes in the world with a reputation for destruction, earthquakes, and smothering ancient civilizations in ash, blowing buildings into shreds and projectiles; but, as I walked in, most of the lights were off, the guards at the front door were watching Turkish soap-operas, drinking black coffee, and smoking cigarettes with their feet up on the desk. The large model of the volcano and its surrounding towns that I study in Chapter 4, was in the atrium of the observatory with crumpled used tissues discarded on it. The head scientist was out for the day and no one knew when he would be back. On the front lawn was a large white door that led to an underground bunker, it seemed to have been built in the 1970s or 80s when the observatory was constructed for scientists in case of an eruption, but in October 2016, it was filled with gardening tools and bags of soil. All of this was missing from anything I read in the literature about risk mitigation, risk perception, forecasting techniques, or the cultural history of natural hazards. The banality, everydayness, boredom, broken instruments, discarded projects, and ruins showed me that forecasting, much of the time, is dysfunctional and repetitive, a mere day job. This, as I understand it, is the practice of forecasting and it includes the way that it is acted and enacted by bodies in space, through routine and ritual and it is as much about the overly long meetings in air conditioned office rooms because that is where the aesthetics of knowledge are on display. The military style civil service uniforms and plastic wrapped office chairs are particular to the enactment of state forecasting services and entwined with performances of scientific authority and expertise. The dysfunction of instruments, models, and architecture, are symptoms of the tenuous reserves of these

functions of power. By studying forecasting as a practice, these dimensions can come into view.[40]

The practice of forecasting is as much determined by the time between spectacular events, waiting and preparing as the spectacular event. Time is spent monitoring instruments and fixing equipment, getting funding from governments, taking field trips to instruments, holding conferences, fasting for religious festivals, and having communal dinners. This is the bread and butter of forecasting practice and for this reason, central to this dissertation because it allows us to understand the multiple, drawn out processes and actions that form cultures of forecasting. Spectacular eruptions, therefore, rarely appear in these chapters because I want to avoid privileging the superficially exciting at the expense of the everydayness of forecasting. It is there that forecasters actually become meaningful and powerful, that their influence spreads, their networks are formed, public's trust them, and they manoeuvre within political forces.

This focus on practice is inspired in part by authors who have also begun to consider the future as a socio-technical affect.[41] The work of Louise Amoore, Brian Massumi, and Ben Anderson has focused primarily on the management of futures in the security state in the post-911 West in which governance has operated through states of emergency, danger and threat. They have linked lived time, its alternation between lulls and moments of intensity, erratic rhythms and repetition, with a technical substrate, governance and control. The security state operates through the management of futures as an affect that mobilizes bodily comportment and sensation with technological instruments and infrastructures. Louise Amoore has sought to link the affective register with state sovereignty by tracing the technologies and infrastructures that translate between these different scales, such as computational forms of translation.[42] Central to this has been creating vocabularies and analytical tools that highlight the relationship between the scale of individual practices and other scales of influence and consequence, the interfaces between imaginaries and materials, how concepts have material effects, and how materials exert their own particular agency.[43]

[40] The turn to practice has also been a central move in the sociology of science and STS which in the 1980s began to understand that science was a practice of making knowledge. It was ways of dressing, speaking, and building instruments, Shapin, 1989; Pickering, 1995; Latour & Woolgar, 1979.
[41] Massumi, 2015; Amoore, 2013.
[42] Amoore ,2013.
[43] Amoore, 2013.

Fixing Attention, Framing Objects

Modern forecasting cannot be separated from the way that it entangles nature and culture, and the future of nature with social futures. What I demonstrate throughout these chapters are the divergent and sometimes contradictory ways that making the future present is also always a way of connecting it to social imaginaries. States, spirits, ghosts, and bodies, appear here because they are fused with the futures of nature and through them those futures are made meaningful.

Forecasting is an everyday practice made up of the ebbs and flows of futures while it is also a means of focusing attention on the future of nature, key moments, and events. It has the power to generate attention and modulate the corporeal intensity of lived time. Urgency, terror, fear, anticipation, extreme waiting, are all visceral states, and forecasting is an apparatus that modulates them.

BEWARE! EVACUATE! Emergency Exit. *Sirens*. "The storm is projected to hit…"

In emergencies we stop everything, daily life is interrupted, other priorities take over.

On Merapi, this is particularly relevant because it has a population of somewhere between one and two million people. There are six observatories on its flanks, and a handful of employees that work in them. During the massive eruption of 2010, over one hundred thousand people evacuated from the southern and western flanks to temporary refugee shelters in the towns of Yogyakarta, Magelang, and Muntilan districts. During the peak of the eruption in 2010 the observatory was left with only one working seismogram because the others had been destroyed. These are the conditions that forecasters have to negotiate: a dense population that in times of crisis can place severe loads on infrastructures and public services. The observatory is tasked with navigating the attention of people on the volcano so that the volcano maintains a presence associated with the state observatory and scientists, and so that they have respect, control and authority over forecasting its future. This work is not given in advance but is central to the ongoing practice of scientists and there is no guarantee that it will succeed. Moreover, there is no single, unified public to which forecasters broadcast but gradated, contentious, and contested publics. Villages have their own forecasters who are sometimes more trusted than those of the state and state forecasters can be associated with centralised, corrupt authorities and as henchmen of an authoritarian state. What volcanic action is and its implications for nature is fractured from the observatory in Yogyakarta to the highest village a few kilometres from the top. But forecasting requires a limiting, reducing, and focusing, in order for it to operate. It requires the trust and authority of others in the singular view of the scientific forecaster. This is how fixing attention is central to the

observatory and why it integrates epistemology and governance at its core. It seeks to generate social attention before things happen to create a sense of anticipation, watchfulness, but it can't be too heavy handed or people will stop paying attention. In some cases, volcanic eruptions can be hundreds of years apart, highly erratic and unpredictable. In this way, forecasting is about fixing attention on volatile and vulnerable nature while at the same time solidifying distinctions between nature and society: attention is not inseparable from the ontological politics of what makes us and what makes nature.

Attention is also about how much content can be handled in a forecast. The daily weather forecast is a good illustration because for many of us, it is a small slice of our attention, it has been well slotted into an ecology of attentiveness and has been, in the terms of Annmarie Mol, "well-coordinated".[44] It gains greater attention if a storm is about to hit and people need to evacuate, or, for people that work on the ocean, the weather forecast will figure differently in their attention regime than people who work on land. This partitioning has been achieved through the technical, mechanical, and mediated systems that forecasting relies on for prediction. As an infrastructure, forecasting negotiates this highly differentiated attentiveness, and the future is highly differentiated according to the needs of a particular community.

It is in part because of this that forecasting is never just about the future. Volatile nature has to matter within a broader ecology of sense making. This is why climate change is also about society, its history, the accumulation of decisions, the history of industrial modernity and progress.[45] It hooks into the meaning of communities lives as a way of tuning attention to the future and making the current social, political and economic organisation of society what is at stake in forecasting the future.[46] Forecasting, to be meaningful, burrows itself into the heart of the matter of how society relates to nature.

I offer a brief example here. The volcano observatory on Mt. Merapi created a brochure (*figure 1&2*) of one long page folded into three for their campaign to raise awareness about evacuation best practices for people that live on the upper slopes. The people who live there are farmers and teachers, mothers and fathers, children doing their long division homework, miners exhausted from overwork, adults on the way home from the office, village heads and their secretaries. They are a highly differentiated group of people preoccupied with the highly differentiated demands of their busy lives for whom it is easy to

[44] Mol, 2002.
[45] Hulme, 2009.
[46] Jasanoff and Kim, 2015; Hulme, 2009.

carry on with one's attention to other things. The pamphlet high-lighted the orderly use of evacuation routes and emergency camps, not returning to villages in times of crisis, and working co-operating with each other and the authorities. Scientists travelled around the volcano in a small squad, visiting villages and distributing the leaflets. The image on the cover of the leaflet is of particular interest because it is doing important work in capturing attention. It is a cartoon of an erupting volcano, with a table with maps on it and a cup of coffee about to spill, trucks, a red cross symbol, and walkie-talkies. It distils an evacuation into its technologies and institutions. But more than this, the frame drawn around the instruments is a triangle shape that references the shape of the mountain figure in the traditional shadow puppet theatre *wayang* from the region. The figure is used in the theatre as the setting, the backdrop to the drama, and conventionally it is filled with figures like dragons or tigers, palaces, trees, and is commonly understood to represent a volcano. In the theatre, it represents the key elements that structure society, nature and the cosmos, and would be imagery that every villager was familiar with. In this case, the signs for the building blocks of the cosmos have been replaced with modern forecasting instruments.

This frame is important because it positions the scientist-forecaster within tradition, implicates them within existing cultural associations and values. It does not break with tradition but becomes an extension of it, constellating the present with the deep past. It is about ensuring that scientific forecasts are not understood as a foreign entity, or imposition, but in continuity with something that already exists. It also positions forecasting, evacuation procedures and technologies as a drama, a performance that can be interpreted within the framework of the shadow theatre, which is to say a cosmological and moral drama between humans and nature.[47] An eruption is not just an act of nature, is about society and how it lives with nature, and is a moral, ethical, political dilemma.

The scientists with this booklet are vying for attention by framing the meaning of the future in the present. An eruption is not just risky but full of potential excess meaning. There are more ways that an eruption can be made meaningful and that allows its band of attentiveness to be wider and the points of intersection with other concerns to be multiplied. It is these bands of meaning that need to be attended to as they cross material, infrastructural, technological, and historical references.

[47] See: Benedict OG Anderson on *wayang* theatre tradition, 1996.

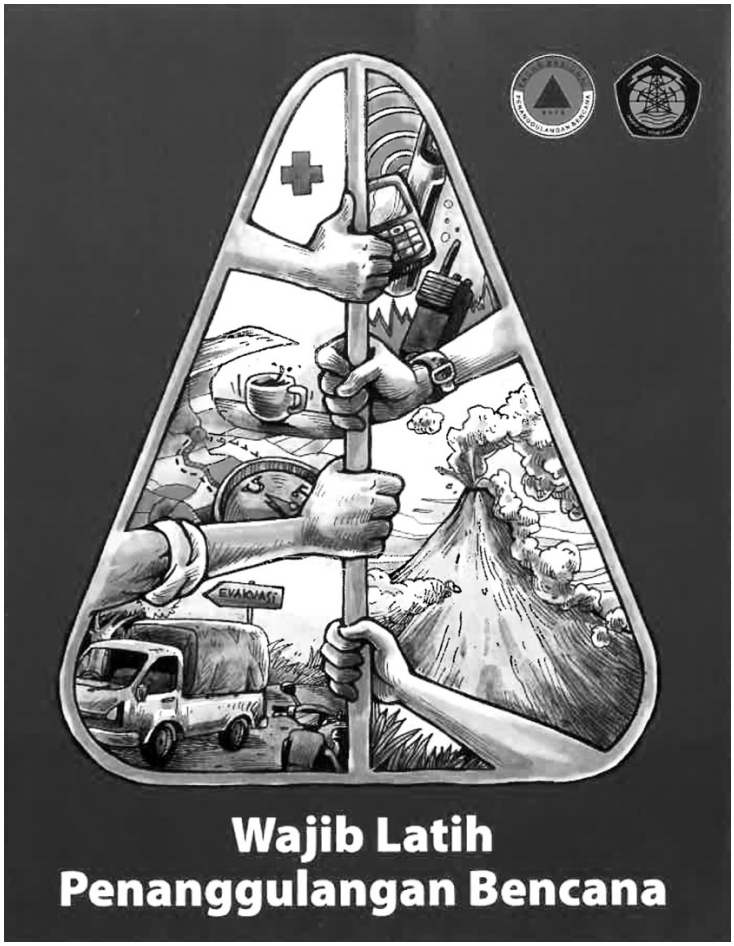

Fig 1. *Wajib Latih Penanggulangan Bencana* (Disaster Training Manual.

Fig 2. A *wayang* puppet that sets the mise-en-scène of action in the play. It is in the shape of a mountain/volcano with a tree and Sultan's palace in the centre.

Nature-Culture-Futures

On May 20, 2016, I was walking out of the colloquium, *Risk and Perception of Natural Hazards: Perspectives of Earth Sciences, Social Sciences and Humanities* at the University of Gadjah Mada in Yogyakarta, in discussion with Kristof Komorrowski, a French volcano scientist had earlier presented on his work in the area of forensic volcanology. He shared with me a difficulty I had often heard expressed by volcano scientists, that volcanoes cannot be predicted but they also must be, there must be a moment when a scientific forecaster makes a prediction when an eruption will happen. There is no certainty that they will be correct but if they are wrong they will lose the trust of the public and at worst, lives. On Merapi, this can mean losing the trust of hundreds of thousands of people and the next time there is an eruption, no one will heed their orders to evacuate. This happened in a Merapi eruption in 2008 when an inaccurate forecast forced evacuations and later a loss of

trust in scientific methods. Komorrowski understood that forecasting is an inexact science of uncertainty, that it has high social and political consequences and that in which multiple forms of expertise are contested and questioned.[48] But, Komorowski insisted that he still be recognized for his expertise and authority. He was looking for a language and concepts that could negotiate this bind between authority and uncertainty.

By attending to the cultural techniques of forecasting, this dissertation develops concepts and terms to explain forecasting in a world without certainty, in which the lines between expertise and publics are porous and their relationships defined by controversy. It shows that the practice of forecasting science is beholden and shaped by the material worlds it seeks to explain and master and that its tools, apparatuses, institutions, and infrastructures create affordances that allow science to speak on behalf of the future without taking a view from outside of the societies and traditions within which they work and that enable them. Instead, they are negotiating partial views, the encumbrances of technique, and material forces. If modern scientists have long operated with the myth that nature is not social, the history of forecasting volatile and vulnerable nature is a history of a science that cannot separate the two because it is always implicated in social controversies, political alliances and statecraft. What the stories in these chapters demonstrate is a refusal to separate scientific knowledge production from the complex, messy, socio-natural worlds they participate in. Instead, I show how there are multiple sciences, each of them are practices of knowing nature and anticipating it in the future and that these ways of knowing are always in complex tensions with local and international political struggles. Particular practices emerge through their negotiations of these political relationships. My argument, then, is an extended response to Komorowski diagnosis that scientific forecasters have a unique expertise and should therefore have authority, but that authority cannot be based on certainty. This is a demand to reconsider the role of forecasting science in society as always incomplete, partial, and limited, that it contributes to imaginaries of what nature is and where the line is between nature and society and that this is where it draws its authority from.

Non-Western Futures and Resistance

Attending to these various worlds of expertise provides a corrective to contemporary literature on futures that has tended to focus on the West and Global North. This work of scholarship has begun to raise critical issues about the way that the future has become a

[48] Renzo Taddei has called these“accountability rituals”, scenes in which forecasters are blamed or held responsible in situations of high uncertainty.Taddei, 2012, pp. 252-254.

vehicle of modern governance and unique forms of control through the management and manipulation of attention and the affective resonances of fear and security threats.[49] It has shown the way that technological infrastructures have been deployed in the service of enhanced forms of controlling borders and securitizing the state. In this valuable work, it is shown that risk and security threats of the future becomes weaponised in the service of managing state sovereignty in fundamentally new ways.[50] The focus on the North and security threats such as terrorism has eclipsed an understanding of the ways that nature itself is a volatile subject of governance. Moreover, it is imperative to understand how science and technology are entangled in the governance of that nature outside of the North and West and in complex relations with other parts of the world. Throughout these chapters, I privilege the encounters between Western notions of forecasting and non-Western techniques. In order to gain a better understanding of the networks of different forms of expertise, their entanglements and exchanges. This presumes a more open field in which western scientists, non-western scientists, shamans, and sultans are negotiating modes of managing and governing the future, exchanging technologies, and are acting both locally and globally.

This open field allows us also to fix a spotlight on the politics of resistance in a forecasted world. Nature forecasting is a way to make futures present and govern the relationships between nature and culture, yet no forecasting practice has a monopoly on the future. I turn again and again to practices that adopt, transform, and undermine dominant futures of nature so as to create openings for other futures, ways of building and experimenting with different relationships with nature. They cannot be separated but need to be understood together. I also argue that the geography of nature creates inherent, as Anna Tsing would argue, frictions to any attempt to control and master it by forecasting it.[51] Materials and infrastructures do not adhere to the wishes of particular forecasts and it is in the meeting point between projects of forecasting, their practice, and how they 'hit the ground', that much of the material in these chapters is directed. It is a zone in which projects of governing the present negotiate a material volatility and unpredictability that is at once cultured and in excess of it. It is these interfaces that are a kind of natural source of resistance, the gaps in which other futures emerge.

[49] Massumi, 2015.
[50] Ben Anderson 2017; Amoore, 2013.
[51] Tsing, 2005.

Outline of the Work

Each chapter frames a different cultural technique of volatile nature forecasting while shifting scales, actors, and objects, so as to explain from new vantages how forecasts are made and implicated in society. While the overall conceptual framework is cultural techniques, it is not necessarily faithful to Siegert or the German school of cultural techniques and media theory. This is not a dissertation on their thinking but a deployment of the core concept and its development in new contexts. The conceptual substance of the chapters draws on the history and philosophy of science, Science and Technology Studies, Cultural Geography, and Anthropology, as I see common causes between these disciplines but also methods that can deepen and embolden how we understand and explain the cultural techniques of nature forecasting. Each chapter combines, to some degree, ethnography, history, image analysis, and theory, and I defend this approach in the next chapter on method. The arc of the dissertation goes from general to particular, beginning with a study of the characteristics of modern western forecasting systems in Chapter 2-4, while the rest of the chapters focus in on forecasting techniques on Merapi between scientists, shamans, and the Sultanate. In this way, my method is broadly comparative.

Chapter 2 considers the methods and field strategies in researching forecasting as a cultural technique. It explains the methods I used in the field and archive, who I interviewed and where, the institutions I consulted and field sites visited. It describes how I conducted ethnographies of infrastructures and machines and the rationale as it applied to understanding forecasting. I then consider the function of de-familiarization as the purpose of theory and a result of taking an anthropological view in relation to the forecasting practices of scientists, animists, and sultans. My method was to be the 'outsider within' in relation to Western forecasting science, the Western and "Western*ized*" modernist science taking place in the observatory, but I was also the outsider and foreigner, as a non-scientist and not Indonesian. This method was carried forward as I began to circulate between villages towards the caldera, shamans, and the sultanate in Yogyakarta. In each instance I was equivocating and controlling my foreignness.[52]

Chapter 3 is a broad analysis of the history and structure of modern nature forecasting systems. It argues that modern forecasting is a technical project of building distributed infrastructures to manage the uncertainty of the future and nature. I demonstrate that the

[52] Controlled equivocation is drawn from Viveiros de Castro. See: De Castro, "Exchanging Perspectives: The Transformation of Objects into Subjects in Amerindian Ontologies," 2004 and "Perspectival Anthropology and the Method of Controlled Equivocation," 2004.

unique politics of nature forecasting emerges through signalling through which the future of nature comes to be known in the present. These politics operate through the standardisation of signals and infrastructures and implicate subjects and publics.

Chapter 4 is about the frames that have been built in modern forecasting to comprehend uncertainty. I argue that the quest for a totalised space and earth in which everything is measureable and measured creates particular conditions for what I describe as rituals of integration between volatile nature and the totality. These rituals are central to modern forms of forecasting as ways to negotiate uncertainty by placing it within a total framework. This defines, in part, the way that knowing the future of nature is a public project.

Chapter 5 turns its focus exclusively to Merapi and the way that scientific practices standardize the radical unpredictability of the volcano. Scientific labour (representations, tools, instruments) are made through standards and are standardizing agents that make the volcano sensible and navigable. Scientific work, then, as it is undertaken in the observatory, is often defined in terms of the translation between standards. This is a way to demarcate which natural events break the standard, becomes abnormal, and unpredictable. In this sense, forecasting is a practice not of foretelling but of creating base lines of standard and non-standard worlds, of loops and repetitions, the expected and unexpected. This standardization extends even to the interior of the earth itself.

Chapter 6, "Cosmological Reason" is about *Kejawen* shamanism on Merapi. I argue that shamans make good geophysicists because they resist the modern constitutions distinction between nature and society through their forecasting practices. Volcanic action is inseparable from the moral, ethical, and political fabric of society. They are also resisting the incursions of monotheism, which aligns with the conventionally secularist modern constitution. I show how shamans are working to maintain an active indeterminacy in the future and radicalizing the social consequences of that indeterminacy. I show this through an analysis of a spirit possession ceremony in which volcano spirits overtake villagers and speak through them.

Chapter 7, turns to the sultanate at the base of Merapi and describes how it has been architecturally, spatially, and infrastructurally organised around the management of the future of the volcano. I show how the sultanate has evolved this system through what I describe as a "shadow state" that is a mirror image of the sultanate operating inside the volcano. This then makes any action of the volcano a political, territorial, and diplomatic issue. I argue that this conception emerged in the Suharto period as an extension of republican authoritarian power

that continues to have resonances today. I also introduce the figure of the gatekeeper as a crucial actor at the liminal edge of the shadow state who can leverage foretelling the future of the volcano to political ends.

Chapter 8, *Go-Betweens: Routes, Lines and Bodies,* turns back to science and follows a geophysical experiment on the caldera. I argue against the prevailing notion that geophysical work is primarily an instrumental and accuracy driven science. Instead, I show how the field is a site of relations and encounters in which expertise and knowledge are asymmetrically distributed, taken up, and repurposed. Bodies, machines and infrastructures are choreographed with each other in order to create flows of action and information. This is a form of forecasting by creating a culture of movement, bodily encounter, and networks of exchange, which is an anticipatory practice and future facing, while creating a shared sense of corporeal attachment and indebtedness to the volcano. I argue that geophysical practice should re-frame its operations in the field in these terms of the kinds of anticipatory communities it participates in and shapes.

Chapter 2

Tracing Cultures of Anticipation

Archives of Anticipation

Mount Merapi may begin erupting at any time. A phreatic eruption could, one night, launch debris a few hundred meters from the caldera or a drawn out catastrophic eruption could begin to unfold over months with global consequences.[53] Likewise, nothing could happen for years. The Dutch engineer M.A. Hartmann in the 1930s contributed to the long line of scientists seeking to categorise the types of eruptions on Merapi when he argued that there were three classes. They ranged between severe, disastrous eruptions, eruptions with little warning, and, "small explosions of the dome". [54] According to his scheme, Merapi had been erupting continuously, in one of the three categories, for one-hundred and one years.[55]

The attitude of Dutch colonial scientists was that permanent activity ought to be met with permanent monitoring. This included the building of observatory outposts where officers on watch, like in a prison, monitored the caldera and along the flanks. They plugged-in to international networks of instrument makers in Japan and Europe to import monitoring tools, install new communication devices between the observatories, build networks of knowledge exchange, instrument distribution, and expertise, that went from the flanks to the lowlands, Yogyakarta to Bandung and Jakarta, and to the Old World, and back. Hazard maps were drawn, dangerous areas demarcated, and careful studies of eruptions were undertaken so as to extract patterns which in turn could be used to apply to future scenarios. In this way, the colonists were building a culture and infrastructure of anticipation.

Studies and accounts of eruptions had already appeared in the late 19th century, and there was a popular colonial literature fascinated with the volcanoes of the East Indies, but it wasn't until devastating eruptions in the 1920s began to threaten the modernist colonial project that engineers and scientists began to predict eruptions.[56] This shift resulted in a

[53] See: papers on 2010 eruption, including Surono, 2012.
[54] Hartmann, 1935, see also *Historical Eruption of Merapi*.
[55] 1837 to 1938
[56] Rudolf Mrazek has chronicled this culture particularly well in *Engineers in Happy Land: Technology and Nationalism in a Colony,* 2002.

flourish of publications, experiments in representational technique and instrumentation, ambitious surveys, theories such as Hartmann's and the construction of monitoring networks. Scientists and engineers, Georges Kemmerling, N.J.M Taverne, Roger Verbeek, Louis Rutten, Charles Stehn, Behrend Escher, and Reinout Van Bemmelen, compiled written accounts of field observation, measurements, and visual recording of volcanoes throughout the archipelago and of Merapi.[57] This record meant, for the purposes of this dissertation, tracing the emergence of new publications by Dutch scientists, such as the *De Ingenieur in Nederlandsch-Indie* (The Engineer in the Netherlands-Indies) *Die Waterstaats-Ingenieur* (The Ministry of Water Engineers), *Volkanologishe Berichten* (Volcanological Report), *Volkanologische Mededeelingen* (Volcano Communications), and *Volkanstudien op Java* (Volcano Studies of Java), that circulated within and without the East Indies. Monthly reports such as *Maandverslag van het Vulkanologish Onderzoek* (Bulletin of Volcano Research), and *Bulletin of the Volcanological Survey* collated observations and measurements of volcanic activity taken at observatories throughout the archipelago. Instrument catalogues from Germany, the Netherlands, France, and the United states travelled between Yogyakarta and Bandung and catalogues from the Pacific Science Congresses in which international scientists met annually (the Congress of 1929 was held in Bandung and Batavia) compiled surveys of the state of the art of volcano science in the region and key volcano scientists such as Neuman Van Padang contributed surveys of volcano science in the East Indies to the catalogues. [58]

The creation of this culture of anticipation was a multi-departmental, cross governmental, institutional arrangement. The Irrigation Service (*Dienste der Irrigatie des P.W.*), water companies, Waterworks Yogyakarta, National Surveyors, Meteorological Observatory in Batavia, the Telegraph Service, all assisted in undertaking these surveys in the service of national interest. While on Merapi, the establishment of the first permanent volcano observatory in the Indies at Maron in 1920 and subsequent construction of four outposts at Babadan, Ngepos, Plawangan, and Selo, between 1932 and 1939, and in the city of Yogyakarta, was facilitated with the blessing of the Dutch regent who governed over and above the Sultan.

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[57] For brief biographies, see: Rab Sukmato, Tjoek Soeradi, and Wikarno, *Menguak Sejarah Kelembagaan Geologi di Indonesia: Dari Kantor Pencari Bahan Tambang Hingga Pusat Survei Geologi,* 2006. See also, Newman Van Padang, "History of the Volcanology in the Former East Indies" *Scripta Geologica* no.71, 1983, pp. 1-76.

[58] Dr. Siebert & Kuhn, Cassel, Thermometer catalogue from, June 1870 held at the Observatory in Bandung was one example.

Reconstructing the early appearance of this modern culture of anticipation required excavating publications, reports, periodicals, and instrument catalogues from within present day observatories. Very little of this material made its way into British collections at the British Library, the Geological Society, Cambridge, or Oxford libraries. Understandably, Dutch archives contain the most substantial collections but due to my limited understanding of Dutch they remained inaccessible. This meant that a complete, nuanced account of the richness of this burgeoning scientific culture does not make it into this dissertation. However, it was a period of international scientific collaboration conducted in many European languages, and many of the publications of volcano scientists and engineers were translated so that they could be in dialogue with scientists in Japan, Europe, England, South East Asia, and the United States. The accounts that I give of this culture in these chapters are reliant in, large measure, on these English language sources and translations into Indonesian.

This material is today located in archives and libraries of the *Badan Geologi Kementerian Energi dan Sumber Daya Mineral* (Ministry of Energy and Mineral Resources Geological Agency) in Bandung, the *Kantor Pusat Vulkanologi dan Mitigasi Bencana Geologi* (the Office of Volcanology and Geological Hazard Mitigation) in Bandung, and the *Pusat Volkanologi dan Mitigasi Bencana Geologi* (Centre for Volcanology and Geological Hazard Mitigation Library) collection, Bandung; and, the *Balai Penyelidikan dan Pengembangan Teknologi Kebencanaan Geologi* (Institute for Research and Development of Geological Disaster Technology) in Yogyakarta. They contain collections of monographs, maps, drawings, bulletins, and instrument catalogues from the colonial period and mimeographed versions translated from Dutch to English and Indonesian. The majority of the research in this dissertation on that period was consulted in the archives and libraries of these institutions.

This material was often neglected in these collections, consigned to dusty back shelves and unorganized boxes in the forgotten corners of the library at the *Office of Volcanology and Geological Hazard Mitigation* in Bandung, or the *Institute for Research and Development of Geological Disaster Technology,* Yogyakarta because it is considered past its years of value to scientific forecasting and hazard mitigation. The librarians in Bandung and Yogyakarta graciously allowed me free reign to sift through old boxes and cupboards to find the remnants of this cultural turn. In this way, the contemporary libraries and institutions of the Indonesian republican state are built within, like archaeological ruins, the initial forays into a culture of anticipation in the late days of the Dutch empire. The architecture of the *Office* and the *Ministry* in Bandung that housed these libraries and collections were of that

same moment, rendered in the optimistic simplicity of Dutch tropical modernism that announced a new flourishing, in Rudolf Mrazek's terms, of smooth and ambitious colonial state infrastructures.[59]

The instruments of that period, including a Wiechert seismograph, are held as artefacts in collections at the *Institute* in Yogyakarta. The observatory outposts at Babadan and Jrakah built by the Dutch in the modernist architectural styles of the period also contain remnant instrumentation and infrastructures. There are (now dysfunctional) bunkers, rain gauges, and dated topographical markers at the outposts. Photographic documentation of the period from 1900 through the war-time 1930s, as Dutch volcano scientists and engineers quickly adapted the camera to their fieldwork and aerial surveys, captured the volcanic landscapes they were trying to understand and often too, engineering works and the labour of conducting fieldwork with their "native" informants, labourers and collaborators. Some of this material is also stored in the dusty back corners of these libraries and archives but others have been reprinted into newer editions published by the *Office* and the *Institute* that situate contemporary Indonesian volcano science within the longue duree of colonial sciences and techniques of anticipation.

These remnants formed the textual, material, instrumental, and infrastructural basis on which I characterise this emergence of a culture of anticipation in the late 19th century and was later adopted and transformed in the post-colonial period. This forms the bedrock for the ethnographies of scientists and shamans that I undertook between October 2015 and August 2016.

Scientists

To understand the perspectives and practices of contemporary scientific forecasters on Merapi, I began interviewing scientists at the main observatory in Yogyakarta. It falls within the national *Geological Agency of the Ministry of Energy and Natural Resources* and answers to the head office in Bandung. The branch in Yogyakarta is the largest outside of Bandung with over one-hundred staff, and two wings of geological and petrochemical laboratories, and a large, real-time digital and analogue observation room. In the offices, I undertook extensive interviews with I Gusti Made Agung Nandaka, or Made, the director of the observatory since 2014, in order to understand the operations, politics, evacuation policies and procedures, science of prediction, and technical monitoring networks and infrastructures of Merapi. I then

[59] Mrázek, 2002.

began to attend operational meetings with Made and foreign scientists temporarily stationed in the *Institute*. I broadened these encounters by interviewing previous observatory directors Subanriyo (2008-2014), and Surono, who, in the *Office* in Bandung, was director for overseeing the monitoring and evacuation of all volcanoes on Java and Sumatra (2001-2014). In 2010, he became acting Head of the observatory in Yogyakarta during the crisis of 2010. In crises, it is a rule that the director in Bandung takes over the role of the acting head of the observatory in Yogyakarta. I worked my way down the ranks in the observatory, interviewing Agus Budi Santoso, a seismologist directly below Made who had been working there since the massive eruption in 2010; Dewi Sri Sayudi, a technician who has worked there for over a decade; Noer Cholik, director of outreach and social media; and Purwoto, the main seismograph technician. In Bandung, I spoke at length with Davy, director of the eastern part of Indonesian volcano monitoring (including Bali, Lombok and Flores) and Rizal, a young geophysicist and recent graduate. Of the foreign scientists stationed in the observatory, some for as long as three years (in Bandung) for an international project which I describe in more detail in later chapters, DOMerapi, I interviewed, Frank Lavigne, Karim Kelfoun, Jean Beauducel, Jean-Christophe Komorowski, Svetlana Byrdina, Jean Christophe Avarre, Jean-Philippe Metaxian, Antoine Laurin, and Clive Oppenheimer. Many of these interviews were extensive, most were several hours in repeat interviews over the course of a year, and resulted in over twenty hours of recordings and one hundred thousand words of notes. To understand the practices of scientists, I joined administrative meetings, and was given a temporary workspace in the observatory library from which I could observe and participate in the day to day rhythms of the observatory, including celebratory lunches for retiring colleagues, the quiet coming and going of the rainy season, nearby food stalls that fed the staff, never ending construction work, and laboratories which were for months empty of scientists. I spoke with security guards, cleaning staff, librarians, joined colloquiums and lectures by geophysicists at the University of Gadjah Mada. I followed scientists on field excursions to the summit to repair and maintain the monitoring systems on three occasions to *Pasar Bubar*, a plateau on the Northern flank of the summit, Babadan Observatory, Jrakah and Selo. I joined fieldtrips with scientists to Kinaredjo village, into the destroyed valleys in the region, Deles village and relocated new villages built after the crisis of 2010. This included a three night fieldtrip with Svetlana Byrdina, a Russian French scientist that forms the empirical basis of Chapter 8. I documented and had technicians explain the function of the seismographs and other instruments in the observatories and joined Purwoto as he undertook his daily routine of analysing and replacing the scrolls on the analogue machines.

Shamans

To understand the cultural techniques of shamans and animists I interviewed shamans, gatekeepers, their friends and families. In 2014, I stayed one month in the village of Kinarejo, where the appointed gatekeeper of the Sultan of Yogyakarta Maridjan had lived, and I interviewed his son and current gatekeeper (Maridjan died in 2010) Asih, the village head, and Padiman, a bureaucrat who commutes to the city. In January 2014, I interviewed Sukiman, the village head of Deles, on the south east and founding member of a Merapi wide radio network JALIN, and Yamik, a medicine woman. Between September 2015 and July 2016, I returned once per week or fortnightly to the village of Keningar on the Western flank, four kilometres from the caldera to interview Sukidi, a 70 year old shaman and farmer; Suparno, in his fifties, a farmer and shaman in training; and, Yehezkiel Sugiyono, an environmental activist in his late thirties and their families. On the Western flanks, along the Senowo River, I interviewed the following shamans and gatekeepers in these villages: Santoso in Talaman, Nang Subrianto in Mangunsoka, Pras in Dukun, and Sabda Langit in Yogyakarta.

In Keningar, a village of sixty families and the closest to the caldera of the volcano that a village could be according to law, I had immediate and welcoming access to Sukidi, who I discuss in detail in chapter 6 on cosmological reason, as well as Suparno (in his fifties), a farmer and shaman in training. I became close with Yehezkiel Sugiyono, an environmental activist and former miner in his mid-thirties. It was common that in the evenings, the sitting rooms and parlours of these three men were transformed into discussion groups for men from Keningar and local villages in which issues of anticipating volcanic action, the role of the state, function of spirits in the volcano and on the flanks, village history, mining, and politics, were central topics. From these, I recorded over ten hours of conversation.

At Kunci Cultural Studies Centre in Yogyakarta, a non-governmental organisation, I convened two, three-hour workshops in 2015 and 2016 about the conditions of sand mining on Merapi, environmental controversies, and local knowledge practices and expertise. Speakers and participants were drawn from villages in the Dukun area, Muntilan, Jakarta, East Java, and Yogyakarta. They included farmers, activists, artists, journalists, and anthropologists.

Sukidi, Suparno, and Sugiyono, all insisted that the greatest threat to their relationship with Merapi was the illegal sand mining in Sunowo river adjacent to the village (*fig 1*). They had watched for years as other villages had transformed from their economic reliance on the

fields to the mining site and as a result of the corrupt politics of the state. They documented and shared with me photographed ledger books that had been manipulated, and correspondence with village heads and local and regional politicians. They documented the illegal usage of heavy machinery in the river beds and sent them to the provincial authorities as a way to bypass local corruption. They watched with concern as village lands were sold off to private, difficult to trace, shell companies, mined for sand, and abandoned without remediating the rivers and banks. The mining was threatening the social structures of the villages because miners could get rich quick if they left the fields and gained authority within villages. Bigger houses built by miners causing jealousy and transforming the spatial fabric. Miners were, according to accounts from Suparno and Sugiyono, becoming landless and in debt as their mines ran dry.[60] This spurned a long held hatred among Sukidi, Sugiyono, and Suparno for lowland republican authorities in Yogyakarta and Jakarta and was often characterized as a continuation of the patronage politics of Suharto's New Order authoritarianism of 1965-1998.

The mining was also transforming the river beds. During eruptions, vast quantities of debris flow down the deep channels that run from the caldera to the south sea fifty-kilometres away. As the volcano is frequently active, this material is flowing through these river beds adjacent to Keningar. The Senowo river is roughly 100-175 meters wide in some places and it has deposits and eruption debris across its length, within its catchment, and riparian zone. This material is mined by hand and heavy machinery which leaves unevenly dug river beds and banks liable to collapse. In future eruptions, the mudslides and pyroclastic flows can over top the banks, endangering nearby villages, due the mining.[61] Miners were also being killed every year; in 2016, there were eight miner deaths in the river valleys from overtopped banks and accidents.[62] I provide an account in Chapter 6 of a miner who died in Keningar on May 2nd 2016, after a river bank collapsed on him. The roads along the river beds to the mining sites on the northern, western, southern, and eastern flanks had been destroyed by the long lines of mining trucks and heavy machinery that carried material to the ports in the north of Java. This endangered future evacuations by creating traffic jams and in some instances

[60] An account of the social effects of the mining can be found also in Arif Rahman's undergraduate thesis *Advokasi Kebijakan dan Manajemen Konflik dalam Kasus Pertambangan Bekas Erupsi Merapi*, 2015, pp 44-140.
[61] Belizal, 2014.
[62] Media reports in local media. See local media sources covering miner deaths in recent years, Tiga Penambangan Batu Ditutup, 2014; Tebing Ambrol Timbun Harno, Penambang tewas di area eks tambang alat berat, 2014; Satu Nyawa Melanyang Akibat Penambangan, 2014; Tebing Longsor Tewaskan Penambang, 2014; 2 Jamaah Haji Asal Magelang Meninggal Dunia, 2014; Fitriana, 2016.

making evacuation routes impassable for residents. For Sukidi, Suparno, and Sugiyono, as well as many other Keningar village men, their concern was that the mining would endanger their relationships with the volcano, destroy the lands and rivers, and create new forms of social and economic dependencies on the lowland.

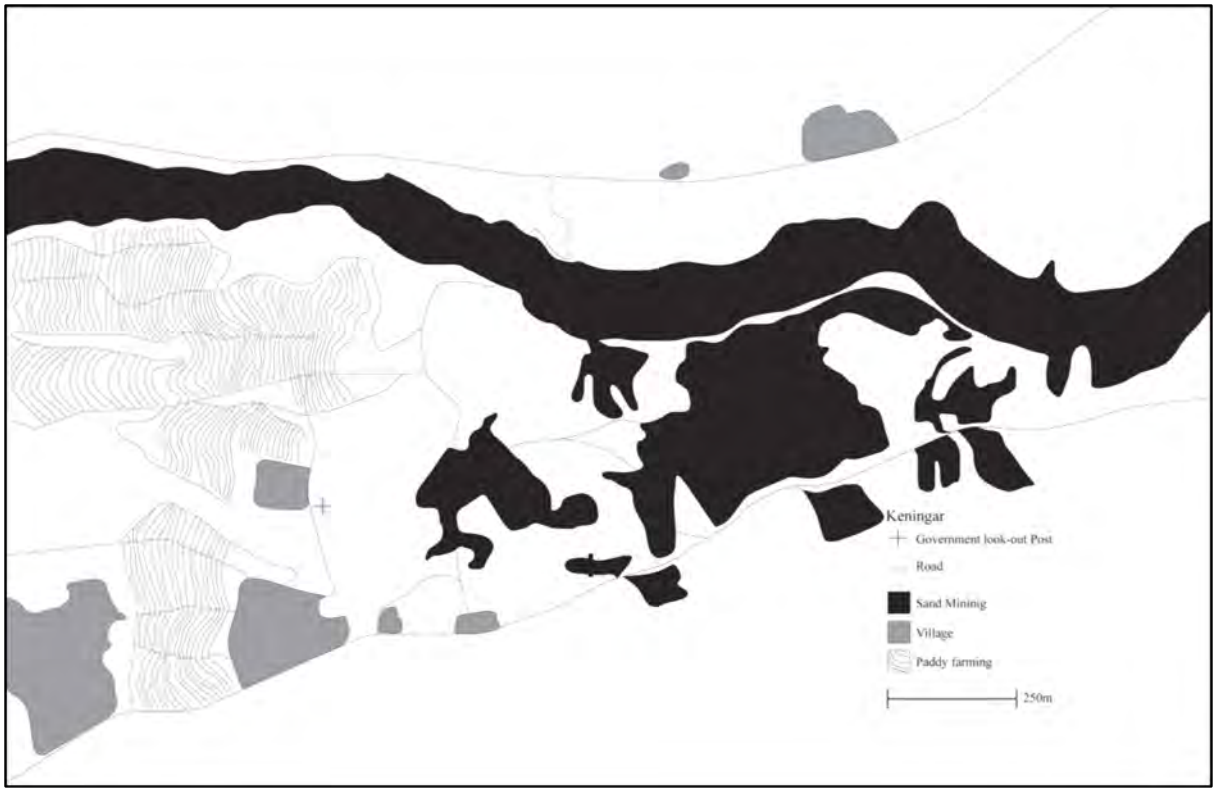

Figure 1. Keningar, 2016. The black zones are current or old sand mines. Grey zones are villages.

It was within this context that I would accompany them to the fields or forests, surveying mining sites, or to visit significant trees and spirit abodes. I joined for a ritual *selamatan* dinner, March 2016, held on a concrete bridge and protective Sabo Dam (weir) that held back dangerous debris. It overlooked an illegal mining site and residents in Keningar wanted to leave traces of the invocation of volcano spirits and ghosts to be visible to miners the next day so that they knew they were also in the company of non-human entities that had stakes in the relationships with the volcano. I was also invited to spirit possession ceremonies in which spirits from the volcano spoke-out against the mining. As our relationship deepened, I would assist them in documenting illegal mining activities in the area for their legal case to the province Central Java.

The culture and techniques of anticipation that are practiced in Keningar cannot be understood without attending to the forces of mining and its relationships with the lowland republican state. Volcano scientists from the observatory are often understood as its

representatives and in this way, the culture of anticipation in Keningar refused to distinguish between natural hazards and politics. I treat the consequences of this in detail in chapter 6. Understanding this also required the development of a method of equivocation and comparison with the legacies of scientific modes of anticipation and modern science that refused to treat "non-modern" practices such as shamanism as irrational, or backward but as contemporary political techniques of negotiating nature-culture boundaries. Shamanism in Keningar and its vicinity is a practice of creating *a*modern futures in negotiation with republican state cultures of anticipation while the act of anticipation and the instruments and infrastructures it creates, is a means of brokering relationships between society and nature.

This meant too that it was imperative to neither play up the conventions that set science apart from animism, and modernity from tradition, but to show how those conventions are themselves constantly contested in practice.[63] The modernism of colonial scientists, as I demonstrate throughout these chapters, is animistic, in the sense that they treat the hidden interior of the volcano as an animate entity that communicates to them. Shamans, on the other hand, are thoroughly modern in the sense that they constantly update their own practices in relationship to contemporary pressures. It was necessary to equivocate between the two practices to break down the status quo ways that each describe each other, and on the basis of which they create antagonism, to make them more alike than they thought they were and to redraw their differences.

Studying Technologies and Infrastructures

Equivocating between science and shamanism meant understanding them both from the perspective of their technologies, infrastructures and practices. With Sukidi and others, we discussed the techniques and instruments they relied on for shamanic practices and communication with volcano beings. This ranged from the ornamental rings they wore with stones embedded in them, the kind of tobacco they smoked, and ingredients they used for communal dinner. I gathered a collection of visual documentation of offerings in forests, sacred sites and politically contested areas as a point of comparison with seismographs, pendulums, and instrument catalogues.

I documented the objects used in offerings and possession ceremonies, their origins in local markets and fields, and their manufacturing. If I came across offerings in the forests or fields, I would document them and follow up with interviews with people who made them or

[63] Candea and Alcayna-Stevens, 2012.

had contact with them and follow the objects: where else did they appear, in who else's rituals? This meant also consulting the histories of ethnographic accounts of South East Asia.

One of the difficulties studying shamans is that scientists have archives and libraries and shamans have oral histories, objects, and sites. This makes reconstructing the history of shamanic practices on Merapi almost impossible beyond the recording of oral histories, which I did not do in great detail except with Nang Subianto about the history of *Kejawen* animism. Because of this, I was unable to analyse the transformation of practices over time. There are few publications which go back to the early twentieth century that document *kejawen*, but again they remained inaccessible because they are written in Javanese. Many of the prayer and mantra books which contain outlines of the metaphysics are written in a now obscure form of high Javanese that very few people speak. Many of the older people who would have grown up with it used in ceremonies have forgotten its meaning. My lack of knowledge of Javanese also hindered my understanding of the shamans that I worked with because it is their first language and the language within which rituals are practiced as well as the most intimate language for communicating with the volcano. In my interviews, they translated from Javanese to Indonesian. For example, the language that differentiates spirits, ghosts, and souls in Indonesian is dominated by Arabic and Malay, whereas the Javanese has a vocabulary drawn from Hindu and Buddhist Sanskrit sources with local linguistic variation as well as Arabic. This means that the Arabic dominated vocabulary of Indonesian is a more Islamic template applied to the spirit world.

Not understanding Javanese prevented me from accessing the archives and libraries in the Sultanate which would have provided a much richer analysis of the gatekeeper system that I present in Chapter 7, *Gates, Gatekeepers, and the State of Nature*. My knowledge of the sultanate system is derived from Indonesian, English, and French language sources. The palace contains documents in Pali and Javanese documenting its history.

Controlled Defamiliarization

In the observatory in Yogyakarta, as I mentioned, I was fascinated by the banal objects immediately striking to any first time visitor: a room full of monitors fixed on the volcano, large, table sized scale models of the volcano and its urban context, photographic prints of eruptions, a wall sized oil painting of the eruption of 1930, obsolete instruments and its Neo-classical atrium. The front lawn contains antennae and beaten-up colonial era instruments which creates a quality of high futurism meeting underfunded ruin.

These are the normalised dimensions of the observatory, and like any institution, it is a warren of habits. Repetitions drive the work; habits of coming and going from work, prayer, and lunch hour. But also, the repetitions of observational labour: reading the seismograms, recording the observations of outpost observatories, going to meetings, replacing the paper on the seismograms, prayer. Repetition, as ritual, creates a banal transparency in objects and practices, and scientists would not dispute that the scratches on a seismograph were Mt. Merapi.[64] It was animate in a way that had nothing surprising about it, but it was a volcano that drew self-portraits.

As the tradition of STS has long argued, it is the transparency and banality of scientific culture that needs to be explained rather than assumed.[65] Obviousness facilitates action and order within the observatory and in the making of the forecasting system. Explaining how obviousness comes to be begins to make it strange as it dislodges what was woven into the smooth repetitions of the everyday. Controlled defamiliarization seeks to dislodge the everyday, not reflect to us the world as we already understand or expect it to be. There is a desire for transparency within social theory that dovetails the desire for transparency in modernist science for a transparent world in which its processes are exposed. It seeks in the world to expose its hidden architecture so that we could participate in its real causes and effects in a more authentic way. This is an idea of the work of theory as exposure and demystification, a notion of knowledge as a form of communion with the truth that comes from the world, and an attempt to build a community around the truth through its transparency. Controlled defamiliarization, however, takes the obvious and every day to make it strange, to reveal that what we thought we knew is foreign. Here, then, a weather forecast, or a Merapi update is achieved through remarkable and strange feats.

It seemed particularly important to present this image to social and natural scientists in the observatory, and those more generally concerned with how to predict volatile natures so as to derange the objects that are being looked at. They would no longer appear as a CCTV feed delivering information of a volcano but cultural techniques of ordering the differences between humans and nature, the present, past and future, through dual processes of abstraction and concretization. This exposure of the real through mundane devices like CCTVs and seismographs sets in motion an inquiry that seeks to reveal and expose the operations of objects as being both what we (scientists and ethnographer) thought they were and otherwise.

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[64] See: John Law and Evelyn Ruppert, 2013 on instruments and ritual.
[65] Annmarie Mol, *The Body Multiple: Ontology in Medical Practice*, 2002.

The ways in which modern scientists demarcate the technological from the human have overlooked how devices are not products of humans but are operative in creating the human in so far as the human comes into being through its distinction from the non-human. In other words, the human is technique. Controlled defamiliarization shows how the mundane is strange through the ways that it is operating within arrangements that create epistemological and ontological distinctions. That strangeness is a result of the epistemological and ontological forms of order that the mundane negotiates. This reveals that mundane techniques of forecasting negotiate a drama not of the unpredictability of eruptions or weather patterns but of the distinction between people, nature and politics. The numbers, calculations and technologies that make claims to accuracy, emerge from this primary drama as its products, and they in turn come to shape us and how the future can be lived.

Pictures

Images appear throughout these chapters and they are used in two ways. One is as an illustration, but more often, they function as research objects for analysis. I draw inspiration from post-colonial Indonesian studies that began to turn to images in colonial archive as texts. These images were often unspectacular, forgotten, or found detritus on the margins of official histories but social and political orders could be gleaned from their banality. [66] What I have inherited from that tradition is the value of building an interpretative dialogue with images because through their repeated interrogation they begin to reveal unexpected orders and contradictions which can then be read back into spatial and materialist – non-representational, concerns. This means taking the common visual culture products of forecasters seriously, their brochures and log books, risk maps, and forgotten photo albums.

Understanding how the observatory was creating a culture therefore came to be an issue of understanding its waste, the material that was forgotten but still around, because if observation determines the what and how of forecasting, then the waste and forgotten material of forecasting can indicate what is excluded from the process and is of no value. We can understand the positive content of forecasting through what is excluded from it. The library archives contained, for example, unlabelled photographs and reports. In more recent publications, the opaque orders that governed the selection of historical material became clear such as the book *Visual Images of the Merapi Volcano* (BPPTKG) where there are reprints of original, discarded publications.[67] This was not the only example, numerous recent

[66] Mrazek, 2010, 2002; Pemberton, 1994; Siegel 2010.
[67] *Visual Images of the Merapi Volcano*, 2014.

publications contain reprints of images, diagrams, and data that have been passed on through publications over the years and in the process the original has disappeared. Having access to these originals then revealed what was valued and what not and from those objects we can derive an analysis of the cultural practices – institutional, practices of labour, the necessities of scientific experimental apparatuses – that formed those practices. This was crucial because it revealed the systems of order that were guiding how the volcano could be known and, ultimately, forecasted. This was because forecasting required the development of networks – institutional, instrumental and human, to observe the volcano and anticipate what it was to do and this was formulated though the analysis of the past of the volcano and the selecting and filtering of what belonged properly to that past and what didn't.

Controlled defamiliarization brings the excluded back into the centre of practice. It does so by foregrounding the agency of infrastructure when it is considered only a medium, and obsolete instruments when it is assumed that progress has replaced them. It foregrounds the agency of gods and spirits when it is presumed that they are irrational myths, the act of standing in front of a model and pointing at it when it is presumed to be a transparent work of reference; it turns to pictures of the interior of a volcano when it is presumed to be a common sense understanding of the interior of the earth. Finally, this means taking seriously the leftovers, rubbish, and forgotten records that once made forecasting possible. It means turning to the cupboard under the stairs that scientists would prefer remain forgotten but where there is several years' worth of communications from Merapi.

Figure 2. March 2016, discarded seismogram rolls in a closet at the *Institute*, Yogyakarta. Photo by the author.

Chapter 3
Forecasting and the Politics of the Signal

Infrastructure and Signal Processing

Off the north coast of Japan, sensors sit on the floor of the Japanese Trench, a ten kilometre deep and thousand kilometre long fold in the ocean floor that connects to the pacific ring of fire. The sensors are arrayed in a grid of eight-hundred kilometres of fibre optic cable and register ground deformation in the ocean floor. One hundred-fifty small signalling stations are plugged into the grid to register hydro pressure, seismic waves, and the slower vertical displacements of crustal deformation.[68] Floating one kilometre above this grid on the surface of the ocean, and two-hundred kilometres from the Miyagi Prefecture coastline, tidal buoys transmit GPS signals to satellites that are orbiting roughly twenty-thousand kilometres above, measuring the vertical displacement of wave height in meters or less. That is where in 2011, the megathrust magnitude 9 *Tohoku-Oki* earthquake, the largest in Japanese recorded history created tsunami wave heights of up to five-meters in the ocean.[69]

If another earthquake of sufficient magnitude to trigger a tsunami is registered, a signal is distributed to land through the Japan Meteorological Agency that "slow[s] down trains, control[s] elevators to avoid danger and enable[s] people to quickly protect themselves…" It will also be broadcast via radio, television, and cell-phone. The oncoming wave may be a few minutes away, and in some cases it can be as long as twenty-minutes before it hits land. In 2011, twenty-seven bullet trains travelling at over three-hundred kilometres per hour were stopped by the signal without derailment.[70]

This monitoring system, while out of view in everyday life, is working in the background reading the pressures, volumes, and three dimensional displacements of material. This is within a network that reaches from ocean basin to satellite, Meteorological Agency headquarters to train lines, and through other broadcast networks. It covers over five

[68] Kanazawa, 2013, and DONET: Dense Ocean floor Network System for Earthquakes and Tsunamis, 2008.
[69] Kanazawa, 2013; Newman, 2011.
[70] Yamada, 2011, p. 148.

hundred-thousand kilometres of topography (not including the topographical complexity of vertical change from mountains to ocean basin, or the total area under surveillance by the GPS signalling satellite that orbits the planet at over fourteen-thousand kilometres per hour).[71] Within this vastness, the network of instruments is tuned to register precision and statistically derived norms of behaviour. A wave that is too high or a tremor of too great a magnitude breaks the statistical norm and dispatches a signal through the network that brings the observation out of the backdrop and into the foreground of everyday life.

Off the coasts of Jakarta, Sumatra, California, Thailand, and Chile, there are 59 international Deep Ocean Assessment Reporting of Tsunamis (DART) that, like the Japanese buoys, transmit real-time readings of wave propagation. They contain pressure sensors (tsunameters) and satellite antennae that transmits data via satellite to the Tsunami Warning Centres and the National Data Buoy Centre (US). [72] If the band of statistically regular tidal motion is breached, the civil authorities dispatch evacuation orders, and entire towns, in hours, clog exit routes across the coastlines of, for example, Chile and Thailand.

Every morning, my computer tells me if it will rain or be sunny, at what time, and with what intensity. As I write this in the fall of 2017, the monsoon season has just flooded parts of Bangladesh, Nepal, and the eastern provinces of India, where the warning systems were underequipped, displacing hundreds of thousands of people.

As catastrophic Hurricane Irma strove towards Cuba in August 2017, the United States Airforce Reserve *Weather Reconnaissance Squadron*, flew a plane above and around the eye of Irma for twelve-hours. The *Squadron* relays real-time data to the National Hurricane Centre in Florida. Flying above Irma, they tracked the eye to shoot dropsonds, an expendable missile-like projectile that free falls from the plane into the centre. As the dropsond falls through the storm it reads the air pressure and temperature profile twice per second and then transmits those readings back to the airplane, followed by the National Hurricane Centre, and the weather channel, maps and diagrams for phone applications, television, radio broadcast, and my laptop.[73]

What connects these vignettes is the architecture of signal translation that enables monitoring to run continuously across regions, material volumes, and different technological platforms. Through it, global scaled monitoring and sensing is possible and a permanent feedback of information connected by infrastructures that move, store, distribute, and

[71] This is approximate.
[72] Newman, 2011; Rabinovich, 2014.
[73] JAMES R. LUYTEN, 1982; Tabrizy, 2017.

choreograph recordings between formats to anticipate the future of volatile nature. This is the cybernetic impulse. It is monitoring and the dream of choreographing nature with society through the automation and synchronisation of signal production and reception. It translates a measurement of the displacement of water pressure on the ocean floor into a signal to halt a bullet train in the countryside. Infrastructure, which, in conventional terms, is the structure between structures, when enlisted to meet the goals of the cybernetic impulse transforms nature into a media broadcasting system. An earthquake becomes a broadcasted signal travelling through networks faster than, and ahead of, the actual earthquake.

This chapter explores the politics of this nature-as-infrastructure-as-media and how the future of nature is made present by these monitoring networks. In doing so, I demonstrate how it is in the negotiation of the unpredictability of the future of nature that the politics of the signal emerges. I argue that we need to attend to these politics at the site of the publics and subjectivities that emerge through the signal, a politics of signal subjectivity that makes it impossible to separate the interiors of bodies from the technologies of forecasting. The conventional methods of separating communications technology as a medium between people and nature has unfortunately overlooked this zone of indeterminacy and complex causal interchange between publics, subjects, networks, and signals.

Monitoring

Monitoring is the complex, technical other half of modern forecasting. It is a constant watching for changes in the planetary system on which foretelling is based and connected to a modern desire for the management of socio-natural relations through technology and information processing. As I argued in Chapter 1, technology is entangled with space, territory, and time, but also representations, imaginaries, and the politics of governing society. Because of this, I trace here the zone in which infrastructures for monitoring uncertainty inflect conceptions of what society is and how it should be governed. An example of this is the way that the unpredictability of volatile nature has often come to be understood to mirror the unpredictability of social systems. The economy stands out in this regard because it is often described as if it too were equivalent to a natural system. It is subject to storms, tempests, volatility, depressions, even climates. While economists have long used the weather as a metaphor for economics, they have also adapted the procedures of weather science to economic forecasting. The Cambridge Economic Service is an example that formed in the 1920s as an “economic barometer”, was created to distribute data “indicative of future business conditions” and published market and business information (factors

speculation, business conditions, monetary exchange rates and values) in newspapers so that it "might be studied by the businessman with the same confidence with which he now consulted the indications of the thermometer or the barometer".[74] The calculation of probability, too, as Ian Hacking and Lorraine Daston have shown, was likewise applied to weather forecasting and economic affairs.[75] Both demonstrate how technologies can become vehicles for making different epistemological fields (economics and the weather) newly equivalent and translatable.

Paul Edwards has shown that the modern history of weather and climate forecasting has relied on the creation of technical and material equivalences. The creation of shared standards of measure, the international standardization of technologies, and models of physical systems compatible across scales and regions was integral to the labour of modern weather and climate science.[76] Achieving this required the synching of expertise across national borders but also and at the same time the overcoming of national cultures of forecasting and observation.[77] This transnational, globalising enterprise of volatile nature observation and modelling formed the templates for climate models today. These in turn are the basis of an imaginary of a total Earth system that different national parliaments invoke, law and policy is drafted in relation to, and is used to forecast a common climate future. In this sense, equivalence is achieved both through infrastructural standardization, or technical equivalence, and epistemological standardisation. What needs to be better understood in these trajectories are the circuits between imaginaries and technologies and infrastructures.

This modern imaginary of a Whole Earth System is built on the circulating signals and synched infrastructures that break down our conventional category distinctions between technology and society, the future and the present, time and space. Instead, to properly understand the forecasting of volatile nature requires attending to non-linear conjunctions between space, material, signal, infrastructure, and politics. It requires understanding how imaginaries are formed through the creation of networks that are in themselves partial and fragmentary objects. From this perspective, infrastructures of forecasting are forms of media and mediums that put society and communities in touch with material forces. Understanding the geography of a signal that is created by the displacement of water pressure in the Japan Trench to the bullet train on land, has to also, then, understand how it participates in the

[74] Shankleman, 1953, p.88; McCloskey, 1983.
[75] Hacking, 1990, Gerd, Gigerenzer et.al 1989.
[76] Edwards, 2010, 1996, 2004.
[77] Edwards, 2010; Tagliacozzo, 2005; Pyenson, 1989; Zuidervaart and Gent, 2004; and James Secord on non-Western imaginaries of the Earth in Secord, "Global geology and the tectonics of empire."

ontological and epistemological distinctions between nature and society, collapsing them or separating them.

Modelling Uncertainty

Agus Budi Santoso, a seismologist working at the Yogyakarta volcano observatory, explained to me that volcanic eruption forecasting relies on knowledge of the past. The deduction of probable futures is based on past records of eruptions combined with critical evaluation of present day conditions. Technologically mediated observation supplies from different strategic sites around the volcano, in vast quantities, rapidity and efficiency, the information that those projections are based on. According to this, Santoso argues that the efficient distribution of information, the technological substrate, and critical human faculties are key to the condition of possibility of achieving an accurate forecast. Santoso' argument is highly modern in this insistence on "information" as an immaterial packet of facts. Technology, in this view, is the vehicle that at its most efficient, delivers no friction in the delivery of the facts, while human minds adapt their critical skills and faculties to the arrival of the facts to base their judgments upon. It is a version of the Cambridge Economic Service.

For many forecasters that work with geohazards, including Santoso, forecasts always contain uncertainty because of the gulf between what humans can know and nature. In his book about forecasting economics, *The Map and the Territory: Risk, Human Nature, and the Future of Forecasting,* Alan Greenspan similarly argues this modern position in relation to economies. He says that humans are naturally predisposed to predict the future but the future is determined to be uncertain. For Greenspan, the issue is fine tuning human nature to accord as much as possible with uncertainty "because our nature demands it".[78] But he argues that the financial crash of 2008, exceeded all forecasting models. "The whole period upset my view of how the world worked – the models failed at a time when we needed them most … and the failure was uniform."[79] The models were flawed because of what he calls, drawing on Keynes, "animal spirits": irrational and unpredictable human behaviour.[80] What he is foregrounding is Santoso' argument that there is a gap between what we know, can know, and what is; between epistemology and ontology. Forecasting is the technical project of closing the gap between epistemology and ontology, the mind and the world.

[78] Greenspan, 2013, pp 3.
[79] Tett, 2013.
[80] Tett, 2013, Greenspan, 2013.

One of the standard modern solutions to closing this gap is through the production of more information: more observatory outposts, more representations, more and different technologies, and hence, more infrastructure to broadcast the information, and the creation of new standards to translate between them.

One of the problems with this strategy is that the signal for volatile nature forecasting is on the move. Constant monitoring does not necessarily mean knowing what will happen in advance. The deformation in the ocean floor before the *Tohoku-Oki* megathrust was considered insignificant and did not produce an alarm, and it is difficult to identify which transformations in water pressure are precursors to fault slippage.[81] The signal for an oncoming tsunami is restricted, then, to an already agreed upon standard expression of dangerous vertical ground deformation. Moreover, signals are scale dependent, they can be seasonal or hourly, or on geological time scales. Another problem with this strategy is that it presupposes a linear relationship between epistemology and ontology. It wishes away the complexity of the interactive agencies of nature, infrastructure, technological instruments, and the human. It overlooks how uncertainty is a distributed, complex, socio-natural entity.

In Andrew Pickering's account, a radical and experimental cybernetics is a science of systems that continuously negotiate and adapt to highly unpredictable and changing conditions by adjusting themselves to the unpredictability of nature in an open ended becoming.[82] The core idea of this cybernetics is that:

> "there exists in the world a class of 'exceedingly complex systems', including the brain, firm and economy, which are in principle *unknowable*. However much data we gather on them, we can never know them completely, they can always surprise us. Such systems can never be dominated by knowledge, and instead we have to learn somehow *to cope* with them, and cybernetics was, then, the science of dealing with the unknown, the science of adaptation".[83]

The problem here is how to account for the politics of this cybernetic machine and to explain that relationship in a way that can take into account the intersection of infrastructural mediums and technologies in relation to an unpredictable, shifting, future of becoming.[84]

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[81] Newman, pp, 441-443.
[82] Pickering, 2004, "Producing Another World"; Asplen, "Going with the Flow" 2008.
[83] Pickering, 2004, p.500.
[84] This is one of Pickering's projects as well though his is in relation to a stricter legacy of cyberneticists and their influence on democratic politics.

Affects and Signals

Ben Anderson has made in-roads in this project by demonstrating that futures have affective rhythms with which they appear in the present and cut across the divisions between bodies and technologies.[85] He has argued for understanding the affective fullness of the future in the present according to the different temporal rhythms through which it is made present and lived. There is the pressure of the near, frightening, future of imminent catastrophe, and the energy of the emergency, or the slow burning dread of the unknown and distant future apocalypse. As affects, they are shared sensations that pressurise, mobilise, and energise bodies in the present. Affects create "scenes" and "atmospheres" of common but differential temporal intensities that project or slowly reveal futures of nature.[86]

The differentiated affective force of rhythm was evident on Merapi in 2015 during the fifth anniversary since the last eruption. The eruption of 2010 had been the largest since 1930 but also much more recently, the eruption of 2006. It was commonly pointed out that Merapi erupted in cycles of five years and that late in the year of 2015 was becoming auspicious.[87] Local newspapers *DetikNews*, *Jogja Tribune*, *Jogja Radar,* and *Liputan*, ran stories throughout 2015 about the potential recurrence of a massive eruption in the New Year. But they also ran other stories that claimed the cycle was actually four years, perhaps six. Surono, then forecaster at the observatory in Bandung, in an interview in Yogyakarta with a *Liputan6* journalist, said that the cycle "Before, at the longest, it was eight years, seven sometimes…once it has been as long as eight years, like 2010 which needed lots of energy."[88]

This logic of repetition makes present the possibility of an eruption at any time. It shifts the coordinates of what is possible, of how everyday life might unfold because it could mean that any day might turn into a day in which people have to prepare to move to refugee camps if they live on the flanks. Just as in Tornado Alley where the spring is a time, depending on where you live, of evacuations. A weather, volcano, or earthquake forecast creates a space of anticipation in everyday life in which the possibility of a dramatic transformation or rupture can emerge, but it is not as if this creates a demobilising fear, but an affect of low-level anticipation that keeps the present open to the possibility of an eruption.

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[85] B. Anderson, "Emergency Futures: Exception, Urgency, Interval, Hope," 2017.
[86] On geographies of atmosphere, see: Amin, "Animated Space." 2015; and B. Anderson, "Facing the Future Enemy US Counterinsurgency Doctrine and the Pre-insurgent".
[87] See: "Siklus Erupsi Gunung Merapi Bisa Berubah," 2016.
[88] H, 2015.

On the evening of November 10, 2015, I was sitting with friends around a dinner table at a house in the centre of Yogyakarta. At just after 7pm, in an atmosphere of conversation and distraction by books and computers, the house began to shake, the hanging light to sway, and the stacks of plates in the cupboards to clang. Within a few seconds, everyone had stopped what they were doing and ran outside to the front yard, safely away from any collapsing material. We had moved instantaneously, without needing direction and barely within the space of reflective thought. The shaking quickly died away. Some of the neighbours had also run outside and were milling around and excitedly discussing the event under the street lamps. As we returned indoors, phones were quickly checked for local news, updates had said that tremors had been felt as far as forty kilometres away in the Bantul region where the epicentre was suspected to have been. Conversation turned to the cycle, and the dawn of the sixth year anniversary of the last massive eruption which all but one of the guests had experienced. There were questions and speculation about whether or not this tremor was connected to an eruption yet to come.

Through this minor tremble, the possibility of a recurrence of the past and of living in temporal cycles of eruptions emerged. The shock, speed and immediacy of evacuation, that it was without thought, were channelled into the anticipation of cyclical rhythms, and the potential for more dramatic transformation, evacuation, and potential destruction. These were affective rhythms as they created scenes of anticipation, of heightened and dissipating anticipation of the future.

Rhythms have tones, too. The sirens used to signal eruptions, landslides, and pyroclastic flows on Merapi in villages towards the top used to be an elongated wooden gong used for the call to prayer in the mosques. During emergencies, Mosques situated higher up on the flanks sent out a signal by banging in a non-stop, repetitive rhythmic pulse.[89] Mosques lower down the flank and within hearing range would repeat the call, and so on down the flanks, forming a network of anticipatory warning signals as a flood or landslide rolled down.[90]

Observation and forecasting creates these circulating signals, material references that are harnessed, directed, and amplified through infrastructures. They are channelled and constrained as they are broadcast. This generates their rhythm and the material dimension of making the future present. It is by attending to the infrastructure of the signal that we can begin to unpack its politics in a more robust way than only as a rhythm of bodily affect. To

[89] Lavigne, on lessons learned after 2010; Estuning, et.al, 2013.
[90] See: Franck Lavigne, 2017.

understand its politics requires integrating its infrastructural and technical dimension. Along this line we can begin to understand how the architecture of the signal begins to produce affects that form groups, publics, and subjectivities, and it is in that transformation that the particular politics of the signal can be witnessed.

In the 1990s, the mosque gongs were replaced by mounted sirens (*figure 1*). They were no longer linked to village observation systems but to radio and electrical communications systems connected to the main observatory in the lowlands and were erected at the same time that electrification arrived in many of the highest villages. They not only made new warning sounds, electrical buzzes and beeps, they also indicated a new infrastructural future of village electrification, radio signals and the new presence of the lowland, state observatory on the flanks.

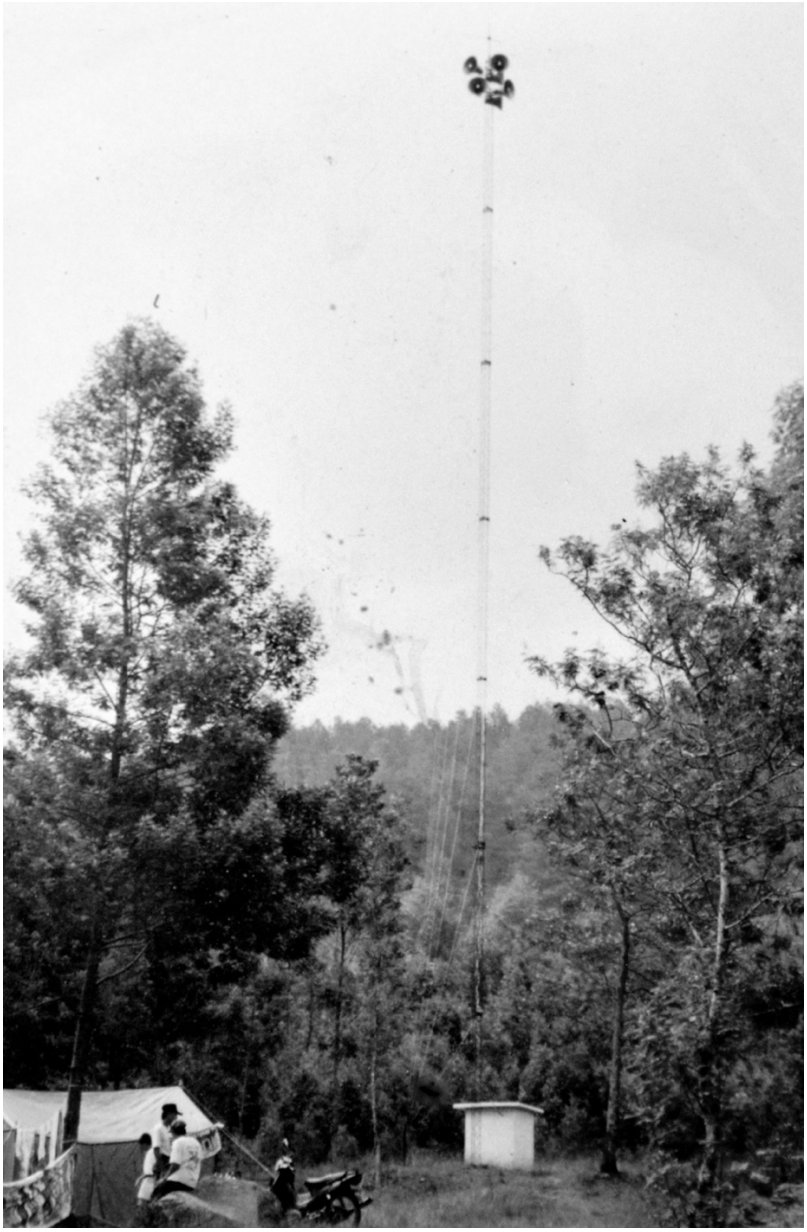

Figure 1. Warning siren, circa 1990. Author unknown, collection of the BPPTKG.

This broadcast infrastructure laid the groundwork for the emergence of walkie-talkie infrastructures in villages within a four to six kilometres range from the caldera of Merapi on the southern flanks. After the eruption of 2010, vulnerable villages became networked by hand-held walkie-talkies that emit a signal broadcast from the observatories on the flanks. There are about sixty walkie-talkies on the western flank and more on the southern and eastern flanks. When the status of the volcano is normal, it is an unbroken buzz; when the status changes, and landslides or pyroclastic flows are a threat, the signal breaks into Morse code-like beeps. In villages, this signal choreographs the temporal rhythms of the villages, speeding it up in case of an eruption. People must prepare to leave, gather their things, locate

their children and bring them home, take care of the pets and animals. The shift changes the comportment of villagers and the way they are living their futures. But these futures are always connected to an authority that is sending the signals and in a network that gives the signals legitimacy.

In Keningar, the walkie-talkies were donated to households by a volunteer run aid agency after the eruption of 2010. By 2015, there was no internet infrastructure in the village and it could be unreliably accessed through cell phones. Cellular phone infrastructure was generally reliable and popular but cost money to send text messages. Suparno, Sukidi, Sugiyono, and their friends used pre-smart phone era phones and it was often only low-land friends that carried smart phones. The walkie-talkies provided a free means to communicate and had by 2015 been repurposed into a complex communications infrastructure between men in Kenningar and adjacent villages. They used them to plan meetings and social events, chat, and broadcast music. One evening, there was a shadow puppet theatre performance broadcast from one nearby village to everyone within the walkie-talkie network channel if they felt they wanted to tune in. Sometimes the walkie-talkie would be left in the background of a conversation playing music, or it could act as a portable radio brought into the fields during the day. Always, too, on channel 1, the signal of Merapi was permanently playing from the observatory. If there were plans to hike to the caldera or deep into the forest, the channel could be left on. Patrick Vanhoebrouck, who supplied the walkie-talkies to Keningar argued that they created an affect of consistency and comfort after the disruption of the 2010 eruption. The unbroken signal, that could always be turned to, created an affect of continuity through the intimacy of listening to the volcano.

Since the introduction of this signal to Keningar, a public has formed through it and become part of the signal. The signal references both the status of the volcano and the co-presence of listeners. The signal is an affect that gathers subjects while subjects participate in the gathering and the production of the signal and its content. What *is*, the ontology of the signal, is complexly entangled with what is known, its epistemology, if in this sense the signal is the known. The signal of the volcano, is both infrastructure and technology, in conventional terms, it is woven through with subjective and interior affects while being a distributed, material infrastructure. Understanding forecasting then, needs to build analytical tools that can trace these entangled zones in which communities are forming around signals, infrastructures, and creating spaces in them to repurpose them. Signals are by nature fluid and mobile but the way that they have been conventionally considered has restricted our

understanding of them as information content within an infrastructure. The walkie-talkies on Merapi show us that signals can produce nested publics with a temporary quality.

This traces the relation between affect as a feeling for the future and the hardened, distributed, multi-scalar infrastructures that act as the mediums of that future. It is around them that publics emerge and are forged and constituted through the infrastructure of the signal. They in turn begin to make demands on the infrastructure, to push on its affordances in order to forge modes of subjectivity.

In this next section, I return to forecasting signals at a territorial scale before returning to the scale of publics, subjects, and bodies. I make this shift in scale in order to consider how signals of the future circulate and choreograph large scale networks with the future. I then argue that the politics of the signal can be understood through a logic of equivalence that situates unlike realities, entities, and actors on the same plane. In order to demonstrate this, I turn first to the case of Hong Kong, then again to Merapi and the radio by way of seismographs and waves.

Synchronizing Signals

Figure 2. Left, Hong Kong cyclone warning symbols. Right, symbol being hoisted at the Hong Kong Observatory.[91]

Consider Hong Kong, an archipelago, once British colonial outpost and entrepot in a typhoon zone. The territory is made of two major landforms, Hong Kong Island which is separated by a narrow straight from the Kowloon peninsula. It was chosen by the British as an ideal entrepot because of its proximity to mainland China but also because of the natural shelter from the open sea by Hong Kong Island and its tall, once volcanic peaks.[92]

Typhoons were nevertheless a danger to vessels arriving into the port or moored off the island, and the colonial government, under the direction of the Royal Society, formed a weather observatory in the late 19th century as a way to mitigate the threat.[93] The government built observation outposts along high points of the Kowloon peninsula and Hong Kong Island that fed information into the main observatory in Kowloon on what came to be called Signal Hill. Based on the design of the Greenwich observatory in London, the Hong Kong observatory was likewise built in view of the vessels in the port and sailors could reference the observatory when entering or leaving.[94] The observatory created a system of large

[91] Image on left from, author unknown, "Notes on the Displays in Exhibition Hall Royal Observatory", Circa 1958. Image on right, from author unknown, "History of the Tropical Cyclone Signal Stations in Hong Kong, 2018."
[92] See: Carroll, 2007.
[93] Region, 2018; Starbuck, 1951; MacKeown, 2010.
[94] Howse 1980; May and Thrift, 2001.

physical signs in basic geometric shapes (circle, triangle, and 'T') (*figure 2*) that were hoisted above the observatory and indicated the status of the weather to vessels in the harbour.[95]

They also sent weather reports to local newspapers for daily publication.[96] If a typhoon was imminent, flair like guns were used to draw attention to the signalling station where there was a hoisted symbol of hurricane force winds (*figure 2*).[97] This was combined with a time setting device that called out 1 pm everyday by dropping a large ball down a pole located on the building roof. The descent of the ball became the time standard for the territory to which chronometers and ships clocks were set.[98] This 1pm was synchronized with the dropping of the time ball in Greenwich (adjusted for time zone difference) which meant that time in the colony was appropriately synched with Greenwich Mean Time. Moreover, time was synched with space because the known, measured, distance from the meridian at Greenwich was used to establish the creation of the time zones, establish longitude, and distances on maps. The signal of the ball dropping was synchronized within this global formatting of time with space and maritime networks. The use of the flare gun to signal an oncoming typhoon operated within this already established infrastructure that made Signal Hill a physical, architectural, material, centre for the formatting of space and time. Even the landscape at Signal Hill was part of this material semiotics by becoming a hill that signalled within a territory that referenced the future through the shifting arrangements of visual and aural landscapes.[99] Through it, vessels could moor in anticipation of a coming storm or move on, the system managed and organised circulation throughout the territory in accordance with the exigencies of the future of nature.

In Foucault's terms, this is a form of governing the aleatory because at Signal Hill unpredictable nature was not something to try to stop, the observatory understood that typhoons were inevitable.[100] The problem was how to build signals that were appropriately legible and synched with other scaled infrastructures, to achieve "accuracy" in their forecasting, in order to minimize damage as much as possible. The goal was not to live without damage but to minimise it.[101] This was governance as a form of choreographing social and natural systems in which the link between them is the signal. The signal travels

[95] MacKeown, 2010.
[96] MacKeown, 2010.
[97] MacKeown, 2010.
[98] MacKeown, 2010. A similar device was used at Greenwich, a red ball on a poll visible from the docks below.
[99] On material semiotics and the legacy of Charles S. Pierce, see: Kohn 2013; Law, "Actor Network Theory and Material Semiotics", 2008.
[100] Foucault, 2007.
[101] Foucault, 2007.

from nature to society in a constant open feedback so that society can adjust and arrange itself to accord with nature. This becomes the consuming logic of modern forecasting and a distinct form of infrastructural governance because it operates through the management of the signal and the synching of infrastructures. The labour of standardizing these infrastructures, the creation of forms of universal measurement, the standard measures of space and time, all of this work is the work of this modern form of governing the signal.

This is to say that the model of society and nature at stake on Signal Hill is of the choreography of society while protecting the networks of movement carrying goods through the entrepot. As Foucault tells it, the emergence of the modern liberal state has been through this attention to the governance of circulation and the territory as a space of flows of goods, people, traffic, and nature.[102] What was key to this development was an aesthetic style that signalled in the landscape and that engineered traffic and water was the work of the state, and that the management of circulation was its power.[103] Engineered systems became the materialisation of the state around the uncertainty of the future, inscribing its capacities to manage the aleatory into topography.

In Hong Kong, this attitude to the governing the signal resulted in the choreography of the harbour within the flows of goods and people between Beijing, Shanghai, Singapore, Britain, and elsewhere.[104] The institution of weather forecasting wove through these long distance networks and mountainous geography, and made the future of nature legible within the conditions of an entrepot where vessels are shifting cargo between ships, and from one scale of ship to another. The signal orchestrated between this and the production of a physical space that was *in advance of the present*.[105] Signal Hill didn't show the power of the state to control nature, but the power to be in advance of it. This is a politics of nature as sign and infrastructure, media and medium.

From this scale, however, we have again lost sight of the formation of publics and subjects. From the scale of the choreography of regions it could suggest that subjects are mere puppets in a global process. There is however much more indeterminacy to the signal. This is the significance of attending to practices because they operate in a zone in-between top down power and bottom up indeterminacy. What I turn to next is back to the radio signal to show this particular indeterminacy of the signal in practice. I do this to foreground again

[102] Foucault, 2007.
[103] Picon, 1992.
[104] Abbas, 1997.
[105] Beck, 1992.

the particular dimensions of the politics of the signal as emerging between the universalising tendencies of standardisation and the creativity of practices through the formation of publics and counter-publics to redistribute the meaning of signals.

Ground Signals

Consider, then, a seismograph. Conventionally, they are deployed in tectonically active regions, can be used for oil and gas prospecting, recording earthquakes from tectonic movements or resulting from the movement of magma through the ground. On Merapi, there are roughly fifteen seismometers positioned in strategic locations across an area of more than one hundred-sixty square-kilometres.[106] Their recordings are of the movements of a wave through the earth, and geophysicists and volcano scientists often refer to earth's crust as a "medium" and "media".[107] The shape of the wave that is recorded on the seismogram indicates the intensity, duration, and distance of the wave as it travelled through the medium (*figure 3*). Like the flare guns fired and the shapes hoisted on Signal Hill, the seismogram is an amplifier of what is at a distance in the sense that the abstract shapes and flares register and make legible a typhoon in the distance. One of the differences is that the seismogram senses the passage of the seismic wave through the machines sensors and amplifies it so that humans can read with clarity what they could barely feel or felt too quickly. A tremor is transformed into a static image that can be consulted repeatedly and analysed. It also allows for the conjecture of where the wave originated in space, whereas a typhoon signal does not carry spatial information. One other difference, and a crucial one, is that the wave is a sign of itself. This means that its form on the seismogram is a reference to the form in the ground.

Like the signal station on Signal Hill, the seismograph is a territory producing machine that makes present the ground as a communicating, media space. This territory is signal rich, a space in which earthquakes are like flickers of Morse code, and the work of the forecaster is to decode the point source of the flicker. This happens at the site of the machine in the observatory, and makes sensible the presence and reality of this hidden depth tens, hundreds, or even thousands of kilometres away. The depth of the earth is made sensible and visceral on the page or monitor, it becomes a thing that can be touched and held and pointed to.

[106] There are also tilt meters, eight CCTV, five fixed DSLR, two Minidoas, One Multi-gas meter, twenty-four landslide monitoring posts, rain gauges and geophones. See: Santoso, 2016; Nandaka, 2015.
[107] There is an existing, robust literature on the notion of the earth as medium within the history of geology. For a recent treatment see: Daston, 2017.

On Merapi, there is a network of six larger observatories with seismograph signal receivers. Most active volcanoes in proximity to dense populations in Indonesia have one or more observatories with networks of seismograms and because of this, the simple seismogram is assembled within architectures that house the machine, technicians that tend it, fix it, and take readings from it. These buildings have a visibility in the landscape for people who live in the villages beside them and a presence that creates assemblages of people, expertise, territories and representations. The seismograph *gathers* these different elements through its networking as it makes observation and forecasting visible within the villages around the observatories.[108] It also brings into being, makes visible and sensible the interior of the volcano as a wave through the seismograph network.[109] The observatories then, in this way, are territorial machines producing the hidden, distant interior of the volcano in a waveform.[110]

For technicians and volcano scientists, the ground is a signal emitting field. The seismogram reads and inscribes those signals and from them, technicians and scientists decipher what the signal is referring to. Volcano scientists read seismograms in order to determine whether or not a wave has come from inside a volcano or a tectonic source. If it is coming from inside a volcano then it could suggest that an eruption is on the way. The labour of the technician and volcano scientist then is to decode the source of the wave and notify the network of observatories. In the case of an emerging eruption on Merapi, if a seismogram result is combined with other observations such as ground deformation and gas emission studies and demonstrates that magma is moving through the "chamber" of the volcano, this translates into a shift in the official "status" of the volcano. This is the formalised, public alert system that ranges from "Active" (the norm), through "On-Guard", "Prepare" and the highest level of alert "Beware", which are then broadcast from the observatory through public channels such as the walkie-talkie networks and with each increase in the level of "activity" public institutions such as schools, hospitals, the police, and fire services, choreograph their labour to fit the requirements of each level, such as closing schools, preparing evacuation vehicles, and blocking off neighbourhoods. Again, we have returned to tracing the signal as it moves through translations and choreographies and that there is labour in each of the instances of translation that transforms the medium of the signal and how it is distributed.

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[108] Heidegger, "Building, Dwelling, Thinking," 2011.
[109] Heidegger, "Building, Dwelling, Thinking," 2011.
[110] On the technical production of depth and the underground, see: Barry, 2016; Barry, "Materialist Politics: Metallurgy," 2010.

The aim of this chapter has been to locate the politics of the signal as it traverses these scales of large infrastructures and standards and the scales of the body, publics, and subjects. In doing so, we could locate those in the trajectory from seismograph machine to the evacuation in a crisis time. I want to return to the form of the wave in order to tease out the politics of the signal because it is in the capacity of the form of the signal itself that there is a unique labour of creating publics and subjects.

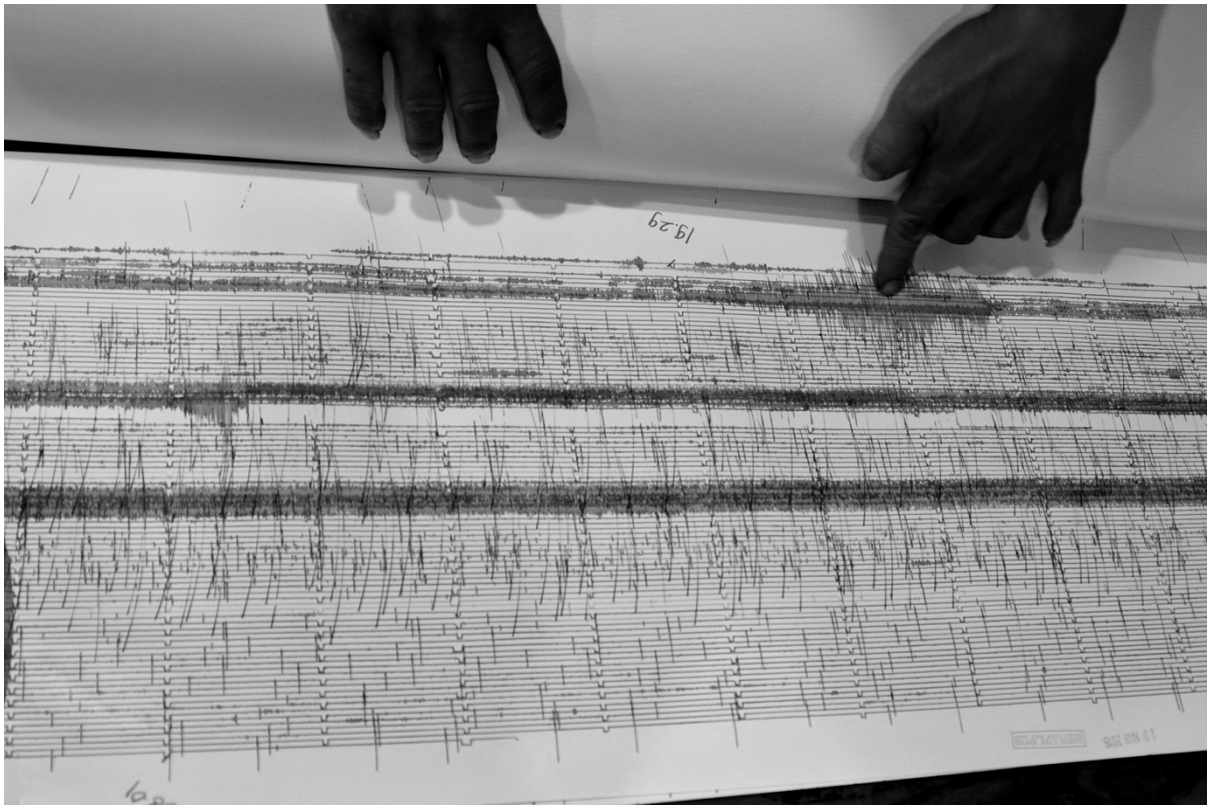

Figure 3. Mt. Merapi Seismogram, 2016. Image by the author.

The Logic of Equivalence: The Earth is a Wave

"Nothing is, by itself, either reducible or irreducible to anything else."

-Bruno Latour[111]

The notion that the earth is a medium for waves was not a discovery of geologists or geophysicists and it did not emerge with the first seismograms. The earliest seismographs were based on pendulums and the movement of the earth was registered in circles, loops, and squiggles on a stationary medium (paper or glass in some cases).[112] The wave, instead, came

[111] B. Latour, *The Pasteurization of France,* 1988, p. 168.
[112] Milne, 1886, pp. 12-40

to prominence in late 19th century experiments in electromagnetism as an understanding of the form of electrical currents. The wave form emerged as a key player in the transition from classical mechanics to quantum mechanics at the turn of the century upending classical modes of understanding matter.[113] This "revolution", in Kuhn's terms, spread across scientific disciplines and the wave form was a shared mode of representation across scientific practices and techniques. As Kuhn writes, "during revolutions scientists see new and different things when looking with familiar instruments in places they have looked before."[114] The waveform was sufficiently plastic to capture a diversity of phenomena and which, in turn, allowed those phenomena to be put into new relationships of equivalence. Physicians, seismologists, radio engineers, all spoke in terms of, and came to see the world, made up of waves. They built instruments that represented matter, from electrons to heartbeats as waves. Electricity, so argued Maxwell, was a wave, and so was light.[115] It was an elementary form that was expressed across domains of reality, across different types of bodies, human and non-human which meant too that different disciplinary practices of science could share the wave as a signal form and it could be invested and explicated with multiple meanings.

In 1900, Dutch physician Willem Einthoven developed the Electrical Cardiogram as one of the first mechanisms to create a representation of the heartbeat as a wave pulse (*figure 5*).[116] To do so, he submerged the limbs of a patient into buckets of water, which carried the vibrations of the heart through the surface of the skin and through the water. These were carried through very thin, quartz coated wire in the water into a giant electromagnet. The wire passed between the centre of two magnets that kept the string vibrating in a regular motion. When a heartbeat displaced water, that displacement would be translated into a displacement of the movement of the wire. Behind the string was a bulb that projected, like a film projector, the shadow of the string onto a photographic plate. A photograph of the shadow was taken at regular intervals, creating a series of snapshots of its movements. Afterwards, they were recombined into a linear, temporal portrait of the movements of the string which showed the heartbeat as a wave of ups and downs.

The String Galvanometer, as Einthoven had originally called it, brought together the wave form with the interior of the body. The body was a pulsing, signalling entity, animated by the dynamic wave structure that it was housed in. But he also integrated time into the

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[113] Kuhn, *Structure of Scientific Revolutions,* 1996.
[114] Kuhn, *Structure of Scientific Revolutions*, 1996, p. 111.
[115] Maxwell, 1982.
[116] On the String Galvanometer and the Electrocardiogram in Fish, 2000; Einthoven, 1925; See also the emergence of the "brain wave" in Jane Stafford, 1935.

representation of movement, drawing on techniques in motion picture technology at the time. Because of this, the wave could be seen in time, and its variations recorded. The Electrical Cardiogram in "discovering" the electrical wave pulses of the body, amplified them, made them more easily sensible, physically larger, inscribed on paper that could be held, shared, stored, and reproduced. This is the meaning at the heart of Kuhn's comment above about scientific revolutions, the body could be seen as a pulsing electrical signal, buoyed in an ocean of currents and projecting currents outwards.

Einthoven's work on wave signals translated directly to work into volcano monitoring and signalling on Merapi through his son, Willem Jr., a radio engineer who participated in the earliest developments of radio technology in the Dutch East Indies.[117] There, he collaborated with the prominent volcano scientist Reinout Van Bemmelen in developing his father's electromagnets for seismographs so that the machines could have greater sensitivity and their sensors could be placed at a greater distance from the recording mechanism.[118] In this way, they could be closer to the epicentre of seismic action on the volcano without endangering the instrument's main, fragile and expensive, body.[119] No doubt, the wave form predated the collaboration between Van Bemmelen and Einthoven's son, but the point is that the movement and distribution of techniques increasingly exposed the world to be structured by waves, and for waves to proliferate as signals. There was a shared conception of the wave as signal emitted into the world that circulated between medicine, radio technology, and volcano science. There emerged at this moment, across these divergent practices, an idea that the interior of the body has the same signal as the interior of the earth, that a radio is a device that broadcasts waves just as the heart broadcasts beats and an earthquake broadcasts trembles.[120]

An advertisement from an oil and gas company trade magazine from 1954 makes this clear (*figure 4*). It commemorates the work of Eindhoven with a paragraph about the

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[117] Fish, 2000.

[118] Van Bemmelen describes his collaboration with Eithoven Jr. thus: "In order to use also these short waves for the volcano observation the author and Einthoven devised a very sensitive electromagnetical seismograph with a heavy electromagnet as stable bob suspended on two hinges, and a moving coil connected to the frame and basement. The induction current in the coil passed via an amplifier to the receiver and an alarm system (bell and red light)."

The instrument was built under the supervision of Einthoven in the radio laboratory at Bandung and mounted in May 1943 in the concrete observation tunnel of the Babadan post. Owing to the decreasing activity of the volcano at that time no satisfactory correlation tests could be made. The limited experiences with this instrument, however, strengthened the opinion that sound vibrations (such as those caused by the friction of rock-faces grazing each other during the activity of the rising magma, the rumbling of escaping gases, the clinking of rock slides, the roar of avalanches the resonance tones of the lava dome, varying with its mass) may be used as valuable additional means of controls of an eruption." Bemmelen, 1949, p. 267

[119] Van Bemmelen, 1949, *Geology of Indonesia vol.1.*

[120] See: Deborah Coen, 2013, on Earthquakes languages and sensations; also, Clancey 2006.

electrical cardiograph and depiction of heartbeat-like waves. The caption reads: "The earth has *heartbeats,* too!" Below, it is written that:

> "Dr. Eindhoven was the father of the modern electrocardiograph, which has been of great benefit to mankind. The seismograph, which records accurate graphs of the earth's heartbeats, has also been beneficial to mankind in its contribution to the development of the oil industry."

Dr. William Einthoven, a Hollander, became interested in Ader's instrument, a simple galvanometer for recording submarine signals, in 1897. Einthoven made an instrument more sensitive than Ader's and by using three leads attached to two arms and a leg of a man, he was able to obtain a graph which represented an accurate curve of the heartbeat. Modern electrocardiography is based on this method. Einthoven won the Nobel prize in medicine in 1926 for this great achievement.

The earth has *heartbeats,* too!

Dr. Einthoven was the father of the modern electrocardiograph, which has been of great benefit to mankind. The seismograph, which records accurate graphs of the earth's heartbeats, has also been beneficial to mankind in its contribution to the development of the oil industry.

We, at Robert H. Ray Company, have been recording the earth's heartbeats or seismic reflections for 20 years now and believe that this vast experience makes us able diagnosticians. We strive to achieve the ultimate in exploratory results through the use of the most competent personnel, the most advanced equipment, and the most approved interpretive methods.

The company you employ for geophysical services is of vital importance to you . . . may one of our representatives give you the facts about the Robert H. Ray Company?

ROBERT H. RAY COMPANY

2500 Bolsover Road • Houston 5, Texas

APRIL 19, 1954 175

Figure 4. William Einthoven, depicted in Robert H. Ray Company, an oil prospecting company.[121]

When I visited the geophysicist Jean-Philippe Metaxian in 2016 in the main volcano observatory in Bandung, Indonesia, he introduced me to the fundamentals of reading seismograms. On a large computer monitor on his desk, he showed me sample seismograms recently taken from Merapi and explained that a seismologist needs to be able to identify which waves are produced by volcanic earthquakes. Ocean waves crashing on the beach

[121] Seller.

propagate through land, he said, and can be registered by seismometers. So too can rainfall, landslides, or people walking close to the machine. “Everything makes a wave,” he said, and part of a seismologists work is to be able to “pick” the wave, to identify between what is the signal and what is the noise.

This is an ontology of nature as a broadcasting signal, and as John Durham Peters has argued about broadcasting, it is unidirectional, a broadcast can be heard but not responded to meaningfully, it is not a conversation.[122] It is at this level of the one way broadcast that we can begin to discern the politics of the signal as a project that cuts across technologies and infrastructures, domains of objects and bodies to make new equivalences between them. It is at this scale of equivalence making that the politics of the signal is sensible. That is where there is a struggle over what is equivalent, what is made equal to what, who gets to participate in making signals, and what and who is excluded from participating. It is this contested and conflicted zone that I would like to foreground and conclude with here.

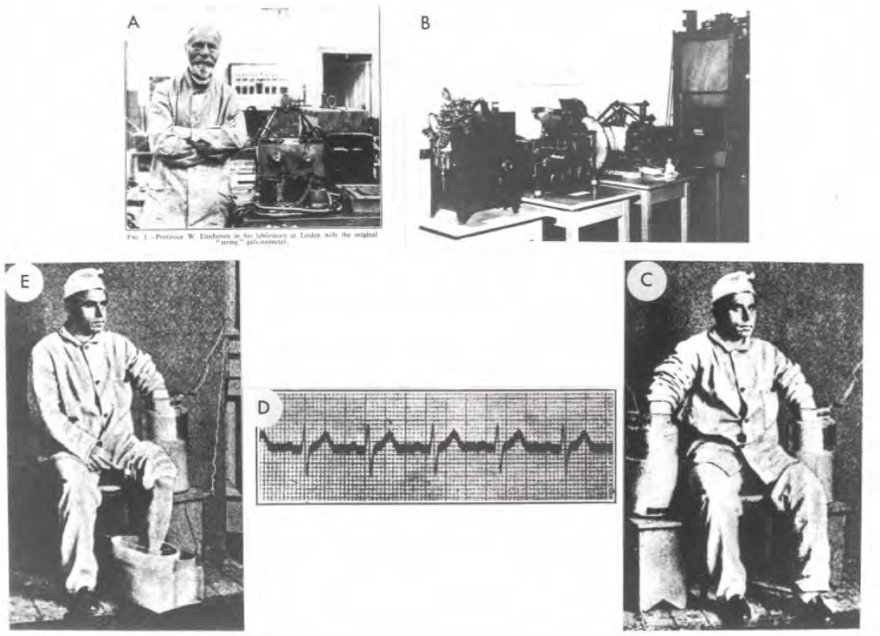

Figure 5. Einthoven’s string galvanometer, Fisch, Centennial of the String Galvanometer.[123]

Santoso

In March, 2016, I was in Suparno’s sitting room in the evening as he began to show me his collection of rings with polished stones and crystals fixed to them. He keeps them in a black crushed velvet pouch which during the day he stashes in a cabinet in the sitting room with other valuables and memorabilia. On one of those shelves is a trophy with gold lettering

[122] See: Peters, *Speaking into the air: a history of the idea of communication*, 2000.
[123] Fish, 2000.

from the regional government and the head of the village, Agus Sumarno, addressed to Suparno in 2010 for "Irrigation Development of the Senowo River, 2009". There was also a ceramic water jug and vase, and a gold plastic sports trophy, an old condensed milk can was repurposed to hold pens and pencils, and beside it were chargers for walkie-talkie batteries, disused walkie-talkies, and cables. The walkie-talkies, used for the purposes I described above, were given a value in this cabinet commensurate with family heirlooms and trophies from the village head, and the rings. This, I think, is because they are also broadcasting devices, and as we will learn, Suparno, in learning to become a shaman and undergoing training in how to decipher broadcast signals and create his own.

Suparno emptied the bag of rings onto the table and some of the stones had not yet been fixed to their silver bands. He spends leisure time sanding down their edges so they fit. The stones had different patterns, some were milky white and smooth, one was black, and small, with a matte finish, they were jade, quartz, and agate. His jade came from Borneo and cost IDR 200,000 (approximately £13). Each stone contains a different property and capacity to affect the health of the wearer, but he remains reticent to explain them to me. He said in a hushed tone, as he flipped through the stones and rings bringing them up to my eye to for a closer look at their patterns, that they have healed common colds and brought luck. As he often did when discussing matters of power, energy, and shamanism, he spoke in a hushed, secretive tone. He sometimes gave the rings as gifts and had rings given to him.

That night, he told me, we were going to meet Santoso who lives in an adjacent village down the flanks and Suparno was in the process of learning how to become a shaman and magician from him. He described to me that Santoso had him tame a scorpion with his hand one night in the paddy fields, that he is often fasting and meditating in the fields, that he has conducted rituals with live chickens. Santoso, Suparno said, used to be an undercover agent for the military in Aceh, west Sumatra, a troubled region that in the Suharto period experienced independence struggles and that it was under those conditions that he gained his powers of vision and foretelling. After he gave it up he moved to the flanks of Merapi and set up shop as a fortune teller, teacher and cobbler.

We moved on from the rings and stones and set off for Santoso's house about four kilometres down the flanks. In the evenings, his sitting room became a consultation room for men who would drop by to consult with him about pressing issues, such as marital troubles, money issues, or difficulty with the kids. Suparno was a regular visitor, along with one of his cousins who worked in the sand mines in the rivers as a heavy machinery operator.

Santoso, who also wore a ring with a large, dark orange stone in it, explained that everything had a frequency. Volcanoes, people, animals, everything emitted waves, he said. "It's just like the radio, you know, the waves are everywhere. And what do you do with a radio? You tune in. It is about matching frequencies"

"Energy comes from the heart (*jantung*), heart energy, that means *feeling*." We are in frequencies like water in water. He went on to explain that when we communicate, we don't send messages out to receivers, we match frequencies. That means that we don't send things out to receivers only but that they send out receivers to us. When we go searching to communicate and know, the things we know and communicate with are also searching us.

He told me that he knew Suparno and I were going to come by that evening without Suparno having to tell him anything. He always knew when Suparno was coming, because their frequencies were matched and a phone was unnecessary between them because the ontology of the world was already a phone and we were already communicating waves. He told me that he often communicated with people in distant provinces and that he could see them.

"Put your hand out and close your eyes", he asked then instructed me to breathe deeply. When I had my hands out, he asked if I could feel anything different. "No," I replied. After a number of failed attempts to demonstrate what frequencies are to me, they were exasperated and gave up. "You are not ready, not sensitive enough to feel the shift in energy. You need to be ready, exercise, shift the way you see things, first."

Suparno was taking this training and applying it in his fields. He was using it to communicate with rats that had been stealing his rice but it was about the acquisition, display, and sharing of strength and fortitude through fasting, encounters with scorpions, spending the night outdoors sitting in a rice field, and the deployment of energies held in stones. The capacity to "tune-in" to the frequencies of objects and others was central to this, to be able to understand the form of entities as communication and that everything was a different arrangement of frequencies. This monism allows for there to be a fundamental, ontological, translatability between entities because they are made of the same stuff, and communication between them can be based on the recognition of this shared condition.

Suparno was learning from a man who argued that communication was about tuning into different frequencies, while at home his walkie-talkie charged in the cabinet, as Merapi signalled in a monotone that it was still active. Beside it, his bag of stones emitted signals of power, health, or disease. They are all signalling devices. Santoso argues that the ontology of

the world is a wave in a place where the interior of the volcano that they live on is a wave and where the future of the volcano is deduced from reading those waves.

It may be appealing to understand Santoso and Suparno's ontology as metaphors for a world that remains obdurately hidden. That they have taken the scientific language of waves and applied them to dimensions of emotions, social power, friendship, and nature. Instead of this though, I want to argue that this is the politics of the signal, that this process of translating the world to a single form is a property of technology and infrastructure development that are beyond the capacities of authors to control. It is through the wave that Suparno and Santoso appropriate and transform the media infrastructures of the volcano. The wave of the seismograph and the radio signal becomes a way for them to rearticulate and participate in the production of their own publics in the sitting room of Santoso's house. This, I want to put forward here, is a property of the indiscernibility of the edges of nature, media, infrastructure, and technologies in practice. A zone at which it becomes impossible to impose a hard edge between them, and at which the contested, and multiplying politics of the signal emerges.

The method of tracing the emergence of these politics at these different scales that I have undertaken here has had to traverse these circuits in order foreground these politics, to demonstrate how signals at the scale of territories come to be entangled with notions of subjecthood, of the very mechanisms through which entities communicate with each other. In this tracing we can understand that technologies are not deterministic in a single direction, nor are they simply bottom-up but that there is a coproduction of signal and subject, nature and infrastructure.

The reason that this tracing is significant in understanding the techniques of forecasting cultures is that in order the understand the future it needs to be legible through a signal. Particular cultural formations create technologies and infrastructures to make those signals legible and those are distributed in space and formed of materials. Those signals, spatially, materially, and temporally, however, are liable to an indiscernibility that transforms their meaning. They undergo processes of equivalence that expand their resonance, shift epistemologies and create new forms of publics and subjects. Rather than forecasting cultures being about simply observing the future and reporting on its status, the very source of the future, the signals that light up and draw our attention to change in the present, are in an unstable and unpredictable zone of political negotiation.

What this alternative cartography of the signal opens up is another way to diagram the operations of cultures of forecasting. As I have shown here, the political territory of

forecasting is in the process of standardizing infrastructures, it is in the material, scientific, technological practices of making things equivalent. This process creates conditions for publics to emerge and make claims about how new forms of belonging are emerging. The politics of forecasting are also taking place in the synchronisation of technologies and infrastructures, of making standards that allow for networks of machines and infrastructures to connect across scales. The politics of forecasting the future is in this process which would conventionally be considered a technical operation because of the zones at which it begins to produce conditions for new kinds of subjects and publics to emerge.

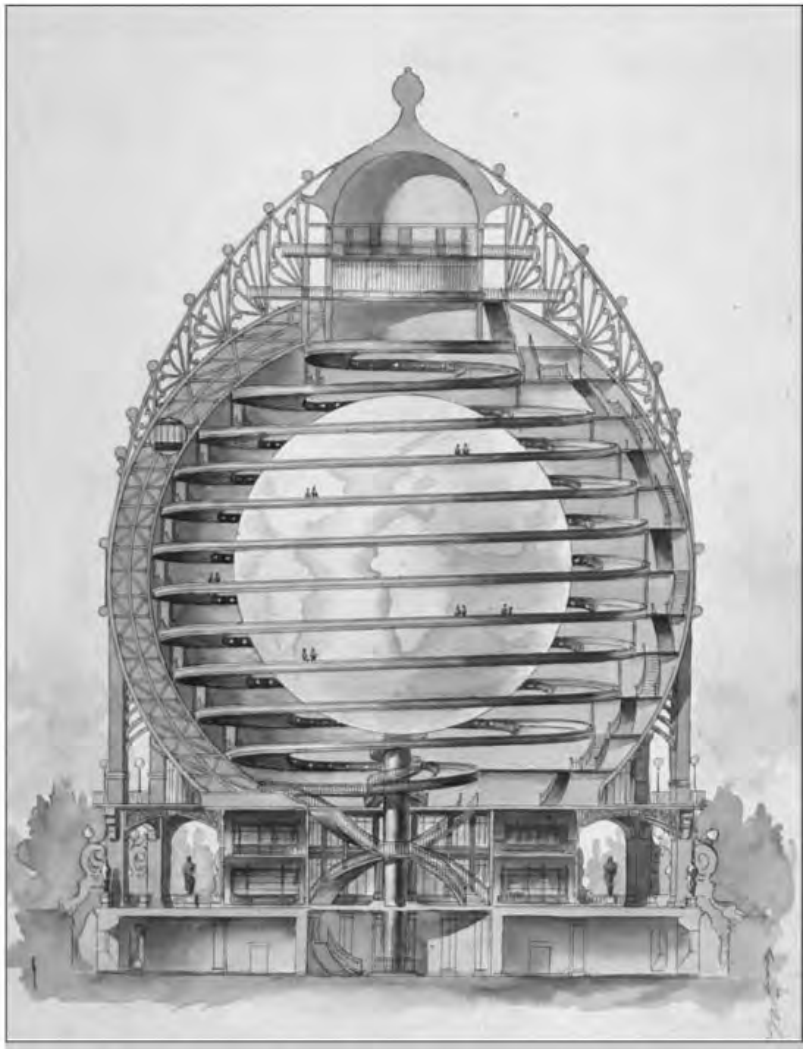

Figure 1. Élisée Reclus' unbuilt design for a "Terrestrial Globe" at the Paris Universal Exhibition of 1900, drawn by Louis Bonnier.[124]

[124] See: Alavoine-Muller, 2003.

Chapter 4

Building the Frame: Totality, Nature, and Ritual in Modernist Forecasting

As from his small window
The astronaut sees all he has sprung from,
The risen, aqueous, singular, lucent O
Like a magnified and buoyant ovum.
-Seamus Heaney, *Alphabets*[125]

From Signal to Frame

The previous chapter argued that the politics of nature forecasting is in synchronising between infrastructures, publics, and subjects. One of the effects of this process is the creation of territories and regions based on imaginaries of unity and consistency. Places come to be understood as unified and whole, and as these processes towards totality and unity of territory, there are also processes of subjectivization and the formation of publics. Synchronization creates new and unique conditions for the emergence of subjectivities to adopt and transform those infrastructures, the publics they engage, and their meaning. They create unique conditions for the formation of subjects and because of this, we can understand that infrastructure, technology, and subjectivity are interconnected (*figure 2*). The politics of the signal, I tried to demonstrate, was in its plasticity, the site at which it could be modified, in its repurposing, bending and transformation through the formation of unanticipated publics, and that as much as modern governance is oriented around creating legible signals of unpredictable nature, making them readable, creating infrastructures to distribute them, and dedicating them to preserving flows of objects within territories, signals are being re-appropriated, bent, and deployed to create counter-publics and subjects. The reason to attend to these processes is to understand the evolution of signals of the future in the present, their networks, and publics. There is a tendency within conventional forecasting literature to imagine that infrastructure provisioning is in one direction, from science, experts, authorities

[125] Heaney, 1990, *New Selected Poems*, p. 213.

or the state, to the public, and that signals of the future of nature are immediately transparent to those publics. But it is in processes of standardization that politics is operating. It is in them that standardization is a formation of publics and subjects – a who is brought into being.

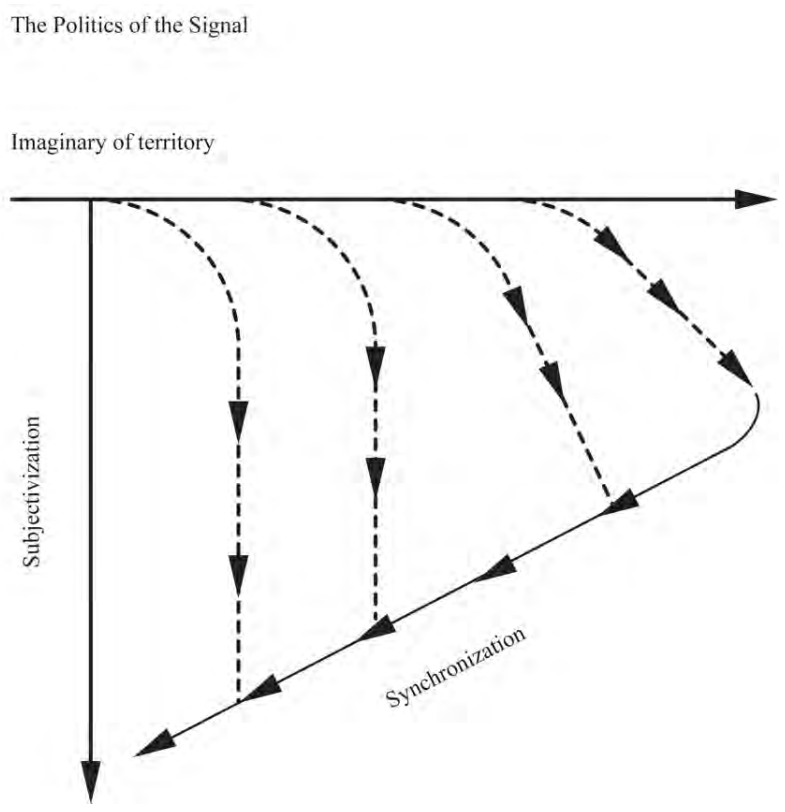

Figure 2. The politics of the signal.

Planetary Scaffolding

This chapter adds another dimension to the labour of synchronization. It turns to the quest of modern forecasting to create a totalising vision of nature and Earth. I argue in this chapter that modern nature forecasting has participated in a project of controlling nature by trying to be in advance of it, to anticipate it by creating an imaginary of a total, unified Globe that could be understood from outside and at a distance. Modernist nature forecasting has been part of a Western dream to collapse the particular into the universal, the abstract and concrete, the local with the global, so as to synchronise society and nature. This builds on the processes of synchronization I described in the previous chapter by showing how, what I call here rituals of integration, enact the dream of synchronisation, of fusing the local and global, the lived space of the earth with the abstractions of natural law. Forecasting is the modern

science that performs these rituals and they are the modern rituals in which the volatility and unpredictability of nature is made to be part of a total process that is otherwise elusive.

The modern quest to describe a total and universal nature is encapsulated in the geographer Élisée Reclus' unbuilt proposal for a dome at the World Exhibition in Paris in 1900 (*figure 1*). The proposal is described thus in the *San Francisco Call* newspaper from 1898:

> "The idea originated with the celebrated geographer and savant, M. Elisee Reclus… The plan of the structure was worked out by M. Louis Bonnier, on the board of consulting engineers of the exposition. The globe itself will be made of sheet metal with a diameter of 26 meters…, and will stand on a cylindrical colum [*sic*] of steel about ninety feet in height. The whole affair will be enclosed in an egg-shaped metallic covering as shown in vertical section in the accompanying cut, whose top will be 250 feet above the ground, with two flanking towers some seventy feet higher still. Underneath the structure and below the level of the ground will be placed the machinery for operating the affair.
>
> By means of a spiral staircase of gentle ascent one can pass over every degree of latitude and longitude of the earth's surface and study the features thereof in minute and connected detail.
>
> The relief feature will be shown on a well-chosen exaggerated scale as in the true proportion. The Himalaya Mountains, five miles above the sea level, would rise on the globe but one-sixteen of an inch in height. As far as possible everything will be given in natural colors. The icy covering of the poles, white; the waters, blue, black, yellow and green, as the case may be; and the lands green, gray, black, etc., according to the prevailing general character of the different countries.
>
> The inside surface of the envelope will be covered with historical writings and pictures illustrating the evolution of the human race, and the peculiar features of life, manners and customs of the different lands. Cafes, reading and sitting rooms will have convenient and pleasant locations in the upper part of the main edifice."[126]

Reclus' vision was not alone but belonged to a modernist project of Earth building that included panoramas, dioramas, hot-air balloon flight and other technologies of the overall view. His proposal, however, is worth considering in some detail for the clarity of its conception of a total Earth. What was crucial in this vision was the function of infrastructure

[126] Huge Terrestrial Globe for the Great Paris Exposition, 1898.

as the framework that positioned viewers bodies and viewpoints onto the globe. Visitors bodies, as they ascended the ramp, occupied the outer space of the cosmos and the ramp was conceived as a celestial infrastructure rendered in steel and ornamented with the slender organic forms favoured in the Art Nouveau and Beaux-arts style that were popular at the moment and had also adorned the infrastructures of the French state such as dams and bridges.[127] The ramp referenced these national infrastructural styles and projected them into the cosmos outside of the globe and enabling the view onto the entirety of the planet. The position of the viewer is also significant in this regard because the scale of the dome meant that the scale of the visitor's body would dwarf that of the Himalayas, and areas as vast as oceans could be traversed in a few minutes. This is an experience of spatial compression as an experience of consuming the world as a totality, an entirety that can be "taken in". Reclus' modernist vision went further than this by suggesting that the globe itself is an infrastructure that can take in all of nature as it put the viewer back into nature. It gave subjects a sense of their origin and where they were as they circled it, they could get outside so as to go deeper back inside.[128] The rendering in *figure 1*, (Reclus went through multiple iterations) suggests that he had in mind that visitors would be able to prospect their surroundings from the top of the dome where the cafes and reading rooms were planned. This means that there was a planned visual relation between the interior experience of totality within the enclosure of the dome and an external experience within the horizon. To arrive at the top of the globe meant to then be positioned outside and within the horizon of the fairground space outdoors, and to leave that meant descending back down into the universal space of the dome. The ramp infrastructure enacts this transition from totality to the enclosure of the horizon and back to totality again; from the capacity to take it all in to being situated within the partiality of the horizon.

Reclus's understanding of totality was of an infrastructure of vision through which the whole of nature could be witnessed. Patrick Geddes recounted that this vision should "be kept continually up to date, and thus form the permanent, yet ever-progressive record of geographic exploration and survey…the microcosm of the macrocosm".[129] Not only was there to be text and images on the interior of the dome but he also envisioned replaceable panels that could be adjusted to accord with change in the real world. The adjustment of the model would position the viewer as the witness of change from the outside, able to take a

[127] Picon, 1992.
[128] See: Cosgrove, *Apollo's Eye: A Cartographic Genealogy of the Earth in the Western Imagination*, 2003.
[129] Sian Reynolds, *Paris-Edinburgh: Cultural Connections in the Belle Époque*, 2007, p. 124.

view from outer space that would otherwise be unavailable. The mastery of space became also the mastery of time; it was futural, in advance, by living at the vanguard of evolutionary processes. Recluse' dome was the infrastructure of progress and progress as infrastructure, to be witness to the system that one was inside of.

This modernist vision of nature was applied to the volatility, violence, and unpredictability of nature. It sought to create total, disembodied views of nature but in order to anticipate its transformations. The great infrastructural project of mapping the globe, building observatories distributed throughout it, and networking observations, was a part of this too, as it would allow the unpredictability to be located, the patterns of turbulence known and predicted in advance and in doing so, society could be choreographed with it and sheltered from its shocks.

The sciences of nature forecasting have negotiated the totality of nature and its unpredictability by developing what I describe here as rituals of integration. I demonstrate here how these modernist rituals are enacted to overcome the paradoxes inherent in the idea that nature is a totality. These rituals take place in between the static globe and change[130] by situating subjects, societies, and regions within the imagined space of the globe. They seek to unify through ritual practice the modern idea of transcendent nature with its changes and uncertainty. Rituals of integration compel their witnesses to participate in the totality of nature through its miniaturization in the model. They enact integration as a form of modern magic that puts us in the model and that nature would conform to the model at 1:1 scale. Latour describes this as the Double Click, the capacity to effortlessly zoom across distances and scales without any friction while all the mechanisms that accomplish the work are hidden in the background.[131]

In this chapter, I describe this modernist vision of the totality of nature in more detail. I explain the role that forecasting has played in creating it and how rituals of integration are central to this vision. I argue that if we are to sufficiently understand the role of the nature forecaster today, it is imperative to understand how they perform rituals of integration between the unpredictability of nature and a global space and it is necessary to consider what, in the performance of these rituals, is included and excluded, how society is imagined, given

[130] Latour on the immutable mobile and processes of inscription, see: Latour, 1986; and *Science in Action: How to Follow Scientists and Engineers Through Society,* 1987; and, (B. Latour, *An inquiry into modes of existence : an anthropology of the Moderns*, 2013.
[131] Latour, *Modes of Existence,* 2013.

shape, and positioned within natural change. In this way we can better understand how it is that nature forecasting frames the unpredictability of nature and renders it sensible.

The Disembodied View

Lewis Richardson, the British weather forecaster, mathematician, and early pioneer of fractal mathematics, imagined, twenty years after Reclus proposal, a strict machine for anticipating the future of nature (*figure 3*). With an intensity of vision that mixed Recluse's Globe with Bentham's Panopticon, his proposal for a Forecast Factory articulated the ambitions of forecasting as a mediator between a stable global space and an unpredictable nature through a vast, networked infrastructure. His was a vision of industrial computation at the scale of the planet, in which mathematical functions are the infrastructure that transforms the enormity of incoming, global information into an output signal. It is a giant, inhabitable representation of the globe as a number processing machine. He wrote the following just before the advent of contemporary computers, so his use of 'computers' here refers to humans.

> "Imagine a large hall like a theatre, except that the circles and galleries go right round through the space usually occupied by the stage. The walls of this chamber are painted to form a map of the globe. The ceiling represents the north polar regions, England is in the gallery, the tropics in the upper circle, Australia on the dress circle and the Antarctic in the pit. A myriad [of] computers are at work upon the weather of the part of the map where each sits, but each computer attends only to one equation or part of an equation. The work of each region is coordinated by an official of higher rank. Numerous little "night signs" display the instantaneous values so that neighbouring computers can read them. Each number is thus displayed in three adjacent zones so as to maintain communication to the North and South on the map. From the floor of the pit a tall pillar rises to half the height of the hall. It carries a large pulpit on its top. In this sits the man in charge of the whole theatre; he is surrounded by several assistants and messengers. One of his duties is to maintain a uniform speed of progress in all parts of the globe. In this respect he is like the conductor of an orchestra in which the instruments are slide-rules and calculating machines. But instead of waving a baton he turns a beam of rosy light upon any region that is running ahead of the rest, and a beam of blue light upon those who are behindhand.

Four senior clerks in the central pulpit are collecting the future weather as fast as it is being computed, and dispatching it by pneumatic carrier to a quiet room. There it will be coded and telephoned to the radio transmitting station."[132]

The inputs would be information from field stations across the globe and processed in the giant computer/globe. The equations were, as Paul Edwards points out, the "program, i.e., an *algorithm* by which forecasting could be reduced to a mechanical series of operations on numerical data."[133] He goes on, "Richardson's striking metaphors of calculation as factory, theatre, church, and orchestra reach to the heart of computing as a coordinated human activity that harmonizes machines, equations, people, data, and communication systems in a frenetic ballet of numerical transformation."[134]

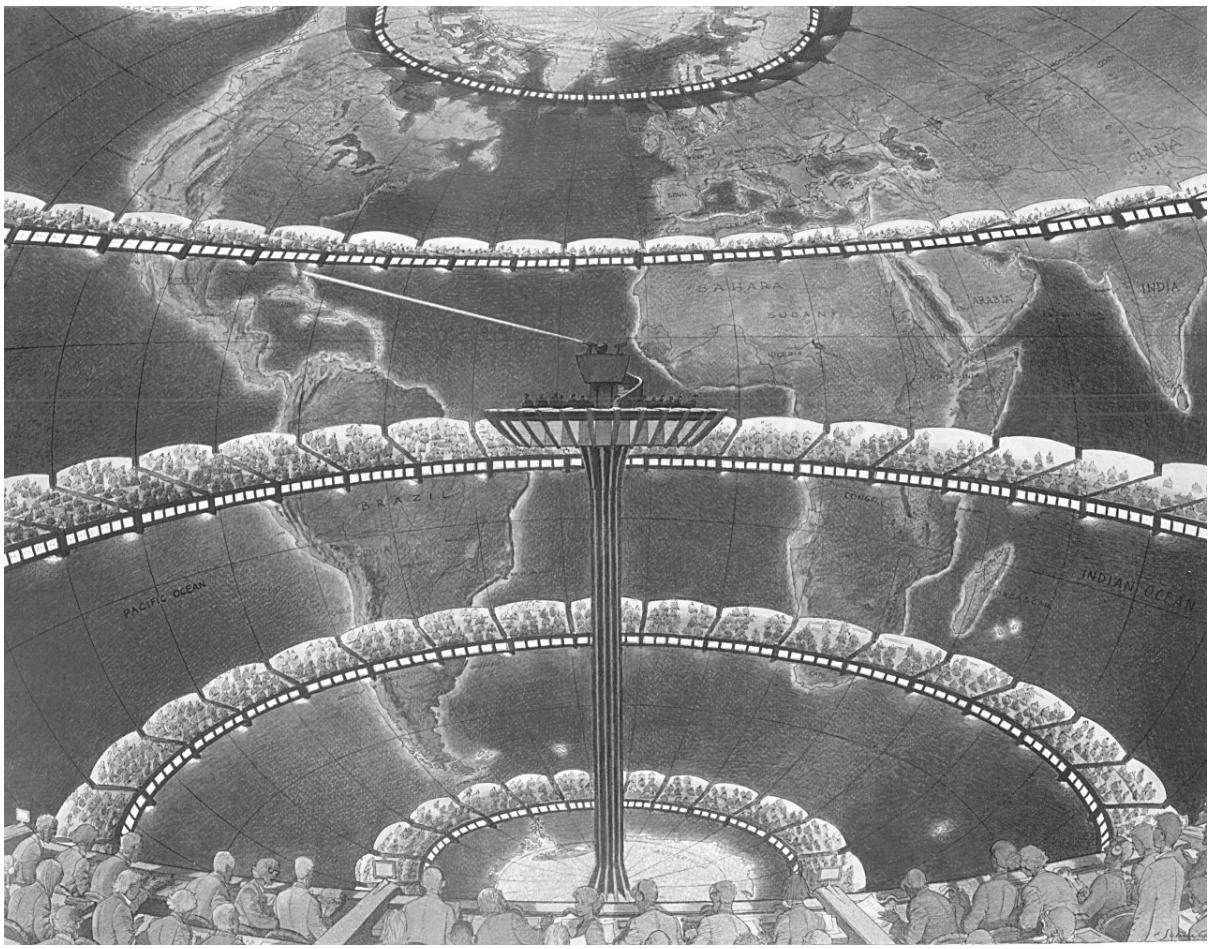

Figure 3. Francois Schuiten's depiction of Lewis Richardson's Forecast Factory.

[132] Richardson, 1922, p. 219; See also, Edwards, *Vast Machine,* 2010, pp. 94-95.
[133] Edwards, 2010, pp. 94-95.
[134] Edwards, 2010, p. 96.

What was essential to this vision was a whole, enclosed globe that contained a Cartesian grid space upon which all data could be plotted. That globe remained a stationary backdrop and container of weather's unpredictability, a vessel on which could be projected spatial and temporal co-ordinates. Like Recluse', this globe was projected in its entirety so that it could become the foundation against which change was understood. Making the future of nature legible in the present–that peculiar futurism of modernism, was at the same time the containment and containerisation of the globe and Earth as the stationary envelope against which the unpredictability of nature was plotted.

What was important in Richardson's vision, and why it represented an advance on Reclus' project, was that the factory was at the centre of a vast, distributed network of real-time information flow that was shaping society. In this sense, it expanded Reclus' vision by using the model to choreograph society rather than as a reflection of society to society. For Richardson, it was a factory of anticipation with tentacles flowing with information across real space faster than nature could change. Boats could dock, factories could prepare their production schedules, and offices could arrange their hours with the knowledge of oncoming change. Richardson's vision was that the model of the world could coordinate the world with it and understanding how the world worked in time would allow the real world to master the future.

The development of modern forecasting systems is based on these epistemological tensions: to be in the globe and susceptible to unpredictable nature while being able to be outside of it, to construct infrastructures that contain it within a single view, to anticipate and be in advance of its unpredictability while being in it. Modernist anticipation of the future of volatile nature then has to be understood in terms of a drive to get outside of it, to construct coordinate planes on to which it can be projected, to miniaturise it so as to predict it.

This project has relied on the construction of disembodied viewpoints, as James Secord has argued.[135] Modern scientists have consistently erased their own embodied presence in their representations of nature. Humboldt and Bonpland's famous depiction of Chimborazo in the Andes from 1839 is one classic example. Their team climbed over five-thousand meters above sea level to create a detailed cross section of the mountain. The drawing erased the interior of the mountain and filled it with written labels of flora in Latin and German, even though Humboldt and his team conducted the survey by placing themselves on the mountain and carrying cumbersome instruments along the way. This vision

[135] Secord n.d..

of objectivity, according to Secord has become the status quo in the earth sciences: the invisible viewer, the view from nowhere, and its transformation into immutable mobiles that erase the bodily labour of creating objectivity.[136] This erasure, as we will see in more detail later, sets the stage for the creation of rituals of integration which return the body to the production of scientific knowledge.

Globality

Globality is this tendency for disembodied totality and objectivity. It is being enveloped by a total nature that is shared by all of humanity, living on a spherical globe called Earth, within a nature that is interconnected.[137] John Law calls this a One-World World,[138] Latour, referring to Descartes' Euclidean spatial vocabulary, calls it the *res extensa*.[139] For both, it is the modern desire to find a natural foundation outside of culture. Philippe Descola calls this mononaturalism, the particular Western ontological framework which he captures in the formula: one nature, many cultures.[140] In this set-up, viewpoints are mere cultural perspectives and interpretations projected onto nature and the work of science, through the project of building objectivity, is to excavate from behind perspectives what is shared and common to all in nature. Anthropology and the social sciences are concerned with the multiple, cultural interpretations of nature, whereas the modern sciences of nature are preoccupied with the exposure of what objectively, and commonly, constitutes that nature.

The science of volatile nature forecasting has played a role in this modern project by contributing to the mapping that make the imaginary of a single unified, mononaturalist world possible. The creation of a One-World World has developed extensive, global networks that have consolidated an imaginary of a unified nature of interlocking systems and nature forecasting contributed to this development by providing instruments for monitoring weather, from barometers to satellite imaging systems, and the modelling software that handles complex, chaotic weather systems.[141]

The Blue Marble, the privileged locus of life in a dead universe, the shared ground and envelop of the human, is also Spaceship Earth, the enclosed vessel riding the open seas of the cosmos; it is the source of Earth Day, the moment of a humanity unified by a common

[136] Secord; Daston, 2007.
[137] Sloterdijk, 2005.
[138] Law, 2015.
[139] Latour, 2016.
[140] Descola, 2013.
[141] Edwards, 2004, 2010, on a computational planet and histories of climate modelling.

globe and marked in the calendrical cycle of the Christian Gregorian grid.[142] As Peter Sloterdijk reminds us, the sphere as human home has long characterised Western thought.[143] This One-World World is distributed in every school class room and was reinforced when the Apollo 17 shuttle snapped its photo from space, 'the Earth is indeed a Globe!'. From Hecataeus of Miletus' ancient depiction of a disk surrounded by water to Fra 'Mauro's spherical map of the world and planets in 1460; from Recluse in Paris to the Whole Earth Catalogue, Spaceship Earth has been celebrated as an ecumenical whole that would unite the diversity of its lifeforms as universal ground. Today, we see this grandiose vision repeated in the globe at the centre of Google Earth, spinning with only the click of a mouse. The Earth has been so reproduced as a whole that we can hold it in our hands, being outside while inside, and *anticipating* its future because we understand it as a whole.

Heaney's stanza in the epigraph to this chapter captures this modern relationship to nature through the figure of the astronaut who, like a visitor to Reclus' dome, gets outside so as to see the whole from which he emerged. The "lucent O" that is Earth, comes into view from the circular window of the space capsule shot away from earth and the astronaut realizes their origin through their separation and distance from it. Heaney and Reclus both articulate this paradox at the heart of modernist conceptions of nature: knowing it requires transcending it, being outside of it brings us closer to it.

Yet, there was always another side to this World Picture – the other side of the map, the back of the blue marble, the side that couldn't be photographed, and always remained hidden from view even if everything seemed mappable.[144] Throughout the many attempts to see all sides at once by flattening the Earth, from Mercator's flat image with a distended Arctic, to Buckminster Fuller's unfolded Dymaxion map that maintains the true geometry of the globe but transforms it into a mosaic floor tile, the Earth also turned away as we looked at it. It is an earth that never revealed itself to us at once, even if we so regularly circumnavigated it. The "lucent O", even from the distance of the space shuttle, is still flat and the globe always has another side, a back. The project of exposure, of laying it all out,

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[142] See: Buckminster Fuller's, *Operating Manual for Spaceship Earth*, 2018.

[143] In *In the World Interior of Capital*, Sloterdijk, 2013, writes that, "When the Greek philosophers and geometricians began to measure the universe mathematically two and a half thousand years ago, they were following a strong formal intuition: that all things ultimately moved in circles. Their interest in the totality of the world was kindled by the easy constructability and symmetrical perfection of the spherical form. For them, the simplest form was at once the most integral, complete and beautiful. The cosmologists who gathered in the ancient Academy and other places of learned quarrelling were now considered not only the greatest rationalists, but also the most distinguished aesthetes. Anyone who was not a geometrician or an ontologist was no longer of any use as a connoisseur of beautiful things. For what was the most beautiful thing – the sky – if not the material realization of the best, namely the whole?" p.15. See also: Sloterdijk, *Bubbles: Microspherology,* 2011.

[144] See: Heidegger, "The Age of the World Picture," 1977.

has been haunted by trying to be two things at once, to be both apart from us and where we are.

Volatile nature is the other side of the map, the unpredictable chaos that resists order and control. Whether tempests or earthquakes, Western modernity has been confronted with unpredictable nature. Rosa Luxembourg exemplified this when she saw the violent eruption of Mount Pelée, Martinique, as an act of resistance to French colonialism. "…A day will come," she wrote in 1902, "when another volcano lifts its voice of thunder: a volcano that is seething and boiling, whether you need it or not, and will sweep the whole sanctimonious, blood-splattered culture from the face of the earth. And only on its ruins will the nations come together in true humanity, which will know but one deadly foe – blind, dead nature."[145] For Luxembourg the revolution is volcanic violence and a kind of natural justice.

Phenomenology is the philosophical correlate of volatile nature exemplified by Husserl's argument that the Earth as *res extensa* does not account for the real ground because it is what you are always already inside of.[146] The *res extensa* has nothing to do with *lived* space because it is not the space in which bodies feel and contact each other. That space looks, or better, feels, nothing like the space of Earth, the "buoyant ovum", not just representationally, but ontologically. Husserl argued that the world was not the Earth, but the lived space of perspectives that we could never extricate ourselves from. Nigel Clark summarised Husserl's contribution, arguing that "… our primary experience of the earth is as a supportive and sustaining ground – as the resting point from which we register the movement and thingness of all other things. The earth cannot simply serve as one astronomical body – one object – amongst others, as it is the very condition of our encountering of everything else."[147] The Earth is split, it is at once idea/model of what envelops us and the condition of that idea.

The World as phenomenological life-world is, therefore, better exemplified as weathery. It is the dimension of unpredictable micro-climates, of fluxes of wind and temperature, of bodies groping their way through spaces which are permanently partly obscured. It is the world not as exposure and total visibility, of a universal nature beneath a culturally conditioned perspective, but of enveloping blind spots and hidden corners. Timothy Ingold, in an extension of the phenomenological argument against the *res extensa*, writes that "A living, breathing body is at once a body-on-the-ground and a body-in-the-air. Earth and

[145] Luxemburg, 1902.
[146] Husserl, *The Crisis in the European Sciences*, 1970.
[147] Clark, *Inhuman Nature,* 2011, p. 5.

sky, then, are not components of an external environment with which the progressively 'knowledged-up' (socialized or enculturated) body interacts. They are rather regions of the body's very existence, without which no knowing or remembering would be possible at all."[148] This is the thick world of the bod; bodies, and selves, are enfoldings of the flux of the world, not bodies in empty space, separate, and surrounded by other bodies and objects. This foregrounds the Earth as Worlding against the Earth as totality, the earth as volatile nature.

Latour has argued that this resistance to the Earth as *res extensa* is a reaction conditioned by the *res extensa,* that both of these versions were produced together, one an alienating outside that failed to fully account for embodied worlding while the other side attempted to fill in the missing pieces.[149] As the modern sciences increasingly disembodied and created the *res extensa*, the phenomological movement resisted by privileging the uncertain, volatile, and embodied state of nature.

The development of modernist nature forecasting emerged in the space between the disembodied *res extensa* and embodied worlding. Through the application of modern scientific practice to the unpredictability of nature, its weathery, flux ridden becoming it became an institution that crosses the space between the two and the role of the contemporary nature forecaster is to operate in between the figures of the World and Earth that modern conceptions of nature have inherited. The forecaster operates in the *mesoscale* between the One-World World and unpredictable, volatile nature.

Into the Meso

Modernist Weather forecasters position themselves in middles. When Robert Fitzroy in the 1860s explained the reasons for the earliest forecasts in the 1860s he argued that the forecaster organized and distributed information in the service of efficient and safe shipping, the general public, and increased of knowledge or nature.[150] C.L. Mitchell and H. Wexler from the United States Weather Bureau (today's National Weather Service) in 1941 articulated the what and who the forecaster was between when they wrote that,

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[148] Ingold, 2010, p. 122.
[149] B. Latour, *Reset Modernity!*, 2016.
[150] Fitzroy offers an example of how forecasting is between the weather and society when he writes that in 1863's, *The Weather Book: A Manual of Practical Meteorology*: "It is obvious that by making a passage in less time there is not only a saving of expense to the merchant, the ship owner, and the insurer, but a great diminution of the risk from fatal maladies; as, instead of losing time, if not lives, in unhealthy localities, heavy rains, or calms with oppressive heat, a ship properly navigated may be speeding on her way under favourable circumstances," pp. 53-54. Malcolm Walker outlines how the Board of Trade and the Royal Society were aware of the purpose of establishing a meteorological and forecasting office in *History of the Meteorological Office*, 2012.

"The object in weather forecasting is to provide the farmer, the city dweller, the shipper of perishable goods, the railroads, the public utilities such as gas, electric, and street-transportation companies, the aviator, and the owners and masters of all types of vessels from fishing and pleasure craft up to the largest passenger liner, and all others interested in the weather, with as accurate weather information as possible and with forecasts as far ahead as practicable."[151]

Drawing on the most up to date information from ships, national and international research stations and instruments, they wrote that the forecaster is ready to "project the present conditions into the future…"[152] The meso of forecasting practice was between the flux of the weather and the long list of objects, publics and infrastructures that it may have consequence on.

In the mid-twentieth century, the prefix *meso* was adopted in meteorology to define a scale of atmospheric events that had been previously invisible. It was defined as the limit at which existing synoptic maps (usually 1000 km) lost their resolution.[153] Events too small to register on the synoptic scale were understood to be in the mesoscale. This included events that occurred within what one meteorologist bulletin described as "a physical scale that falls between the microscale processes of raindrop and hailstone formation and the macroscale motions of regional and global weather systems."[154] In 1951, the meteorologist Myron Ligda coined the term in a paper in which he argued that "We have already observed with radar that precipitation formulations which are undoubtedly of significance occur on a scale too gross to be observed from a single station, yet too small to appear even on sectional synoptic charts. Phenomena of this size might well be designated as mesometerological."[155] There are still disputes between meteorologists of different national allegiances[156] about the exact range of the meso and what it encompasses, but there is broadly a consensus that it encompass the origin of phenomena and systems of weather that most immediately affect human affairs, the function of cities, and regions. [157] It is the scale at which tornadoes, cyclones, thunderstorms, and the squall lines that precipitate snow or rainfall originate.[158]

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[151] Mitchell, "How the Daily Forecast is Made", in *Climate and Man: Yearbook of Agriculture*, 1941, p. 583.
[152] Ibid. 583
[153] P. M. Richardson, 2010, p.3; and, Thomas and Goudie 2000, p313.
[154] UCAR, 2016.
[155] In T.T. Fujita, 1986, 'Mesoscale Classifications,' p. 23; See also, W.F. Hitschfeld, "The Invention of Radar Meteorology," in *Bulletin of the American Meteorological Society,* vol. 67, no.1, January 1986.
[156] Ibid, p.4.
[157] Markowski, 2010.
[158] Gregory Tripoli, "Introduction to Mesoscale Forecasting," 2016.

The meso is a good prefix to think with in trying to understand the modern function of forecasting because it was created as a way to name something sensed in the world but not yet formalised. The mesoscale was a boundary of what was known, between the mapped space of the earth and its edge, it was a way to bring something out of hiding by marking its boundaries, giving it a name, a scale, and making it mappable. Tetsuya Fujita, the theorist of tornado formation and trajectory whose work relied on the formalisation of the meso scale, argued that carving the weather into rigid scales was imposing an artificial stability on something inherently in flux.[159] The meteorologist Kerry Emanuel shared his view in the preface to a volume which Fujita also contributed to, dedicated to mesoscale meteorology. It opened with the following: "…the layman…might conclude the atmosphere is somehow quantized and the scales are discreet. In reality, of course, the spectrum of atmospheric motions is smooth and continuous between the limits imposed by the mean free path of molecules on the short end and the circumference of the Earth on the large."[160] Weather crosses the boundaries of measured scale, its messiness does not respect them, but it is nevertheless a necessary artifice to simplify it by breaking it into three horizontal units so as to then build up more complex descriptions of the interactions of the parts. [161] It was an act of simplification and disassembly in the service of getting closer to the complexity of the weather, of getting outside to get inside, and in advance. The meteorological definition of the meso was an instance in which Ligda, Fujita and Emmanuel understood the necessary artifice of what they had created. Moreover, the necessity of artifice for truth did not undermine truth's access to the world, rather it bolstered it through a disposition towards uncertainty, the artifice of the middle brought them closer to the messiness of the weather.[162] The *res extensa* created an outside to get back inside.

Mesoforecasters weren't only looking outwards, they were also positioning themselves and being positioned by the meso scale in relation to the publics they forecasted for. Since Fitzroy first introduced the term 'forecasting', they had positioned themselves between the weather, the future and society just as shamans and priests position themselves between worlds and a public. For forecasters the drawing of the boundary of the mesoscale, however flawed and faulty, belonged to a boundary marking that also included the position of the forecaster, who their forecasts were for, how they should be distributed and how they

[159] Fujita, 1986.
[160] Kerry, Emanuel. "Overview and Definition of Mesoscale Meteorology" in *Mesoscale Meteorology and Forecasting,* 1986. p.1.
[161] Fujita is working at the dawn of chaos theory and theories of non-linear dynamics.
[162] Deleuze, 1987, see in particular the "Treatise on Nomadology".

related to the public of the forecast. The meso of the weather was delineated, marked, drawn, represented as the middle from which the forecast was released and distributed, what it would look like, what its marks and representational conventions were just as the forecaster was given a convention, a style of acting and a milieu of instruments. These middles were intermingled in giving shape and sense to what could be included and excluded from making the weather and the future, the causes and effects that could be visible and what their patterns were.

Forecasting has emerged in this liminal space between the *res-extensa* and the unpredictability of nature, the body and the planet, the phenomenological body and the abstract space of the globe. Its technologies have been driven to negotiate these differences, and as I will turn to now, rituals of integration are the modern rituals that enact this negotiation.

Rituals of Integration

In December 2015, when floods were forecast for the north of England, it was an unusual time of year for floods in the region and had been one of the wettest on record in over a century. Roads were closed, river banks were breached, and villages marooned.[163] The chair of the Environment Agency remained on holiday in Barbados and was fired for it.[164] In the midst of the storm, many claimed that it was a dry run for climate change and that the breached flood defences were a kind of warning of what was to come. As it has been argued, the new norm that climate change promises is one of increasing unpredictability and intensity of weather.

As the flood waters were beginning to subside in the North, Helen Willetts broadcast a standard BBC weather forecast that tracked the tail end of the tropical cyclone named Frank. The broadcast was conventional in its use of graphics, maps that moved, large icons that represent rain, wind, and clouds; and, constant zooming in and out to transform the scale of the forecast. Willetts, standing in front of the maps, appears to be the scale of a giant because her hand is the size of the south of England, which echoes Recluse's figures wandering around the globe, and is a gesture so banal because of the normalcy with which we encounter the *res extensa* space of nature. The work that needs to be accomplished to cross scales has become invisible, including the data that is circulating to the met office, the

[163] McKie, 2015.
[164] See: Woolley, 2016. Barbados in 2017, narrowly missed the total destruction of Hurricane Irma in the Caribbean Islands

construction history of the screens themselves, or the long history of the MET office and the Royal Observatory at Greenwich in international shipping around the globe. Willetts, in this forecast, is Richardson's man at the top of the tower, and we, the audience, are inside the theatre of Earth, watching it unfold.

We witness this negotiation between *res extensa* as world, Earth and Globe in the opening sequence of the weather forecast, the standard sequence of the BBC (*figure 4*). In it, Willetts is standing beside a hovering, transparent globe. Inside of the globe are rain drops and autumnal leaves, it looks like a window onto a storm. Clouds can be seen rushing past in the background and new flecks of rain drops land on the surface. It is not attached to anything, nothing is visibly suspending it, it floats beside Willetts, who ignores it as she launches into the forecast. The globe is diegetic and extra-diegetic simultaneously; it is both in the scene and out. The weather that is in the background is reflected in the globe at a different scale and intensity. It is at once planet Earth and crystal ball. But the smooth, reflective surface makes it seem like a planet without relief or contour, and indeed, all the weather is happening inside. In older weather forecasts, the BBC used the conventional, stylised Blue Marble rendition of the globe with a surface and hidden interior. Now it is a bare sphere that we look through that repeats Heaney's 'O'. The globe as crystal ball and the *res extensa* as magic, the forecaster the magician.

Figure 4. Helen Willetts, BBC, December 30th, 2015.[165]

[165] BBC News: "Storm Frank: Latest forecast as UK towns brace for flooding," 2015.

The next move in the sequence brings us past the globe into a plan view of the entirety of the UK, Iceland and western continental Europe, jumping from the scale of the planet to the region. This happens on screen but also in the living room of viewers who can now position their immediate environment in relation to Frank the Depression. I was in Yorkshire at that time and watched as Willetts choreographed the mushy front lawn and streams of rain coming off the roof of the house where I was staying, with the depression that was bigger than the north of England and Scotland, a scale which I came to position in relation to the scale of my body and the house I was in. Willetts was integrating what I was experiencing around the house, in the local village, with Scotland, and the coming three days. It was the creation of a sensation of integration of a place with an imaginary globality via media infrastructures and the rushing water outside. The *res extensa* became the vehicle for these imaginary linkages of a world, and pundits wrote articles about how the storm was also the fruition of hundreds of years of modernity, it was the evidence of climate change. The ritual involved each of these parts orchestrated together, a here and now packed with futures, pasts, and elsewhere's. Willetts forecast was a ritual of integration.

Forecasting is an institution built to negotiate the gap between world and Earth, to put worlds into conversation with Earth, to fold it into the *res extensa* as seamlessly as possible through the present by making the future liveable, sensible, and bringing it into being through the materiality of that world. Rituals of integration accomplish the work of scaling and laminating worlds onto the *res extensa*, onto the space of the globe, to such a powerful effect that worlds are implicated within that of the *res extensa.* Through these operations that require complex infrastructures, technologies, representations, the shifting of views from inside to outside, bodies can be integrated with the volatility of nature.

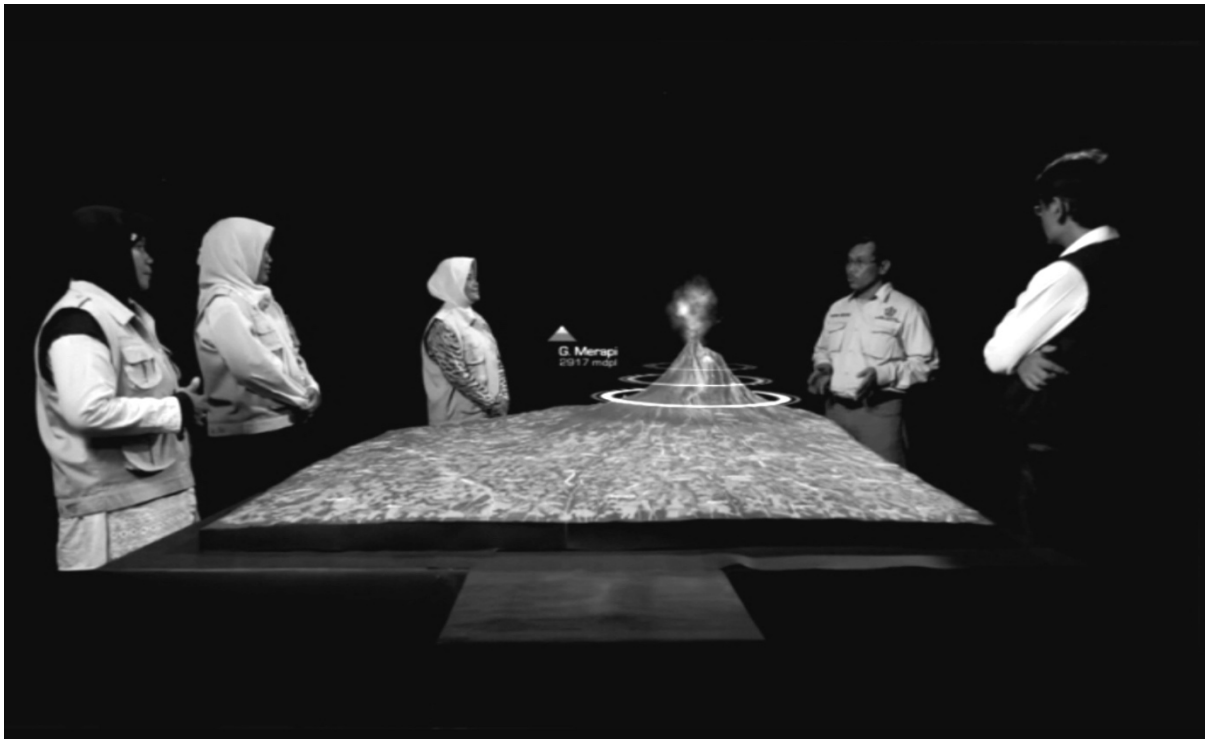

Figure 5. Performing a ritual of integration in the video *Mahaguru Merapi*, filmed in front of an animated Merapi model, volcano observatory, Yogyakarta.[166]

The film *Mahaguru Merapi*, produced by the volcano observatory, chronicles the eruption of 2010 and contains a recurring scene of a ritual of integration (*figure 5*). At the centre of the scene is the large, scale model in the atrium of the observatory (the same disused one I described in Chapter 2), and which I have described in previous chapters as neglected. In the film, they use the model as a prop and animate it to represent what occurred during the 2010 eruption. The original model is animated by lights embedded in its surface that show the spatial extent of the eruptions of 2010, 2006, 1997, and 1930. The scene depicted in *figure 4* resembles a public tour through the observatory because observatory staff often stand in front of the model to explain eruptions to visiting school children and teenagers as part of their public programming. In the film, however, this scene is presented with volcano scientists who work in the observatory and were present during the eruption of 2010.

The scientists, much like Willetts, point to the model as a way to position subjects in space. The lead scientists conducting the demonstration in the film point at the volcano in order to say "We are Here", meaning both himself and his support staff in the film but also to position the viewer in relationship to the volcano. This requires the model or a map, a crowd, and a process of witnessing being both in the representational space of the map or model and

[166] BPPTKG, Agency 2015.

outside of it because it is the space between the map/model that is being generated. It is a collective effort, like in the film, in which participants identify the object and where they are in relation to it. It is integrative because it is the work of crossing different ontological orders – representational space (the model, the picture of the model), actual space – and integrating them. It is also crossing the thresholds between the order of the model – a poorly constructed, old, shabby model of a volcano in the atrium of the observatory, with an event that happened in 2010. The event was enormous and this intimate moment in front of the model was a way to make it sensible by integrating spatial and temporal orders across differences.

This scene is ritualistic because it has to be repeated. Integration is not something given in the world. Rituals of integration place subjects in relation to objects while participating in generating the imaginary that those objects are whole, single, with forms and identities. Standing at the table and looking at them is the performance, again and again, of being part of them and separate from them, above them while subject to them, integrated in a continuous, whole, unified, though unpredictable world.

These modern rituals complement the boundary work of science by bringing together actors that reference and stand in for entities as a way to draw a distinction between the outside and inside, a here and there. This demarcates forms of scientific and non-scientific knowledge, and where the appropriate space is for scientific knowledge to be practiced.[167] Our scientists in *Mahaguru Merapi* wear the military style uniforms of state civil service that demarcate their position. They speak the language of the observatory: warning signals, the terminology of seismology, and readings from gas monitors. Their ability to hover together above the volcano is also their ability to wear a uniform and speak with the authority of the state. The infrastructure and architecture that signalled Recluse's Globe as a continuity with the infrastructural style of the moment is here transformed into the continuity between the uniform and the republican, Indonesian state. Boundary work, then, does not only demarcate what is not science but what else is included within the project of making scientific statements, and here, in *Mahaguru Merapi* that is the capacity to compress the profile of a state body, with its right-angle shoulders, vest, and hijab, with the model of a volcano that in real space is over three thousand meters above sea level.

Rituals of integration require these nested enclosures such as domes and spheres within outer, enveloping enclosures. These outer enclosures in the *Mahaguru Merapi* are made invisible so that the focus is on the observers and the model but outside of the space of

[167] On boundary work, see: Gieryn, 1983.

the film, the model is within the enclosure of the observatory, a neo-classically inspired atrium, that generates the sense of a state space which has the capacity to enclose the volcano model within it. In order to access it, one has to pass a security desk and will be led by an official from the observatory. This complements the ritual by integrating the icons of state forecasting into the referential capacity of the model. Rituals of integration, in this way, cannot be separated from the act of separation, cutting, and including. As Isabelle Stengers has argued in relation to modernist science, scientists enact – spatially and epistemologically – a series of cuts so that new entities can become sensible.[168] Rituals of integration are what are undertaken after the inheritance of these cuts so as to create new associations with the entity. The observatory architecture is this as it becomes a part of the ritual of re-integration, of housing models within models, so as to ritualise the performance of the choreography with nature.

From Enclosures of Control to Care

I have described here how modern nature forecasting inherits two visions of nature, the *res extensa* and volatility, and that in doing so it has developed rituals that integrate the two modes. My aim in doing so has been to draw attention to the legacies which structure contemporary forecasting so that its implementation might be more mindful of what and how it integrates. In these final paragraphs, I would like to propose that we consider how rituals of integration can enact forms of care within uncertain and unpredictable environments.

Volcano forecasting in the state observatory in Yogyakarta, has, as I have shown, inherited the modernist conception of the *res extensa* and that it is exemplified in the model in the atrium. It presents an image of the volcano as an entity that can be pictured from above, as if taken in in its totality, at which scenarios of the past and the future can be played-out and enacted in preparation for the future. It undertakes this within the housing of the architecture of the state and with the aim that those who participate in the ritual will continue to place themselves in relation to the performance of the ritual after they leave the observatory. Away from the observatory, the model will become a reference that facilitates them to place themselves in relation to the volcano in the landscape. These distributed chains of reference cross spatial scales from the model to the room to the volcano thirty kilometres away and the unknown distance of the magma chamber underground. These chains of reference enacted through the ritual, go some way towards creating a shared sense of being

[168] Law and Ruppert, 2013; Stengers, 2011.

subject to and vulnerable to the uncertainty of the volcano. The ritual draws together, in an act of communion, these differences between bodies, scales, and times.

The reason that it is important consider the work of forecasting in these terms is because it furnishes it with a different language. It expands the repertoire of entities that are participating in the ritual, and it moves our understanding of forecasting towards one of acts of inclusion and exclusion. These rituals are about forms of enclosure and housing, but also cutting and separating in order to make particular kinds of communion sensible. If they are about creating enclosures then they are also about creating publics within that enclosure, participants who share in their relation and experience of volatile nature.

This shifts the common language of the observatory from one of risk reduction and hazards to one of forecasting as a form of care.[169] This idea is implicit in volatile nature forecasting but side-lined by the language of the modern constitution, of technical proficiency and mastery, of disembodied views that trump multiplicity. By looking closely at rituals of integration, we can understand that forecasting contains within it mechanisms for building shared experiences of the future and of unpredictability, that they are negotiating deeply inherited perspectives for how that future is shared in the present.

The consequences of this is also that we understand rituals of integration in terms of negotiating the relationship between embodied space and the abstract space of the *res extensa.*

[169] For more on care and ritual see: John Law and Vicky Singleton, "Devices as Rituals," 2013.

Figure 1. Analogue seismographs at Mt. Merapi Observatory, Yogyakarta. Authors photo.

Chapter 5
Standardizing the Unpredictable

Unclassified Entities

The modern scientific imaginary of Merapi is conflicted and contradictory. Scientists have long sought to understand if the volcano was predictable and patterned. Did it erupt in cycles, was it connected to the other volcanoes of Java or did it act independently? Perhaps, scientists reasoned, its eruptions were the result of unpredictable and chaotic forces forever beyond the grasp of science, and they would have to learn to live with a violent nature that resisted their presence, and forever hampered technological, and infrastructural growth? They struggled with how to measure eruptions, and how to classify eruptive activity. What counted as an eruption, and what counted as a precursor, they asked? Was an explosion in the caldera a sign of something bigger yet to come, was an earthquake a signal of magma recharching the chamber like the barrel of a gun? The imaginary of modern science on Merapi has been obsessed with distinguishing and understanding predictable behaviour, order from chaos, the unique from the repetitive, the anomaly from the law. More than only driving the prediction of eruptions, it has influenced the creation of warning systems and the demarcation of forbidden zones that can't be inhabited. The ability to predict eruptions, landslides, volcanic ash clouds, and the communities they will affect, has been determined by this ongoing struggle over how the future of nature can be known in the present.

In this chapter, I explore these themes through the notion of standardisation. I mean by this the shared methods of representing and measuring volcanoes. The adoption of standards allowed representations to be shared across time and space between different scientists and in the context of different volcanoes. So too could the practices of scientists be standardized as they got to know the volcano. In another sense, standards were projected onto volcanic action too, in such a way that it seemed to follow predictable, repeated, patterns of behaviour. These different senses of standardization have been held together in the scientific imaginary of Merapi as both a subject of standardised procedures and that it too could be a standardized object.

One example of this stands out. Scientists have long struggled with sorting out the multiple languages that have been applied to Merapi. Javanese, Dutch, Indonesian, and English, have been the four principle languages that have been used on Merapi since the late 19th century. Pyroclastic flows, for example, contain a multitude of names across these languages. In Indonesian they are: *hujan abu, batuan piroklastik, aliran piroklastik, awan panas,* and *domba gimbal.* In Javanese, they are: *wedhus gembel, ampa, guguran;* English also used to commonly use the French term *nuées ardentes*, and today, for the most part, the term pyroclastic flow has been replaced by Pyroclastic Density Currents. The Javanese has even more complex vocabulary than what I have included here. And all of these terms are still in circulation. This cornucopia of terminology for the same thing is acknowledged in the modern scientific writing in the late 19th century and continuously throughout the 20th as a challenge to be met through translation and standardization, to find a straight line through the maze. Who gets to decide what becomes the standard and by what means, was always the crucial question that accompanied these moments. This is why it is important to attend to processes of standardization as they intersect with practices of knowing. The knowledge of nature that became dominant and the language that supports it are, in part, forged through the project of standardisation.

This is significant for forecasting because we can see how it is a project of standardizing the future. Of defining what constitutes newness and sameness, the volatile and the norm. The volatility of Merapi would disappear if the volcano became a standardized object. It would be anticipated, expected, it could be perfectly choreographed with society, its feral pieces put in their place, its eruptions could be expected because they are patterns that repeat themselves.

The Linear Model of Forecasting

One reason to consider the history and effects of standardization is to displace the dominance of the linear model of forecasting. Today, according to many scientists in the observatory in Yogyakarta, and sites of volcano forecasting and natural hazard management worldwide, hazards are governed through an understanding that there is a linear relationship between natural phenomena, observation, and dissemination.[170] In this view, scientists observe from as many locations as possible and gather as much data in as many formats as possible in order to disseminate information to the public. This amassing of information

[170] Donovan and Oppenheimer, "Science, policy and place in volcanic disasters: Insights from Montserrat," 2014.

intersects with a rigidly hierarchical state organisation that positions scientific experts in a vertical relation to each other (heads of observatories and senior scientists, technicians, support staff and volunteers). The idea of the linear model is that science gathers information on nature to then communicate it to the public. Without this, the feedback between scientific observation and the management of civil society would be compromised.[171] The challenge, according to this view, is how to increase the quality of information coming into the observatory and reduce noise in the signals.[172] Noise includes the media that distribute false reports, word of mouth channels, and unqualified voices gaining authority over experts. One such example was when the previous director of the observatory Surono, described the forecasts of Maridjan, a local religious leader, as "voodoo", and a threat because people believed him over his own modern scientific forecasts.[173]

The linear model of forecasting has two goals. The first is to control broadcasting and access to media channels so that qualified experts can govern the distribution of information. The second goal is a notion of accuracy as an instantaneous, 1:1 correlation between observation and choreographed action in which what is perceived as happening or immediately about to happen can be responded to without friction in the lines of communication distribution. There ought to be an immediate and appropriate feedback between what is observed and forecast and the execution of measures to respond to it, such as the evacuation of villages or closure of a road. The linear model imagines that accuracy is the perfect choreography between unpredictable nature with society.

The director of the state observatory in Yogyakarta, I Gusti Made Agung Nandaka, expressed to me his own take on the linear model. He pointed me to the stacks of seismograph machines permanently recording from four different stations on the flanks, their signals being received by radio transmitters (*figure 1*). CCTV cameras stationed on utility towers along river banks or fixed to infrastructures like bridges, sent their signal to a bank of twelve large screen monitors fixed to the wall. Another forty-six monitors played digital seismograms rolling across the screen and real-time gas monitoring. He told me that there were no communication issues between the observatory and villages at the top, that there was perfect trust between scientists and residents. In a lecture at the Gadjah Mada University, Made presented an often used slide show that he uses to introduce novices to the observation system on Merapi, this time to undergraduate students of geography and geology, some of

[171] Garcia and Fearnley, 2012; Solana, Kilburn and Rolandi, 2008.
[172] Solana, Kilburn and Rolandi, 2008; Donovan and Oppenheimer, 2014.
[173] O'Brien, 2010.

them en-route to becoming forecasters and volcano scientists in his observatory. He emphasised the linear relationship between the monitoring instruments on Merapi and the flow of all of their data to the observatory.[174] He presented an image of the observatory as the centre into which information flowed and from which advice was distributed to the public. On one slide he showed all sixteen methods of observation in a flow chart that classed them between "Episodic" and "Continuous".[175] In the background was an image of a scientist with a beaker, and like many of the slides, the suggestion was that this multiplicity of inputs always led back to an authority at the centre the head of the observatory. In another, he showed a map with all the input points and listed the instruments and their number: "15 Seismic, 3 Seismic array, 10 Reflektor EDM, 10 GPS online, 8 Tiltmeter, 8 CCTV, 5 fixed DSLR, 2 Minidoas, 1 Multigas, 24 AFM."[176] This, he expressed, was the most effective strategy for managing the uncertainty of the volcano by centralizing data about it into one place, creating a rigidly hierarchical chain of command and authority that ends not with him but above him in the head of the observatory in Bandung to whom he has to answer to. This linearity by-passed interruptions along the flanks and took control of knowing what the volcano did and would do. The infrastructure system of monitoring reduced noise and controlled the signals coming from the volcano.

It is important to consider standardization because it is the basis of the linear model. It requires standardizing scientific practice of information acquisition, data transfer, analysis, and dissemination. This would, he argued, accurately locate the sources of eruptions, their effects and real-time unfolding in space so that communities could effectively choreograph their evacuations. What this imaginary aims to produce is a centralized system of co-ordination in which the forecasting of the future is located in a single, small group of experts who decide when and where evacuations occur, what areas are under threat and what the threat is so as to minimise the number of people engaged in the process. In other words, the small group of observatory scientists take on the perception and management of uncertainty of the volcano in the place of a larger number to reduce the possibility of misconceptions, miscommunication, and inaccuracy. Through these operations of standardization, uncertainty is seemingly located only within the small group of high level observatory scientists.

However, uncertainty is not necessarily overcome or resolved by the linear model of forecasting. This became clear to me at another conference at Gadjah Mada University, this

[174] Nandaka, 2015.
[175] Nandaka, 2015.
[176] Nandaka, 2015.

time of volcano scientists, anthropologists and geographers from Indonesia and abroad. Agus Budi Santoso, a seismologist trained in France[177] (after completing his PhD became the second in command to Made) gave a prepared lecture like Made, also with a reproducible slide show that featured some of the slides that Made had showed earlier and projected the imaginary of the linear model of forecasting. At the end I asked: "can we say that volcano scientists make predictions?" After a long pause he said, "We often say that scientists don't make predictions. But we actually do in times of eruptions. But we say instead that there is a probability that it will erupt." Then he added, "you can say we have the *fortune* to make the proper decision." He knew he was leaving the script of the linear model behind as he conflated probability with fortune. He was shifting the incalculability of unpredictability into the domain of the religious and predestination. It was a cosmological order that guided decision making not the linear model of accuracy.

This tension, I want to show in more detail here, is central to the long duree imaginary of forecasting on Merapi and which the linear model has sought, unsuccessfully to overcome. The linear model of forecasting has been unable to account for how forecasting is more than a narrowly technical operation of watching and information distribution, but a cultural technique of standardizing uncertainty. As I argued in the third chapter here, it is at the site of standardization across infrastructural and technological systems that the particular politics of forecasting emerges because that is where certain groups come to speak for the future. As a development of that argument here, I show how the standardization of scientific practice and nature have been implicated in complex and, crucially, non-linear ways with attempts to manage, predict, and create authority at the edge of certainty.

Inventing Depth

The interior of Merapi that forecasters today seek to understand and predict, of which they make images and models and is understood to power its eruptions, was invented in the 1920s. Between May 16 and 25 of 1929, the Fourth Pacific Science Congress was held in Batavia and Bandung. Scientific delegations from around the world descended on the two towns for days of reflection on the state of the sciences. One of the themes was volcano science and in the publication that resulted from the conference, *Science in the Netherlands East Indies*, Nicholas Wing Easton penned the chapter on volcano science in which he

[177] With Jean-Philippe Metaxian in Chambery. Metxian ran the DOMerapi project which I describe later in this chapter. He also was in Surono's geophysics PhD cohort in France.

reflected on its history and the establishment of the volcanological service.[178] The story he narrates is important because he argues that the reason for the establishment of the government service was the discovery of the interior of East Indies' volcanoes. In his words:

> "In order to make the vast amount of profitable [scientific] work done a matter of general benefit and a blessing to the population, it was an imperative necessity to consider not only the *exterior* of the volcanoes, but to do the utmost to solve the many puzzles as regards their *interior*, in order to obtain an exact appreciation of the visible features."[179]

Prior to this moment, the efforts of scientists and engineers had been devoted to observing the exterior morphology of Indies' volcanoes and their eruptions. They had mapped them in surveys and studied the sequences of their eruptions, not however, in view to understanding the interior mechanisms that drove them but to understand the extents of damage or understand the course and events of an eruption. This turn to the interior was consequential because it marked a transition in the modern scientific imaginary of volcanoes in the East Indies to objects with an inaccessible depth except through mediation and representation at a distance. There was also, at the same time, a transition towards the future, to anticipating eruptions, getting ahead of them by understanding their depth rather than studying their eruptions during or after the fact. What was crucial to this was creating a method for explicating that depth.

Wing Easton pointed to one decisive eruption as a driver in this search for depth. Kelud, a volcano in east Java with a massive crater lake, and surrounded along its flanks with market towns, erupted in 1919. The entire contents of the lake emptied over the edges of the crater rim, rushed down through the forests, valleys and villages, and killed over five-thousand people. Newman Van Padang, based on the account of Kemmerling, estimates that thirty to forty cubic meters of water spilled over the edge. He writes that "within 45 minutes 131.2 km2 of cultivated land was covered by mud and debris to a height of 1 ¼ - 2 ½ m, and to a distance of 35 to 40 km from the crater."[180] The eruption, Wing Easton tells us, spurred the creation of the *Vulkaan Bewakingsdienst,* Volcanological Survey (V.S.).[181] Wing Easton does not go into detail about why the Kelud eruption was so consequential when there had

[178] Easton, 1929.
[179] Easton, 1929, pg. 83
[180] Easton, 1929, pg. 30. Italics mine.
[181] Easton, 1929; Van Padang also mentions the story this way: "After the catastrophic eruption of Mt. Kelud in 1919 a 'Vulkaanbewakingdienst (Volcano-Watching Service) was founded as a subdivision of the Dienst van de Mijnbouw (Department of Mines)." Padang, 1983, pg. 24.

already been a long history of devastating eruptions, or that only thirty-six years earlier the eruption of Krakatoa killed over thirty-six thousand people. In 1900, Java and Sumatra contained eighty potentially active volcanos in proximity to twenty-eight million people.[182] From 1902 to 1904, Merapi was almost continually active, its mouth a glowing red and effusive punctuation on the horizon. There were months of continuous activity from the crater including rock bombs, "tossed lithic blocks" and "incandescent rock falls."[183] In January 1904, "a violent explosion produced a 'glowing rock rain' with 'glowing streaks on the slopes' and roaring noise" that destroyed plantations and villages.[184]

The Kelud eruption was also significant because it was there that the Dutch undertook the first monumental infrastructure project to mitigate eruptions from the inside of a volcano. Applying irrigation and tunnel engineering, they sought to drain the lake from the inside out by drilling a tunnel from the outer flank of the volcano into the giant lake from below to then empty out the contents of the lake like a giant drain pipe in a kitchen sink (*figure 2)*. Hundreds of native workers were enslaved to dig horizontally into the flanks of the volcano (*figure 3)*. On their first attempt, the tunnel wall collapsed underneath the pressure of the lake water and killed the workers in the tunnel. They tried again, the next time successfully, to graduate the release of the lake water through a stepped system of tunnels.

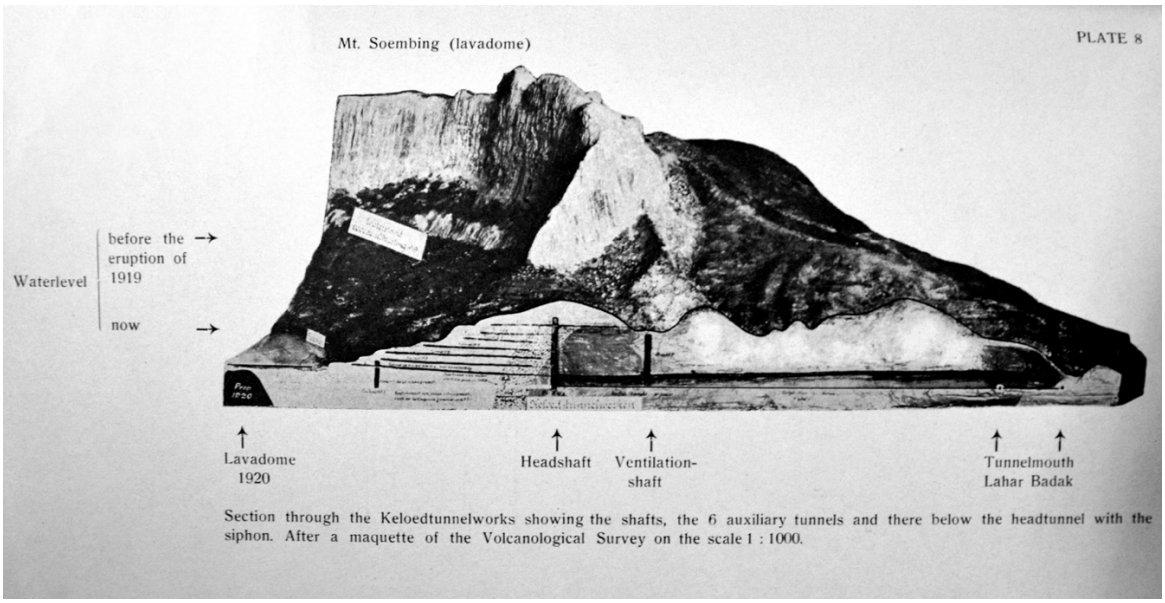

Figure 2. Cross sectional model of Kelud tunnel works. The tunnel can be seen as planned to run through the face of the volcano and then elevate inside the crater, lowering the level of the lake in stages. The label of the image says Mt. Soembing in error. From the *Bulletin of the Netherlands Indies Vulcanological Survey, 1936-1939.*

[182] Peper, 1970.
[183] Voight, 2000.
[184] Voight, 2000.

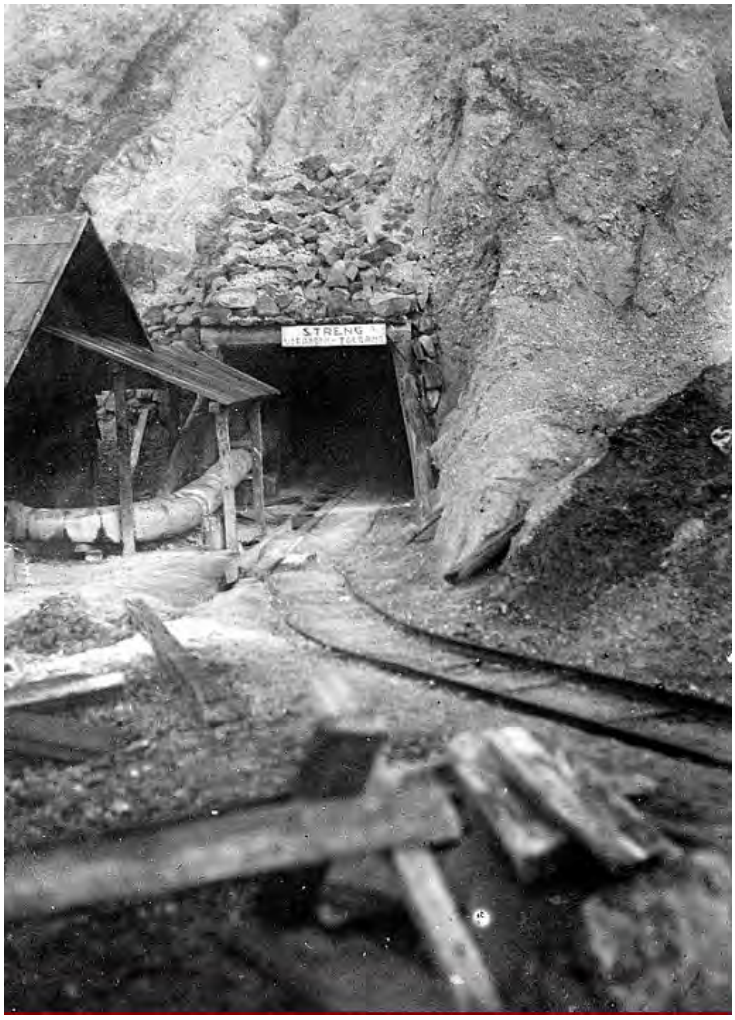

Figure 3. Entrance to Kelud tunnel shaft, circa 1921. Author unknown. Tropenmuseum.

One of the drivers of this interest in the mechanics of the interior of volcanos was the emergence of the Dutch liberal period and the civilizing aspirations of the "Ethical policy". While maintaining the Dutch stranglehold on resources in the Indies it sought to mitigate the devastation of late 19th century famines amongst the "native" Javanese through a process of provisioning resources.[185] This meant, at least notionally, a more equitable distribution of the products of colonization such as infrastructure, education, public health and services. This project flourished around the early 20th century until the end of the colonial period in 1945 and coincided with the modernising and civilizing aspirations of the colonial period. Wing Easton was writing on the far end of this period, in its restless twilight days before war and a nationalist revolution brought an end to the colonial system.[186] The author Louis Couperus, a

[185] The language of indigeneity in the Indies was based on Kinship. Two native parents made a child a "native", mixed European and Native parents produced an "Indo" child, two whites created a "European".
[186] Mrazek, 2002; and, Li, 2007.

popular novelist at the time, captured the sense of unease at the moment of founding the Volcanological Service in his 1900 book *The Hidden Force* in which the distant interior powers of volcanoes come to stand in for the uncertainty of the colonial presence in the Indies. He writes that, "This colonizing territory alien in race and mind, appears a masterpiece, a very world created…Beneath all this peace of grandeur the danger threatens and the future mutters like the subterranean thunder in the volcanoes, inaudible to the human ear."[187]

The flanks of Merapi at the time had been terraced into a system of teak, coffee, sugar, and rice plantations, and its upper flanks logged for timber.[188] Water was engineered to run from the slopes through large dam works and dykes to the urban centres of Magelang, Yogyakarta, Surakarta and Boyolali, for sewage, waste removal, hygiene and irrigation. The plantation system was in the form of large single owner parcels, divided amongst natives who were heavily taxed on their production and forced to share a portion of their produce with the state. The *Cultuurstelsel* system of monopolistic colonial ownership had by that point long energised the expansion of Dutch plantations up the slopes of volcanoes while expanding modernist infrastructures across the Indies to move the material produced by the plantations.[189] New highways, train lines, and radio communications infrastructures were dug out of or strung across the flanks of volcanoes and their valleys and because of this, eruptions were increasingly a threat. It is within this bigger picture that Kelud erupted and destroyed not only the towns on its flanks but the plantations associated with it and the infrastructures that made it a key node within eastern Java's predominantly east west commodity trade axis.[190] Merapi was a concern because of the density of population on its flanks up to a few kilometres from the caldera, the extent of the timber, sugar cane, tobacco, coffee plantations and infrastructures in proximity to them. The two cities at the base of Merapi, Yogyakarta and Surakarta, were strongholds in the Dutch power over central Java because they were two Sultanates submissive to Dutch authority and they governed a large and territorially expansive population. The threats to the plantation system on Merapi were equivalent to those of Kelud and because of this the Volcanological Service established their first permanent observatories on both volcanoes.[191]

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[187] Couperus, 1922, p.151.
[188] Peluso, 1994; Boomgaard, Colombijn and Henley, 1997; Boomgaard, "Southeast Asia: An Environmental History," 2007, pp. 203-271; see also, Boomgaard, "In the Shadow of Rice: Roots and Tubers in Indonesian History, 1500-1950," 2003.
[189] Peluso, 1994; Li, 2007.
[190] Peluso, 1994; Li, 2007.
[191] Van Padang, 1960, 1983.

The Volcanological Service was an extension of this modernising project because it was established to protect "life and property," developed at the vanguard of the plantation system and Ethical policy, and the interior "hidden force" of the volcanoes. [192] In doing so, it coaxed that depth to the surface through the establishment of permanent observatories at a safe distance. From there, they would develop standards of measure and techniques of representation that would, it was hoped, predict eruptions. Like many of his contemporaries, Wing Easton hesitated about this: "At this moment it would be premature to expect a definite answer as to which features are conclusive for the prediction of an eruption and which are of little or no importance."[193] Yet, "One of the most important conclusions, however, that experience has taught, is that *only permanent watching with the use of instruments, and daily observation of a considerable number of active volcanoes may lead to success*."[194]

Emanations

This shift to the hidden interior coincided with a broad re-orientation of the language and concepts with which volcanoes were understood. Wing Easton describes them in terms of emanations, both a theological and modern scientific term that suggests that what was present, visible, and empirically sensible, was the effect of something hidden behind or deeper than the emanation. Volcanoes became divided entities with an inside and an outside, and the outside the effect of the inside. The nature of that causal relation was opaque, hidden in its distant interior, and observation was the practice of revealing what was behind the visible. This was ultimately driven by the will to get in advance of it, to predict it, to know what it was going to do before it happened. The hidden interior was the key to the future.

With permanent observation and the attempt to reveal the interior, came recording and representing, and the first seismograms installed shortly after this period (in the early 1920s), as well as building the first observatory outposts that were connected like branches to the main observatory trunk to which they funnelled observation data. They were networked by the new, modernist communications technologies of radio, telephone and electricity. The outposts often contained look-out towers in view of the caldera, designed in a modern, prison yard tower style (*figure 4*), as well as a main building rendered in modernist Dutch domestic style common to wealthy Dutch colonial villas already on the flanks (*figure 5*). The

[192] Van Padang, 1983.
[193] Wing Easton, p.85.
[194] Italics in original, Wing Easton, p.85.

observatory was both an instrument of permanent surveillance in a network that surrounded the caldera while fitting in to the dominant domestic architectural language of the moment.

Figure 4. Observatory lookout tower at Ngepos, 1935. From *Visual Images of Merapi Volcano.*

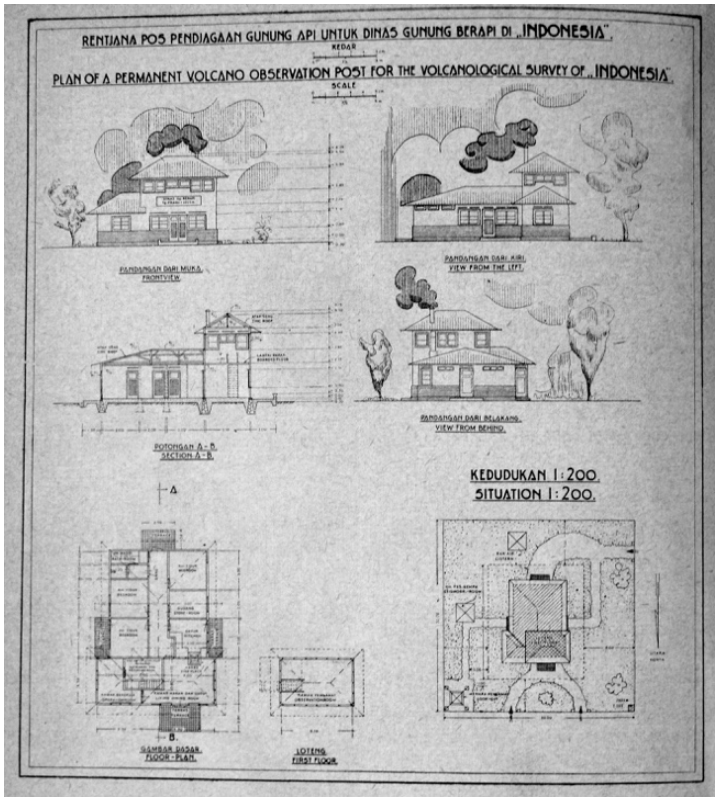

Figure 5. Proposal for a new observatory outpost with domestic design that mimicked colonial villas already on the slopes. Image from *Berita Genung Berapi*, 1952 September.

Towards standardising the hidden mechanisms of the interior, the Volcanological Service began printing and distributing the *Bulletin of the Netherlands Indies Volcanological Survey* twice a year at the beginning, then more sporadically. They included photographs from scientific expeditions (the still camera was a relatively recent introduction to the tool kit of volcano science) aerial photos but also maps and diagrams (*figure 6*). In the *Bulletin* they described what they were seeing: temperature measurements, rainfall duration and volume, seismograph readings, detailed descriptions of eruptions, and general, introductory commentary. They were written in English and sent across the world to other volcanological surveys in an international network between major hubs in the US, Japan, and Europe. The *Bulletin* collects in one place the diversity of representational techniques experimented with on volcanoes across the East Indies. They were permanently watched and recorded, transformed into representational material that was then distributed beyond the volcano, into international research within different contexts and other volcanoes in Indonesia and abroad.

Figure 6. Merapi aerial reconnaissance, circa 1930s.[195]

This diversity and volume of representational material invested the interior with a surplus of representations that cut through the stone and forested flanks to make them transparent. In doing so, the observatory produced an excess of representations which didn't only reveal the interior but proliferated representations of Merapi's interior in space and time, through networks of scientists and laboratories.

This quest for depth and prediction was, as Thomas Huxley in the *Method of Zadig* from 1880 put it, an act of retrospective prophecy. He writes that,

> "The term prophecy applies as much to out speaking as to foretelling; and even in the restricted sense of 'divination', it is obvious that the essence of the prophetic operation does not lie in its backward or forward relation to the course of time, but in the fact that it is the apprehension of that which lies outside of the sphere of

[195] From *Visual Images of Merapi Volcano,* Geological Agency of Indonesia, p. 195.

immediate knowledge; the seeing of that which, to the natural sense of the seer, is invisible."[196]

Huxley thought that this capacity to conjure absent worlds was essential to the empirical sciences: archaeology, biology, and geology, brought invincible and vanished worlds into the present by projecting them through fossil, stone and microbes just as fortune-tellers projected into the future based on what they know today. This retrospective prophecy is a part of the power of the observatory on Merapi, to conjure the absent interior through ongoing, multimedia representations, and to put them into circulation through networks of scientific expertise, conjecture the interior which can never be seen except through its representations, never measured but through its emanating mediators, never felt but through its transformation into rain, ash, or earthquakes. An eruption is not a thing that can be experienced except at great distances without risk of injury or death. The presence of the interior can only be achieved through this work of mediation and translation, investments of instruments and information, the distribution of publications, and permanent watching.

This proliferating interior was in the service of forecasting because by revealing what was inside the volcano, observatory scientists could foretell eruptive intensity, material compositions, and duration. It would transform the colonial orientation to infrastructure development because eruptions would cease to be a 'menace', as they were often called, to the system of modernisation. The paradox of this process is that as the interior became ever more subject to representation and speculation as a way to tame the menace, it did not make Merapi more transparent or predictable, instead it produced wider networks of expertise, larger communities of people representing it, and became more "informationally rich" as Andrew Barry has described this process.[197] As it multiplied the volcano, it multiplied also the sites of contact with it and the formation of cultures around it. And as it multiplied the volcano it exacerbated the project of standardising it. In becoming more transparent, the object itself was multiplied, distributed, and networked in ways that were beyond the control of the observatory and standardisation became a means to manage the excess. The standardization of techniques of representations, ways of speaking, measuring, and acting could tame the flourishing of representations of the interior. This is not just about ordering data but the standardization of a way of acting, of a "method" of producing representations so that what was conjured from the hidden interior could at least be guaranteed on the basis of how it was done.

[196] Huxley, 1901, p. 7.
[197] Barry, *Material Politics*, 2013.

Finding the Pattern

I turn now to the work of Reinout Van Bemmelen because in it we can witness how standardization was brought to bear on the volcano. I turn to him also because we can see how standardisation became an ontological problem that surpassed issues of method, and became a problem of the reality of the volcano itself.

Reinout Van Bemmelen's *Geology of Indonesia* was the most exhaustive and rigorous catalogue of geology in the archipelago. It was published in English in 1949, three years after independence and the creation of Indonesia. Van Bemmelen was of Dutch parentage, born in the East Indies, and studied in Leiden. He became head of the Volcanological Service before World War II and carried on in that capacity throughout the Japanese occupation of the Indies. He had been working on the *Geology* in the decade leading up to the revolution but,

> "[The] first manuscript was almost completed when the war with Japan broke out. This [manuscript] with all the original drawings, photos and literature references had been committed to the charge of an Indonesian functionary of the Geological Survey, in order to save it from the Japanese when the author became a prisoner of war in 1942. This functionary refused to return the [manuscript] after the liberation of Java in 1945, and took it with him to the Republic of Djokja [Yogyakarta]."[198]

His wife and family were jailed and Van Bemmelen was made to forecast for the Japanese. In 1942, from May until the end of 1943, he writes, "this volcano passed through an eruptive cycle which lasted more than a year. After a fore-phase of 10 months the cycle reached its main-or gas-phase at the end of March 1943. The unwilling population of the Upper Batang sector was then forced by the field-police to evacuate…"[199]

The *Geology* is a two volume, four part set of over one thousand pages of prose, photographs, bibliography, tables, diagrams and large fold-out maps. It is exemplary of a proliferation of representations and the will to penetrate the interior of volcanoes and with them, the earth. This is why I turn to him here, and in particular to an analysis of the *Geology* because it illustrates the second order of the process of multiplying Merapi that the turn to the interior produced. As communities formed around the missing centre, scientific practices like Van Bemmelen's sought to fix that centre at the intersection of different technologies of representation. Merapi emerged in this process as a singular expression of a universal power of dynamic equilibrium.

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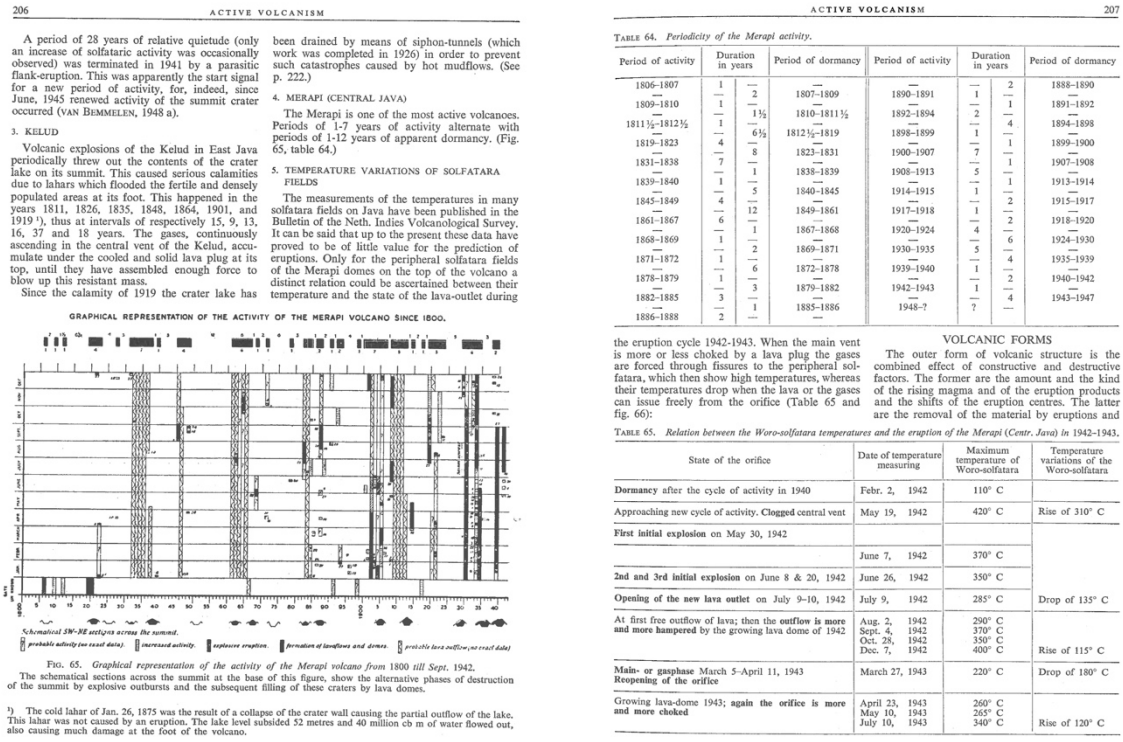
[198] Bemmelen, 1949, p. IX.
[199] Bemmelen, 1949, p. 223.

Volume 1 of the *Geology* is an analysis of geological dynamics, Volume 2 is about the geology of resources. That this was the division of the two books indicates how understanding geological mechanisms and volcanic action was combined with the economic project of resource extraction of the colonial system. Before the Japanese occupation, he had participated in experiments seeking out possibilities for harnessing energy from volcanoes by means of low pressure turbines; "even the menacing volcanic energy might be used in some favourable instances", he wrote.[200] He also wrote in the *Geology* of how capitalism in the colonies –resource and plantation based, was cruelly dependent upon the devastating force of volcanic action. He writes that "Abundant rainfall is the cause of continually increasing impoverishment of the soil. The only regeneration of the soil that spells radical improvement is that produced by volcanoes. Without active volcanoes the future can only mean retrogression."[201] The tendency in the Indies, he argued, is towards barrenness and desertification and without the force of volcanic action, Java could no longer play its role as plantation to the world.[202] This necessary destruction – annihilation for the purpose of life, made the economic prosperity of the colonial system inseparable from the destructive forces which set it in motion.

This idea of the creative destruction of economic and material orders finds a temporal expression in the *Geology* worked out in the terms of 'dynamic equilibrium' in which nature is guided by temporal loops of differing lengths that originate in the primal disequilibrium that sets the process of earth formation in motion. These cycles intersect with each other and the formation of volcanoes and mountain chains are their visible, material expression. The material world is an assemblage of pressures and releases, sinking and rising, according to these temporal loops. He argues that the entire process is striving towards a return to its original state, an equilibrium that has long been lost. Creation and destruction is the very engine of the colonial system, it is not an issue of escaping it but of *fitting* with it, of figuring out how to be there, on a volcano, while being impermanent. Rudolf Mrazek writes of this moment in Dutch colonialism in the Indies that the problem was how to fit in a place when presence in that place was never certain to last.[203] Van Bemmelen's notion of the interior was an implicit acknowledgement that it created a unique network and community around it to

[200] Bemmelen, 1949, p. 224.
[201] He is here citing Mohr from 1938, p.254, on p. 224 of *The Geology*.
[202] For an extended discussion of ideas of desertification, see Povinelli, 2016.
[203] Mrázek, 2002.

make it present, but that it also threatened their annihilation. This was a network that was formed through the very possibility of the erasure of that network.



206 ACTIVE VOLCANISM

A period of 28 years of relative quietude (only an increase of solfataric activity was occasionally observed) was terminated in 1941 by a parasitic flank-eruption. This was apparently the start signal for a new period of activity, for, indeed, since June, 1945 renewed activity of the summit crater occurred (VAN BEMMELEN, 1948 a).

3. KELUD

Volcanic explosions of the Kelud in East Java periodically threw out the contents of the crater lake on its summit. This caused serious calamities due to lahars which flooded the fertile and densely populated areas at its foot. This happened in the years 1811, 1826, 1835, 1848, 1864, 1901, and 1919 [1]), thus at intervals of respectively 15, 9, 13, 16, 37 and 18 years. The gases, continuously ascending in the central vent of the Kelud, accumulate under the cooled and solid lava plug at its top, until they have assembled enough force to blow up this resistant mass.

Since the calamity of 1919 the crater lake has been drained by means of siphon-tunnels (which work was completed in 1926) in order to prevent such catastrophes caused by hot mudflows. (See p. 222.)

4. MERAPI (CENTRAL JAVA)

The Merapi is one of the most active volcanoes. Periods of 1-7 years of activity alternate with periods of 1-12 years of apparent dormancy. (Fig. 65, table 64.)

5. TEMPERATURE VARIATIONS OF SOLFATARA FIELDS

The measurements of the temperatures in many solfatara fields on Java have been published in the Bulletin of the Neth. Indies Volcanological Survey. It can be said that up to the present these data have proved to be of little value for the prediction of eruptions. Only for the peripheral solfatara fields of the Merapi domes on the top of the volcano a distinct relation could be ascertained between their temperature and the state of the lava-outlet during

GRAPHICAL REPRESENTATION OF THE ACTIVITY OF THE MERAPI VOLCANO SINCE 1800.

Schematical SW-NE section across the summit.

probable activity (no exact data). increased activity. explosive eruption. formation of lavaflows and domes. probable lava-outflow (no exact data)

FIG. 65. *Graphical representation of the activity of the Merapi volcano from* 1800 *till Sept.* 1942.
The schematical sections across the summit at the base of this figure, show the alternative phases of destruction of the summit by explosive outbursts and the subsequent filling of these craters by lava domes.

[1]) The cold lahar of Jan. 26, 1875 was the result of a collapse of the crater wall causing the partial outflow of the lake. This lahar was not caused by an eruption. The lake level subsided 52 metres and 40 million cb m of water flowed out, also causing much damage at the foot of the volcano.

ACTIVE VOLCANISM 207

TABLE 64. *Periodicity of the Merapi activity.*

Period of activity	Duration in years		Period of dormancy	Period of activity	Duration in years		Period of dormancy
1806–1807	1	—	—	—	2		1888–1890
—	—	2	1807–1809	1890–1891	1	—	—
1809–1810	1	—	—	—	—	1	1891–1892
—	—	1½	1810–1811½	1892–1894	2	—	—
1811½–1812½	1	—	—	—	—	4	1894–1898
—	—	6½	1812½–1819	1898–1899	1	—	—
1819–1823	4	—	—	—	—	1	1899–1900
—	—	8	1823–1831	1900–1907	7	—	—
1831–1838	7	—	—	—	—	1	1907–1908
—	—	1	1838–1839	1908–1913	5	—	—
1839–1840	1	—	—	—	—	1	1913–1914
—	—	5	1840–1845	1914–1915	1	—	—
1845–1849	4	—	—	—	—	2	1915–1917
—	—	12	1849–1861	1917–1918	1	—	—
1861–1867	6	—	—	—	—	2	1918–1920
—	—	1	1867–1868	1920–1924	4	—	—
1868–1869	1	—	—	—	—	6	1924–1930
—	—	2	1869–1871	1930–1935	5	—	—
1871–1872	1	—	—	—	—	4	1935–1939
—	—	6	1872–1878	1939–1940	1	—	—
1878–1879	1	—	—	—	—	2	1940–1942
—	—	3	1879–1882	1942–1943	1	—	—
1882–1885	3	—	—	—	—	4	1943–1947
—	—	1	1885–1886	1948–?	?	—	
1886–1888	2	—	—				

the eruption cycle 1942-1943. When the main vent is more or less choked by a lava plug the gases are forced through fissures to the peripheral solfatara, which then show high temperatures, whereas their temperatures drop when the lava or the gases can issue freely from the orifice (Table 65 and fig. 66):

VOLCANIC FORMS

The outer form of volcanic structure is the combined effect of constructive and destructive factors. The former are the amount and the kind of the rising magma and of the eruption products and the shifts of the eruption centres. The latter are the removal of the material by eruptions and

TABLE 65. *Relation between the Woro-solfatara temperatures and the eruption of the Merapi (Centr. Java) in* 1942–1943.

State of the orifice	Date of temperature measuring	Maximum temperature of Woro-solfatara	Temperature variations of the Woro-solfatara
Dormancy after the cycle of activity in 1940	Febr. 2, 1942	110° C	
Approaching new cycle of activity. **Clogged** central vent	May 19, 1942	420° C	Rise of 310° C
First initial explosion on May 30, 1942			
	June 7, 1942	370° C	
2nd and 3rd initial explosion on June 8 & 20, 1942	June 26, 1942	350° C	
Opening of the new lava outlet on July 9–10, 1942	July 9, 1942	285° C	Drop of 135° C
At first free outflow of lava; then the **outflow is more and more hampered** by the growing lava dome of 1942	Aug. 2, 1942 Sept. 4, 1942 Oct. 28, 1942 Dec. 7, 1942	290° C 370° C 350° C 400° C	Rise of 115° C
Main- or gasphase March 5–April 11, 1943 **Reopening of the orifice**	March 27, 1943	220° C	Drop of 180° C
Growing lava-dome 1943; **again the orifice is more and more choked**	April 23, 1943 May 10, 1943 July 10, 1943	260° C 265° C 340° C	Rise of 120° C

Figure 7. Van Bemmelen, *The Geology of Indonesia vol. 1*. page spread 206 to 207 demonstrating the juxtaposition of different standards of representing time in a single space.

Van Bemmelen used all of the tools at his disposal to create a book that relentlessly juxtaposed serialised tables of recorded data,[204] planometric projections, transects, photographs, and axonometric drawings, with sectional techniques, and prose descriptions (*figure* 7). This complexity comes across in a highly modernist tone because of the velocity of its fragmentation and the relationships that emerge between the pieces. On the page spread in figure 1, dedicated to Merapi, Van Bemmelen introduces the volcano through a claim about the periodicity of its eruptions: "The Merapi is one of the most active volcanoes. Periods of 1-7 years of activity alternate with periods of 1-12 years of apparent dormancy".[205]

Inserted in the text is a table that lists periods of activity and dormancy drawn from written records from 1806 to 1948 and a table that compares solfatara measurements from around the caldera and the "state of the orifice". He includes a remarkable diagram (*figure 8*) which is cinematic in its capture of time through the layering of segments of the "alternative

[204] Hopwood, Schaffer and Secord, 2010.
[205] Bemmelen, 1949, pg. 206

phases of destruction of the summit by explosive outbursts and the subsequent filling of these craters by lava domes."[206] Within a single diagram he compresses one-hundred and forty-five years. As we read along the horizontal axis, the filling and emptying of the crater is animated in section, while the types of action (probable lava flows, formation of lava flows, and domes, explosive eruption, and activity level) is notated by the simple differences in hatch patterns. This radical reduction of space (the actual scale of the volcano) and time (145 years) sets in motion the temporality of the diagram with a cinematic animation of the volcano laid out on the page. It is also meant to be read in comparison with the serialized tables on the facing pages. Each table can stand on their own or be read laterally from one to the other and back into the prose of the text.

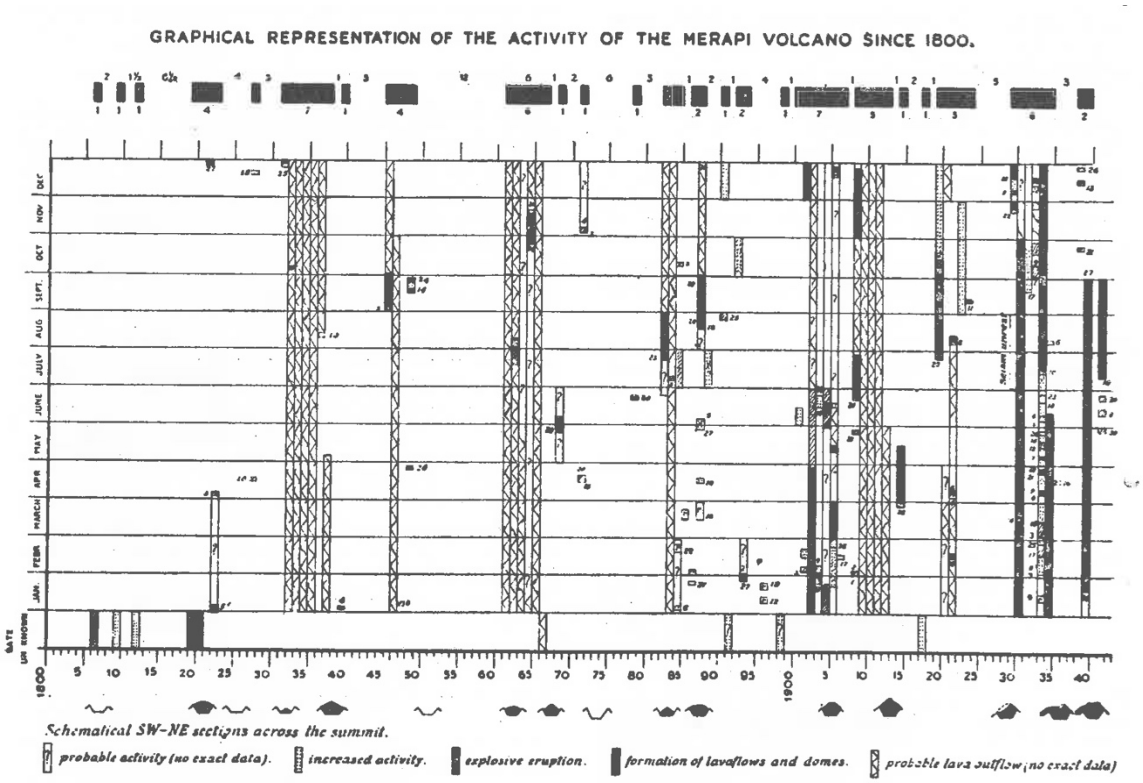


FIG. 65. *Graphical representation of the activity of the Merapi volcano from* 1800 *till Sept.* 1942.
The schematical sections across the summit at the base of this figure, show the alternative phases of destruction of the summit by explosive outbursts and the subsequent filling of these craters by lava domes.

Figure 8. Detail of Figure 1, page 206, *The Geology of Indonesia.*

Standard, serialized time is crucial to holding this multiplicity of perspectives together. What he is intersecting on the pages to achieve that effect is a linear temporality and spatiality and cinematic view that zooms, speeds up and slows down the passage of time and movement through space. The book, for Van Bemmelen, is a time and space machine that

[206] Bemmelen, 1949, pg. 206.

sets up juxtapositions of standards beside each other in a way to suggest, and point towards a causality that could unify all of the parts into a whole.

If this spread is combined with two corresponding maps from Volume 1B, the spatiality and temporality of the narrative is pushed further still. In the 'Geological Sketch map of the Surakarta Area in East Java' (*figure 9*) Van Bemmelen shows the territory stretching from the Indian Ocean to the Java Sea in the north, an area that includes Merapi and surrounding towns. Its goal is to show the superficial geological trends and faults between them. He uses a system of hatches to call out the different rock types and patterns of dashes and lines for the faults between them. He also calls out towns in a crude way to fix scale and orientation. No topographical information is shown, only material composition. Merapi is a blotch, bisected by four fault lines and described as a "young volcano".

In 'The Orogenic Evolution of East Java' (*figure 10*), Van Bemmelen represents the formation of a section of what is represented in the plan of "Geological Sketch map of the Surakarta Area in East Java" since the Eocene (40 million years ago) to the Holocene (roughly 11,000 years ago to the present—the term was proposed in the 1860s). He accomplishes this compression serially through snap-shot sections along an axis through the plan. It speculates the land in the Eocene was flat and composed of two types of material. Over time, these materials depress into an irregular topography until there is an intrusion of magma which magnifies the differentiation of the surface. The overwhelming force shaping this surface is vertical, pushing up while depressing and creating torsional horizontal forces of mass displacement and different material compositions against each other. These forces are taken into account by his drawing as the formation of new materials. The volcanoes represented in the sections (now dormant volcanoes Wanajasa and Karangkobar to the west of Merapi) are crucial engines in this material differentiation from simple to complex. This simple to complex structure governs the development of mountain orogeny and is characterised by a narrative that is highly theological in its structure:[207] In the beginning is a sameness into which a difference is added to generate complexity, which in turn generates new dynamics of harmony and dissonance while within dissonances are nested harmonies. This was the law of nature, Van Bemmelen argued and he stated his idea in this way in a 1957 essay:

> "In the past twenty-five years the author has tried to pursue this […]. The basic assumption is that all geological processes are the result of a general strife for equilibrium, and that they are accompanied by readjustments of the distribution of

[207] Van Bemmelen was not alone in adopting theological narrative structures into geological science. See also, Rudwick, 2010, on the theological structure of geological arguments.

matter with its associated forms of energy (nuclear, chemical, thermal, gravitational)."[208]

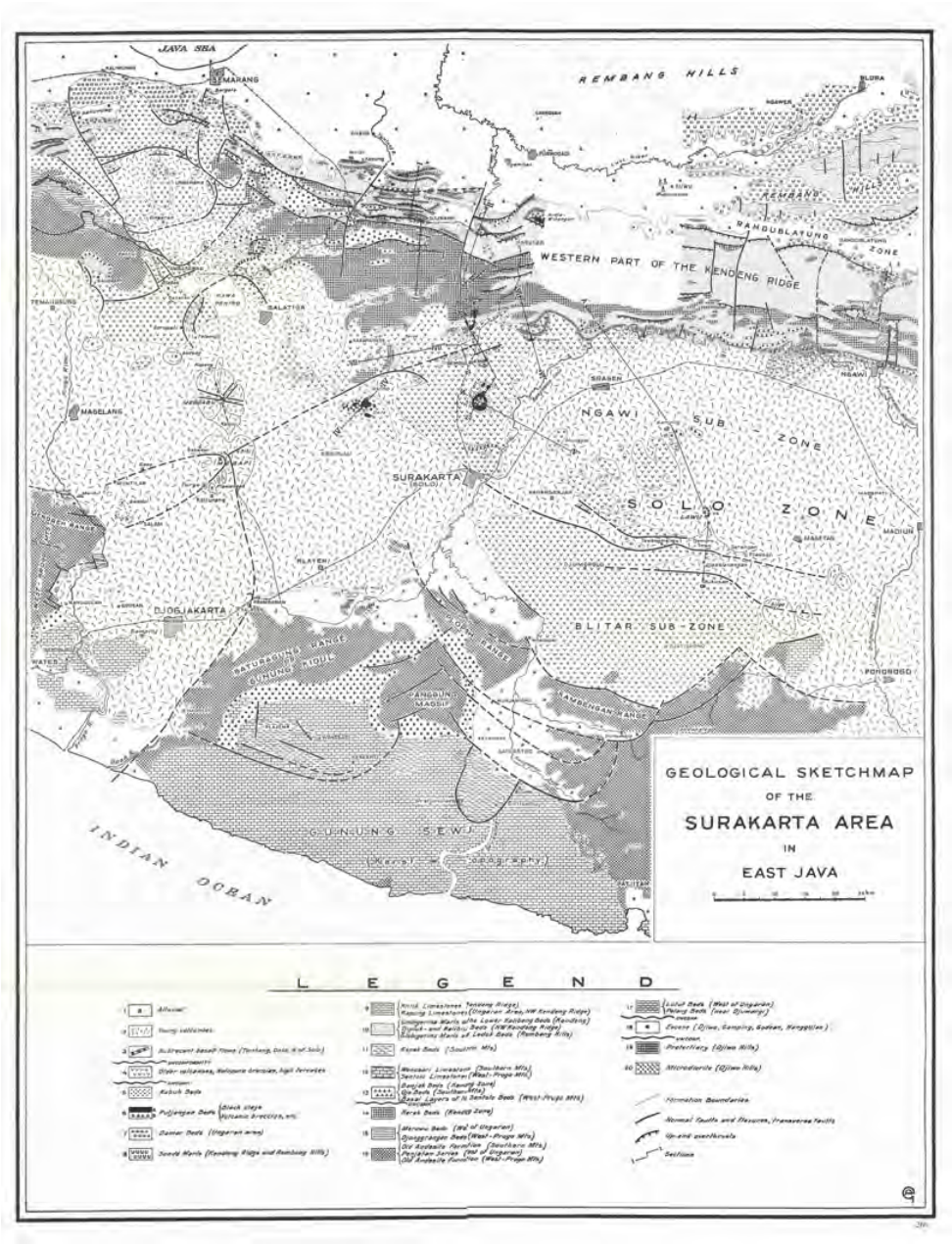


Figure 9. 'Geological Sketch map of the Surakarta Area in East Java' (plate 268)

Van Bemmelen's representational practices of intersecting, overlapping, and collaged times sought to produce a picture of this constantly shifting play of harmony and dissonance in order to close the gap between the present and future. It would do so by making the patterns of repetition that governed geological forces visible within the materiality of the landscape. But this visibility was achieved by applying the standards of spatial and temporal

[208] R.W. Van Bemmelen, 1957, pg. 2. Publisher and location unknown, accessed at the Geological Library Bandung.

measurement that governed the production of representations we find in publications like the *Bulletin* and of which Bemmelen's book freely draws upon and reproduces. These were also combined with cinematic serialization that would allow a progression of shifting views from above as well as inside the geology that was not so commonly found in the *Bulletin's*. The once distant interior was now on the outside and moving within the pages of the *Geology*. The combination of standard practices of representation facilitated this roving eye that sees the formation of Java in hyper-speed and slowed down to the scale of geological epochs, cutting land away to see the interior of the volcano, and then suddenly shifting to an aerial view.

The irony is that what that eye discovers in Merapi are more standards: the temporal loops of eruption and quietude that guide mountain building are in themselves standards that if Van Bemmelen could discern their pattern he could get ahead of the menace. He was searching for a universal law of repetition that could, if it were ever achievable, resolve the uncertainty of the scourge of destruction. In this we can see the logic of early hazard mitigation on Merapi: a choreography of people and property with the menace which those people and property rely on for their sustenance and productivity. The *Geology*, while a time making machine, is also a machine to be used to choreograph the colony with the volcano. Like his other work with the observatory, such as work on the monthly *Bulletins* to be sent back to observatories and scientific institutions in the old world, the *Geology* was meant to move, to be put in motion, compared with the results and ideas of other places, to be a piece that could plug into, chafe against, or agree with the work of other volcano scientists. The project was to set this work in motion along the chains of international volcano science and its representations in order to discern the laws governing volcanic action.

Van Bemmelen's work on Merapi and with the Volcanological Survey was crucial because of the way that it tried to resolve the problem set out by Wing Easton as the key problem of forecasting: the causal relationship between visible, and sensible exteriors, and the hidden interior. The scourge of the menace cannot be avoided, it is rather to be coordinated with. This coordination needs to operate within the rhythms and according to the varying degrees with which those rhythms are repetitions of the same or of difference, dynamic or static. The power of the forecasting system is to bring the interior to the exterior and set it in motion, and to breathe temporality into it through representation. He brought together the mass of representations coming out of the observatories, fieldtrips and surveys, but the work of synthesis was actually accomplished through the addition of temporality to the static image in book form. Seeing Merapi in time in the spread of the book was a way to

prepare to see Merapi in time in the observatory. In other words, the standards of scientific representation came to inform the conception of the interior as governed by standards of repeatable and repeating action. Standard procedures for representing the world became also the conception of what the world is, even for such a volatile entity as a volcano.

Moreover, the capacity to hold the internal dynamics of Merapi in a book in your hands overcomes the physical problem of the volcano. It becomes a living artefact and a key actor in the forecasting network, because not only does it operate between the observatory, its instruments and communication systems, it operates also through the book. Forecasting after this can operate between the book, observatory, and volcano. It becomes a model and the function of the model is to coordinate between disparate scales and spaces, to entangle them with each other. What before could not be accessed is now not only accessible in the hands of the forecaster it is also vibrant and changing with time.

This is a key moment in the trajectory of forecasting systems, when they go from the diagnosis of a missing centre to the proliferation of that centre at a distance. Through representations, and the assemblage of those representations in model form, in turn become key actors in reorganising the forecasting system. Everything else afterwards refers back to the model, and eruptions become examples or exceptions to the model. Forecasting then becomes simultaneously the forecasting of the validity of the model.

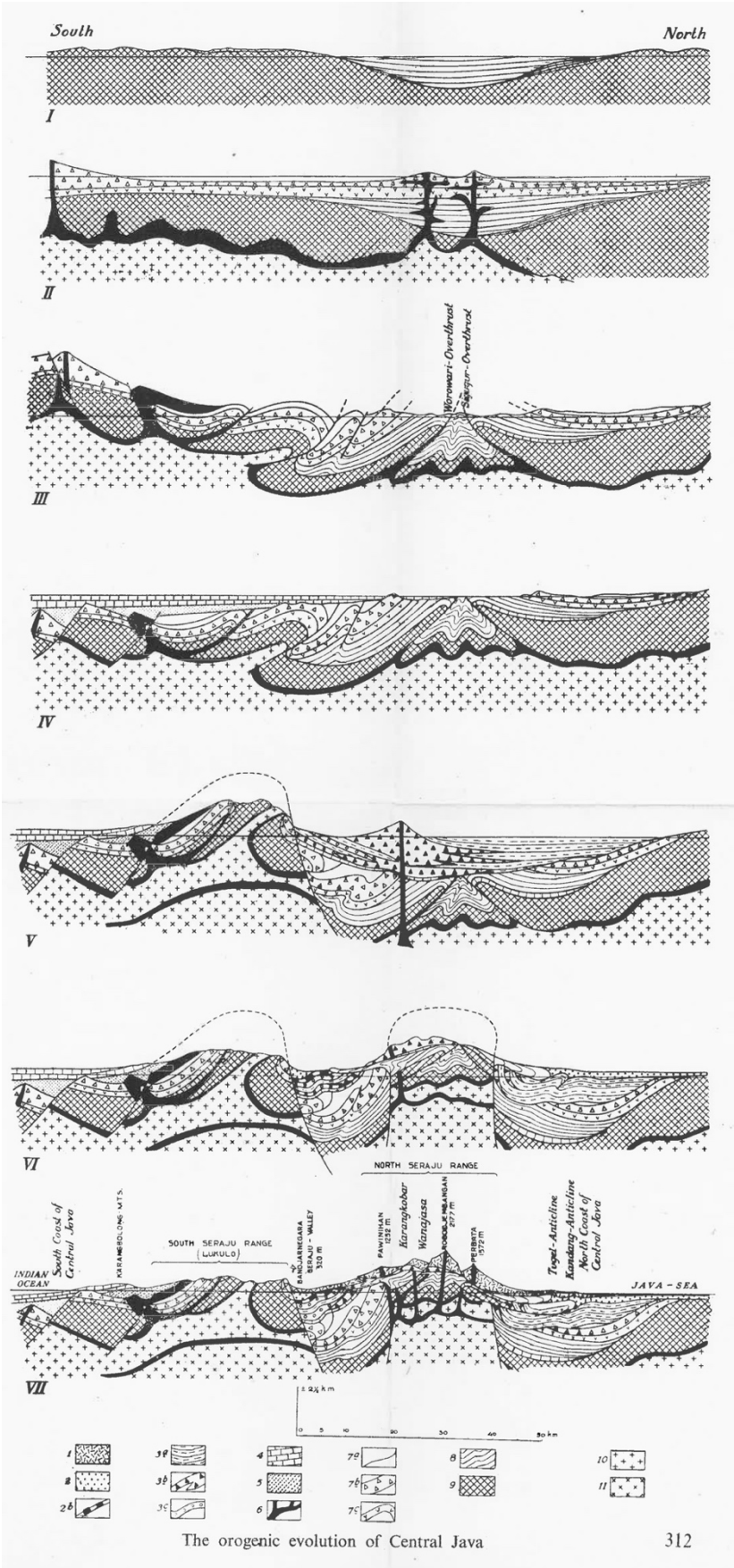


Figure 10. Orogenic Evolution of Central Java, Van Bemmelen, *The Geology of Indonesia, vol. 1B, p. 312.*

The Dome

The legacy of this turn to the interior continues in the much more recent history of the DOMerapi scientific project based out of the Merapi observatory. It was a two year collaborative project between (mainly) French national scientists and Indonesian scientists. Its intention was to better understand the dome of Merapi, the giant, building sized rock plug in the caldera that seals shut the lava conduit below. The principle investigator of the project was geophysicist Jean-Philippe Metaxian. He explained to me that the project was established because there was still very little understanding of how the dome actually worked. The state of the art at that time was that the dome was understood to expand as material was injected into it from below until it couldn't hold its own weight anymore or a fissure opened from inside and parts of it would collapse in on itself. It could also be destabilised by earthquakes produced by lava moving inside the conduit. When this happened, it often exploded and ejected massive pyroclastic flows, the searing hot clouds at hundreds of degrees, rolling down the side of the volcano and exploding trees, animals and houses. The dome played essential functions in eruption life-spans but it was not so well understood how, even after almost a century since Wing Easton announced the birth of permanent monitoring. Metaxian's team would try to understand it through the intersecting dynamics of hidden processes such as the hydrothermal system (the interior dynamics of heat flowing around the interior) and seismicity; the fluid dynamics of lava viscosity within the conduit; the dynamics of the chamber (the giant reservoir of magma that sits below the mountain) and which builds until it ejects material upwards.[209]

Over two years, the project created a revolving door of international scientists in Bandung and Yogyakarta who set up a laboratory inside the observatory, collaborated with Indonesian scientists and produced another surplus of representations and formed a focused community around the dome. They would bring new technologies and techniques and would train young Indonesian scientists in new data gathering methods. The French were required to share all of their data with the Indonesians as well as present monthly reports.

The funding for the project came from French state money, the Agence Nationale de la Recherche (ANR), and the Centre National de la Recherche Scientifique (CNRS), an institutional arrangement that has been in place between French volcano scientists, Indonesia

[209]When I began interviewing scientists on the team, their estimates about the distance of the chamber below ground were so different from each other that some said it was ten kilometres inside the volcano and others suggested almost three times that much. The dome was the visible, outward effect of a still distant and misunderstood interior.

and Indonesian scientists since the 1980s Mitterrand government. This project is built on the long history of international institutional networks between France and Indonesia that include the ANR and CNRS as well as French universities which, since the 1980s have offered scholarships to Indonesians wanting to study volcano science. According to Metaxian, these networks were forged and remained relatively secure because Indonesia is a laboratory for France. It has so many permanently active and populated volcanoes whereas France's volcanoes in the West Indies and overseas territories are rarely active though potentially very dangerous. The interior of Merapi, in this project, became a substitute for the interior of Pelee in Martinique, Piton de la Fournaise in Réunion Island, and Soufrière in Guadeloupe. The frequency of eruptions on Merapi gave the French scientists a way to test new modelling tools, and seismological sensors, which could then be potentially deployed in volcano observatories in their overseas territories. Many of the scientists who worked as part of DOMerapi were circulating over the period of the three year project between Merapi, France, its overseas territories, or other European volcanoes, bringing instruments, holding meetings, seminars, and writing papers.

Explicating the dome turned into a production and distribution of more representations throughout these networks of expertise, travel and instruments. New seismic stations were built around the caldera to increase the seismic data coming from inside. These small assemblages of solar panels, global positioning systems, and seismic sensors were installed at different strategic points on the outside of the dome. Scientists undertook constant fieldtrips from the observatory to the caldera. Antoine Laurin, an engineer and technician, typically undertook a field trip to the summit once a month to take care of instruments. Svetlana Byrdina, who we will meet again in the final chapter, undertook fieldtrips to measure CO2 emissions, fix seismograph stations and conduct experiments on subsurface activity. There was a surplus of representations of the hidden interiors that were networked into global circulation patterns of images and text. Byrdina, for example, in addition to presenting her findings on subsurface geothermal systems to the lead scientists in the observatory, published two papers in international volcano science journals based on the same image.

The dome became, again, more "informationally rich" through the distribution of representations and their multiplication, the gathering of scientists around them, their own transformation of representations into new forms, such as adding the results of Svetlana's experiments to other published papers, or referencing the dome modelling practices of Karim Kelfoun. Getting to the interior actually means building networks of communities,

establishing a shared matter of concern and investment that was ultimately facilitated through the long temporal and distant spatial networks of institutions – French and Indonesian diplomacy – reaching back to Wing Easton's diagnosis that there was an interior that needed to be made present.[210]

What was different about DOMerapi though was that they had begun to emphasize that what governed Merapi were non-linear and chaotic systems. The conventional representation of magma moving below, cracking the dome, and the dome then exploding may be a flawed conception. In its place, they were considering how these processes could be related in a much more complex way to each other on divergent temporal scales and in chaotic processes. This would then mean a departure from the traditional, modern, linear models of forecasting. It was beginning to develop a different logic of standardisation that was breaking from the modern convention.

What I explore in the rest of this chapter, in a brief way, is how forecasting might be conceived non-linearly. I also want to stress, based on this chapter, the inseparability of representation and practice, that the building of standards of representation is inseparable from projecting a world that accords with those standards. The opening of a non-linear model of volcanic action is also the opening of a non-linear way of forecasting.

Toward an Imaginary of Cracked Objects

Van Bemmelen's manuscript disappeared into the ruptured history of the colony, passed between unknown hands, and perhaps it is on a bookshelf somewhere. As much as the movements of scientists followed stable, repetitive trajectories from Bandung to Yogyakarta, and Merapi and back, choreographing the volcano with its modernising infrastructure, plantations and subjects, these trajectories were interrupted by the time of occupation, revolution, and its upheaval. These interruptions are the cracks in the construction of standardisation. Slinking below the legibility of temporal cycles, these cracks are the edge of the page, its columns, diagrams and drawings, in the movement of the book from desk to printer, and the hand-off between Van Bemmelen and his assistant at the dawn of the Japanese occupation.

An image that encapsulates this point is from an obsolete photo album that was buried in the depths of a dark cabinet in the archive of the observatory in Yogyakarta in 2015. *Lava Dome Photo's Merapi* (*figure 11*) contains photos from the years 1989-91 from expeditions

[210] Shapin, 1989; B. Latour, *Pandora's Hope: essays on the reality of science studies*, 1999.

to the dome. It worked according to the same serial, linear temporal logic as the *Geology*, each page was a different spread of photos of the lava dome that progressed forwards in time, the spreads were date stamped. What was unique about it and why it helps us understand the cracks of standardization was its status as a forgotten object in a state of decay. Rather than functioning as a time-image of the transformations of the morphology of the dome, the material composition of the book itself was foregrounded. Its capacity as an object to disappear behind its reference to the lava dome was weak–it chaffed against the brittle, yellowing tape that held the pictures together, and in some cases had dissolved completely to let the photographs hang precariously from the pages. Photographs in some of the series' had fallen out, leaving a white gap in the image. The panorama's had been taken in a sequence of snapshots and were governed by a serial progressive movement from page to page. But what was visible was the fragility of the seriality as it relied on these material compositions that were in themselves brittle, recomposing into other arrangements – into dust.

The book machine on the edge of failure allows us to see the architecture of temporality in construction. It operates just below the level at which referentiality takes off. It would be like receiving a copy of the *Geology* at the printers with all of the diagrams and drawings laid out to meet the specifications of the printers plates. Or, I like to think, it is the state of the *Geology* when Van Bemmelen handed it off to his assistant: I imagine it a case stuffed with pages, inscribed with different mediums – ink, cut out diagrams from other publications, roto-printing on carbon paper, glue, and metal clips. The crucial point of thinking time as movement and movement as time is not just that things fall apart and decay, but that materials have their unique life spans which they maintain even if they are assembled with other materials. The book can become a referencing machine, as Van Bemmelen wanted, it can work to create a Merapi governed by long cycles of eruption and quiet, and this vision can move through networks of scientific expertise, but a photo album picture of Merapi shows us that that machine is made up of fragile parts not reducible to the whole. This is the meaning of the *Geology* going missing and Van Bemmelen having to recompose it, recompile the base data, and reorder the field study results he had been working with, to recreate the machine in time and movement.

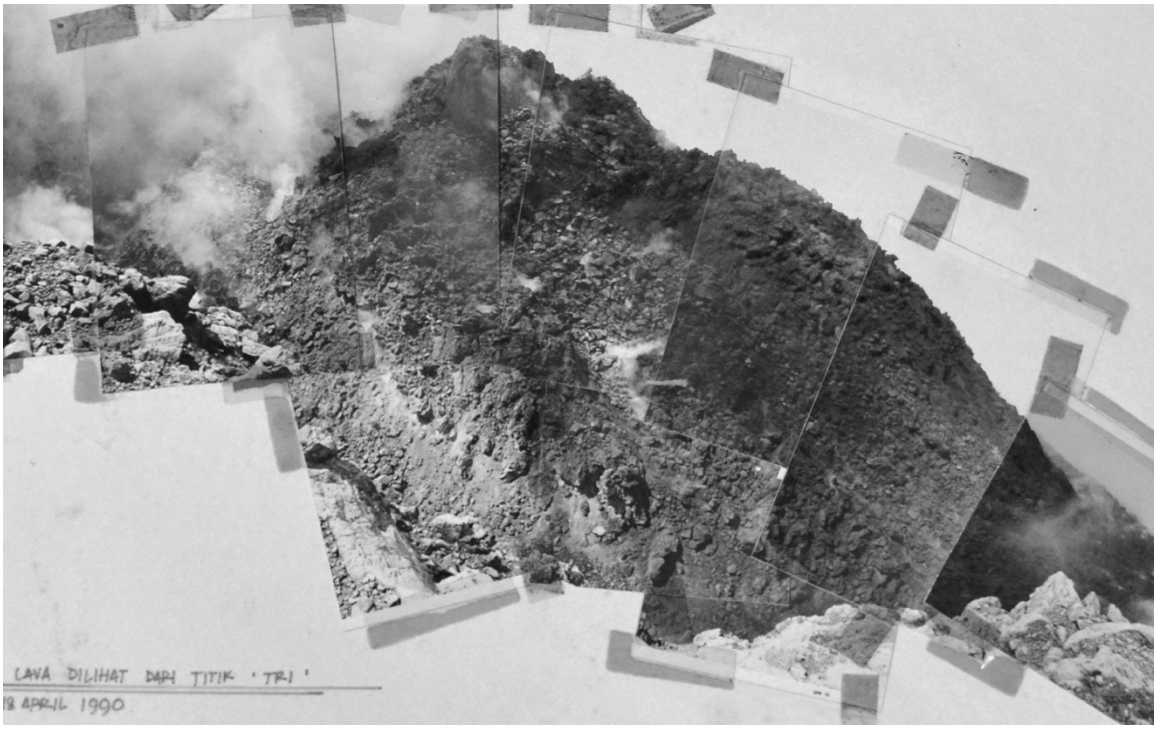


Figure 11. Photo album, *Lava Dome Photo's Merapi*, "The lava dome seen from 'Tri', 18, April, 1990

Standardisation seeks for an all-seeing, disembodied perspective to overcome these fragile intersections and material vulnerabilities. But from the vantage of this forgotten, rotting scrap book, Merapi is not a unified single object – there are no bands of repetition and eruption which govern it – but a non-linear composition of time-movement relations. This means that it cannot be separated not only from the representations that circulate it but those representations' vulnerability and tendency to fracture, dislodge, and disappear. The time-movement machines of representations, whether books or more contemporary forms of data representation are vulnerable to material decomposition just as they are to the shifting interests of librarians, the carrying capacities of library buildings, and the shifting machinations of politics that can erupt in revolutions or civil war.

Forecasting is not at all about watching Merapi and then linearly distributing information. It is about the production of representations and objects multiplying them while trying to stabilise, materialise, and localise what can't be experienced by scientists. In the process, it subjects its representations, models and objects to unpredictable material consequences, to a fragile world of disappearance. Our grasping of objects as objects, with the allure of their completeness and wholeness, is only ever as complete as this discarded picture book.[211] The standardization of Merapi and of scientific practice contained the desire

[211] W. Connolly, *The Fragility of Things,* 2013.

to overcome this fragility but in that project created new instances of material fragility, missing books, decaying photographs, the exile of scientists in war. It is at these intersections of representation and practice, or the practice of standardisation itself that forecasting science needs to attend to. If we are to better equip ourselves to understand these non-linear intersections the results would look like a science of intersections.

The linear model of forecasting has consistently fallen for the lure of the modern constitution, the notion that nature is separate from society and the role of science is to probe into that nature and bring its results back to society. The scientists in the observatory often insist on this function even though if they study their own practice they understand that it is not the case. The stories of standardisation here go a way towards this demonstration that volcano science and its forecasting have never been modern and that volatile nature forecasting is wrapped up in complex ways with practice, representation and knowledge. This *a*modern account of forecasting science aims to provide a language with which to describe this fragility by positioning standardization as both an injunction to practice and a project of producing particular kinds of entities in the world.

This practice however operates amongst a thick tapestry of practices and traditions which volcano scientists do not sufficiently comprehend. Practices of standardisation such as the linear model of forecasting have so shaped modernist volatile nature forecasting that it has become a project of imposing its world and forcibly enlisting others to participate in it. This is the call of modernisation and it informs practices of scientific nature forecasting, and has crucially shaped the science of forecasting on Merapi. What I propose in the next chapter is to understand a fault line directly beneath the project of scientific modernisation on Merapi. I argue that animism and shamanic practices of spirit possession are this fault line. They are resisting the injunction to a modernist politics of nature through *a*modern practices of forecasting.

Chapter 6

Cosmological Reason

Geography and Ontology

This chapter is about how people living on Merapi have developed concepts which facilitate their capacity to live in a volatile environment. Cosmological reason is the name I give to this process and one of its consequences, which I explore here, is that metaphysics is geographically contingent. *Kejawen* is the body of thought that I study in this chapter and it is the thought that is most commonly associated with Central Javanese animism and people who live on the slopes of Merapi.

In *Kejawen* cosmology there is an ontological distinction between beings that are from the upper slopes of the volcano and beings from the lowland. Within these parameters, up-landers are in a zone of exchangeability with the many beings of the volcano. Spirits and ghosts pass between and communicate between people and the volcano. Lowland beings, however, are conditioned by the state, monotheism, and modernist science. Ontology, in the sense of what *is* in *Kejawen* worlding, I suggest here, is structured in part by this upland and lowland distinction and it is the driver of conflict and tension between upland practitioners of *Kejawen* and lowland volcano scientists seeking to impose modernist notions of risk and hazard mitigation. As I argue, *Kejawen* develops a metaphysics which is adequate to living in an active, tumultuous, and radically unpredictable landscape. Lowland monotheist and mononaturalist science has been unable to adequately comprehend this distinction and this has resulted in a legacy of modernising incursions along the flanks.

The second dimension of my argument here is that the geographic and ontological distinction between upland and lowland is conditioned by time. The struggles between lowland scientists and upland *Kejawen* practices are defined by this struggle over the meaning of the future of nature and how to craft a life within uncertainty. As with the preceding chapters of this dissertation, I demonstrate this through an attentiveness to practices but here it is of volcano scientists and *Kejawen* shamans. I also show how these ontological distinctions are enmeshed with and enacted by technologies and infrastructures.

Constitutional Monotheism and Polytheist Futures

The 1945 draft of the Indonesian constitution states that one of the five principles (*sila*) of the Republic is the belief in "One Almighty God" (*Tuhan yang Maha Esa*).[212] This monotheist cosmology etched into the founding document of the state an explicit disavowal of the syncretic animist practices that flourished throughout the archipelago at the time. With active civil society organisations of animists, polytheists, and mystics, recognized since the late 19th century by the Dutch colonial authorities as "traditional" (*adat*) indigenous belief systems, this founding gesture excluded multi- and otherwise complexly-theistic Hindus, Buddhists and Confucians, and the various strands of syncretic Islam's (such as pagan dimensions of Sunnism) some of which had long hybridized with the animist kingdoms of central Java and Sumatra.[213]

Kejawen, an animist, Islamic metaphysics with magic, witchcraft, and shamanic dimensions, in addition to influences from the Javanese sultanates, was one of those practices that was directly under attack by the draft constitution read by Sukarno in 1945. In that early republican period, "modernist" Muslims in Jakarta sought to combine monotheism and political power and *Kejawen* has since been at the margin of official religious practices. It does, however, continue to exert a powerful role in the imaginary.[214] Influential politicians, for example, consult with *Kejawen* magicians, *Kejawen* shamans have had their expert testimony of witnessing magical forces admitted in high profile court cases, they appear on television soap operas, even as spokes people for health drinks.[215] Liberal, modernist, cosmopolitan Muslims in Jakarta will sometimes call on a *Kejawen* shaman to manage the rain if there is an outdoor concert or wedding.[216]

The Indonesian state civil servants, however, project a modern and pious Islam.[217] Government offices, state scientific laboratories, hazard observatories, and outposts across

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[212] The story of official religions in Indonesia is more complex than this. Confucianism, for example, was removed then re-added to the constitution in response to the ebbs and flows of racist hatred against so-called "ethnic Chinese" Indonesians. See, Ananta, 2015 on how the list of official and unofficial religions has changed over time.

[213] See the canonical literature on Javanese power, Benedict O.G. Anderson, "The Idea of Power in Javanese Culture," 1972; James T. Siegel, *Naming the Witch*, 2006; James T. Siegel, *Solo in the New Order,* 1986; Tarling, *Cambridge History of South East Asia vols. 1-2.,*1992. Also, Mark R. Woodward, *Islam in Java: Normative Piety and Mysticism in the Sultanate of Yogyakarta*, 1989, pp. 53-79, 149-199; and, Woodward, *Java, Indonesia and Islam,* 2011; and, Clifford Geertz *The Religion of Java*, 1976.

[214] Woodward, 2011.

[215] In 2015, there was a court case in Jakarta in which a "magic stone" was admitted as evidence in a paedophilia show trial.

[216] In Geertz's cannonical taxonomy of Indonesian Islam, these liberal, urban Muslims would be a variation of "Abangan".

[217] 87.5% of Indonesians were Muslim identifying in 2010, and Java ranges from 75%--95% Muslim majority by population. See: Ananta, 2015.

Java reflect this in the musalla inside of them.[218] In Yogyakarta, for example, the volcano observatory and outposts that face Mt. Merapi volcano, have a musalla that inscribes within the architecture of the observatory a geographic orientation to Mecca. This orientation is reflected in other ways too. Budi Santoso, the second in command to I Gusti Made Agung Nandaka, the Head of the Observatory, dresses, as Caecil Nindya Hapsari, a Catholic in her late twenties put it, in "very peasantren style", referring to the popular Islamic boarding schools that he appeared to have just graduated from because of his "Arab" mode of dress – long beard, white collared short-sleeve shirt and black pants that stop above the ankle. In the same observatory, women office workers and scientists wear headscarves underneath their military-style, civil service vests and hats.

The dangerous, upper western slopes of Merapi, however, look different from this Republican state style. The area called Dukun, a historical nuisance to state presence because it is difficult to get to, far away, poor, and in a centuries old line of fire for superheated gas clouds, mudslides, forest fires, and lava tongues, is predominantly Muslim too but at the contested front line of state monotheism. Villagers drawn to monotheism are negotiating the appeal to a sense of participating in a shared urban, national, and international project in which become urban and cosmopolitan often means performing the contemporary script of Islamic monotheistic piety and denouncing the practices associated with animist, pagan, and syncretic metaphysics. The performance of piety, such as going to Mosque regularly, diligently observing the fasts, or wearing clothes like they wear in the telenovelas (the most popular in 2015 were Turkish productions) are ways that bodily comportment signal a monotheist posture. The style with which the hijab hangs, the colour, and pattern, and the positioning of the hair bun on the crown of the head to create a sloping profile; or, a father with a baby girl too young to speak, and wearing a hijab; or, the insertion of *insy'allah* and *Alhamdulillah* into everyday Javanese and Indonesian speech, are routines in this performance of urban monotheistic piety in the lowland.

Within this milieu of monotheist vectors pointing downslope to the cities and towns of Yogyakarta, Surakarta, and Jakarta, in Dukun is the practice of *Kejawen.* It is a syncretic, animist metaphysics that hybridizes Islam, Hinduism, Buddhism, Christianity, Taoism, and colonial period Central Javanese cultural practices. It is monotheist, polytheistic and animist at once. One practitioner, Sukidi, who in his 70s, lives in the village of Kenningar, and is a shaman when not working as a farmer, told me that he "believes in everything, every religion

[218] This is based on observation.

is true. Jesus, Mary, Mohammad, Buddha, Confucius, they are all true." Another, Nang Subianto, who is 27 and lives across the river from Sukidi and also farms, keeps a small lending library of *Kejawen* titles for the public in a network of mostly underground libraries stashed in sitting rooms and bedrooms. He built it himself; it is narrow with two floors, the main floor is for a single shelf of *Kejawen* related books, the upper floor is for praying to the volcano in front of a large volcanic stone with incense and candles on it. During the week, he meets with older people in the area, mostly his neighbours, who sit on the floor of the library, drink tea and coffee, pray together, talk metaphysics, gossip, or recite old *Kejawen* poetry from the 1920s in the disappearing High Javanese. Subianto insisted that *Kejawen* is the metaphysics of oppressed farmers.

He also told me that it has no sacred book, it has book*s* and therefore its definitive history depends on who is asked. There are no headquarters or centralized authority to grant distinction to who gets to be a shaman, and there are no priests. There is no orthodoxy that determines how to progress from being a student of *Kejawen* to a teacher, or from a farmer to a shaman. There is no proselytizing or grand narrative of conversion. As Sukidi said, all religions are true, which means that Jesus is both God incarnate and a mere prophet who preceded Muhammed.

In the 1920s, during the foment of nationalist and anti-colonial sentiment in the East Indies, *Kejawen* congresses were held in Surakarta to try and generate a unified presence and gain recognition from nationalist and modernist Muslims (in particular *Durul Islam*).[219] But aside from Subianto, the practitioners I spoke with in 2016 didn't know about these congresses and didn't really care that there was once an attempt to unify and institutionalise *Kejawen*. Some practitioners don't even call it *Kejawen*, they said they practiced *kebatinen*, 'from the inside' (*batin*, means inner or spirit). For Sabda Langit, a shaman and magician who lives within the walled enclosure of the sultanate at the base of the volcano, *Kejawen* is the primordial, original ontology of the Javanese people. It is the pre-European thought of the early modern sultanates and for him, this primordialism is the future of Indonesian identity and global geopolitical power. The source for contemporary Indonesia is Java, and Islam, he argued, is a four-hundred-year-old form of Arab "contamination". *Kejawen,* instead, is a pure, ethno-nationalist ontology.

On an evening pilgrimage in October, 2015, to the graveyard at Kelir mountain, east of the Yogyakarta sultanate, where ancestor spirits thrive around graves, trees, and ponds,

[219] See: Mohamad Sobary, *Phenomenon Dukun Dalam Dunia Kita,* 1997; and Stuart Robson, *The Kraton: Selected Essays on Javanese Courts,* 2003; and, Ricklefs, *History of Modern Indonesia,* 2001.

Sabda Langit[220] brought a small following of men and women in their twenties. Some of them were converts from Islam, like Adi, who was wearing a t-shirt that read "A spiritual awakening for Nusantara" (the old term for Indonesia). He said that he "had no religion", and renounced Islam because he couldn't agree with a single transcendent and omniscient God. The evening consisted of supplicating the dead in their graves, spirit photography, and mediumship. Cell phone photos were taken with the flash pointed into the forest and the white orbs that were captured on screen (and looked like dust caught in sunlight) were sure signs of the ghosts and apparitions hanging around.

Later, at his house, Langit showed me a text message he received from his son, still in the womb: "how was lunch?", it read. He was there with his twin sister and one of them, Langit said, would be born when the timing was right for the arrival of a Just King or Queen to restore Java to its pre-colonial glory. By that time, the 12th of October, 2015, they had been in his wife's womb for three years. She was in her sixties. Their regular text messages in Javanese often consisted of daily gossip and banter about the quality of lunch at the local canteen.

Rather than a unified institution, then, *Kejawen* holds contradictions together in a flexible and rhizomatic ensemble of practices of self-making that resist the vectors of monotheist piety. As Langit did, he insisted that the dead do not leave this earth, and the unborn have full presence of mind and speech at all stages of life. In this cosmos, bodies, including trees, rocks, and wombs are mediums, which is crucial in *Kejawen* because its cosmos is one of excessive communication: the dead, unborn, distant humans, forests, lakes, groves, caves, all murmur, yell, whisper, or scream, and demand to be deciphered, translated, and understood. There are no entities that are beyond the capacity to enter into communication, and there is no hierarchy through which all communication must pass, such as a transcendent Allah. Instead, there are body mediums as infrastructures. A bird trainer in Yogyakarta named Adam explained to me that birds have the capacity to be inhabited by human souls and that some of the old Kings and Queens of Java from the early modern period will take up a position in a Myna bird body and speak with a child in the crib. This expansive world of mediums includes modern technology such as cell phones, computers, and radios, which also communicate with spirits and animals. It is a technological practice while at the same time a practice of reaching across species and material divisions.[221] The

[220] His name means, roughly, Venerable Word of the Firmament.
[221] On the longer Western history of ideas of communication that cross boundaries between the living and dead see John Durham Peters, *Speaking into the Air: A History of the Idea of Communication,* 1999.

story that considers animism to be a pre-modern or traditional religious thought, often misses the fact that it is an entirely contemporary technological practice of probing and repurposing the capacities of the most up to date consumerist, popular technologies towards a more plural network of communicating entities.[222] We can think of this as a process of world reformatting in which the grave, forest, and volcano are "sacred topographies" which act as infrastructures for counter technological practices to resist state monotheism.[223]

These infrastructures make futures sensible such as Sabda Langit's wife's womb pointing to the arrival of a new kingdom that is also the resurgence of a deep past. The Javanese calendar on which many of the codified *Kejawen* ritual practices are based has annual cycles in which the space between the human, ghost, and spirit realm come into contact through porous boundaries. At those times of year, long dead ancestors, including those who died traumatic, unnatural deaths at the hands of government violence, periods of famine and slavery, or post-colonial mass killings, return to communicate and will continue to do so in the future, at those times of year, every year. Because of the horizontal and vertical orientations of the *Kejawen* cosmos death can lead to the transformation of a soul from a human body to an animal, stone, or tree, or it can rise vertically to the sky and wind, or finally, according to Subianto, reach its telos in *Jono Loka*, the vaulted space of the sky sphere. [224] Death does not necessarily mean leaving this world behind but changing forms, and the future of nature inseparable from the future of human life.

Negotiating the meaning of the future for *Kejawen* practitioners is a way to compose the relationships between nature and culture a few kilometres away from a caldera that sometimes erupts for months on end, flattens entire villages and regularly trembles. Since the massive eruption of 2010 and the volumes of material that it deposited into the river valleys, people in Keningar have been drawn from their labour as farmers to mine volcanic sand. The yield is faster and more lucrative than chilli or rice farming but in the Adem and Senowo rivers adjacent to Keningar, it is illegal. Through chains of patronage from regional officials to the workers in the makeshift canteen tents, and the thugs that keep watch over the river banks for police, the mining continues irrespective of its legal status. According to Sugiyono, Suparno, and Sukidi, who are all farmers and *Kejawen* practitioners who refuse to enter the mines, the village head was paid off by the illegal miners. He is also supposedly in an

[222] It is a trope in the literature to consider *Kejawen* to be a "traditional belief system" that can be drawn back to the colonial period standardization of "native" perceptions and continues to be mobilized in Indonesian and English language scholarship. See Burns, 1989 and more recently, Tyson, 2010.
[223] The notion of a sacred topography is drawn liberally from Pemberton, 1994, pp.269-311.
[224] This is Subianto's description but can also be found in Skeat's *Malay Magic*, 1984.

alliance with the village imam and does not participate in *Kejawen* events. For Sugiyono, Suparno, and Sukidi, the modern Islamic monotheist cosmos produces the idea that nature is a resource to be exploited and when in May 2016, a miner was buried and killed because a river bank he had been mining collapsed on him,[225] Sukidi argued that Merapi took him because he so violently hacked away at it, and that landslides were the volcanoes critique of being transformed into a resource. This cosmological reasoning redraws the causal relationships between nature and culture so that environments are as alive as a human being; they actually are humans. This transforms the kinds of futures that can be sensed in the present because when everything is alive, the human is distributed throughout all of nature, and its future is a human future.

Kejawen and Monotheist Volcano Science

Sugiyono, Suparno, and Sukidi are also engaging modernist, monotheist scientists who don't trust or recognise *Kejawen* and claim it is backward, unscientific, and irrational. This is because monotheist science does not sufficiently understand the value of *Kejawen* forecasting, nor the ways in which *Kejawen* shamanism is a productive geophysical practice. *Kejawen* forecasters, in fact, make good geophysicists because they are creating ontologies in which the future of the volcano implicates the politics of the state with the ethical and moral action of people. The uncertainty of the future of the volcano is inseparable from volcanic action and its anticipation is a vector for re-thinking and critically evaluating the composition of human culture. They understand that politics is a form of tectonics and tectonics a form of politics in which the future is lived as an ongoing circulation of ways of seeing between the volcano and society. The volcano intervenes and transforms society, while society is becoming the volcano. Moreover, *Kejawen* shamans and their students commonly argue that the volcano is the condition of life, it is made sense of through the volcano's continuous, unsettling transformations,[226] it is the ground from which everything grows, and all animals and humans are held upright by. Fruits and vegetables are grown from its soil and provide nourishment to the people who live there, and in this sense the volcano is ingested while movement and an upright posture are extensions of volcanic activity. This geophysics departs from modernist narratives that humans occupy a disenchanted earth oblivious to human life

[225] Four miners were killed in Senowo river in 2016, see: Pranoto, 2016; and Fitriana, 2016.
[226] This is an old trope of European volcanoes as well and there is much literature on European's ambivalent relationship with volcanoes. John Brewer recently touched on this in a seminar at Cambridge, "Reforming Naples/How to Use a Network: Vesuvius and savants in the two kingdoms of Sicily", November 9, 2017.

that will outlive their presence. *Kejawen* animists take another route by embedding human agency within the deepest actions of nature and making nature and the human a flat ontological plane along which human, animal, plant, and rock spirits enter into exchanges, change places, and make claims on one another. If classical geophysics sought (at one end of the spectrum of its tradition) to create a sublime reverence for "deep time" through the spectacularly long formation of the earth, *Kejawen* diffuses and folds the human within that nature, embedding, entangling, mixing and hybridizing with it.

Shamanic forecasting, in the sense of foretelling the future, is a practice of enacting this ontology by making futures and causal relationships pragmatically concrete. The uncertainty of the future of nature and its relationship with society is a corporeal event of engaging the extent, veracity, and intensity of the relations between nature and society. Understanding what nature will do, whether erupt, rain, gust, or drought, becomes a kind of laboratory for testing the ontological border lines that have been drawn around the human and its connections with nature. Shamans work on this fragile and porous boundary by creating lively infrastructural systems of sacred sites, paths, and portals, that ensnare human perception and the souls that enliven it within volcanic processes; infrastructures and instruments of offerings, bodily practices, eating, drinking and praying, are these zones of causal interchange between the volcano and society. Forecasting is a technique that translates between the manifold interiors of the volcano, and publics (such as group, village, region), and while generating ethical attention by enfolding human action, gesture and thought with the volcano.

Shamanic forecasting on an active volcano deserves our deeper understanding because geophysicists and other scientific forecasters have begun to take seriously the lay, non-expert, or traditional communities they work with. They have done this through experimenting with methods of community participation, citizen science, and participatory mapping to destabilize and re-distribute environmental expertise.[227] The argument is that people who live in volatile and vulnerable places are well positioned to speak about what they think is volatile and vulnerable. This redistribution of expertise creates the opportunity to nurture relationships of mutual trust between state scientists and civil society. This is particularly significant in the context of Indonesian forecasting systems because the republican state has traditionally marginalised heterodox religious practices while mononaturalist, top down science has been aligned with monotheist piety. Taking *Kejawen*

[227] Donovan, 2016; Whatmore, 2013; Whatmore and Landstrom, 2011.

seriously therefore means the "controlled equivocation", as Viveiros de Castro has described it, with others' metaphysics that destabilise the mononaturalist and monotheist project.[228]

The significance of *Kejawen* is that it is a practice of forecasting that situates uncertain nature at the centre of social becoming. This is the source of its threat to republican, monotheist science, and why, I argue, it needs to be understood. Its metaphysics resists the modernist distinctions between politics and nature, and by extension an anthropocentric ethics by insisting on the shared liveliness of nature and society. It cuts across the distinctions between the living (as the privileged sphere of the biological and organic) and the inorganic (the passive, dead matter of rocks and minerals) that republican state science and monotheism rely on. *Kejawen*'s marginal position in the state (due to its exclusion from the constitution) is the advantageous stance from which it traces counter maps of the relationships between humans and nature and produces new futures in creative and productive tension with mononaturalism, the contemporary Indonesian state, and its politics. The radical uncertainty and excess of the volcano, its boisterous, deadly and unpredictable transformations are a productive force for *Kejawen* metaphysics because it harnesses it to flatten the cosmos and redistribute the agency of the human through it.

To take *Kejawen* seriously means understanding how gods act, and this means becoming *a*modern.[229] Contemporary geographies of the politics of the future, uncertainty, risk and hazards are often written from a modernist, Western, secular atheist metaphysics[230] and, as crucial as this work has been, if it is to successfully redistribute expertise it has to understand actors which it has long banished behind illusion, belief, and cultural relativism. It is also crucial to bear in mind that modernisation has not been an even planetary process, but has unfolded through encounters, hybrids, and transformations from within and without the West.[231] This has meant that the history of modernist geophysics and volcano science on Merapi has been a story of encounters between Islamic practices of a monotheist cosmos and a disenchanting, rational, mononaturalist science. The two have been in contact since Dutch colonial scientists established the first observatory in 1930 and worked with their Muslim counterparts. These two positions, monotheist believer and geophysicist, have often been held together in one person's head, and the templates from one have conditioned the contents

[228] Viveiros de Castro, 2002, 2015.
[229] On the ahistory of gods and the use of ethnographic methods which resist secularism, see Marisol de la Cadena, 2015.
[230] Amoore, 2013; Anderson, 2011, 2017; Massumi, 2015.
[231] The literature on modernisation theory is vast and so are the accounts of its unevenness. Classics of the genre are Chakrabarty, 2000, Appiah, 2007.

of the other. Budi Santoso explained to me in May, 2016, that Allah determines when an eruption will occur and his seismological training allows him to get as close as possible to the mind of God. This is consistent with the 17th century clergy-men scientists such as Robert Boyle who argued that the purpose of experimental, empirical science was to get closer to the working of god.[232] When Latour argued that we have never been modern, he meant this inability to think across and between the epistemological templates we in fact constantly and by necessity are always moving between. To be *a*modern then, is neither post-, or non-modern, but turns to the ways that modernist categories are constantly being undone as they are enacted. This means taking gods and spirits seriously as actors within the templates of modernist science and as rebels against the republic from within its borders.

Taking gods seriously, challenges the humanist tradition of understanding uncertainty, natural hazards, and risk because they often insist that politics and economics are the primary drivers of social vulnerability to volatile nature. They assert that in order to mitigate the uncertainty of nature, people's political and economic positions should be the first line of defence because that determines the uneven exposure to risk and life chances.[233] To transform the exposure to risk means transforming the political and economic conditions that produce it. But this secular humanist perspective reaches a limit when it encounters the real action of gods; they become the effect of a political economic underlying cause, an illusion projected onto nature, and secularism is inadvertently imposed onto people for whom gods act and intervene in human life and nature. To avoid importing secular modernist models of nature and culture necessitates the creation of modes of encounter with the agencies of spirits and gods, a "controlled equivocation" that can account for how they work. *Kejawen,* as I will develop in the rest of this chapter, creates this opportunity for a different kind of account of the future and nature.

A Volcanic Eruption is still a Moral Catastrophe

Jan Wisseman Christie reminds us that *Kejawen* metaphysics draws on a longer Javanese experience of causality: "The massive eruption of the volcano Merapi at the heart of central Java late in 1822, perceived as an omen of the coming of the mythic 'Just King' in a time of famine and oppression, helped to precipitate the Java War of 1825. Eighteenth-century central Java perceived the ash-rains and eruptions of the volcanoes Merapi and Prahu in the 1760s and 1770s as signs heralding the collapse of the state. The *Babad Tanah Djawi*

[232] Shapin, 1985.
[233] Klein, 2008; Smith, 2006; K. Donovan, 2010; Loewenstein, 2015; Wisner, Gaillard and Kelman, 2012.

states that the death of the great seventeenth-century king Sultan Agung was marked by Merapi's rumblings, and, according to the *Babading Sangkala,* that volcano's major eruption of 1672 not only killed many out-right, but presaged far greater political and military calamities".[234] This remained true for *Kejawen* shamans in 2015 and 2016; Merapi eruptions can be caused by corrupt politicians swindling money and destroying the countryside, illegal mining on the volcano, or presage the fall of empires. The massive eruption of 2010 that lasted for three months was, for the religious leader appointed by the Sultan, Maridjan, in the village of Kinrehdjo, a result of the greed and corruption of the Sultan. For Sabda Langit, the death of Maridjan in that same eruption was because Maridjan had lost his way from *Kejawen* and become "Arabized" and the volcano took his soul as punishment.

The labour of contemporary *Kejawen* shamans, in this regard, operates in this zone between society and nature in which the future of nature is inseparable from the actions of humans. For shamans, forecasting makes sensible a fundamental limit to knowing the nature of the relationship between society and the volcano and, as Isabelle Stenger's frames it, generates an "obligation", meaning attention and commitment to what is brought into the world through the creative practice of truth making.[235] For shamans, the causal relations between people and nature are plastic while forecasting diagnoses the openings of possible relations, and forms communities around the possible ways that human action can be entangled with volcanic action. The work of the shaman is not to seal, solve and make causal relationships disappear into the background – black-box them – but experiment with practices that keep their unknowability at the sensible surface, and bend attempts to order society through the solidification and securitization of causality. It is in this way that shamanism is creative and generative of a flexible grammar of action that so frustrates modernist science because causation is not derived from replicable experiments, probability, or status quo models of nature. Shamanic geoscience is in this sense a science of flexible, plastic causality in which both shaman and their subject have to experiment every time something unpredictable happens in order to re-invent causality. Causal relations are not given in advance and neither can they be relied on to repeat because they can't be found lying in wait behind a layer of sensible reality, they need to be practiced, shared and brought into being in every moment of crisis.

[234] Christie, 2015, p.46.
[235] Stengers, 2011, pp.324-339.

Shamanic Infrastructures

Shamanism creates the conditions for this inventiveness through its infrastructures. Across Merapi, there is a network of instruments that receive messages from the spirits or ghosts who live in the volcano or on its flanks about what the volcano will do in the future. Through dances, eating, fasting, supplication, and gifts, ghosts and spirits enter the shaman, and others, to deliver forecasts. Dreams can be a vehicle to communicate with the volcano, but so too can being sick, or simply a normal day's work in the fields. The body can act like a seismograph station that receives a signal and is animated in advance of an event as ghosts and spirits can say that the volcano will erupt at a certain time. The body is in a network of mediums and instruments that facilitate movement along the route, such as smoke, drinks, flowers, eggs, chickens, rice, and prayer (*figure 1 & 2*). Ghosts and spirits need to be enticed, beckoned, tricked, tickled, and bribed, to give up what they know about the future, and they, in turn, are liars and can't be trusted. They don't always show up when people want them to, or they do when people least expect it. This is crucial to the network because it guarantees an unreliability to the future that is not a result of error or a lack of knowledge, it is ontological, it is in the being of the world to not know the future.[236] Ghosts and spirits can be funny, in strange shapes, or ghoulish: Supri, a farmer in his 60s from Keningar, told me about seeing severed heads moving through the forest with the blood stringing from the neck. Sugiyono, 37, an anti-mining activist and former farmer, told me that he once saw a group of people driving in a mining truck up the volcano only to never come back. They had already died and were headed to reside in the volcano. He'd seen the same thing happen with people walking up the road in front of his house. They were dead strangers from villages down the road that he didn't know walking to the volcano. Ghosts can also be two faced, with the front of a beautiful woman and a back without skin and an exposed skeleton. Each ghost establishes a relationship with the future in the present in a different way, they make the future live with a different force and sensibility. The work of the shamans that I met was characterized by entering into relationships with these spirits and ghosts and negotiating how the future of the volcano and society were braided together.

[236] I use the terms ghosts and spirits separately because ghosts are roving human souls after death. Spirits, while sometimes they can be human souls too, but only after they have died centuries or millennia ago, can also be from heaven and the other world, so are not a recently dead person.

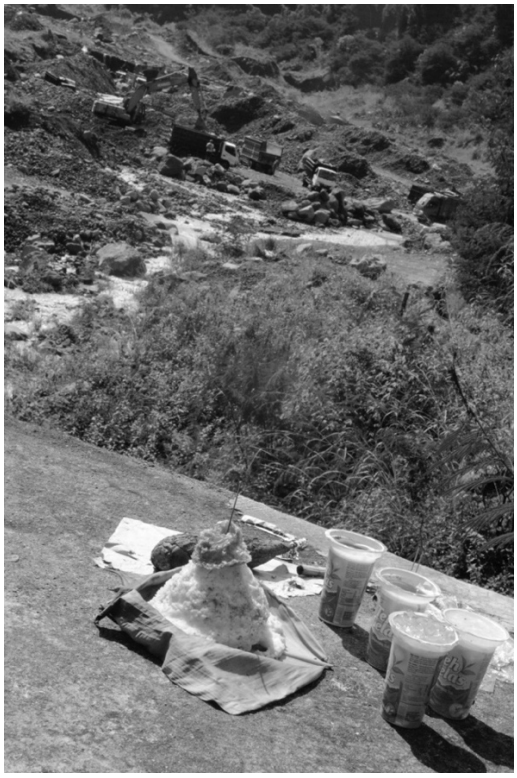

Figure 1. Sukidi's offerings on a Suharto era Sabo Dam in front of illegal mining activities (seen in the background). It includes a rice volcano with a fried egg on top and a cosmic axis/incense stick. Behind it is a piece of cassava root, and tobacco. To the right are cups of sweet, rice jellies. Together they are food for spirits, models of the cosmos, and interventions into the causal relations between the mining and the riverbank/volcano. Photo by the author.

Figure 2. Offering at edge of narrow footpath, forest and paddy fields, Keningar, consist of lunch, a banana, fried noodles and shrimp crackers, sweets, and rice wrapped in banana leaf. Spirits find delicious what humans find delicious, pleasures are shared across body forms. Photo by the author.

Rats are People, too!

To understand how this is so, it is necessary to outline the animist metaphysics of *Kejawen* shamans on Merapi. This is drawn from roughly forty hours of interviews, and twenty four weeks as a guest in the homes of Sukidi, Suparno, and Santoso. This was in the village of Keningar, on the western flank, within four kilometres of the caldera. I describe them as shamans because they have acted as mediums for spirits either in their own bodies or others. Many others that I have described here practice *Kejawen* but not spirit possession or mediation. I witnessed Sukidi practice spirit mediation while Suparno and Santoso, only related their experiences to me.

I visited Sukidi in Keningar, one evening in June, 2016. We were in his sitting room, surrounded by plump burlap bags of rice waiting to be taken to the markets in the lowlands and some for household consumption. The television was on and played a documentary about traditional green tea production in China.

He explained to me that he and his friends had been having trouble with rats eating the rice shoots before the harvest and because of that the harvest was small this season. They had tried state subsidised rat poison to keep the rats away but, according to him, only the lowland rats had taken the bait. Those that descended from the slopes higher up above the village into the crops refused the poison because Merapi rats, he said, are smart, while lowland rats are stupid.

"How did they know the poison was poison and not food," I asked?

"Because rats are people too."

There are two obvious implications to this. The first is that lowlanders, who for Sukidi, include: urbanites (like me), representatives of the republican state who issue fertilizers, rat poison, and genetically modify crops (such as rice), state politicians, bureaucrats, corrupt officials, and markets that trade his rice and upon which he is dependent for money capital – are stupid. The second and related implication is that there is an ontological equivalence between rats and people. It is the latter that I want to focus on first because it will begin to outline the animist metaphysics that founds the former. This metaphysics allows his volcano forecasting, as a shaman, to be a process of an intimate "becoming-with", as Donna Haraway frames it.[237]

To argue that rats are people too is also to say that they are or are not as smart as Sukidi. Sukidi knows that he put down poison, so therefore, so do the rats. He was trying to

[237] Haraway, 2016, pp.30-57.

fool himself, and he knew it, and like playing chess against oneself, you can't forget your own intended move no matter how hard you try. But he also knew that it would kill lowlanders who couldn't recognize their own poison. That the volcano rats didn't eat the poison actually confirmed what he already knew, Merapi rats are smart, he is smart, and they are both smart because they know what poison is and is not. The argument hinges on, in an obvious way, a form of identification that doesn't adhere to the modern constitution's species boundaries. Instead, it hinges on an ontological distinction between upland and lowland beings – those that recognize poison, and those that don't. But there is more, and it is more refined: The distinction is also between those who cannot recognize themselves in others and those who can. According to Sukidi, the volcano rat is not a rat, but a human in rat form. This identification does not end with the rat but is extended to upland trees, rocks, and the volcano itself. As Suparno, a friend and neighbour of Sukidi's, and sometimes his student, explained, "the volcano is full of people". When people die, as I mentioned above, they do not go to heaven, but to the volcano.

The ontological and geographical divide between upland and lowland, for Sukidi, in part, determines how you relate to what can kill you (your poison), what you identify as yourself and what you can know. And these ontological boundaries are susceptible to tests of verification such as the rat poison. The poison doesn't just test a belief system but what actually is and is not. It is not the projection of a thought onto the world but a corporeal event of what is and what is not. The emphasis of the epistemology, what can or cannot be known, lay in the practice of the knowing and the laying of the rat poison was a way to enact what constitutes an upland and lowland body on the volcano.

The conventions of Tylorian anthropology inherited from the 19th century would describe Sukidi's animist metaphysics as anthropomorphism.[238] According to that tradition, Sukidi's understanding is based on projecting human like characteristics outward and onto the natural world: that rats display human like characteristics, or that volcanoes get angry like humans. Nature is therefore understood by animists as operating by analogy as they project the human form out. But more recently, the work of Viveiros de Castro has refined this understanding by arguing that animist metaphysics posit the *perspective* as primary. "The subjective aspect of being" argues Viveiros de Castro, "is the universal, unconditioned given (since the souls of all non-humans are human like), while objective bodily nature takes on an a posteriori, particular, and conditioned quality." He continues, "there are no points of view

[238] Tylor, 1903.

onto things, things and beings are the points of view *themselves*."[239] Animists flatten the human, animal, vegetable, and mineral, and create a plane within which perspectives circulate between forms. When Sukidi claims that rats are people too he is not ascribing human like qualities to rats because for him, if rats are people too, then people are therefore also rats. For Sukidi, people become rats, rats become people, people become rocks, volcanoes become people.

Because perspectives circulate among this world of forms, humans can be possessed by other perspectives while maintaining their unique bodily form. For example, if a human is possessed by a rat they may begin to move like a rat, but they will not grow rats teeth. As beings that are structured by the relation between forms (or body) and perspective, we are primordially fragile to the perspectives of another.

By the same logic that there is a translation from interior perspective to interior perspective (rat ←→human), there is also translatability between interiors and exteriors, or perspectives and forms (body ←→ perspective). On this plane of nature there are bodies, perspectives and threshold states through which perspectives circulate. Body-forms are the porous enclosures through which perspectives pass. Sukidi, as a shaman, is an expert in the material manipulation and mediation of body forms to negotiate the circulation of perspectives. For example, he has a laboratory of instruments dedicated to this work (*figure.3*). His technique, gained through training and apprenticeship with his father, places himself in relation to perspectives in a way that he can communicate with them and on their behalf by knowing the technologies and materials through which they become mobile or unfixed from their bodies. But he can also be inhabited by them, possessed while he is asleep, in the fields, or undertaking long, exhausting and disorienting walks.

The transference of perspective relies on these infrastructures of bodily practices such as meditation, fasting, dancing, prayer, but so too, technical instruments such as fruit, tobacco, animals, flowers, fire, water, and milk. These materials are sometimes also analogies and models, and Sukidi knows at what particular time to employ one or the other to negotiate with a perspective.

It is in this regard that intimacy is a form of relating through which knowledge of other beings can be known by the becoming-interior of their perspective. The knowledge created through possession is conditioned, not like the modern constitution would have it, through relations between an inside subjectivity internalising and processing an *external*

[239] de Castro, 2004, p.11.

scenography which remains outside and is translated through the senses, or born down upon by preformed internal structural features, but through *intimation,* the movement from one external perspective to an interior. Haraway's notion of "becoming-with", which highlights the way that two entities exchange with each other while retaining degrees of autonomy, can be transformed then into a "becoming-intimate", an interiorization that is a mutual act of take-over and surrender. The effect of possession can then be described in terms of Stengers' use of the term "obligation" because to be intimately over-taken leaves a residue of the perspective to which the obsessed feels obliged. The obligation is not full with a particular content though, it is not normative and doesn't necessarily produce rules, it is rather an open-ended form of attachment to the perspective that possessed an interior.

Sukidi made explicit how this obligation was supposed to work in practice one evening during a spirit possession party. The intimacy created a vigilance to not knowing the future of the volcano, when it would act, and that because of that it could not recede into the background of peoples concerns, it created an obligation to the volcano. It worked on another level too, the comportment towards the volcano was such that what people did – their choices, politics, affairs of everyday life, and work – could be *potentially* causally linked to volcanic action. This kept open the possibility that landslides and lahars were caused by humans, though what that cause was, its nature, history and location, remained open. It was not the content of the obligation – settling on a cause – but rather the obligation to be attentive to the ongoing openness of how anthropogenic action related to the volcano that was at the core of Sukidi's practice.

Sukidi's animist metaphysics resists the causal relations of the monotheist "risk state" through this metaphysics of vital, horizontal, indeterminacy. His is one in which up-landers are constituted through an ontology of surviving an unpredictable and volatile nature by interiorizing it. The indeterminacy of the future is a source for the becoming-intimate with other beings. This upland ontology facilitates surviving with the radical uncertain future of the volcano.

Jatihlan

October 31st, 2015, aligned with the month of Suro in the Javanese calendar. The divisions between bodies and barely material perspectives is always porous on that date. In Keningar, it is a month to undertake physical exercises that communicate with other perspectives through possession and because of this Sukidi, Ali, and Supardi, each in their 70s, walked for fourteen hours in a non-stop circle around the volcano. They carried nothing,

wore only their plastic flip-flops, and were donated food and drink along the noisy, bumpy, pot-holed, and dusty roads. They didn't speak to each other unless they were eating. Through their exhaustion, thought itself became subject to possession. Supardi described feeling outside of himself, a dislocation from his own body and Sukidi explained that consciousness became consciousness of another within his own thought. He was not the author of his own thoughts, but the companion to an others' thought within his. These foreign perspectives within had things to say about the volcano, that it was "not happy" with the actions of people on the volcano because they were disrespecting it, mining it, they'd become materialistic and money hungry. "There would be a landslide", it told Sukidi, or, rather, Sukidi came to know. It gave no time or place, instead it was a warning about the coming year, where the indeterminacy of when and where the landslide would happen exactly was not important. What was important was making the claim that landslides are not natural, geophysical events, but Merapi's critique of sand mining. They are political statements.

The Jatihlan dance is a spirit possession ceremony that can be held at any time of year. It is often a day long dance but can be as short as a few hours. Versions of possession dances appear across regions in Java but the Jatihlan may be particular to central Java. Typically, there is a shaman present to mediate spirit possession within a group of dancers and as they dance to exhaustion they become vulnerable to possession and the shaman intervenes to negotiate with the spirit. At some, dancers eat glass shards or metal, motorbikes are driven over their legs, and they are beaten with whips on their bare skin, but the possessed show no signs of harm. The men wear make-up and dress like medieval Javanese cowboys and mimic riding a small, narrow, woven, bamboo hobby-horse.

After the massive eruption of 2010, it was common for Jatihlan to be held by members of destroyed villages and possessed by ancestral spirits or those living on the volcano.[240] Elisabeth Inandiak, a French-Indonesian journalist who participated in reconstruction efforts in high altitude villages, said that in the months after the eruption, she was regularly seeing Jatihlan performances in villages and that they were mechanisms for negotiating the trauma of loss and destruction.

A small group of households in Keningar organised a Jatihlan on October 31st, 2015, and Sukidi would be the shaman. The dancers came from the lowland urban centres, villages along the flanks, there was a Turkish musician there to record the music, and a local television network. It lasted from early afternoon until night and took place under a rented

[240] Conversation with Elisabeth Inandiak, 2014.

canopy in front of Sukidi's house. The neighbouring three houses transformed their living quarters into staging and prop areas, and cooked food. They rented a large sound system, set up a stage and brought in musicians to perform in a cabaret style mixture of Javanese and Indonesian popular, high and low musical styles.

By mid-afternoon, a festival feel had overtaken the area around the canopy. Mobile vendors on scooters and shops on the flat beds of trucks had set up in adjacent alleys selling food, tea, souvenirs, and blinking lights on strings. The *gamelan* percussion group of five members had set up their gongs, drums and keys begun to play the percussive, repetitive beat as the first dancers, children, entered the ring in a military-like line formation while holding up red and white republican state flags. The first line of children were dressed in costumes that referenced the 17th century Mataram kingdom, pre-dating the arrival of Dutch colonisation, and for people like Sabda Langit, the origin of *Kejawen*. It was also the kingdom in which the founding myth of the lowland Sultanates below the volcano were created through a peace deal between the sultan, the goddess of the south sea, and a giant who lives in the volcano. This created a continuity between the Republican flags from 1945, and soldiers of the 17th century sultanate. They were followed by cowboys with hobby horses (*kuda kepang*), and masked dancers (*topeng raksasa*) and finally two Sultans (*Raja*) representing the competing kings of the lowland sultanates. Their movements were proscribed, simple and repetitive.[241] They circled about each other, breaking apart and reforming into a circles again, until the final sequence involved a sword battle between the two Sultans and referenced the original battle that divided the two sultanates in the lowland at the base of the volcano.

As darkness fell, the lights were cut in the ring and the music stopped. The crowd was dense, stomach to back, with only the pointillist glow of phone screens in the dark. A small procession with bamboo torches entered the ring and the torches were laid in the corners. A weretiger (*barongan*), half-tiger, half-human[242] entered the ring from the front door of Sukidi's house. It had a wooden head and red curtain draped over the rear four men who carried it from underneath. Its jaw opened and closed with a rapid, intense, wooden snap as it swept through the centre of the ring and back out again.

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[241] Wolfgang Marschall, in a brief ethnography of a Jatihlan in a village east of Keningar, noted something that the movements, which usually involve circling steps and lifting a leg could have been developed to induce fatigue in the dancers and the onset of possession. See: *Indonesia Circle*, No. 66, 1995.

[242] The weretiger is a common form in South East Asia. See Robert Wessing, 2010; or, Skeat's *Malay Magic*. For a comparison between the masked Weretiger and the tradition of the shadow play, see P.J. Zoetmulder *Pantheism and Monism in Javanese Suluk Literature*, 1995, pp. 239-169.

A Weretiger famously defeated Dutch colonists of the Dutch East India Company in the 18th century, and the figure occupies a liminal, violent, hybrid human-animal zone.[243] People can be killed by it or transformed into it, taking on its ferocity, unpredictability, and power.[244] As Robert Wessing argues, the Weretiger is liminal also because, like the people of Keningar, it lives at the edge of forests and the village, and between the lowland, engineered rice paddy systems and the upland volcanic forests. Keningar is that site of ontological distinction that Sukidi described in which animal and human spirits exchange perspectives. The weretiger is the form of possession, the internalisation of otherness and a form of surrender as violent, barely controllable force.

As the Weretiger left the canopy the lights were turned-on and its afterimage of violence and disruption lingered as the new, this time young male dancers entered the ring. They kept the same formation as the children but had transformed their costumes. They had adopted dreadlock wigs that referenced the Papuans in the east of the archipelago, and their face paint referenced north and east Java in a pan-Indonesia, multi-cultural referencing. With the presence of the republican flag, and mediaeval outfits, there was an excess of lowland state references. Their faces were painted with a red star and black vines were on their chests and torso. Some wore masks with the exaggerated, bulging, white fangs of the Weretiger and their faces were painted blue. As the music increased in intensity so too did their movements, until the refrain "*da, da, da*" heard throughout the day every time the music reached a crescendo, dancers dropped into convulsions on the hardened dirt ground. The music continued with the same intensity and their movements were stiff and erratic. Some took on the movements of animals and ate tree branches tied to the edge of the ring and freshly picked cassava roots with bits of mud caked to them. Buckets of water with flower petals had been placed in different parts of the ring for the possessed. One of the men approached the cassava roots on all fours, darting closer, then away like a suspicious dog. A large, wooden hand drum was thrown into the middle of the ring and Ali, a farmer in Keningar, and close friend of Sukidi, fell off the stage and began to stagger, his limbs so stiff he walked like a wooden figurine, his arms flailing, he staggered close to the crowd, then away. Four men swooped in and grabbed him, he punched one of them hard in the chest, then more came to help drag him across the ring into Sukidi's workshop, suppressing him as he resisted.

In the workshop they managed to sit him in a chair as Sukidi held him and spoke with the spirit-soul-perspective (*roh*) in a hushed Javanese close to Ali's face. He offered a *balut*, a

[243] Marschall, 1995; Wessing, 2006, 2010.
[244] Wessing, 2006, 2010.

chicken embryo still in the egg and[245] Ali slowly peeled the egg, the bits of white shell falling on his black trousers, and the slick head of the fragile embryo appeared. He took its curled body and gently straightened it between his hands, cupped in a prayer formation, then brought it to his face while Sukidi slowly murmured. With the chicken in his cupped hands pressed to his nose and mouth he suddenly snapped his arms away from him and into a bucket of water with red and white flower petals in it, like in the ring earlier, drowning the chick and releasing the spirit from his own body, then he slumped back into the chair.

The table in front of Ali was laden with Sukidi's instruments (*figure 3*). They made co-present different historical periods, brought together multiple scales of the volcano to the scale of the body, and the scale of the body to the scale of the cosmos. The inside of the body was exchangeable with the materials on the table, but some of them were also grown on the volcano. The instruments were made of the same stuff (such as rice) but shaped into different arrangements of objects that overlaid references at different scales, histories, locations, and to the inside and outside of bodies.

There were four clusters of objects on the table. Two of them in bamboo baskets, one in a plastic tray, the other an assortment of plates. In the bamboo baskets were raw vegetables, some from the village (bananas, cucumbers, mangos) but also small bags of peanuts, processed crackers (*krupuk*) and sweets. There were two rice volcanoes, and packages of rice wrapped in banana leaves. One of the rice volcanoes had crackers on it and fried dough balls sticking out of it on tooth picks as planets or stars. The other rice volcano was smooth and unadorned. It is common in communal and ritualised feasts to eat a rice volcano and it is important to note that the rice is grown on the volcano and shaped to look like where it was grown, and it is in turn digested communally. There is both the scaling down of the mountain to the size of the plate, but also the rice grain to the size of the mountain, and the body to the scale of them both. This scalar displacement is part of the intimacy of communion, ingestion, intake, of both putting inside and being put inside the scale of something else. The rice volcanoes are "stand-ins", just as the Indonesian flags are "stand-ins" for the lowland state and the Sultans costumes are stand-ins for old battles. Whereas the latter two reference, the former is interiorised in the body by being eaten, as the perspective of the volcano is also interiorized. But so too, as Sukidi told me, the flag of the republic is ingested, in the red jellies in a cup that represent the flag. Even the state is eaten. Sukidi's work then allows the possessed to be outside the volcano while the volcano is inside

[245] Balut is Tagalog, I do not know the Indonesian or Javanese term for it.

them. It is in this gesture that worlds are enacted and held together, connections between the eater and the volcano is one that goes from outside in, and facilitates the obligation of the inside to the outside. Sukidi's management of the spirit inside Ali was a focusing of this practice: rather than the rice volcano, it is the perspective of the volcano intimately entering the body, forcing Ali to become another from inside out, and to see and speak from the perspective of the volcano. They are the same practice of ingestion as the basis of obligation.

Figure 3. Sukidi's workshop table. Photo by the author.

The Future is a Violence

When I asked Sukidi about his discussion with the spirit, he said that it warned of an oncoming landslide. It didn't say when or where; its message was as vague as when he circumnavigated the volcano. When I asked him to give me more details, he leaned in close to me, looked severe and whispered that it was best not to talk about it. When I later asked Ali what the spirit said, he told me he didn't remember. Did Sukidi tell anyone else what the spirit said? I don't know. Did Sukidi lie to me because he knew what I wanted to hear? Perhaps. Does it make a difference? Perhaps not. Had I been able to understand what the spirit said through Ali's mouth would likely not detract from the work that was already accomplished in the *jatihlan* and by Sukidi's report.

The infrastructure of the *jatihlan* is one of catastrophic breakdown, dissolving forms and splitting the human. It is one in which the future is made present not as an ordered choreography of the state with unpredictable nature or an anticipation of risk and vulnerability, but as a violent transgression of the border between humans and nature. This is a vulnerability that is deeper than the vulnerability of the loss of property or possessions in natural disasters. It may be that the *jatihlan* performs the origins of the human in and through its permanently facing uncertain natures. The human faces this uncertainty through the porosity of its forms, and taking on perspectives is an act of transgression of the conventionally, everyday boundaries of the human.

This is in part the productive conditions of the excessive signalling of the jatihlan, it lays out the fraught symbols of the state, ethnic histories, and human-animal exchangeability, in a way that allows them to be recombined, bent, and transformed. Spirits speak in a way that does not recognise the distinctions between nature and politics, and polytheism cuts across and makes new, hybrid, speaking objects, a half-formed embryo, gestating. When Sabda Langit texted with his unborn son, it was a way of being in contact with a Just and Right future that the present wasn't yet ready for, an eschatology via SMS that crossed the boundaries between the deep past and future. The kiss of the *balut* embryo offered no guarantee about when something would happen in the future, only that something would happen. It entangled the corrupt politics of the state and its mining, the draw of lowland capitalism, and the history of the republic.

Jatihlan bends the incursions of monotheist state science not only through the recognition of nature spirits as active agents, or in the unleashing of fervour and ecstasy outside of the confines of the mosque. It is not only by adopting postures that don't belong in the repertoire of modern monotheism, it was also through the way that the future of nature was lived as a part of a broader project of boundary transgression and dissolution which allowed the human to become implicated in volcanic action as its agents and causes. The stage of the *jatihlan* can be conceived then as an analogy for the *Kejawen* cosmos. Humans enter into painful hybrids with feral volcano animals, the symbols of the state (flags and uniforms) whether of the medieval sultanates or the Republic of Indonesia, parading across the flat plane but are susceptible to be caught off guard, the ordered dancing in formation jerked askew by the possession of an ancestor. To be on the flat plane is both to be out in the open equally with all other dancers, exhausted with repetitive behaviour, and fragile to possession.

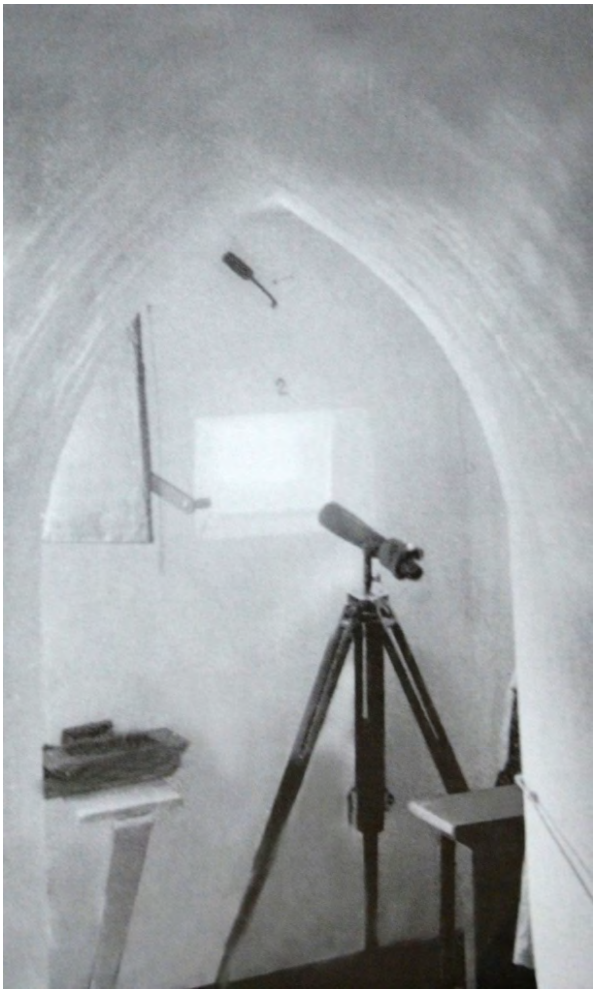

Figure 1. Babadan Bunker look-out window to the south western face of Merapi. The window is reinforced glass, a metal shutter to the left protects another window. It was designed to be inhabited during a pyroclastic flow and make them visible. Author unknown, circa 1931. Author unknown, from *Merapi Volcano.*

Chapter 7
Gates, Gatekeepers, and the State of Nature

Animism, the State, Walls

This chapter traces a route between state architecture, nature, the future, and forecasters as a way to more forcefully interrogate the politics of forecasting as I have developed it through these chapters. The previous chapter demonstrated how cosmological reason is forging futures of nature otherwise at the contested edges of the lowland republic. I also argued that modernist forecasting practices are aligned with monotheist religious practices, while animism is materialising another ontology of the future of nature as a way to keep open the causal relations between nature, culture, and politics. This refusal to modernise is creatively resisting the incursions of state science. It is keeping open the nature of the relationships, dependencies, and reciprocities between communities on the flanks and the interior of the volcano. This chapter shifts its attention to the ways in which a proto-animism – the conception that the volcano is alive has long been operationalised also by state authoritarianism. I demonstrate how the liveliness of the volcano has been harnessed by the state as a means to justify its own authority through the management of volcanic activity, disasters, and uncertainty. Forecasting, an intrinsic part of disaster management, has long been a way to exert the authority of the state over nature and, in turn, to project the state into a state of nature. Pursuing this line of inquiry avoids succumbing to the temptation presented of the previous chapter, and indeed in broader discussions of the turn to animism today that uncritically celebrate animist ontologies as subversive of dominant, modern Western ontologies. For shamans living in Keningar, it is too much responsibility to bear, and to put on them, for them to be the liberators for others. My interest is not to find a people who provide, by the way they live, a solution to the criticisms and set backs of modern Western science. The controlled equivocation developed by Viveiros de Castro and Marisol de la Cadena tries, and that I have attempted to pursue as a method in these chapters, navigates these anthropological conundrums by keeping an ambiguous relationship with the allure of the encountered 'other' culture so that it does not turn into a romanticised object living in a kind of paradise shaped by the resolution of Western problems. The shaman, certainly, is a

figure with a long history of bearing this burden and for this reason, I have tried to equivocate between both shaman and scientist, to allow them to be both figures for other people's problem solving, but also to escape that, transform, for shamans to look more like scientists and scientists more like shamans, to allow them not to be themselves. In this chapter I make that shift by looking at the way that the animate force of the volcano has been a source of authoritarian power, how shamans claim authoritarian power, how it is possible to be a tyrant and an animist by channelling and monopolizing the power of nature. But, likewise, I also show how that power is resisted by the friction of geography, in space and materials, that power is never absolute or evenly diffused.

In order to describe these contested sites of control, I introduce in this chapter the figure of the gatekeeper and the gate. It is here that the state seeks to harness a proto-animist nature and invest the state of nature with the nature of the state. Through gates and gatekeepers of volatile nature, the state invests, garnishes, and subsumes the animate powers of volatile nature in the service of its own powers of reproduction and territorial expansion.

The ability to forecast volatile nature, I explain here, cannot be separated from processes of legitimizing and de-legitimizing authority. Forecasts are folded into a deep demarcating of what and who has the authority to take care and manage populations. It is therefore bound up with the legitimacy to govern others. An accurate forecast can save a failing regime, can restore confidence, it can be the sign of divine power. An inaccurate forecast can be the end of a regime, all confidence can be lost in those who govern. The authority of the state can rest on its capacity to accurately foretell the future. In this chapter, I don't mean the forecasting of weather, but of big events, disasters and massive disruption. It is these large scale events and natural phenomena associated with them that have the ability to throw governance off kilter.

I undertake to demonstrate this through an analysis of the Sultanate in Yogyakarta and in particular, the edges of its territorial boundary where it meets the caldera of Merapi. That is where there are gates that divide the social sphere of the sultanate and the sphere of nature. It is the economy between these borders that I am interested in foregrounding because it is an economy of political power as much as one of material flows. Nature, in this system, is what I describe as a shadow state; it too is a sultanate but is operating within the morphology of a volcano.

Architecture is a crucial agent in the state politics of forecasting because it shapes the legibility and sensibility of both the state and nature. In its built form, arrangement, and positionality, architecture constrains and makes sensible what the future of nature can be and

that because of this capacity, it is a vital instrument of power. Its materialisation, territorialisation, demarcation of insides and outsides, works to shape the distinction between nature and society, the politics of the human and the politics of the wild, the future, and the present.

To fully appreciate this, we must understand how architecture is operationalised in practice within a territory. Those who undertake this work of enacting architecture are gatekeepers. Through their occupation of this architecture they make the relationship between the state, nature and the future legible, they translate what is on the inside and outside of the state and state of nature. But they also understand its weaknesses. They leverage those fragilities and find openings, create new passages between the state and nature. They find ways to leverage authority, redistribute it, for trust to dwindle or intensify. Gatekeepers can transform the meaning of a disaster, they can plug it into state authorities, the distant efforts of a god, or a local despot. While they are dependent of the state and they operate in its architecture, its buildings and gates, they are not beholden to it. Indeed, they show us how state projects of managing volatile nature are always tenuous because they are reliant on territory and territory does not stay still. It is at the sites of volatility that territorial control and authority is insecure, where the state sets up borders, gates and walls to mediate it, where its legitimacy is in question.[246] This is one of the meanings of a cultural technique because it is the physical and abstract division between an inside and outside, of the legible and illegible, the formed and unformed in action. Gatekeepers occupy this edge-land geography and open the gates – the straight gates – as Siegert has described them, between the realms.

Architecture of Anticipation

Windows, doors, shutters, and stairs, frame visual perspectives. They open vistas and create enclosures. Their shape and position establish relationships of spatial proximity, but they also enable and constrain the circulation of bodies. They meld the repetition of movements, gestures, and the circulation of objects. Figure 1 is an image of a telescope set within an eruption bunker at Babadan scientific observatory.[247] The window in the bunker is pointing at the caldera so that scientists could watch eruptions. This architectural framing separates the bunker from its surroundings while making a view possible and the telescope oculus, a miniature window itself, enlarges the detail of the caldera four kilometres away and mechanically transforms proximity, creating the sensation of being closer while being at a

[246] On territories of insecurity, see Felicity Scott, *Outlaw Territories: Environments of Insecurity,* 2016.
[247] Until the glass broke. It is not clear if it was ever used, but the import of military technologies is clear.

safe remove buried into the ground. In this way, the bunker is both an enclosure and a technology of vision that separates while bringing closer.

Architecture, as Siegert points out, is a cultural technique of demarcating insides and outsides that are material, spatial and conceptual. Architecture, he says, operationalises conceptual distinctions in the real.[248] For Siegert, this means that cultural distinctions do not come preformed, nor do they hover in a realm separate from cultural practices, but instead they enact each other. He writes that,

> "Operating a door by closing and opening it allows us to perform, observe, encode, address, and ultimately wire [in the sense of a logic gate] the difference between inside and outside. Concrete actions serve to distinguish them from earlier no differentiation. In more general terms, all cultural techniques are based on the transition from non-distinction to distinction and back."[249]

This is true even of the cultural distinctions that create territories by articulating the presence of states with borders and gates. State boundaries such as borders are often imaginary entities that are articulated and materialized at gates and fences between one state to another. There are also gates at more fine grained distinctions between jurisdictions, provinces, territories or regions. The architecture of boundaries and borders in these instances operationalises the imaginary of the state as a homogenous substance defined by insides and outsides.

This power of architecture is pivotal to cultures of forecasting too because they, like the telescope in the bunker, are made of technologies that observe nature, but the borders are between the state and the state of nature. Forecasters are regularly tuning their view and adjusting their position in relation to nature by building new gates and modifying old ones. Observatories are these architectural actors that shape, constrain, and focus what is sensible of nature. And they often contain instruments that record and transmit data and in this sense they are information gates between forecasters and nature.

Architectures of observation are not only in observatories but are distributed through states and come to articulate the imaginaries of the state as a uniform territory. The sultanate of Yogyakarta, for example, is defined as a limited spatial enclosure by gates. At the northern end of the territory is a gate between the regional borders of the sultanate and the interior of the caldera. In the south there is one on the beach at the edge of the south sea (*figure 2*). These gates between the caldera and the ocean frame the distinction between the state of the

[248] Martin, 2016, p. 104.
[249] Siegert, 2015, p. 14; Martin, 2016, p.105.

sultanate and the state of nature. Because the sultan is at the centre point of power and authority within the territory, his power is spatialized through these gates.

The gates of the sultanate are different from but always in proximity to gates of the Republic. The Special Region of Yogyakarta designates the realm of the Sultan and he is its governor (*figure 2*) though it is within the Republic of Indonesia. Its residents vote for the president, mayors of towns including Yogyakarta, and regency representatives. The Sultan maintains significant landholdings throughout the realm and influence over the mayors though his legal capacities are restricted to governorship. The gates to the sultanate demarcate a Special Region, created in 1950 in recognition of the authority and autonomy of the Sultan as hereditary governor. Its borders are roughly the same as the older colonial of the sultanate which also recognized the autonomy and sovereignty of the Sultan. The territory reaches from the caldera down a pie shaped section on the southern flanks of Merapi until it widens throughout the plains to the coast in the south. There are gates at both borders of this territory.

Every village on Merapi has an entrance gate, often an archway, with the dates of the founding of the village or the date of colonial independence. There are gates, also archways, that reference in architectural form, the village gates, but transposed to highways and articulate the passage in and out of the Republican divisions between provinces such as between the Special Region and Central Java, or to the city of Yogyakarta and the region of Magelang. It is common for the architecture of these gates to reference the architecture of the Hindu-Buddhist period through exaggerated gates that referenced mountain forms. Conventionally, they are made to look as if the mass of the mountain is split down the centre and the entrance is through the gate into a palace space or temple complex passing through the voided centre of the mass, as if the mountain is being traversed through the centre. These forms often hug roadsides and today it is motorbikes or trucks moving through the void.

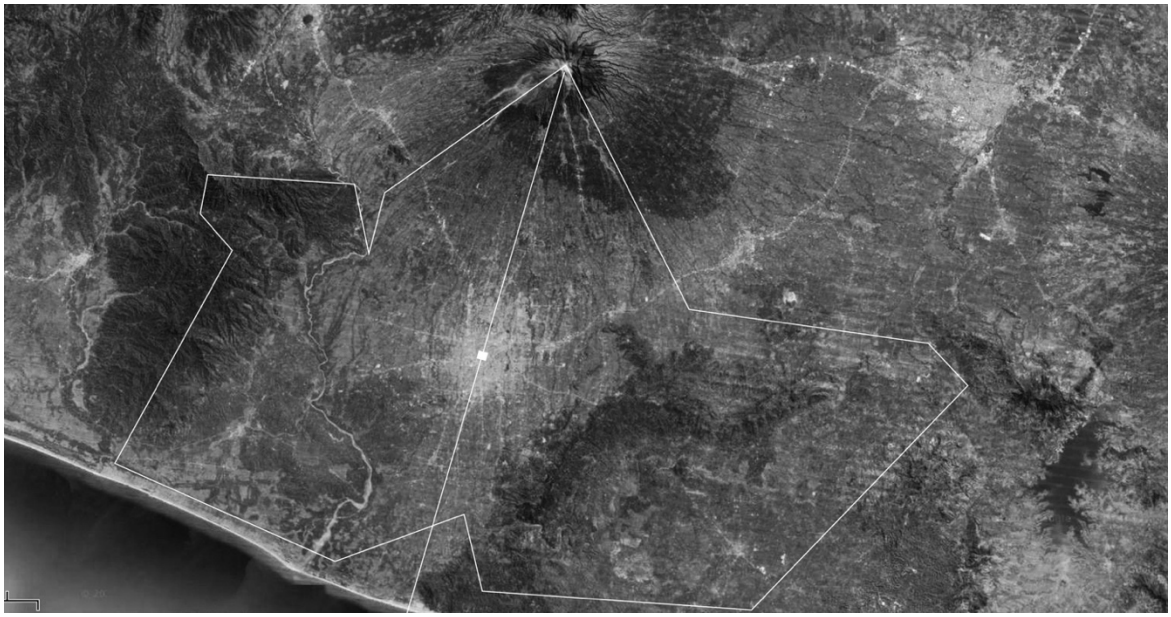

Figure 2. The Special Region of Yogyakarta with the royal axis from Merapi (top) through the Sultan's palace (centre) to the south sea (bottom). Image modified from Google Earth.

The territory of the sultanate is structured by an axis between the northern and southern gates that runs through the palace complex (*figure 2*). The city Yogyakarta is oriented by it along its main street. A monumental obelisk to the north of the palace and an outbuilding to the south further articulates the axis. The ground plan of the palace straddles both sides of the axis in such a way as to give the impression that the axis traverses through its centre. The main entrance is through north and south gates, both of which have monumental, open-plan public spaces and each a round green (*alun-alun*) with two squared banyan trees framing the axis and a long, diminishing single-point perspectives into the palace (*figure 3*). This continues through the sultan's palace with receding archways and gates and axial views creating the organising principle of its plan.

Figure 3. Public square (*alun-alun*) entrance to the sultan's palace materialises the royal axis, 1930s. Image from Troppenmuseum Collection.

In the forest at the top of the volcano, a few kilometres from the caldera, north of the village of Kinaredjo, there is a green painted, smooth limestone gate in the same style as palace walls and gates which leads to a clearing onto a rock outcropping (*figure 4*). This is the northernmost point of the axis two kilometres from the caldera and the gate to the interior of the volcano. A mirror image of those gates is at the shoreline on the Indian ocean to the south. At the centre of the axis is the sultans body, his head the peak of a vertical axis to Allah. Here then we see repeated the upland/lowland distinction of the previous chapter but rendered through the Sultan's extension of his sovereignty into the caldera.

Figure 4. The gate in front of the stone outcropping in fig.7. This is the gate to the interior of the volcano and the end point of the *Labuhan* procession and northern part of the axis. The caldera of Merapi can be seen in the background. The crowd was joining the *Labuhan*. Image of the author.

The territory of the sultanate, according to its origin myth requires these gates as crucial passages between the socio-political realm of the sultan's sovereignty, his subjects, and the realm of nature.[250] The origin of the gate, according to the myth, lay in the founding of the late 16th century fledgling Kingdom of Mataram by Senopati, a soldier and later its

[250] Sometimes this peace deal is framed a bit differently: The current sultan flattens the volcano, his sovereignty, the kingdom and family, when he wrote that "For me, it is a symbol of marriage, it means there is benefit for the community, especially the people of Jogja. But what do I mean if I do not know the aspirations of the people. The symbol of marriage is a relationship between the vertical and the horizontal. People are symbolized as a sea that is homogeneous and does not stop moving. This implies that a leader must manage events and flows." Quote drawn from his *Meneguhkan Tahta untuk Rakyat* in Muhammad Sholikhin, 2009, p. 69.
Access to older versions of this narrative and how it may have been deployed in the Dutch colonial period have been restricted by my lack of understanding of either Dutch or Javanese.

king. It is speculated that his descendent, Sultan Agung, was the first to make up the origin story to bolster his own authority in his fledgling kingdom more than a century later.[251] Whatever its actual origin and whose authority it bolstered, the myth has had a complex and uncertain history but gained particular potency in the post-colonial period, and particularly in Suharto's New Order. My brief account of it here is based on the hybrid versions of it as it has been told since the New Order and, as I'll explain later, should be understood as emerging from the nature-culture ordering techniques of that particular period. The gates at both ends of the axis hold together the abstraction of the myth of sovereignty and are the sites at which the politics of nature, the sultanate, and the future are performed. The architecture of these gates are the sites at which the territorial expanse of the sultans power are made legible.

The myth says that Nyai Roro Kidul was a beautiful but diseased outcast from a rival kingdom, exiled from the court to wander the south coast. After some time, she entered the sea to build her own Sultanate with underwater entities. Enlisting servants and a retinue like the sultanate on land, she also became part dragon or fish, depending on the version, a *chthonic* – underworld entity, with a half human form and came to rule the beings of the ocean and operate the hydraulic tidal motions.[252] Senopati had failed to found his new kingdom through violence and conquest and in despair went to the edge of the south sea to meditate. His meditations were so profound they began to shake the sea and, alarmed, Nyai Roro Kidul left her palace to see what was happening. They fell for each other (here, also, details are fuzzy) and made love for three days and nights at the edge of the ocean. Some accounts (contemporary royal rituals) portray this as Senopati's strategy to enlist her powers of protection and the support of the ocean's beings because earthly sovereignty had to enlist nature. They are also both aligned in their exile from their contemporary states. Nyai Roro Kidul offered Senopati an egg (which as we saw in the Chapter six in the possession ceremony can also be ingested to swallow the cosmos as well as being a symbol of fertility) but in fear of being poisoned and captured Senopati in secret gave it to his servant Ki Juru Taman (later to change his name to Ki Sapu Jagad) to eat.[253] When the servant ate it he became a giant and Senopati charged him with becoming a minister in the existing palace inside the volcano. Once installed in the volcano, he joined the palace as a kind of minister of defence – his new name *Ki Sapu Jagad* translates directly as 'Venerable Cleaner of the

[251] Wessing, 1997.
[252] Wessing, 1997; Triyoga, 1991.
[253] Triyoga, 1991; Inandiak, 2014; Schele, 1996; Suryo S. Negoro, *Javanese Traditional and Ritual Ceremonies,* 2001, pp. 93-100.

Cosmos' but it can also mean 'destroyer', his eruptions and other volcanic effects would be a kind of sweeping clean, annihilation. Military defence and aggression were coupled with household management.[254] He was part of an administration ruled by two masters, Empu Rama and Permadi.[255] The retinue reflected the structure of the sultanate Senopati would later create. Both the sultanate inside the volcano and in the lowlands would have agricultural areas, animal husbandry, markets, and banquets and would engage in trade with its neighbours. The plateau to the west of the caldera, of black sand and littered with giant boulders, is the site of the market and the volcanic sultanate holds its sales at night and in the early morning and it is usually known by its sound, the rummaging and scratching of rock against rock.[256] One can tell the sultans sheep have been grazing the slopes if a patch of forest towards the top has been stripped of leaves (the Javanese word for pyroclastic flows is *Wedus Gembel* – sheep clouds). The volcanic sultanate was a shadow version of the lowland sultanate, as if *wayang* – the traditional shadow puppet theatre from the region, with its double sided screens, one side the shadow, the other side the puppet, was applied to the relation between the volcano and the sultanate.[257]

Shadow State

There are, then, three palaces on one axis: in the ocean, the fertile lowlands, and inside the volcano, each is a version of the other but they are structurally the same: hierarchical, with sovereign Kings or Queens, retinues, animals, and markets. According to the myth, they were established simultaneously through a peace deal, founded in three days of copulation which was their origin through both reproduction and interpenetration, but also the will to betray and enslave one sovereign to another. This originary structure remains coterminous with the relationships between the palaces and because of this, the palaces sovereignty originates through the fragile settlement and co-creation of three sovereigns. By sovereignty I mean here also, and crucially, the capacity for the sultan to be the sole ruler and

[254] The Greek term *oikos* gives us economy is also a reference to the house.
[255] Tiryoga, 1991, pp. 41-50; see also, M. Nasruddin Anshoriy, *Neo patriotisme: etika kekuasaan dalam kebudayaan Jawa*, 2008, pp. 183, and Wessing, 2006, pp. 45–68; See also, Inandiak, 2014.
[256] Triyoga, 1991; Michael Dove, 2008, 2008 b.
[257] Drawing analogies between the wayang and structures of Javanese society has long been exercised by anthropologists from Geertz to Benedict Anderson. I hesitate a bit because of this but find that it's a more useful analogy than 'mirroring'. Mirrors don't play a particularly significant role in the Sultan's palace whereas the Shadow plays have long been a popular art form for the sultan, court and his subjects. The screen with two sides, the shadow and the projection, all seem to me to be techniques that also give metaphysical sense to the world.

authority of his territory *and* sole representative of Allah on earth. These contradictory forces constitute the Sultan's territorial system of the shadow state of nature.

While it may sound exotic, this system does share some features with modern sovereign-state systems. Legitimate power is extended evenly within the territorial boundaries, exerted at its borders by allowing or refusing what flows in and out.[258] It is co-produced with adjacent sovereign territories with which it strikes agreements on the management of what flows between them. The modern state system rarely encounters radical difference with its neighbours in the sense that while neighbouring states might act differently, have different values, and visions for how to organise themselves, they are nevertheless sovereign states with territorial boundaries, self-determination within those boundaries, and they manage the movements of things between them. In other words, sovereign states for the most part, face other sovereign states.

Yet, the three sultanates (ocean, lowland, volcano) are not only horizontally adjacent, they overlap in more complex ways, through their shadowy relationships. I can't help but see in the three sultanates, resonances with the overlapping territories of the Dutch colonial system in which two state forms, the Dutch East Indies and the administrative district of Yogyakarta in which the authority and rule of the sultan was recognised though ultimately subservient to the Dutch Regent. The Dutch state and the Sultanate shadowed each other, in that the one produced the other, and were separate entities that do not exist apart from each other. After the republic was created, this structure remained intact but rather than the sultanate being a 'native' institution to the Dutch, it became, for both dictators, Sukarno and Suharto, a heritage polity that represented an *ur*form of Indonesian governance. They both, in their own ways, referenced and referred to their rule through the history of the sultanate, even incorporated the sultan into their governments as a minister in the 1960s and later as a political party member.[259] This shadow structure turns out to be consequential for gate keepers and forecasting because it frames the way in which the future of nature is sensible. The shadow system has determined how the future of nature can be anticipated because it is always sensed in relationship to the shadow state system. The gates of the territory are where the three sultanates exchange with each other and through them, futures emerge.

What is pivotal about the shadow state system however is that it does not conform to the state of the modern constitution. Those forms of state, which we see emerging with the

[258] Anderson, 1990.
[259] For more detailed treatment of the Sultan's role in Republican politics see these sources: Benedict Anderson, "Exit Suharto: Obituary for a Mediocre Tyrant", 2008. Riklef's *History*, 1981.

post-colonial state and founding of the Republic of Indonesia, are broadly based on a different myth that separates nature from society while institutions like modern science are dedicated to access nature,[260] what constitutes a resource, what is subject to plunder and processing, and where the lines are between the state of nature and the nature of the state. As a part of this, as Agamben argues, modernist state sovereignty is based on the principle that sovereignty is a uniquely human attribute.[261] It designates the threshold between the human and nature, the dividing line between a political, rational animal and a wild animal. The sovereignty of the modernist state is worked through simultaneously as a border problem between nature and culture in which the inside and outside of the state is coupled with ordering the border between nature and culture in material space.[262]

On Merapi, the volcano is a Sultanate and does not operate within or on the edge of the realm of sultanate, as its other, it *is* a shadow sultanate. Rather than a sultanate on top of the land, like the palace in Yogyakarta, the sultanates in the ocean and volcano have taken to the other side, the back, shadow side of the landscape. From there, they also go to war, make diplomacy, good and bad decisions about their neighbours, trade with them, enter into exchanges, incur debts and give gifts of supplication, but they do so through a different arrangement of bodies: wind, waves, lava, and earthquakes. This transforms the notion of the state of nature, and the circuitry of differentiation that Siegert described, from a separate ontological configuration between the state of nature and the state of society, into one of shadow polities in front or behind, and which operate in relation to each other. The state of nature is actually the state of the sultanate but within the depths of nature. Even if they are shadows of each other, they move and operate independently. They mimic each other's autonomy even if bound by the same structure, overall shape, in the same way that modern states are all the same by virtue of being territorial states, but act independently and in relation to each other. This may explain why they still require borders and gates as points of contact and exchange because, again as Siegert argues, they are architectures of differentiation and connection.

[260] Latour, *We Have Never Been Modern*, 1993.
[261] Agamben, *Homo Sacer*, 1998; see also Latour, 1993, which sets up this argument.
[262] The establishment of state borders are in this tradition part of the process of establishing also, gates between the nature and culture.

Figure 4. *Abdi Dalem*, in the sultan's retinue carrying offerings from the Sultan to the South Sea and Merapi for the annual pilgrimage the *Labuhan*. May, 2016. Photo by author.

Labuhan

The yearly ritual *Labuhan* in which a lavish procession from the sultan's palace travels to either end of the axis references this shadow politics of nature in a loud and boisterous way throughout the city. When I joined it in 2016, the Sultan's entourage begins inside the palace, carrying offerings in wooden boxes while wearing their palace uniforms to the line of the Sultan's parked black cars (*figure 4*). As the procession moved through the city, it was given a full police escort of wailing sirens through the traffic clogged streets. Land adjacent to the axis is owned by the sultan and stops are made along the way in small towns that he continues to rent at low cost (I was told that this was in part why people felt obliged to show up, to keep the rent low). Lavish offerings of fabrics and small packets of flowers and herbs are given accompanied by scripted key words in old, high Javanese (*figure*

5). At the gates at both ends of the axis, gifts are given to the shadow sultanates. For Nyai Roro Kidul They buried her gifts into the ground beneath the spot where she and Senopati made love in the sand, an area cordoned off by white perforated walls in the style of the palace. Afterwards, floats made of bamboo stuffed with bags of flowers were launched into the ocean for her (*figure 6*). At the other end, before the rock outcrop that leads to the interior of the palace inside the volcano, another round of fabrics, incense, flowers and key words to conjure the presence of the shadow court (*figure 7*). The sovereignty of the sultan is annually reaffirmed through this movement of goods through the gates to the shadow sultans, which simultaneously reaffirms the co-production of his sovereignty through them. They are also routine forms of giving so as to memorialise the origin of the peace deal and perpetuate it into the future. By bringing crowds to the gates at these times of the year they are also bringing the shadow sultanates towards the gates to make them sensible and present. What appears on the other side of the gate is a polity in the shape of a volcano. This shadowing has two effects, it both colonizes nature by turning it into a human institution but also threatens that institution because volatile nature does not act in accord with the wishes of that institution.

Exchanges are routinely moving between the gates because of this asymmetry: the ocean and volcano are restless beings. Every time there is an eruption, landslide, earthquake, violent wave, or pyroclastic flow it signals an act to be decoded in the political terms of the peace deal. All of this has sophisticated and shifting doctrines: what does a death in the ocean mean, what does a landslide say about the mood of the volcano palace? One of the consistent forms of decoding since the 1980s is the argument that big, disastrous events such as eruptions are the result of the defences of the volcano (*Ki Sapu Jagad*) and the breach of the peace treaty. Eruptions, the various behaviours of the volcano–landslides, a caldera glowing with red lava, increasing and decreasing intensity of tremors–are political events and/or events of diplomacy.

To uphold the shadow system, disorder of the volcano is disorder within the political system. But within the system, coincidence is not enough to establish causality – it would not be enough to point to these coinciding dates in order to say one simply caused the other. In desperate times like war and coups, the causal relation becomes obvious because the events are big, calamitous, and difficult to miss. But the Merapi sultanate is highly nuanced and boisterous in its actions, it can be active for years and then complete silence, or mixtures of both. Its actions range from thick smoke columns, quick blasts at night and short, barely registered tremors. It is not a matter of on or off, but gradients of action, and like any state, it contains multitudes; these gradients of action become complexly embroiled in, indicative of,

and related to the sultanate in the lowlands. This is where the work of gatekeepers becomes pivotal to the system because they do the interpretive work of decoding the relationship between volcanic action and the sultanate. This is also the source of their agency and power because they can begin to expose causal agents that are not necessarily to the advantage of Sultans, presidents, kings and queens. They can begin to transform volcanic activity into matters of concern that implicate human action and the division between nature and culture. While they are the products of the sultan system, and necessary for that system to survive. Gatekeepers, as we will understand in more detail in the next section, also have the power to transform how it is operating.

The shadow system relates to disasters in a different way than republican modern science which sees nature violently 'intruding' or 'disrupting' the social order, making the background of soft 'whirring machines' that keep everything working spring into the foreground. It is because the modern constitution has such authority that nature disappears into the background, only to become present and expose the entanglements with humans when it breaks. As Sarah Whatmore puts it, disasters, according to the modern constitution are "the becoming molten" of the material-conceptual distinctions between nature and culture that are otherwise so strong. Latour describes this as the breaking of the "black box".[263] In the system of shadow sultanates though, volcanic eruptions and floods are not *intrusions* of an othered nature that disrupts the social order, they are interstate exchanges, events in the economies of relating. This also means that disorder in the above ground sultanate or the republic, the fall of a tyrant or acts of unceremonious rule are also acts of violent nature.

Gatekeepers

Gatekeepers are the front line of these ordering techniques. They are at once message bearer, translator, guard, and priest. They operate at the borders between the shadow and lowland sultanates, making the shadow world legible by giving it offerings and translating its signals in diplomatic terms. They are the ones that operationalise the ontology of the shadow system by enacting it, undertaking its rituals, carving its ontology into the yearly cycles of walks, prayer, eating, and fasting. They clean and guard the architecture of the gates that open on to sacred sites, and sacred sites are determined because they are portals of communication between the shadow world and our world. Their labour is to keep that

[263] Latour, *Pandora's Hope*, 1999.

architecture clean and in good working order so as to keep a crisp image of the territory—power nexus of the sultan.

The *Juru Kunci* are the gatekeeper class of the sultans retinue (*Abdi Dalem*) paid by the sultan to work for him for life [*figure 4, 5, 6*]. With a blue collared shirt, dagger, and sarong that signal their rank and devotion to the court, their role is to manage the gates at the borders of the sultanates. On the volcano, that role has been hereditary for three generations within one family. There, the *Juru Kunci* conduct the yearly *Labuhan* rituals, keep the gates, cemeteries and pathways clean, conducts ritual feasts and walks. In addition to the gate there are other topographical features through which the shadow sultanate circulates and the *Juru Kunci's* work. A banyan tree that was the home of a volcano spirit – and spared damage from lava and pyroclastic flows because of it, also required attention from the *Juru Kunci*.[264] A large boulder near the banyan had been left untouched by lava flows and was thus also tended to.[265] At the royal cemeteries, the site of Dlepih, village cemeteries, Turgo, the burial ground at Sentono, each have gatekeepers because they are all the architectures in the shadow system.[266] The gatekeeper didn't only work for the sultan, he also had responsibility to other visitors as a facilitator, translator and interpreter for them. And he was a significant figure in the village with the authority to order evacuations or emergency planning in the case of a disaster.

What becomes evident as we follow gatekeepers is that their labour is also negotiating the way that people on the volcano can understand their relationship to nature and the modern state, and how they can be modern subjects. Any project of nature forecasting has to operate through gatekeepers because it operates through representation, action at a distance and networking; those gatekeepers, through their autonomy, are responsible for an unpredictable reshaping and transformation of the nature-culture distinction, and a remaking of its affordances. Gatekeepers bring forth the distant interior of the volcano – one is a volatile centre of gasses and lava and the vast pressures of rock, one node in a system of crustal plates rising and falling and the line of volcanos that spread across Java belong to one system. The other interior is a political interior in a fragile order with the exterior. Events like eruptions and floods are the expressions of wills and decisions, they are acts of shaping the world. These two interiors, then, I think it should be clear, are brought forth at the gates by

[264] Inandiak, *Babad*, 2014.
[265] White banyan, personal visit, 2013.
[266] Negoro, 2001; Dove, 2008, 2008b; Triyoga, 1991.

gatekeepers. They constrain and facilitate what the interior of the volcano can be—they give it a depth which is an ordering of both nature and culture at the same time.

Nature forecasting on Merapi cannot be understood without taking into account the economy of this shadow system because it is an *a*modern–neither not modern or post-modern—future of nature on Merapi in which the distinction between nature and culture is negotiated in relationship to the legacy of the shadow system and the contemporary republic.[267] The shadow system is not a story of an ancient untouched tradition that continues to this day but one which has been continuously re-written, and re-imagined from the colonial period to the present. The power of the Sultan and the President of the Republic is articulated through it, and therefore, always also through the future of nature and the territorial system. The shadow system, in this way, is not simply a "belief" system or a "culture" projected onto nature, or a "perspective". As a cultural technique, it is embedded and made possible through the iterations of practice and architecture that co-constitute the shadow sultanate and through which it gains its capacity to act on people, the future and nature.

What needs to be understood in more detail is how the shadow system interfaces with Republican state politics, nature and the future, at the site of the gates and through gatekeeper practices. This is the space where the forecasting of futures becomes a crucial political act by gatekeepers as they create, diffuse, or redistribute political forces through the shadow system. But it is also the site at which the proto-animism of the shadow system, the lively actions of nature are co-opted by Republican state power. The *ur*form of the shadow system has been harnessed by authoritarian power as a way to diffuse its own energies into all of nature by showing that the power of the state is also the power of nature. For authoritarian state power to operate in the past it has done so by folding into itself, and identifying its own capacities to manage and manipulate populations with the power to manage and manipulate nature. As I will show in the next section, the very story of the shadow system and its mythical origins are themselves constructions of Suharto's New Order system of violence. The *Labuhan* that I gave an account of here, is itself a continuation of that totalitarian moment into the present, a repetition of the authoritarian governance of nature within the contemporary so-called Reformation period (1998-present) of contemporary Indonesia.

[267] Latour, 1993.

Figure 5. *Abdi Dalem* carrying offerings from the sultan to Nyai Roro Kidul in the South Sea. May 2016. Photo by the author.

Figure 6. *Abdi Dalem* praying on the beach before releasing offerings from the Sultan, in the foreground bamboo rafts, to Nyai Roro Kidul at the south end of the axis. May 2016. Photo by the author.

Figure 7. *Abdi Dalem* giving offerings from Sultan at Merapi, the north end of the axis. The stones are the entrance to the interior of the volcano and the shadow state system there. Front row, middle is the current *Juru Kunci* gatekeeper, Asih, the son of Maridjan. A mountain shaped offering of carrots, chillies (as eruptive material), Indonesian lychee's, and apples, is visible in the centre. The *Abdi Dalem* to the left is giving offerings from the Sultan and reciting code words and prayers to the shadow Sultanate on the other side of the stones. May, 2016. Photo by the author.

Maridjan and New Order Violence

Maridjan was the *Juru Kunci* in Kinarehdjo and took over the position from his father in 1982, during the New Order, until his death in 2010 when he was believed to be in his 80s.[268] He lived through the bloody days of the transition to the New Order and would have witnessed its violence on Merapi. The purges of communist party members in the 1960s and 70s and their affiliates lead to the deaths of up to a million or more and swept through the hillsides of Merapi through Suharto's special project, the Merapi-Merbabu Complex.[269] The

[268] Accounts differ about how a gatekeeper is appointed, sometimes it is hereditary sometimes based on character. See for instance, Yuyun Khabibi, *Kharisma Mbah Maridjan Sebagai Juru Kunci Gunung Merapi di Yogyakarta,* 2008, pp. 29-31. Khabibi traces Maridjan's lineage to Wonodiryo, allegedly the first gatekeeper on Merapi in the village of Kinahredjo in the late 19th century under Sultan Hamengkubuwono VII.

[269] This was part of the Petrus, a reign of terror, indiscriminate killings and violence. In his autobiography Suharto writes the following about the violence: "Some of the bodies were just left where they had been shot. This was meant as shock therapy so that people would realize that loathsome acts would meet with strong action that was taken to stamp out all the inhuman criminal offenses." Soeharto, *Soeharto: My Thoughts, Words and Deeds,* 1991, p. 336.

violence was eruptive, and a perpetual possibility. No one could be certain of the logic of who would be chosen: it was a strategy of permanent paranoia and fear. Some evenings, it was described to me in Keningar, soldiers would travel up the slopes of the volcano looking for entertainment and villagers, terrified, would perform the *wayang* shadow plays for them, sometimes throughout the night, unable to stop for fear of angering the soldiers. What happened on Merapi took place across Java. Bodies of so-called criminals and communists would appear floating in rivers, relatives would disappear in the night. Ening Nurjana, who was a school girl at the height of this period known as Petrus, recounted walking to school one morning passed a corpse floating in a canal.

Suharto championed the *wayang* and *jatihlan* trance dance and his central Javanese roots to shore up his association with the Sultanate. Competitions were staged between villages, and state representatives would attend as judges and present awards.[270] The celebration of 'traditional arts' was a practice that articulated the New Order within a continuum with a primordial and mythical past of Javaneseness that predated colonialism, and the violence of the military regime with an *ur*form of Indonesian state.[271] Suharto had gatekeepers within his retinue who managed the gates to the shadow state across Indonesia, but especially in Java. They gave offerings, practiced magic, and ritual. During an eruption in Bali in 1980s, he sent offerings in a grand public display.[272] His capacity to undertake diplomacy with the spirit world was an expression of the depth and endurance of his power and adopted the animist practices of the sultanates shadow system. To achieve the new order, the sultan-president had to be in diplomatic exchange with the shadow world through his gatekeepers (*figure 9*). In the 1980s, Suharto ordered *Labuhan's* at election time and had his clothes launched into the ocean for Nyai Roro Kidul[273] to demonstrate that his power operated also through the power to order nature, to exchange with it. His power was not only made sensible through the unpredictable eruptions of military violence on the slopes of Merapi but also through the ability to enter into exchanges with nature. If there were no eruptions, then, his power was defined by maintaining a "balance" through harmonious relations between society and nature. If there were eruptions, it signalled a cosmos out of order and his authority would be restored through supplication and offerings, but also through the deployment of the military and civil service and the modern technological equipment

[270] This is drawn from Sugiyono presenting me with certificates issued by the state.
[271] Siegel, 2006.
[272] Marcel Bonneff, "Semar Revele," 2002, p. 13.
[273] Marcel Bonneff, "Semar Revele," 2002, p. 13.

associated with them (helicopters, trucks, large machinery) to assist with evacuations and recovery. The modernist technological state of the New Order and the shadow system were woven together.

Maridjan became a gatekeeper in this renaissance of the shadow system and that system was, in good measure, an invention of the New Order, not created whole cloth, but the significance of his role and the appeal of the shadow system of governance, the stories told about it, were amplified by it. He came to stand-in for the shadow system at the moment that he began to build international networks that explained, amplified and distributed it. Many were fascinated by and celebrated the sultanate system and its rituals, and projected them back into the primordial Javanese past just as Suharto had done. French architectural historians and anthropologists wrote about how the palace operated according to ancient Hindu-Buddhist cosmologies and joined as ethnographers the *Labuhan* to the south sea.[274] In the 1970s Claude Guillot and Cecile Bigeon both visited and wrote ethnographies of the rituals and offerings of the *Labuhan* at the south sea, including accounts of the role of the *Juru Kunci* and the founding myth of Senopati which I drew on for my account of it here.[275] In 1989, Elizabeth Inandiak, a French journalist who settled in Yogyakarta, began a translation of the neglected Yogyakarta court epic poem and encyclopaedia *Serat Centhini* for the first time into French, and began work on a book about Maridjan, *The White Banyan*, in French and Indonesian (later translated into English) which covered to some degree the shadow system in interviews with him.[276] In 1991, the Indonesian anthropologist Lucas Triyoga published a systematic account in Indonesian of *The Javanese and Merapi: Perception and Beliefs* that outlined how villagers on Merapi thought there was a shadow sultanate in the volcano. He did so under the tutelage of Yale anthropologist Michael Dove, who would later in 2008, pen his own papers on the shadow system and how it interfaced with volcanic hazards[277]. Dove's time in the anthropology department at the local prestigious university Gaja Madah, Triyoga pointed out, influenced local anthropologists to undertake their own field work on Merapi and study the interfaces of what was understood as ' belief systems' and volcanic action and that they had not been interested before in such matters.[278] There are still many in the faculty that continue this work today. The shadow system became interesting to international, national and local writers, and scholars at the end of the New

[274] Behren, Archipel, 1989, p. 89
[275] Claude Guillot, 1982; and, Cecile Bigeon, 1982.
[276] Inandiak, 2011, pg 5. Some of this is also contained in *Babad Ngalor-Ngidul,* 2014.
[277] Dove, 2008.
[278] Triyoga 1991; and in personal conversation with Triyoga.

Order period but they often treated it a historically and outside of its wider entanglements within the system. It is not that these writers were celebrating Suharto, far from it. Many of them were his critics, but they celebrated Marijan, folk belief, and non-western systems but overlooked how that system was central to the New Order.

The founding myth of the sultanate that I retold here was widely distributed and coalesced in the New Order by its government, visiting anthropologists and journalists, while it was adopted as a model of sovereignty by the Suharto regime. This was so much so that in order for there to be 'fair', democratic elections, Suharto had to give his clothes to Nyai Roro Kidul.[279] There needed to be transactions between the two sultanates for his democratic sovereignty to be legitimate. He was realising the myth: sovereignty is extended through nature, the actions and events of nature are in themselves political events. Maridjan participated in this because it is only through the gatekeeper that the clothes end up in the ocean and the right words are uttered. With the arrival of international journalists and anthropologists, that shadow system was broadcast as a plausible system of traditional beliefs even though it was propped up through the institutional support of the New Order regime that allowed them visas to cross state borders and conduct research under the regime's strict guidelines.[280] As a project of modernisation the New Order didn't operate only through the modern constitution that separated nature from society but rather its opposite, extending society through nature both at home and through the management of global networks in and out at the republics borders (and their modern gatekeepers in border guard uniforms) and what they had access to. It supported the function of the president as sultan whose powers extended outwards to the shadow sultanates of nature and through which he had to trade and negotiate in order to maintain his own power.

[279] Marcel Bonneff, "Semar Revele," 2002.
[280] Geertz famously described ditching his institutional affiliations with Indonesian academics under the New Order restrictions. It was also famously difficult to get access to the interior of the Sultan's palace as a foreigner.

Couverture du magazine *Misteri* (20 juin - 4 juillet 1998) :
« Témoignages des *dukun* de Soeharto » en est le titre principal

Figure 9. The title caption reads: "Suharto's shaman's supernatural powers", *Misteri: Majalah Investigasi Supernatural* [Mysteri: Supernatural Investigations Magazine] 1989. One of the other stories in the issue was titled "Hitler Died in Surabaya". From Marcel Bonneff, "Semar Revele," 2002.

Maridjan continued on as a gatekeeper after the fall of Suharto. Through encounters with him and other gatekeepers, writers and academics came to misunderstand the shadow system as primordial system, as "local knowledge" and wisdom. Much of this came to a head in the controversy of 2010. I turn to this controversy now in order to explain what I set out to understand in the beginning of this chapter, the particular capacities of gatekeepers to negotiate their power at the gates. I have described how Maridjan was a gatekeeper for the Suharto era notion of the shadow state as also a state of nature, that it gained its legitimacy to order and manage a population through its exchanges with nature. This system persisted through the Reformation period because of the continued work of Maridjan, and caught the imagination of foreign scholars and writers, while modernist monotheist science flourished in

the observatory in the reformation period. For many, the shadow system carried a powerful appeal because it resisted the demystifying, cold, and often also authoritarian dictates of the scientists in the observatory. But in the controversy that emerged in 2010, I want to argue, was a crisis over the ontological distinction between nature and society. It was at the very site of the gate and through the work of the gatekeeper that the essence of what distinguishes the nature of the state and the state of nature was made controversial, up for grabs, in which authority had to re-establish not only social order but the field within which political authority could be established.

Controversial Futures

Maridjan vocally defected from the new Sultan Hamengkubuwono X and claimed allegiance only to his father Sultan Hamengkubuwono IX. He claimed that he no longer represented him because the new sultan was uninterested in the shadow system. Like a good modern, the sultan said it was superstitious, though at the same time he was a good orthodox, monotheist Muslim and neo-liberal capitalist. He refused to join the rituals and abandoned the axis. He undertook to transform the face of the volcano by building a golf course on it, leasing land to international hotel chains and building a museum, Museum Gunungapi Merapi, that included displays of "folk beliefs" such as Nyai Roro Kidul. The museum consigned the shadow system to history in a progressive narrative that placed modernist science as the most advanced method of forecasting and mitigation. Maridjan, though, had become an even more compelling figure in national and international media because he continued to insist on the shadow system. Many international journalists understood this New Order era invention to have been a timeless tradition. He became a kind of gatekeeper in another sense, of tradition and journalists from National Geographic, the Guardian, and BBC wrote profiles of him.[281] In these interviews, Marijan often defied the new sultan and insisted on the capacity of the shadow sultanate system to be able to make sense of the present. His charisma and charm as a figure with odd but compelling beliefs meant that he was often interviewed when Merapi became active and his views had a wide reach beyond his small, remote village.

In 2006, the state scientists at the observatory Suryo, told Marijan's village to evacuate, the dome was increasing in size and they suspected it would erupt, but Marijan refused. He said, explaining the terms of the shadow system that " Merapi is building up and

[281] Alfano, 2006; Guzman, 2006.

releasing lava and hot clouds. It is cleaning itself. There is no need to be afraid, the Cangkringan area [his village] is safe".[282] His resistance was reported by NBC in an article that, like so many others, identified the peculiar belief systems of people on the volcano simply in its title: 'Naked Men try to Calm a Volcano'. In another interview he said, "When I listen to Merapi, I don't hear any danger…Merapi will not hurt the residents, but the residents must look after the mountain and not take everything they want greedily."[283] A reference to the current sultan. Agreeing with Maridjan, the people in his village refused to leave. There was a small eruption but it never touched the village. This bolstered the sultanate system because it was proof, even if the current Sultan had turned his back on New Order era shadow system, it wasn't reliant on the "belief" of the sultan for it to continue to work. Instead, the village and those in Marijan's network were beginning to see that they were leveraging the shadow system of the New Order against the transgressions of the current sultan. And perhaps things would get even more dangerous.

This became particularly evident in 2010 when the dome began to build once again and volcano scientists began to suspect that they were on the verge of "the big one". Surono had thought that the volcano was due for a repetition of the massive eruption in 1930 which killed over a thousand people. He suspected, like Van Bemmelen had before, that there may be long cycles between eruptions of this scale – spaced every seventy to one hundred years of "build up" within the system, and small eruptions were releases of tension along the way.[284] Earthquakes had become more regular – many per day, throughout the months of July through September of 2010. People described the ground as 'buzzing' and loud bangs could be heard echoing throughout the lowlands from explosions inside. In October, the status was changed to Beware, the highest level issued by the observatory and Surono was flown in from Bandung to take over the operations and make the decision to order evacuations. He wasn't yet certain of when the evacuations would begin but was putting communities in the identified danger zones on the southern flanks on guard and to prepare to evacuate to refugee camps. He sought to enlist the help and support of Maridjan, knowing that if he agreed to evacuate there would be a greater numbers of evacuees. Maridjan again refused to leave, arguing that he would be safe, Merapi would not harm him. The president, Susilo Yudihono Bambang, had a letter delivered to Maridjan, personally requesting that for his own safety,

[282] DetikNews, May 15, 2006.
[283] CBC, May 19, 2006.
[284] Temporal cycles and repetitions is a common way for the modern constitution to find deep, non-human patterns.

the safety of others and the state, that he please leave. Maridjan refused his request. In October, as activity continued to increase, Maridjan ordered his family and the rest of the village to evacuate but he remained with a small retinue of journalists and friends. On October 28, Sabda Langit, the shaman from Yogyakarta, visited Maridjan to offer help and support. Marijan turned him away and Sabda related to me that as he drove back down the volcano a pyroclastic flow was beginning to engulf his car but he could see in his rear view mirror that *Nyai Sapu Jagad*, the giant and secretary of defence of the volcano sultanate was holding it back as he drove in order to protect the car. That night, a massive pyroclastic flow swept over Maridjan's house and mummified his body, and the ten others with him, in *sujud* prayer positions. The image of his singed body went viral after journalists got access to the destroyed, post-eruption village. The BBC ran the headline "Spiritual Guardian of Volcano Dies".[285] A local news source JPNN headline read "In *Sujud* till the End."[286]

In the days following Maridjan's death, Surono said to the media about Maridjan's forecasting techniques that, "I don't believe in voodoo." The public called for the Sultan to name Surono the new *Juru Kunci* because the evidence was in, the modern constitution had won, the shadow system had lost its credibility, there was no longer a gatekeeper of the New Order. The death of Maridjan signalled the end of the New Order and the transition to the modern constitution of the Reformation. There could no longer be any belief in superstition. The narrative of the new Sultan had won.

During the fifth year anniversary of the 2010 eruption in Maridjan's village, Surono was invited as a guest of honour to the *Labuhan* ceremony. Maridjan's son, Asih, had taken on the hereditary role of *Juru Kunci* it was not, in the end, offered to Surono. Unlike his father, Asih didn't renounce the current Sultan. He was a city bureaucrat before taking on the role of gatekeeper and in 2014 he said to me that the rituals of his father were still performed because they were cultural heritage. He invited Surono to sit with local dignitaries and lowland corrupt politicians and men in military style uniforms for the all night *wayang* shadow theatre performance. Surono agreed, and joined them for a feast in front of the screen, looking onto the shadows cast by the cut outs and manipulated by the puppeteer on the other side. Across from them was Maridjan's grave, and his large portrait beside it.

Surono had changed his position in relation to Marijan and the *Juru Kunci*. In the five years since the eruption, he was now defending the shadow system in the media, claiming that it was necessary in order to fend off the convergence of the modern constitution with

[285] Lang, 2010.
[286] "Bersujud Hingga Ajal Menjemput," 2010.

monotheistic Islam, that it was a threat to religious diversity but also to the establishment of relations of trust between scientists in the observatory and people who lived on the volcano.[287] Surono had defected from the modern constitution and used his position to transform the links between nature and society. The border between nature and culture, as Surono understood, was plastic, and it was the task of gatekeepers to push against its contours.

When I met with Surono in May 2016, he described to me the difficulties he had faced as a Christian in a Muslim majority country. Achieving one of the most prestigious science jobs in the country required navigating, through all of its stages, the institutionalised privileges afforded to Muslims. By 2016, he said, he was witnessing an increasing conservativism in the country, which he in turn had begun to understand that his prior strict adherence to the modern constitution in science was facilitating. His joining of the Labuhan ceremony at the request of Asih was an entrance directly into the politics of science. It was an affirmation that the modern constitution of the Reformation was in fact already a political project of the state that aligned with conservative religious politics. By turning to the Labuhan, and affirming its practice, he was making a tactical, diplomatic move, as the well-respected figurehead of modernist science to affirm the shadow system. This was a gesture directed not only at Asih, and the crowds of people at the Labuhan who witnessed it, but also at the scientific institutions of the state. When he visited the Labuhan, he also met, on the same trip, with top scientists from the observatory, and he is close and continues to work with Made, the head of the Yogyakarta observatory. They would have known of his attendance. He is something of a celebrity in Indonesia (taxi drivers have accosted his family for any news that may have been leaked by him about potential volcanic eruptions). He also gave an interview to the national, well regarded magazine Tempo, stating his position in support of the Labuhan and religious diversity.

Surono had become *a*modern. He understood that volcano science and forecasting was a political act that could not be disentangled from the state. His insistence, earlier in his career, that the Reformation meant allowing modern science to enact the modern constitution, to let scientists take care of nature and politics to take care of society, had broken down. Instead, he understood that doing volcano science was a form of tactical negotiations, that the truth of nature was always in a relationship with modes of governance and social power. To be a forecaster, and to speak on behalf of the future of nature was then, also, always to be in a

[287] "Penuhi Hak Gunung Berapi," 2015

relationship to the future of the state, and the burden of the forecaster is then to devise tactics that can leverage that power, that can undermine or facilitate state forms of governance.

This brings us back to Maridjan's death and an opportunity to make a broader characterisation of the function of gatekeepers. When I discussed Maridjan's death at length with Elizabeth Inandiak over the course of 2015-2016, who had known him since she settled in Yogyakarta, and had written books about him, as well as assisted with reconstruction efforts in his village, she remained puzzled about why he hadn't evacuated. The signs were clear to her that there would be a massive eruption, avalanches, pyroclastic flows and earthquakes, the like of which hadn't occurred in over a decade.[288] He was anxious enough that he ordered his family to leave. Why would he stay? Pride, she asked? Vanity? He had recently become a spokesman for an Indonesian aphrodisiac/energy drink called *Kuku Bima*, which Inandiak thought degraded his image. It associated virility with his powers over the volcano, with the shadow system, and cheapened it into consumer culture. There were scandals that she was privy to in the village about who received the profits from the ad campaign, apparently none of it was redistributed to the village. It was beginning to look like Maridjan had succumbed to lowland corruption. His purity, in her vision of him, had been degraded. Perhaps, then, his refusal to leave was suicidal. Sabda Langit, as I wrote in the previous chapter, had considered Marijan too "Arabized", that he had already disappointed what Langit thought the primordial Javanese animist system so that his death was actually Sapu Jagad's assassination of Maridjan. Since his murder, according to Langit, the gatekeeper position is still empty. Asih is not fit to take it because he is a lowland bureaucrat. The volcano and the state of the sultanate has no intermediary, which for Langit is a very dangerous situation. After Maridjan's death, there was a cacophony of other interpretations as well.

This cacophony, I would like to argue, is a fundamental trait of gatekeeper work. I want to make this argument before returning, by way of a conclusion, to the spatial and geographic dimension of this argument that I set out at the beginning. My interest here is less in speculating about Maridjan's motivations than to point out the significance of the controversy it created. It was able to bring together competing and contradictory narratives of the meaning of a volcanic eruption and natural disaster. It was able to create a controversy over the fundamental relationships between society and nature and the nature of the state. As Latour, Whatmore, Hulme, and other have argued in relation to environmental controversies,

[288] This is drawn from Elizabeth Inandiak's diaries, "2010 Merapi eruption journals," 2010.

they are significant because it is in the controversies that the status quo alignments of nature-culture relations are suspended and the operations of the systems that made those relations (the shadow state system or the modern constitution) are placed under scrutiny, or, they are placed in tenuous relations with each other. Mechanisms are then set in motion to put them back into place and re-align their orders. Maridjan's refusal to leave, because he was a gatekeeper opened up the very problem of the nature of the relationship between society and nature, the protocols and procedures, appropriate diplomatic gestures, was up for grabs.

The problem that arises from these kinds of environmental controversies is how far the controversy can travel, who and what it can implicated and for how long. If Maridjan's death was immediately understood afterwards as a victory for modern science and the end of superstition, then it would not have been a controversy, it would have been a well-known story. But it didn't end this way. The reason for Maridjan's refusal was disputed in newspapers and comments sections on the internet, by people like Inandiak and Langit, and was even responded to by Surono showing up at the Labuhan six years later. If there is such a thing as a successful environmental controversy, it is one that is able to keep open the fundamental problem of the alignment of nature-culture relations as long as possible so that it is able to implicate as many actors at the furthest reaches, from the village beside the caldera, through the Sultan's palace, to the Presidents house in Jakarta. Gatekeepers can act as henchmen of the nature-culture order but they can also use their position in a way that Surono and Maridjan did to create and prolong controversies so as to keep the order from settling, to slow down its arrangement, to widen its reach and implication. Because gatekeepers work at the borderlines of nature-culture, they can exert pressure and refuse to let the gate close.

Territory

At the beginning of this chapter I argued that it is important to bear in mind that territories are spatial entities with border and gates throughout them, and that these make state power legible in relationship to nature. Territory is an ordering device that also legitimates what gets governed and how. In addition to this, gatekeepers are put in place to operate the borders and gates in the service of that system. But, as the story of this chapter has shown, gatekeepers can exert their own autonomy at the gates because state power is not uniformly distributed. Instead, gates, both in the sense of their architecture and the gatekeepers, are contested sites which feedback in complex, multi-directional paths with the "centre". The gates of Merapi are, in this sense, simultaneously inside and outside of the state and the state of nature. If the state has consistently tried to demonstrate its power to control

and manage nature, it is at the site of the fates that this project becomes unhinged and for which we need a different vocabulary for how to describe their function. The concept of gatekeeping has been my attempt here to furnish that different vocabulary that can capture both physical, architectural form and practice, that is neither a subject of political power nor outside of it, that is located and networked, historically shaped and irreducible to its past.

Chapter 8
Go-Betweens: Routes, Lines and Bodies

The Lure and Fallacy of Accuracy

This chapter follows forecasters as they circulate from the office to the field and how the routes and instruments of travel shape scientific knowledge of nature. This knowledge, I show, is made in the negotiation of movements along topography, ridges, into valleys, driving along dirt pathways and through narrow passes, but also on the run-way strip and motorway. Scientific knowledge is made in motion, circulating through lines between points, from 'A' to 'B' then 'C'. But not only linearly, it is also moving sideways, breaking off, peeling away through a passing conversation in a field, or in the evening over dinner at a field site camp, or walking along a trail in search of a sample. Along these trajectories, scientists encounter interpreters, translators, helpers, friends, what have been described by Simon Schaffer as Go-betweens, that create the networks that support, transform, and distribute their work beyond the confines of scientific papers and reports.[289] These networks allow that work to move among new publics. Scientists, as I will explain, do not move in isolation but are performing various kinds of public work along their trajectories.

One of the reasons to understand how scientists circulate is because scientists that forecast volatile nature are inherently concerned with the public face of science. They are concerned because they rely on public trust in order for their forecasts to be taken seriously and so need to carefully consider their relationships with non-scientists. It is common for scientists to consider their work to be public only at the point of consumption: within the media, as facts or knowledge, rather than the process of making scientific knowledge about the volcano which is itself a public act. Forecasts of the future are not only delivered to a public, the formation of that knowledge about nature is first of all a formation of a public.

Another reason to consider the trajectories of scientists is to counter the privileging of technological and instrumental means of achieving accuracy. In particular, within the geological sciences such as volcano science, as Naomi Oreskes has shown, there has been a desire to mimic the certainty of chemistry and physics, and to stress the controlled conditions

[289] Schaffer, et.al., 2009.

of lab work or computer modelling over the uncertainties of fieldwork.[290] Volatile nature forecasting has sought to bolster its legitimacy by incorporating lab work and high powered computer modelling with its fieldwork requirements and invest trust and authority into bi-tech equipment. Often, the high-levels of uncertainty and unpredictability of forecasting is confronted head-on with a performance of technological fetishism that promises to overcome uncertainty and domesticate an unpredictable world. Or, alternatively, as I witnessed in the field, volcano scientists and geophysicists, retreat from the uncertainty of forecasting behind diagnostic claims about the present, making statements of fact produced by their instruments at the expense of statements about the future because of its uncertainty. This is often because scientists are nervous about accountability and facts, in the Western scientific tradition, can seem to offer a position of neutrality. This condition is pronounced on the volcano as well because eruption forecasts have been strictly confined within the rigid hierarchy of the observatory. Likewise, there is a long history of disputes within volcano forecasting about inaccurate forecasts, botched evacuations, forecasting too late or too soon. The conservative scientific response to this is to retreat behind instruments and to try and find the indisputable, imaginary common ground of facts. This project is still alive when scientists seek to enlist as many instruments as possible and the most up to date technologies to sense eruptions, or earthquakes, or tsunami's before they occur, and this dissertation has shown throughout its chapters, this is an old ambition. What I propose here is a shift in emphasis in how we understand this project. The instruments deployed to study volcanoes and predict eruptions require labs, fieldwork, and retinues of labour, and making facts is also at the same time the creation of publics who bring those facts into existence. And those publics are not self-same along the process, they shift and are variegated because the production of facts requires movement. I argue, then, with Latour, that we need to follow the movements. The retreat into forms of certainty and the fetish of accuracy that contemporary instruments offer is a poor way to understand how scientific knowledge is made public because it cannot understand the relationships that are built by scientists in the production of knowledge.

I propose here that we consider geologists on Merapi as *go-betweens*. I draw this idea from work in the history of science that has offered that we consider the history of scientific knowledge in terms of the actors that move, translate, support, and otherwise do the labour of network making in order that scientific knowledge can travel.[291] This shift has facilitated a focus on the relationships formed between scientists and their support in the field and has

[290] Naomi Oreskes, 1999, p. 283
[291] Schaffer, 2009.

allowed for a focus on the lives and biographies of those traditionally written out of scientific accounts. Moreover, it has allowed for a reconceptualization of scientific knowledge as a form of brokering of movements across spatial and temporal scales before it is a production of facts about the world.

On Mount Merapi, *Go-betweens* play a pivotal role in the infrastructure of data flow into the observatories by transporting information from sites on the volcano to observatories and labs in the lowlands and then, sometimes, around the world. They are integral to the apparatus of forecasting not only because they circulate information but because they are the public presence of state science and expertise. In this way they are participating in negotiating relationships of trust between different publics on the volcano by producing an imaginary of the production of scientific knowledge. By considering the brokering of scientists with publics en-route, we can begin to understand how futures of the volcano are differentially constituted on the move and through encounters.

Movement and the Body

Knowledge is made on the move. It is in circulation, transmitted, carried across distances, handed off at crucial junctures; transcribed, translated, stolen, hacked, stereotyped. From one storage device to another, it is formatted to its containers. They compress, shape it into satchels, pant pockets, pages, and then recording devices and code. The movement and transmission of knowledge is always in relation to a medium that is facilitating transmission, the apparatus that does the carrying and the holding; the road, the path, and the container. It would seem, then, that knowledge is in relation to some infrastructure of support with an inbuilt conspiracy to facilitate, an infrastructure with a deep material solidarity with what can be known because to know is to know something that has travelled, and what has travelled has travelled on the infrastructure of roads and by-ways. That is what makes knowing possible, the solidarity with infrastructures that, when feasible, lend consistency to the objects on the move so that they can endure across their transformations between infrastructures.

Fig 1. Haroun Tazieff, still from *Genung Merapi: A Volcano in Java*, 1980. Still from INA France.

Fig 2. Haroun Tazieff, still from *Le Volcan Interdit,* 1966. Still from INA France.

Volcano scientists, in particular, are exemplary of the scientist on the move: scrambling up calderas, long-haul flights, hacking through the forest with a retinue of assistants. Haroun Tazieff, the French volcano scientist, epitomised this image of the volcano scientist on the move in his films from the 1950s to the 1980s. Even Jean-Luc Goddard celebrated Tazieff's in-the-field and one the move, travel-style portraits of the interior of the earth.[292] What Tazieff wore was always crucial, from a topless stroll on Etna's crater rim to the insulated, barely-human, astronaut-on-Earth gear that he wore in approaching Merapi's vents. His science was defined by negotiating his movements and his body's proximity to the centre of the volcano. The source of knowledge, the interior of the volcano was like the sun and he inverted Icarus' flight towards the centre of the Earth. The amount of his own exposed flesh in his films was the index of his distance from the source, the closer he got to the burning centre, the more disfigured a cyborg he became as he donned reflective suits. In his circuits of movement, from long-haul flights and back-packing up Mount Merapi's slopes, he went from near nakedness to an unrecognizable anthropoid machine-creature.

In *Genung Merapi: A Volcano in Java* from 1980 (*figure 1*), he is depicted in the process of taking samples of the volcano. Portraying him in the protective suit with a gas mask, suggested a continuity with the conventions of European's to associate volcanoes with portals to the underworld, and gaining proximity to them is to approach the limits of earth and hell.[293] But more than tapping into those clichés, Tazieff is also, in this scene and many others like it, acknowledging that scientific knowledge of volcanoes is facilitated by an ecology of mediators: clothing, bags, masks, beakers, gloves, and boots, because they facilitate his movement and capacity to gather samples to carry down the paths along the slopes and onto the roads back to the lab (*figure 1 & 2*).

Tazieff was drawn to speechifying about his intuitive connection with the volcanoes he adored. His understanding of Merapi, he stressed, was the result of his "naturalistic approach" derived from direct experience and observation of volcanic eruptions. "The fact still remains," he argued in 1978, "that too many volcanologists involved with the problems of civil protection possess very little experience of actual eruptions, and sometimes no

[292] Goddard, 1985. He writes of Tazieff, "…what is prodigious in *Les Rendez-vous du Diable* is that by showing the underwater eruption of the volcano in the Azores, graces with such a terrifying richness of forms that only Tintoretto would dared to paint it, and by showing us a river of lava twisting through a cauldron of purple and gold, colors that Eisenstein alone dared to use in the banquet of *Ivan the Terrible*; by showing us all of the prodigies of his talents in mise-en-scene, Haroun Tazieff, *ipso facto,* proves how prodigious mise-en-scene can be." Translation from Kline, 2014.

[293] For glosses on the histories of volcanoes as portals to underworlds, see Oppenheimer 2011; Fisher, Heiken and Hulen m1997; and, Pyle, 2017.

experience at all… It should be admitted that volcanologists should not spend their time in observatories built on dormant volcanoes, but should continuously improve their knowledge of the eruptive phenomenon by studying eruptions themselves, wherever and whenever they occur."[294] This approach insisted on movement, travel, and fieldwork outside of the lab and observatory.[295] For Tazieff, volcano science was a haptic experience in movement. It was to be always negotiating proximities to the source – how close a body could get before it was endangered.

This naturalistic vision of the volcano scientist was the terrestrial version of the astronaut, with his (they were, in the majority, male) silvery suits that functioned as an architecture of enclosure and capsule in earth space.[296] His haptic knowledge was garnered through his encounters with spaces at the edge of life, where bodies cannot survive without vital life support systems. Being able to approach the limit of the living so as to better understand the force of volcanoes meant immersion in a place where the body could not exist without the instruments, mediators, and infrastructures that shelter it.

Tazieff's physical proximity to the source of volcanic action was regularly accompanied by meticulous and dedicated image making and distribution. He made roughly thirty-eight films in forty-three years, the majority of them feature length and resulting in over 1,400 minutes of edited film. Entering these inhuman zones was a project of bearing witness and reporting back to an audience; it meant carrying camera equipment, film reels, and energy sources. These technical instruments of image production were carried alongside the tools that facilitated the production of naturalist haptic knowledge. The film reels descended in back-packs and trunks to then be distributed to the editing bays as his samples went to laboratories. These two nodes, the editing bay and the laboratory, were of equal prominence, image production and the production of scientific facts. Between them was Tazieff's body in various states of adornment and undress, climbing ridges, hacking through woods, standing beside a billowing fumarole, pointing at it, and explaining it to the camera.[297]

What I want to stress is that we consider Tazieff's work less in terms of the quality of his production of realist knowledge claims about volcanoes than in terms of the routes of circulation that he created for the movement of materials and images. It is as a go-between in

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[294] Tazieff, 1979, "What is to be forecast" pp. 327-329.
[295] There was a well-known spat between Tazieff and other scientists about the use of instruments in forecasting, see Tazieff, 1977.
[296] Dorrian, 2012.
[297] Tazieff, *Genung Merapi.*

this sense that he worked, circulating from summit and caldera to lab, newspapers, and cinema audiences. These trajectories become media routes along which films, stills, radio, magazine, and newspaper columns, moved. Volcanoes became a media frontier of routes of representation and volcano science was about imagining how that frontier would be colonised and integrated, the inhuman space of the volcanic would be reproduced and distributed within these networks. It was a way to probe what it meant to live, as Nigel Clark describes it, on an "inhuman earth", a planet not built for us, without regard for us, that will survive us, while we depend on it for our existence.[298] Wearing heat reflective suits, peering through a reflective face guard that obscures the eyes and turns the face into a mirror, is to become partially inhuman while peering at the edge of human life.

Perhaps it is unsurprising that Tazieff's circulation routes were a continuation of the routes that had carried Europeans into proximity with the sublime for over a century.[299] Consider, in this regard, the train tracks that carried wealthy Europeans along the slopes of Vesuvius to ponder the limit of civilization and life.[300] Tazieff continued this tradition through the language of modernist science, and in both cases, they are wearing down paths of movement and representation – circulation as media and medium – that facilitates what gets to be called knowledge, science, forecasting, the future, and a disaster.

Going Between

The convention of privileging the results (data or facts) of scientific practice very often overshadows this messy, public kind of labour that makes scientific fieldwork. It is made of encounters between scientists and communities, their entourages, porters, and translators. This is the brokering work of go-betweens. On Merapi, scientific go-betweens move between the caldera, observatory outposts, way stations, and laboratories (*figure 3 & 4*) and along the way they translate knowledge, carry objects, meet with technicians, hire farmers, negotiate payments for guides and parking spaces, and places to sleep. The bedrooms for scientific go-betweens in observatories on Merapi and other volcanoes in Indonesia are like hostel rooms of one or two beds for temporary stays along routes of travel. Jrakah outpost on Merapi contains four bedrooms, one is dedicated to the shift work of technicians on twelve hour rotations, the others are given over to scientists going between the observatory in Yogyakarta and the caldera of Merapi. In Jrakah there is a kitchen where shift

[298] Clark, 2011.
[299] Oppenheimer, 2011; Fisher, Heiken and Hulen 1997; and, Pyle 2017.
[300] Ibid.

workers prepare their meals and food is kept before the trek to the summit. From Jrakah, the trip is usually undertaken in the early hours of the morning before the sun rise. In the sitting room at Jrakah was a visitors book with entries of European and Indonesian scientists dating back to the mid-1990s.

These waypoints are porous, made as much by things coming and going as the solidity and permanence of their walls. The *to-ing* and *fro-ing* of scientist go-betweens between their instruments, labs and the field, puts the volcano into circulation, translating across platforms, distributing it. To do so, scientists create trajectories of movement, and these station houses as places to crash and/or stash, and they need to be adept at the logistics of facilitating movement, such as securing permits for carrying instruments across borders. French scientists in the observatory in Merapi had a heavy duty, four-wheel drive SUV shipped to Indonesia from overseas to be used for driving the difficult roads up the volcano. They have to master the fine art of packing fragile technologies for harsh conditions. There is even a subsidiary industry of companies that manufacture special weather proof cases for tools and sensitive instruments in harsh conditions.

Geophysical knowledge in this sense is not only about access or representation to some reality but about acts of transmission and distribution. The knowledge of the future which forecasting is organised around, then, is also conditioned by this. And go-betweens are in relationship to different communities along the way, the porters that help them move, show them the way, and carry their stuff; farmers who tend the fields they walk through and mind their parked vehicles when they are in the field; cooks along their route make them dinner in roadside stalls and at each of these encounters there are transmissions of knowledge and the careful brokering of relationships of familiarity and difference.

Another reason that it is important to consider this for forecasting is because it provides a an analysis of the edges and boundaries of the networks that forecasting relies on and the publics it forms. By looking at those edges we can begin to consider what gets excluded, what kinds of movement, proximities and encounters, are left out of the route of the go-between. It demonstrates how the go-between is actually operating in highly structured and scripted forms of movement that limit the kinds of encounters and material that can be included in their movement and also then, the kinds of knowledge that can be produced.

Figure 3. Go-between bedroom, for technicians and scientists en-route to the summit for fieldwork, Kelud Volcano, east Java, April 2016. Observatory outposts on volcanoes across Indonesia have similar sleeping quarters. Photo by the author.

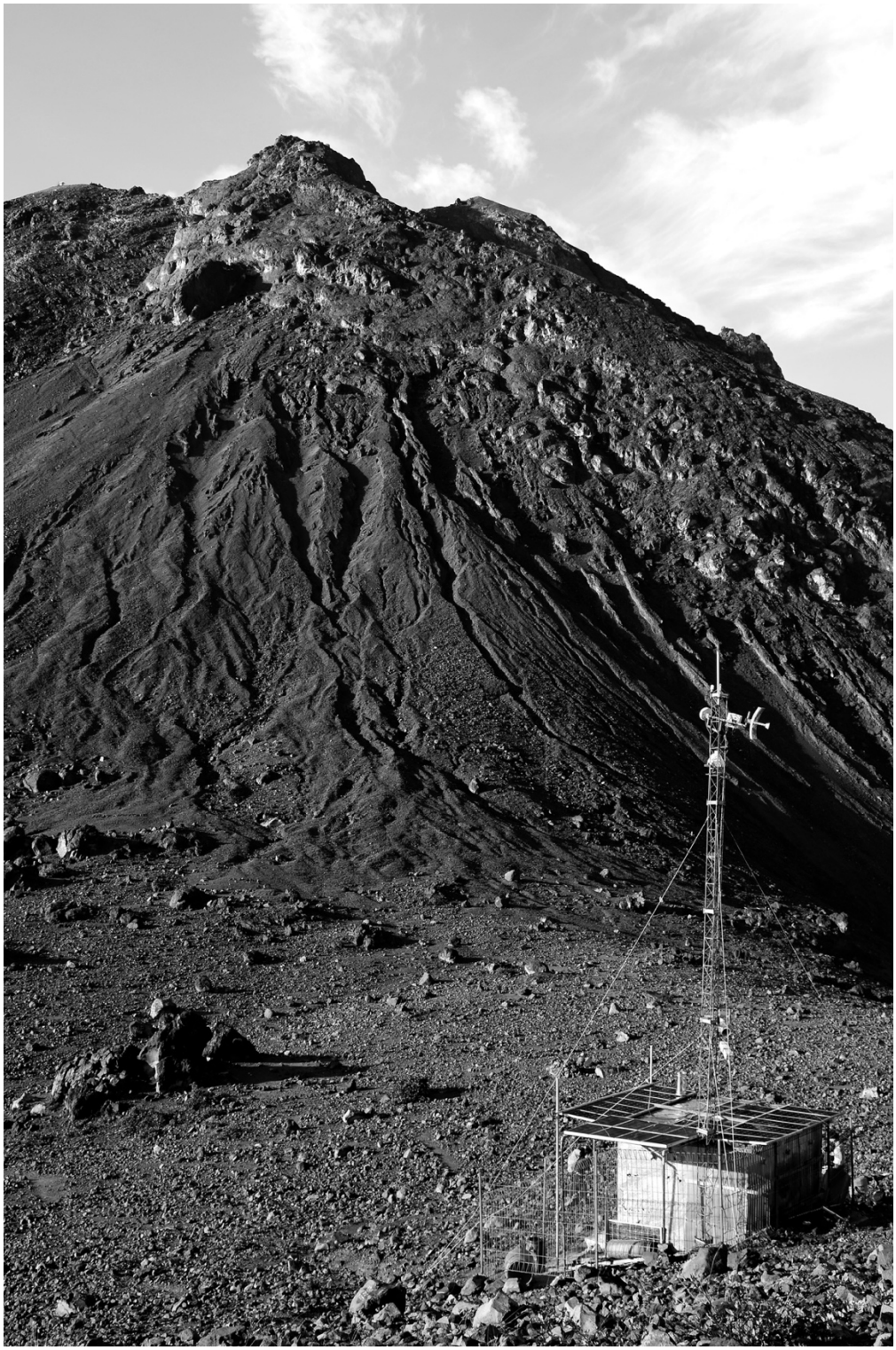

Figure 4. Go-between bunker on Merapi that can sleep four people, contains transmitters, supplies, water, tea, sleeping bags, batteries, and solar panels. The north face of the caldera is visible and *Pasar Bubar* is in the middle ground. The station was built by roughly 200 porters, carrying materials from the base, between a 2-4 hour walk depending on fitness and the load. The materials included cement, barrels of water, cinder blocks, fencing, and a thick metal door. Photo by the author.

An Expedition

Svetlana Byrdina is pouring cat litter into a plastic cola bottle. She tells me that "it is good for conductivity". We are in the office of DOMerapi, the French, Institute Nationale de Researches Scientifique supported research project focused on understanding the dome of Merapi. In the corner of Byrdina's small office of four researchers is the wash basin where she is prepping her bottles of conductive mixture. She will, in a few days' time, if administrative issues don't interfere and there are no mechanical troubles with the truck, carry those bottles with her to the top of the volcano. On that day, the truck will also include her research assistants Rizal and Suhari, and 200 meters of 12 gauge electrical cable, provisions, heavy duty field laptops, sensors, sleeping blankets, tents, hiking boots, tubs of food, laptops, and electrical switch boxes for an electrical tomography experiment.

This cat litter will play a key role because it will facilitate the movement of electrons from a centralised source, through the 12 gauge cables to electrodes and into the ground. Without the cat litter, the chances will be higher that electrons won't travel as smoothly through the electrodes into the ground and the image that Byrdina is trying to produce of the interior of the volcano will be less accurate. The cat litter, improvised and ad-hoc as it is, is part of a broader ensemble of mediums that includes the cables, external hard drives, laptops, switch boards, amplifiers, seismometers, batteries, water, and USB drives, in the back of the truck. Each of them transmitting, moving, signalling, mediums that carry and translate content along the way across formats, from the hard, rocky, slippery ground of the volcano surface to the contents of the cross sectional drawing that Svetlana wants to make. And that image will in turn circulate through online academic journals and citations in authored scientific papers.

On the expedition, Byrdina, a Russian born French geophysicist, was assisted over the course of three days by a core group of five Javanese porters whose day jobs were as farmers in the valley below in the area of Selo. She described to me how, to her surprise, they understood her techniques and instruments with fluidity, and assisted her in the execution and maintenance of electrical tomography experiments and CO2 monitoring. They too were not only go-betweens between Byrdina's plan and their knowledge of the topography of the volcano, carrying her instruments, and material, but were observing, learning, and reproducing Byrdina's methods with her. One of the porters, Tono, had taken the hike up to the summit and back once a week for years. He knew the changes to the summit and north western flank more intimately than any of the scientists.

On his expeditions, Tono had spent long days and nights with those scientists, taking them up and down the steep hills, carting materials, helping them set up experiments, and spending the evening sharing stories through translators around the campfires and tents. When Byrdina was there, he told stories of recent eruptions, where lava extrusions had begun to change and the locations of recent landslides. Byrdina explained to Tono how her electrical tomography experiments operated and how to set up the instruments. As the facilitator of their movement, Tono became a go-between between the pathways on the volcano, the knowledge of scientists, and his own family and community in Selo. The night before we had left for the hike up, Rizal and Svetlana walked over to Tono's house, which neighboured on the Jrakah observatory outpost. Tono was out but his wife insisted they sit for tea and wait for his return. With Rizal translating, they shared stories until Tono returned after an hour or so. With him they arranged to meet in a few hours before daybreak with a crew of porters that Tono would assemble in the meantime.

Memory Practices on the Move

Memory practices are crucial for go-betweens. They are the material inscription devices that translate and store the past and facilitate the movements of scientists; there is no field trip without the recording of the field trip. The recording device, in the terms of Lorraine Daston and Geoffrey Bowker, filters and selects impressions and "…permit both the creation of a continuous, usable past and the transmission sub-rosa of information, stories, and practices from our wild, discontinuous, ever-changing past."[301] Byrdina took data from the summit, stored on safe, external hard drives, but she also took selfies with Tono and other porters. The techniques of memory practice, Bowker is pointing out, organise what impressions belong to what categories of remembering – science, leisure, tourism. Byrdina's electrical tomographic experiment was a form of memory practice too, that inscribed recordings of the movements of electrodes into a cross sectional image of the interior of the volcano. This stabilized and ordered the past into a snapshot in time which was then circulated between the observatory office and peer-review journals, while selfies and other touristic photographs were sent to her husband back in France. Here, we can see the divergence from Tazieff for whom the distinction between scientific representation and the personal was more blurry. The publics converged for Tazieff between the representation of

[301] Bowker, cited in Daston, *Science in the archives*, p.3, from Bowker, 2008.

scientific facts, art, and the presence of his body. For Byrdina, these were strictly different sorts of memory practices because they were different orders of knowledge.

Scientific images of the temporality of volcano are also memory practices and creating them preoccupies much of the labour of go-betweens. The reason that Byrdina undertook her electrical tomography experiment was to provide an image of the volcano at a particular moment in time so that it could be combined with other portraits of the volcano at other moments, and the appropriate authorities at the observatory could produce a diagnosis of its potential future. From her images scientists could speculate about the state of the volcanic system: Was it near or far from erupting, were there pockets where heat was trapped, preventing the release of pressure from the system? She presented her images formally in a meeting to the head scientists at the observatory, where she diagnosed that indeed, heat was being trapped beneath the western flank. An old conduit that used to release heat through a fumarole had long been covered over in an eruption and was now storing pressure. She then carried her image back to France and recomposed it into a co-authored article that appeared in *The Journal of Volcanology and Geothermal Research*, under the title, 'Geophysical Image of the Hydrothermal System of Merapi Volcano' in which Rizal and Suhari were cited as co-authors, though not Tono.[302] It was subsequently used by other volcanologists as reference matter in their own papers.[303] The cross sectional portrait of a moment in time moved along its own channels. It became another referent of the time of the volcano, a memory practice alongside tourist photos, and journal notes.

Memory practices structure the trajectories of geophysical work because they have a subtle determination in how they affect the kind of knowledge that can be produced about the volcano because as forms of storage they are constrained by their capacity in relation to its physical presence. For example, a memory card for a camera is lightweight, compact, and can contain large amounts of data, but this capacity is coupled with the amount of food that can be carried, for the amount of people, for three days' worth of a stay. No matter how much data storage there is, there also needs to be enough other forms of storage to replenish a body because storage is in relation to the other containers it is in proximity to and enabled by. And these are conditioned by trajectories of movement, distance, and terrain.

The memory practices that abstract and order experiences of the volcano enable the circulation of knowledge by formatting it as it moves. This collapses the conventional distinction between movement and time and points to a key element of go-between work. The

[302] Byrdina, 2017.
[303] Guillot-Frottier, 2017.

vitalist tradition, in targeting the tradition of dead, container time, a time only of measuring what is between things or how things are between one point of time and another proposes that time is movement.[304] It is the connective tissue that enables entities to endure with consistency.[305] In this understanding, movement is understood in differential relations of speeds and slowness to create a picture of the world in which objects – even volcanoes, are assemblages of different movements at variable rates of speeds and slowness.[306] They do not sit "in space" or "in time" but are compositions of durations, some of their parts moving faster than others, some of them as slow as the formation of a mountain. As scientists circulate up and down the volcano they make images of it which fix what the volcano is in time while those images are themselves in movement. Representations, then, take on a life of their own in their own movement, and understanding them means having to consider both of these sides of an image at once, its mobility and its content, so as to grasp how it "speaks about" the time of the volcano. This collapses the conventional categories of image analysis which would separate form and content, reception and distribution by foregrounding its material stratum, and its trajectories of movement as it signifies, is both abstract and concrete, a device that orders the world while never being able to complete the ordering. Learning how to notice this means tuning to how scientific practices are constantly in the process of negotiating images on the move, producing them while going-between.

A Mountain of Folds

Western geologists have long imagined that the geological record is an inscription of time, its spatialisation and materialisation. Inspired by James Hutton's work, Darwin imagined that geology was the physical writing of time into the landscape. No doubt, these metaphors were informed by inscription technologies of the moment: forms of writing and image making in which representation was an act of material inscription, such as early seismometers.[307]

[304] Deleuze, 1988.
[305] Deleuze, 1988; Massumi, 2015.
[306] Deleuze, *Spinoza*, 1988.
[307] John Milne, 1886.

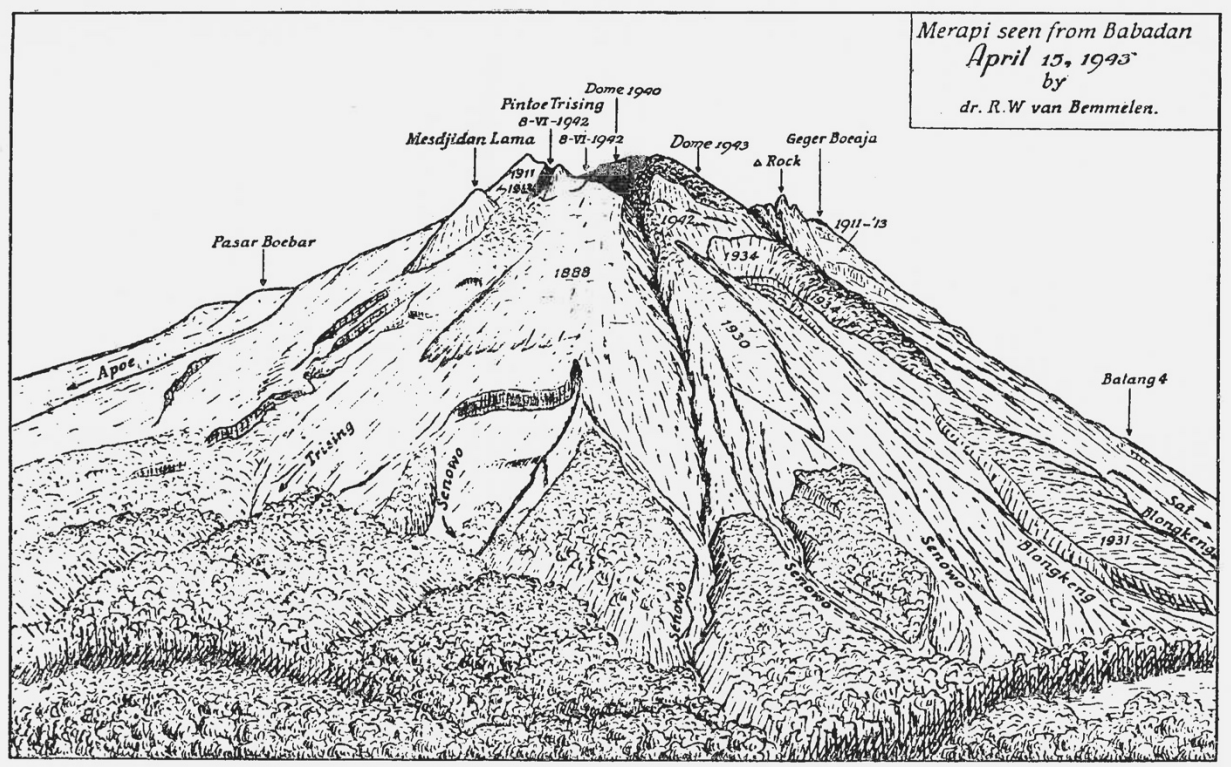

FIG. 68. *Merapi seen from the observation post Babadan* (April 15, 1943.)

Figure 6. From Van Bemmelen's *Geology*, "Merapi Seen from Babadan, April, 1943."

This was also true of Merapi in the sense that it was understood by Van Bemmelen and other scientists to be an inscription of its past events. In an image that Van Bemmelen made of Merapi during the Japanese occupation. The articulated topography of the volcano is formed through the erupted events of its history (*figure 6*). He calls out that topography according to dates in a way in which we can read the history as matter in form. Time and matter are interchangeable in the image and matter's indexical of time, time can be walked upon when traversing the volcano, and walking becomes a circulation through time.

When Byrdina was preparing to scale Merapi's northern face in December, 2015, it was still considered as a material accumulation of its past events. In the hallway in the observatory there was a large photograph of the caldera taken from a satellite just after the 2010 eruption which reproduced Van Bemmelen's image but in plan. It too contained arrows to different material arrangements and dates on top of them. This technique can also be traced back through the *Bulletins* of the Volcanological Survey, when it was applied not only to Merapi but all significant monitored volcanoes across Indonesia.

The conflation of time and matter suggests that the volcano is a collection of events folded together. Every event that is called out on the volcano, the "1888", "1911-13", "1931", are citations that can be read back through the literature of the observatory in the work of

those other scientists who were around to document the events that produced that material and topography. The consequences of this are that the slopes are at once a physical morphology to traverse but also archives.[308] They reference the archives in the observatory and the publications and records of those events.[309] This means that for go-between scientists, the volcano is itself a form of media, and matter, space, and mediumship become one in this image. Going-between collapses the distinction between landscape and topography, the labour to get there, representation, and memory work. The work of going-between that Svetlana was involved in was in part a labour of upholding this network that crossed the thresholds of matter and reference to fuse them together.

This folding of reference, matter and time, is what needs to be negotiated in any field experiment and was the work of Byrdina during her electrical tomography experiment. It is about creating a line through the folds of matter and reference, the archive and the volcano while in circulation. What I would like to focus in what follows is the combined mobilization of points, lines, and bodily movement as a way to explain how that process operates.

Finding a Line

The electrical tomography experiment that Byrdina undertook oriented a group of scientists and porters along a path of points and lines that choreographed bodies in relation to them so that representations could be ordered and begin to flow. She had been stationed in Yogyakarta for a few months as a specialist in electrical tomographic technique, a method of making transect images below the surface of the earth. It is often used in resource prospecting but has its roots in medical diagnostic imaging such as X-ray and CT scanning. The principle is to use electrons to pierce through material that our eyes can't and the scale of the electron is small enough to move through the material without displacing it and become a visible imprint on a sheet, or in the case of Byrdina, through many more steps, an image on a screen. As Barry F. Saunders has pointed out in relation to the role of the CT Scan in medical practice, these related technologies, whether applied to the body of the earth or the human, have their roots in privileging visual knowledge above other sensory sources, and the drive to go beyond the invisible and "see for oneself".[310] It is a part of a project of making the earth visually transparent. Being able to see what is happening inside the earth stems from the

[308] Daston, 2017.
[309] Latour, "Circulating Reference", in *Pandora's Hope*, 1999.
[310] Saunders, 2008, pp. 1-92.

desire to be at a real-time temporal relation to the interior in a way that Tazieff too sought the limits of the body at the limit of the interior of the earth.

Byrdina had been preparing the logistics for the expedition for a few months and on the evening of the 8th of December, 2016, I met her, Rizal, and Suhari in the village of Selo, not far from the caldera where we would spend the night at Jrakah observatory. At around 3:00 am, we woke and drove to a base camp at New Selo, that led to the entrance onto the trail, where we would leave the vehicle and meet the porters that Tono had organised to help us. It was still dark and the parking lot overlooked the valley below onto the gold lights of houses and street lamps. There were thirty porters who met us in the parking lot and Byrdina choreographed with Rizal what everyone would carry for the hike up. With only flashlights in the stark black, the scene was of thirty beams of light bobbing or cutting through the dark and illuminating piles of packs, containers of equipment, and bodies. There was the sound of English, Javanese, and Indonesian.

We began to ascend in a line towards the peak along a paved walkway, still unable to see except the beams of torch light bouncing to the sway of the walker. To the left and right were the silhouettes of giant ferns with their narrow trunks and horizontal, draping, foliage. Pines and leafy trees sometimes crowded them out. We cut through farmers' fields, of which we could only see the rows of soil beside our feet. When it is that dark, our sense of sight is reformatted to the beam of the torchlight and the step of feet, one in front of the other. If I swiftly looked out, past the beam of light, my eyes would readjust to the dark. As the pathway increased its elevation and the pitch of its slope, everyone's steps and breath became heavier and our bodies hunched forward to adjust our balance. I was carrying my bag of supplies for two nights of camping but the porters were carrying fifty or more pounds of cable and instruments. Some porters balanced the cargo on their heads, sitting on top of a piece of cloth or Styrofoam for comfort. This top heavy weight oriented the shape of their bodies straight like a poll as they zig-zagged up the hill to ease the intensity of the angle of ascent. I could make this out from the swinging spotlights that would catch their movement in passing.

Hiking like this foregrounds the way the body negotiates a heterogeneous terrain. Hiking in the dark, foregrounds the way the body does this without being able to rely on vision. It is instead revealed in its limitations and how it has to work in concert, negotiating the other senses. The world in which one is hiking and inhabiting is not given by being able to take in vistas, just glimpses of partiality, fragments, and the redistribution of sensory intelligence away from vision to other parts of the body.

As the walk pressed on, the sky began to lighten on the horizon, objects in the landscape turned crisp and stood out from each other. Vision returned to its dominion but in these early hours, the light was still not strong enough to give objects depth; they were silhouettes of trees, people, packs, rocks.

At this point in the journey we were following a ridge that led to the northern face of the caldera. It was of rocky outcrops woven around by a dirt path, without ferns or fields, and the grade had evened out slightly and made the climbing less taxing. Much of the walk happened in silence except for the sounds of packs rustling, and the heavy, rhythmic breathing of the line of thirty-three walkers. As we progressed upwards, there was the slow illumination of the objects around us without the aid of torches; the greens of leaves began to appear, the grey of boulders, mottled emerald, and browns of the valleys below. The emergence of visible objects was at the threshold of perception, too slow to watch but quick enough to register after the fact, after an object was clear.

The torches were turned off and their fragmented cutting through the dark disappeared. What became sensible was that we were walking in a field of frozen lava flows formed by the speeding up and slowing down of erupted material. We were walking along a smooth, white, anthracite valley that in 1968 was over a thousand degrees and flowing like a river. In view towards the summit was a wall of white limestone which Svetlana called “54” because in 1954 it was a slow moving mass of lava as tall as a four story house and half a kilometre wide until it cooled solid in place. The volcano was an index and we were walking in Van Bemmelen’s drawing, through the archive in the observatory, a representation and an object.

Figure 7. Byrdina, Tono, and Rizal, taking a CO2 reading, along the well-worn hiking path. Photo by the author.

Byrdina then asked a small group of us to pause while the rest of the porters continued ahead. With Tono's help, she took out a CO2 reader that looked like a sci-fi back-pack with cables dangling from it (*figure 7*). On one cable there was a metal bowl with a handle on the bottom. She descended into an eroded crevice, kneeled and placed the bowl against the ground. She watched as a signal was registered on the iPad connected to the pack to produce a real-time reading of CO2 emissions.

This was the first instance in which it became clear that the forms of representation that Byrdina was interested in were acts of bodily choreography with the ground and an attunement to the movements and fluxes of the volcano, a practice of sensing the ground. The

experiment was this collective sensorial attunement, facilitated by the instruments we were carrying with us with the moving target of the volcano. The walk to the summit was choreographed by the pathway, we were brought into formation by the path, not us bringing formation to the path. So, too, the darkness of the night formed our bodies attunement to the torch light, the feel of the path under our feet, the loudness of our breath. We were being shaped by the volcano at the moment that we were trying to get to know it by applying instruments to make images of it. The pathway – worn in parts by the movement of go-betweens over time – was made at the meeting point between enterprising feet and the slow coming and going of the north flank, its erosion, and rebuilding. As we followed the course of the path until morning light we were also drawn and walked by the volcano. This "meeting the volcano halfway" as Karen Barad would frame it, is the result of a groping to find the way forward like Byrdina descending into a crevice – or a crevice opening – to put a cup on a piece of dirt so as to sense what none of us could sense, CO2 that registers below the radar of the five senses.[311]

While Byrdina was being choreographed by the volcano, she was also pushing the capacity of her own body to sense the volcano, opening it and transforming it with instrumentation, keeping an eye for the geological composition of the pathway and vegetative cover to find a clearing where she could use the instrument. Meeting halfway suggests a polyphonic relationship between bodies, movement and the volcano in an improvisatory relationship between them. Machines like the CO2 recorder, but also sensation, are negotiating the incompleteness, flows and transformations of the pathway and its adjacencies. The flows from point to point, from the observatory to the summit, are not entirely on pre-established routes, at least not in the sense that the route is a simple, transparent medium for the passageway. The route and the passage of the route are created together in the improvisation of encounter. This is closer to what Donna Haraway describes as "becoming-together", a shifting scene of affordances, openings for action and closing. It is not a relationship where one part comes completely predefined, but in an interplay in which both are transformed.

At the summit it was still early in the day, the sunlight was intense with no cloud cover in the sky. On the plateau to the north of the caldera, known as the "old Merapi" on *Pasar Bubar* there is an above ground, cinderblock bunker built by 200 observatory scientists to house instruments, signalling stations, and a sleeping place (*figure 3*). It is the final point in

[311] Barad, 2007.

the long network winding from the observatory in Yogyakarta and a pathway that has been under constant construction since the days that Van Bemmelen used to go there to take measurements. In front of the bunker is a flat field, speckled with boulders fallen from the caldera. The ground is dark, almost black, and compact; it leads to loose sand on the outer wall of the caldera and the bunker faces the wall of the caldera with a few hundred meters of open, rubble strewn black field between them. On the other sides are the edges that plummet into deep valleys worn out of the side of the mountain, and further on, into the plains of central Java. At that hour, with the still clear sky, we could see deep into the planes and as far as neighbouring volcanoes hundreds of kilometres away. There was a sense of the disorientation of being above the world, on a moon like landscape, where there is no ambient sound but the crunch of the ground under one's foot and the capacity to see unusually deep into the distance.

Byrdina and the porters began to get to work, unpacking, storing, sorting equipment as the weather quickly changed: clouds floated along the flanks, rose and engulfed the caldera and us with them. The world went from a gods eye vantage to a view of only a few meters in minutes as the walls of white cloud blew up over the edge and descended upon us. Soon after, the rain came and we retreated to the bunker. Just as quickly, the clouds broke. This to-ing and fro-ing, opening of vision and closing, created the effect that the space we were in was in a flux of processes, the caldera a concatenation of movements at different speeds: wind, rain, the intensity of the sun, eroding stone, rocks lurching towards the valley so slowly I could only pick out their movement by abstracting from their finger like shapes. The prospect onto the valley opened and closed with the clouds, was brought up then pushed away by the aerial movements of crystallisation and mineral transport.

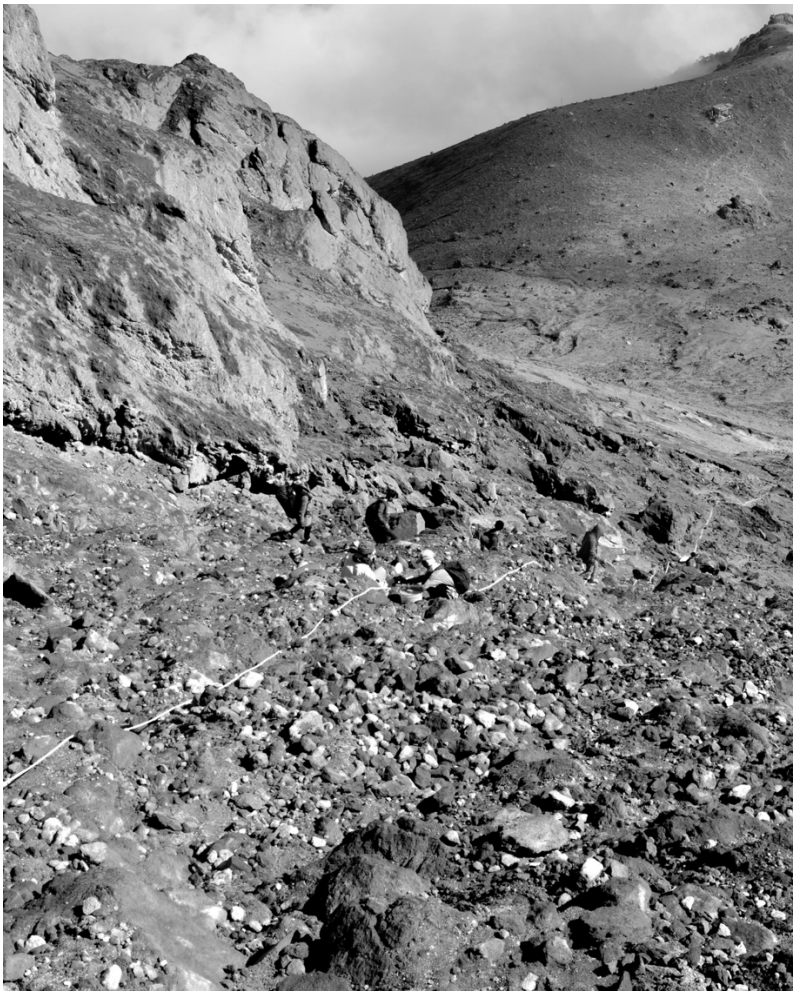

Figure 8. Drawing a line to draw a cross section through the caldera wall of Merapi. Notice the cable, it will later become a representational section line on Byrdina's drawing. Four assistants unfold the cable. Photo by the author.

Figure 9. Fixing an electrode to the cable source: tephra, cat litter, electrode, cable. Photo by the author.

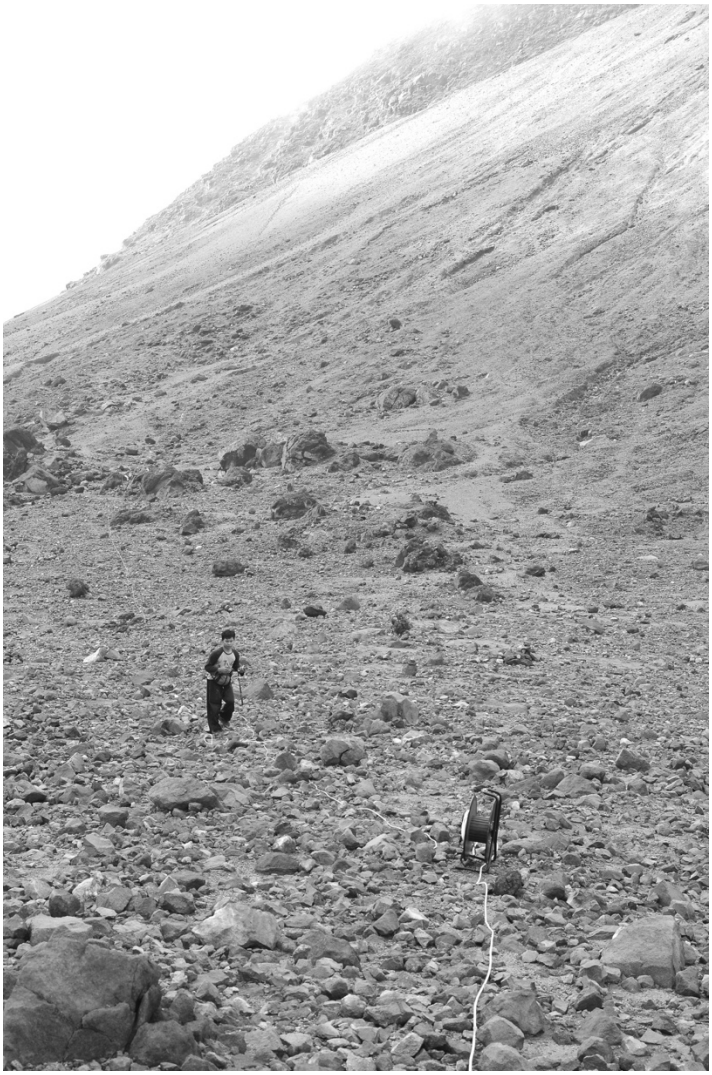

Figure 10. Suhari Making a line 200 meters that will make a line on a drawing at A4 scale. Photo by the author.

When Byrdina set to work she marshalled seven assistants and hiked to the lip of the caldera filled with clouds. When they parted, blown by wind and the intensity of the sun, dissipating their moisture, the expanse opened up below onto the black desert of smouldering vents. It would then, in a few minutes fill up with clouds and we were returned to a space that felt no bigger than a few square meters.

Within this ongoing opening and closing of vision, Byrdina would try to make an image that would expose the most resolutely distant to us – what was below our feet. Byrdina was to draw a line through this metamorphosing landscape as a way to bring a partial order, a single line around which all of her team would devote their energy to creating. It was a thread

of connection and continuity, not a totalising view from outside. The line is instead a way to transverse something that is too big by making a path through it.

They set to work on the edge of the caldera unspooling two hundred meters of electrical cable in a line (*figure 8*). At two meter intervals along the cable, metal spikes – electrodes – that looked like tent pegs protruded (*Figure 9*) that were hammered into the surface and would be the conduits for electricity. Laying the cable was a challenging bodily affair as her assistants were working on their sides, fixing their feet against stable stones as the sand on the steep surface rolled away beneath them. Anchoring their feet in, they leveraged the pull of gravity on their upper bodies, dug at the ground, hammered the electrode in and poured the concoction of cat litter and water around it. Then they would move on, unspooling the heavy roll of cable, hunkering down, hammering, moving on. On the plateau at the bottom, another team was doing the same with another spool and Byrdina was circulating between them, negotiating technical issues through a walkie-talkie (*figure 10*). This process was not only the choreography of the unfolding of these lines stretching across a volcano but the physicality of the process, the way their bodies had to contort to lay the cable down and to meet the topography. This physicality is lost in the final transect image that Byrdina produced, the labour of getting close to the ground and the countless micro decisions of where to hammer in the electrode, the occasional errors and corrections. The image that Byrdina made, and which can be carried around on a USB memory drive, is an image of this labour along the line *with* the flows and vagaries of the volcano, of bodies and their choreography with stone, wind, metal and sun. Indeed, the achievement of exactitude and precision of Byrdina's final drawing was this labour of bodily comportment to the slope of the volcano.[312]

Once the line of cable had been laid and the electrodes nailed in place, Byrdina set to work making the image. She injected a stream of electricity through the electrodes into the ground, the electrodes switch back and forth between a positive and negative charge, rotating between injecting a current and "receiving" a current. When an electron is injected into the ground it changes the rate at which it moves depending on the density and temperature of the material it is moving through. When the electron reaches a negatively charged electrode it is registered by the receiver. Through an "inversion method" the rates of the electrons are calculated through a model which projects the materials and temperatures that should have been underground to make the electron move at the rate that it moved at. There is no material

[312] Coen, 2013.

imprint on the travel of the electron, it is rather the speed at which it moves entering the electrode. It is like clocking the speed of a runner at the end of a race and then projecting backwards what the terrain must have been to generate their speed. The bet is that the bulk of the sample size will give a more accurate indication of the terrain. The measurement relies on an above ground model of generally known subsurface properties that are then projected onto the movement of electrons. Rather than creating a picture of the subsurface then, it is a test that verifies the validity of the model with the specificity of the case. In other words, it is not a process of going underground and bringing back a portrait of what is there, no section is actually created, it is a case of verifying how much the model corresponds with the electrons pouring in. They don't match each other but come into relation and meet in the middle, the model and the electron.

The result of the process is a cross sectional image that has lopped off a chunk of the volcano and exposed its interior. This is the danger of images that expose and reveal, they are not realist depictions but tests of the meeting points of material worlds and their models along a line.

Of Lines and Routes

I suggest that we understand Byrdina's picture making as a choreography of bodies and instruments along a line through the shifting and swirling flows of the volcano. Rather than the volcano being a whole object, it is a concatenation of continuous transformations, of clouds and rain sweeping in, then clearing up. Her experiment had to proceed by building lines through these transformations throughout the two days, stopping when the rain began, retreating to the bunker, beginning again when it cleared up. It required navigating the difficult terrain such as scrambling up the outer face of the caldera, on all fours, to navigate the slippery, sandy, surface. She used walkie-talkie radios to communicate across the landscape and co-ordinate her assistants and they with her, to build the line that would become the transect. It was a 'becoming-with' along the line, navigating the shifting polyphony of material forces with each other, testing what the body could do, how to hold on to stabilities and when to let them go. Making the experiment was an attempt to find a way into the volcano, to cut through the fluxes of it, to expose it but in doing so it was transforming the team. It was, as Andrew Pickering would have it, a "dance" in the "mangle of practice". The different terms that I have been using thus far – 'becoming with', 'polyphony', 'flows', and 'lines' are each ways of trying to think with the ongoing transformations of the volcano and Byrdina's team on the volcano in which neither is a

master or in control. Instead the material forces and fluxes of the volcano are encountering the material forces and fluxes of the team.

This lays stress on a different dimension of how experiments and fieldwork operate. Instead of the pauses for rain, equipment failure, the difficult navigation of the night time path up the volcano being interruptions, or secondary effects to the production of knowledge, they are inherent to it. The field expedition is the comportment of bodies, their choreography, in relation to an object which is in flux and transformation. The knowledge of the object is not its exposure to truth but a test of how knowledge is a process of choreographing what is revealed and concealed. Byrdina's experiment revealed not that the volcano is a whole thing but rather that it is an assemblage of parts along lines which are in themselves shifting relations of stability. The part that she was revealing on that day was the thin slice of her tomography experiment on the northern flank. But back in the observatory, her colleagues were dedicated to visualising and understanding other parts – some to the lava dome, some to the conduit, some to the movement of seismic waves. Each of these parts had their unique ways of representing them and trajectories of circulation.

The second order of this labour of go-betweens is how to connect the parts. In order to do this, the scientists held meetings, conferences, and co-published papers, that sought to bring the parts together into a whole. Byrdina often spoke in terms of systems and considered that below the surface of the volcano there was a 'hydro-thermal system'. The idea of a system suggests that parts can fit into wholes, with functions subsumable within the whole. But following an experiment in the field shows that the volcano is not a system of parts subsumed within the whole but rather that the parts never disappear. The notion of the system becomes a model that is deployed to choreograph the bodies of scientists around the volcano, it is instead the part that is primary in an ever shifting relationship of parts without wholes. It is the line of the transect that organises the parts, connecting other parts along it.

From a Line to the Future

This has consequences on how we understand the emergence of cultures of forecasting on the volcano. It shifts the nature of the object under consideration if we abandon the notion that the natural science that forecasting is based on is based on achieving accuracy through a deployment of tools. Instead it is about making lines and trajectories along which representations a distributed and create sensations of proximity and distance to the object. More than this, it is about creating the lines through the object and the choreography of bodies along those lines. Going-between is the carving of ruts and routes

that form infrastructures of passages, orienting bodies around those infrastructures of movement to facilitate and pass along. Rather than making the present transparent, the science of forecasting builds relationships that assemble parts together. Rather than judging whether or not forecasting succeeds in making a whole picture of the system, whether it is accurate or not, the question is what kinds of lines does it make, what parts does it exclude and include, and how do those parts allow the future to be sensed.

This brings us back to my point at the beginning about how we understand the public work of science. By turning to the movements of scientist go-betweens we can understand that along their routes they are constantly navigating multiple publics and that those publics are shaping and facilitating their routes and trajectories. Those publics too are enlisting non-human actors, instruments, supplies, packaging, which create affordances, they need to be choreographed in order to facilitate movement. Moreover, in doing so, they shape and order what can be known as particular kinds of knowledge. They enact deep seated patterns of excluding particular forms of representation and knowledge from "scientific knowledge".

By shifting our focus to the movement of scientists we can understand that all along the process of producing knowledge are multiple, heterogeneous publics, and in order to overcome the will to "purify" volcano science, we need to attend to where, when, and how these publics emerge. We need an analytics to describe encounters along the trajectory that can take into account the choreography of bodies with steep slopes but also the stories swapped with Tono's wife. By understanding that the production of knowledge about Merapi is always already a public act it could shift the grounds on which that knowledge is produced and consumed. There is a tendency amongst observatory scientists to understand that scientific knowledge of the volcano is "disseminated" to the public. But, I am arguing here that scientific knowledge of the volcano is made by the public. More precisely, it is made by public*s*. This shifts the emphasis to how knowledge is produced, and who and what participates in its production.

This would also transform the way that forecasting is conceived because it would be considered in terms of the routes and trajectories that form differentiated publics along the ways. Forecasting, in these terms then, is a way of choreographing actors around a shared, or common, concern for the future. In Chapter 1, I argued that volatile nature forecasting fixes objects of concern by orienting publics to danger and threats and in part constructs those objects. I mean to extend that argument in this chapter by arguing that forecasting practices form publics that participate in a shared (if uneven) concern for the future through processes of circulation and movement. It is in movement that futures emerge and are made sensible.

Conclusion

Where Have We Been

The aims of this disertation, as stated in Chapter 1, have been: 1) To understand how cultures of forecasting generate futures, and mobilize and organise anticipation; 2) to understand how forecasting systems know, frame and shape nature in multiple and contested ways; 3) to understand the liveliness and agency of infrastructural and technical systems. 4) The fourth aim is to understand how forecasting systems shape nature-culture relations. In what follows I summarise the main results of this study and gesture to some of the problems it has opened up for further consideration.

I have described forecasting as a culture, by which I have meant the ensemble of practices, ideas, and material forms of forecasting. I have attempted to show that culture as it has emerged through complex technological milieus, wherein it is shaped by and transforming technologies and infrastructures. This culture of anticipating the future does not come pre-formed, but is emergent in practices, in spaces, and through contested publics. While it is a culture, it bears no simple relationship to nature; it is, rather, a hybrid nature-culture, formed through pressure and frictions with non-human forces.

One of the reasons I chose to pursue this conception of forecasting on Mt. Merapi was because it is not a domesticated form of nature, but a radically unpredictable and volatile force. It could not be accounted for in terms of a cultural construction in any simple sense of human minds, or language, projecting ideas and values onto the volcano, and the volcano being domesticated by those projections. With every idea projected by scientists, shamans, sultans, presidents, and farmer, it refused to conform to it, or be completely described by it, and the volcano often acted in a way that forced those ideas to change, find new coordinates, create new technologies, practices, and infrastructures to make sense of it.

Another reason that Merapi is compelling is that even though it is extremely unpredictable and volatile, it is nevertheless densely inhabited. While it pushes back upon human attempts to know it, it also creates affordances to settle, dig in, and stick around. Because of this, the volcano facilitates the formation of complex cultures of knowing it,

investigating it, taming it, choreographing with it, while also resisting all of those attempts through an excess that cannot be contained, its violence and annihilation.

I have aimed to demonstrate then, that cultures of forecasting are ways of making sense of not having control of the future or nature. As we have seen in these chapters, different cultures of forecasting struggle to make unpredictability meaningful. Negotiating unpredictability becomes a way to constitute social relations as well as relations with nature. It becomes a way to gain and maintain power over others and in relation to places, but so too to leverage the power of others. It is in this way that forecasting is always a form of governance.

This turn to understanding how cultures of forecasting make sense of not having control over nature opens up the possibility for conducting histories and ethnographies of anticipation. As I have attempted here, turning to forecasting can allow us to excavate the different ways that senses of the future of nature are mobilized within complex ecologies of feeling the future. It opens up ways to understand how emergency, urgency, and delay are integral dimensions of governing the relations between nature and culture and for a better understanding of how the exigencies of anticipation enable particular regimes of governance and speed up and slow down particular forms of management.

This dissertation has also pointed to a constitutive contradiction of forecasting cultures. They participate in the making of what can be sensed. This is akin to the way that frames also participate in the creation of what is inside the frame, and because of this, cultural practices – in their spatial, material, technological, and infrastructural arrangements – bring realities into being in the process of getting to know nature. As modernist nature forecasting inherited the idea of the *res extensa* of the globe, for example, it also set about creating and implementing it, it even developed rituals to integrate it with the specificity of place, and the particularities of events. The republican state, as another example, appropriated the framework of the sultanates power over nature for itself and brought into being the sultanate within the volcano within the republic. Ritual offerings into the volcano, as I showed, are practices that also like scientific practices, enact and bring into being that to which they are giving offerings. The souls in the volcano, in this sense, are brought into being, in part, through the cultural techniques of offerings, just as the notion that the volcano is an effect of plate tectonics is brought into being through the cultural techniques of the modern scientific observatory.

A lot hangs on the qualifier *in part*. This is because no agent, culture, or practice has the sole responsibility for "constructing" the volcano. It is not a human product, a cultural

product, a technological product, or a product of nature. The theory of cultural techniques that I have engaged and expanded throughout these chapters, has shown how distributed and multiple are the agencies and actors that participate in this. If cultures of forecasting emerge at the interfaces of social-technical arrangements and unpredictable nature, I have also shown that there are many forms of forecasting, and as a result many ways of making the future of nature present. None of these ways have a monopoly on the natures that they forecast.

I have attempted to create analytical categories for forecasters that would allow us to see that they operate in this space where their forecasts are co-producing the nature they are forecasting while they are only ever doing so *in part*. Following the work of go-betweens and gatekeepers are two ways of considering how forecasters participate in the construction of the nature they are forecasting. This is work that happens on the ground, in the lab, fieldtrip, archive, possession ceremony, and lookout tower.

Worlds and Worldviews

If cultures of forecasting co-produce the natures they forecast, and there is more than one culture of forecasting, then there is more than one volatile and vulnerable nature. In other words, there is more than one Merapi. In the aims of this dissertation, I set out to study, broadly, how multiple cultures of forecasting intersected with the lively agencies of technical and infrastructural systems.[313] This has gone a way towards upsetting the mononaturalist presuppositions of the canon of risk and hazard literature and modernist forecasting practices that suppose there is one nature and many cultures and that culture is projected onto a unified nature. This suggests that there are world views which are contained within a world. But by stressing the agency of non-human actors, including instruments, infrastructures, volcanoes, and storms, and the co-productive capacities of practices, the single world which would unite all worlds becomes tenuous. In the place of worldviews, there are multiple worlds, and cultures of forecasting can be understood as dynamic traditions of bringing worlds into being and lending them durability. In this understanding, the modernist sciences of forecasting can no longer be understood in terms of their success or failure to access nature behind culture but in terms of how it participates in the endurance of worlding nature-culture relationships. This, as I have shown, is how the sciences of forecasting on Merapi are engaged in processes of generating publics, negotiating the legacies of the state, excluding certain practices of forecasting, and building local, and international networks. Forecasting the future of nature,

[313] On lively infrastructure, see: Amin, 2014.

according to this framework, can never be separated from negotiating the endurance and legibility of worlds. For Sukidi in Keningar, as I argued, forecasting the future of the volcano is a way to negotiate the incursions of the monotheist state and state corruption in the village by maintaining the liveliness of the volcano. It is to keep alive another Merapi from the Merapi of mononaturalist science, but that is always in relationship to the volcano of monotheist science. They are then, ontologically different, not just perspectives on the volcano. And these different volcanoes are in relationships with each other. Forecasting is a practice that negotiates those relationships, tests them, builds infrastructures extended in space that, in part, materialise worlds.

The consequence of understanding that Merapi is multiple is that scientific forecasting practices can begin to account for their own histories and practices in terms of how they negotiate with other Merapi's, extinguish them, or build associations with them. One of the strongest criticisms of my approach is invoked by discourses of risk, hazard, and danger. The goal of forecasting, according to this critique, is to reduce the harm that it poses to vulnerable populations and that modernist science has the best tools to accomplish this. This argument turns Merapi, and natural hazards, into straw figures in which a volcano and any other natural hazards are simply dangerous. This same position argues that the future is a shared, common space that is best accessible by modernist science. The stories in this dissertation are different because they describe how even disasters create encounters between different worlds, they generate suspicion of the state, sultanate, and local politics, and complex agencies emerge to realign relationships of power and authority. By shifting our understanding from one to multiple worlds we shift the vocabulary and conceptual terrain from which we understand volatile nature. Instead, we understand forecasting in terms of the encounters it generates between worlds, what it speeds up and slows down, what worlds it prolongs, intensifies, and nullifies. It becomes a problem of understanding the disjunctions and associations that are created between worlds. It is no longer about discovering and bringing back the laws of nature that operate back stage, behind the scenes of worldviews so as to create shared, uncontroversial facts that unify worlds, but to develop ways of thinking with intersections and crossroads, between worlds and their effects. It is to begin from the presupposition of plurality as what is in common.

A disaster, then, is the result of the spirits of dead humans and plate tectonics and, as the history of Merapi attests, no matter how heavy handed state science has attempted to eradicate "irrational" and "backward" animist "beliefs", they have persisted in keeping alive other futures and relations to volatile nature. Modern scientific forecasters have been unable

to understand how these other worlds are in conversation with their own mononaturalism, shifting it, hybridizing with it and opening up other possibilities for other futures. The work in this dissertation furnishes forecasters with concepts and categories that stress the relationships between cultures of forecasting, how they come into contact and negotiate each other, so as to evade these reductive tendencies.

The building of technologies that sense the volcano, whether they are seismographs or assemblages of rice mountains and flower petals, and the infrastructures that network them, are crucial because they materialise the frames that bring different Merapi worlds into being. This is why I have argued throughout that the politics of forecasting rest in the assembly and synching of tools and infrastructures. This would conventionally be seen by forecasters as technical problems to be resolved with technical intelligence but in fact, how infrastructure systems are made to work is a political problem. It is around these pragmatic issues of how parts fit, where they come from, who shares expertise with who, that publics and counter-publics are formed and brought into proximity with each other. That is where disputes emerge and worlds can be extinguished by powerful interests and in order to make worlds disappear, their infrastructures needs to vanish. But what Merapi teaches us is the resilience of threatened infrastructures to adapt and transform, to perpetuate worlds even as they change.

Toward a Cosmopolitical Observatory

Observatories are not new, modernist observatories such as Greenwich were dedicated to the construction of a One-World World system through the synching of time with space. They have been at the vanguard of producing a conception of a unified *res extensa* while volatile nature observatories such as those on Merapi and in Bandung have sought to synchronise the unpredictability of nature with the *res extensa* and society. As I have shown though, more than being at the vanguard of an imperial drive to unify a One-World World, the observatory also operates in an in-between space, between nature and the state, city and the volcano, city and rural villages, civil society and public services, ideas and material forces. This shift of emphasis creates a novel understanding of volcano observatories as mediators that facilitate encounters between nature and culture. In this way, they have the capacity to put what they are between into proximity and contact. It is imperative then that observatory scientists consider what they bring into proximity in broader terms. Observatories are, in this sense, proximity making machines, they generate intersections, they are world modifying. Shifting the frame from one that shows the observatory to be a

modernist institution at the vanguard of a One-World World to an institution mediating between different worlds transforms the way that observatory practice can be conceived and enacted. It becomes one of proximities, juxtapositions, and adjacencies, and how to strategically create them. This can become the political calculus of the observatory in Yogyakarta, one which creates agencies, pressures, juxtapositions in the process of forecasting futures. It can employ a political logic of collage in the creation of policy within the observatory: which fragments to deploy and into what adjacencies, to what effect? At the same time, it can be mindful of the way that counter-publics are emerging within its infrastructure networks and articulating alternative futures so as to facilitate the networking between them. This changes the meaning of what it means to observe away from one of seeing through culture and nature to an art of arrangement and creation, the collage of parts.

Go-betweens, Gatekeepers and Inbetweeners

Achieving this means being mindful of how forecasting is a form of mediation. It means that observatories ought to attend to how they locate and deploy actors that move between disparate publics, counter-publics, infrastructures, and technologies, as a way to trace lines and open new adjacencies and proximities. Go-betweens are translators, and like gatekeepers, they can operate between different worlds, from spirit worlds to worlds of modernist science, and in their translating, they transform what crosses between the worlds. They can move between the worlds of mining pits in the river valley mines and the volcano scientists. In each site, the work of translation and transformation is operating at the same time as networks are forged, as well as alliances created, and dependencies made.

Go-betweens, gatekeepers, and inbetweeners are collage makers. They facilitate the ways that futures are lived in the present by shaping their meaning. They also multiply the demands of the actors with claims to make. Mindfully placing go-betweens resists the reductions of modernist science by thickening the futures that are lived in the present as well as its uncertainties. Go-betweens pluralise future worlds instead of reducing them.

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