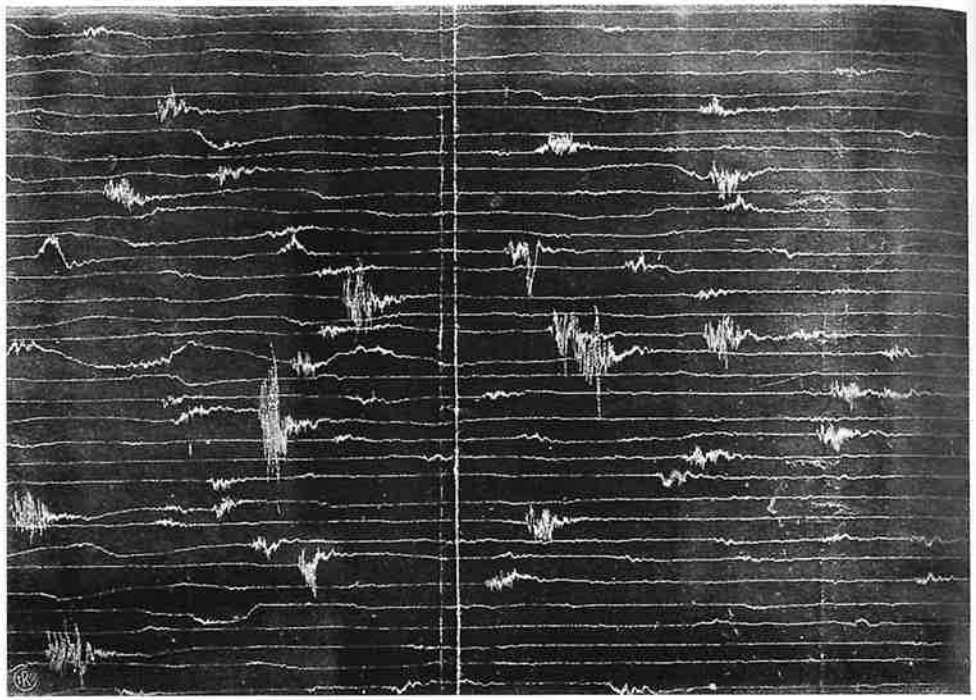

Seismograph recording from an eruption of Merapi volcano, November 23–24, 1930.
Vulkanologische en Seismologische Mededeelingen 12 (1933): 138.

ADAM BOBBETTE

THE PULSE OF THE EARTH

Political Geology in Java

DUKE UNIVERSITY PRESS · DURHAM AND LONDON · 2023

Printed in the United States of America on acid-free paper ∞
Project Editor: Ihsan Taylor
Designed by Matthew Tauch
Typeset in Alegreya and Comma Base by
Westchester Publishing Services

Library of Congress Cataloging-in-Publication Data
Names: Bobbette, Adam, [date] author.
Title: The pulse of the earth : political geology in Java / Adam Bobbette.
Description: Durham : Duke University Press, 2023. |
Includes bibliographical references and index.
Identifiers: LCCN 2022055559 (print)
LCCN 2022055560 (ebook)
ISBN 9781478025054 (paperback)
ISBN 9781478020073 (hardcover)
ISBN 9781478027089 (ebook)
Subjects: LCSH: Historical geology—Indonesia—Java. | Religion and science—Indonesia—Java—History—19th century. | Geology—Indonesia—Java—History—19th century. | BISAC: SOCIAL SCIENCE / Human Geography | SOCIAL SCIENCE / Ethnic Studies / Asian Studies
Classification: LCC QE28.3 .B633 2023 (print) | LCC QE28.3 (ebook) |
DDC 555.98—dc23/eng/20230519
LC record available at https://lccn.loc.gov/2022055559
LC ebook record available at https://lccn.loc.gov/2022055560

Cover art: Mount Merapi, Indonesia, ca. 1930. Courtesy
of Balai Penyelidikan dan Pengembangan Teknologi
Kebencanaan Geologi archive.

Thank you Giyono, Suparno, and Sukidi

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PREFACE

THE MODERN EARTH WAS MADE IN JAVA · We—as in the *we* who believe that the earth is broken into tectonic plates that glide across the surface of the earth and grind into each other, and that the ocean floors are bisected with massive trenches that ooze the stuff that makes continents—*we* inherited these stories from Java. Our orthodoxy, the taken-for-granted scientific picture of the history and structure of the earth, was forged on the slopes of Javanese volcanoes as scientists watched them shudder, explode, crumble, turn to dust and ash, and wash into the oceans. Scientists photographed the remains of houses cracked by earthquakes, then they circled smoking calderas in airplanes, hid in bunkers, peered from prison lookout towers, trekked through forests of giant ferns and pine trees growing from volcanic soils. It was in these volatile, rambunctious landscapes that a new, modern story of the earth was forged; a story that stressed how the earth was formed under duress, a system of creative destruction, a surface remaking itself in deep time—buckling, crushing, and reemerging from its own split seams.

Java has been, for more than a century, an intellectual center for earth narratives. These narratives were built not only by Western scientists conducting work in Indonesia but through uneasy and complicated collaborations between mystics, colonial Christians and Muslims, Sanskritists, ethnologists, antiquarians, occultists, postcolonial revolutionaries, and ethnonationalist animists. Earth stories were cosmic stories, told with one foot on a caldera and the other on the ruins of a Hindu temple. Volcanologists carried binoculars and tilt meters, guns and oblations;

they prayed to ocean goddesses and mythical jihadist serpents in craters. We inherit this past, it made the earth *we* now know.

When we imagine that the Anthropocene is an unprecedented moment, shocking because humans are now acknowledged to be participating in processes as ancient and soundly inhuman as geology, we actually *should* be surprised by how little we have understood of geology and how late many of us are to the game. The Anthropocene is revolutionary only for a small few, often scientists and humanists in Western metropolitan circuits. But the core problem of the Anthropocene has been central to modern geology for more than a century, and it was crucial from the beginning in Java. How humans are or are not implicated, and to what degree of profundity (how ontologically deep), in geological processes was the prevailing metaphysical riddle for geologists there. The question was asked with a special intensity even before colonial geologists began extensively mapping the island for the first time in the late nineteenth century. Societies in Java were traditionally ordered on the principle that geology was social, that social history was geological history, and that volcanoes were societies. Modern European geophysics was built amid this expansive conception of the sociality of geology, and European colonists were fascinated by it; they learned how to understand the relationship between geology and society from it. Standard Western geological science was not simply imposed on a prior indigenous geology; instead, Native and colonial geological knowledges produced each other, even if the process was uneven, indirect, and sometimes violent. And now they contain each other. The Anthropocene was theorized with profound intellectual and political intensity in Java long before it became of interest to contemporary Western scholars.

Acknowledging that society was considered geological in the Javanese geological sciences goes some way to pluralizing the intellectual traditions that have helped shape contemporary theories of the Anthropocene. Much Anthropocene theory remains unfortunately bound up with histories that continue to center Western science at the expense of its much more plural and cosmopolitan origins. While geological theory is currently seeking to identify the material markers of the Anthropocene, there is also an opportunity for us to expand our appreciation of geological thought beyond the conventional focus on the West and toward traditions that have often been suppressed in conventional narratives.

Javanese geology helps us understand how thoroughly contemporary discussions of the Anthropocene are a spiritual project. It is often assumed that the earth sciences could not be further from theology, that geological narratives are the result of a secularizing society shirking the grasp of its Christian narratives. Java shows us otherwise. It was not only Christianity that was at stake in geological narratives, it was also Islam, Hinduism, Buddhism, and animism. Deep time was contrived in a space crowded with temporalities—catastrophic, circular, rhythmic, spiraling, linear. And it adapted to them, incorporated them, and sometimes sought to repress them. Geological time—and, in particular, Anthropocene time—thus remains religious time, the inheritance of struggles with religious traditions. It is strange to think that geology was ever secular, or that secularism ever succeeded, or that the Anthropocene is a secular science. Instead, Javanese geologists learned from and leaned on Hindu temporal narratives, ancient Greek myths, and Islamic saints and ancestors to build their modern science that shaped the very standard modern earth stories that we have inherited, even the theory of plate tectonics. This book is about these pedagogies, these messy intercalations from paranoid praying mapmakers to scientist mystics with seismographs; it is about how they created "our" modern earth on the slopes of Javanese volcanoes.

LIVING WITH VOLATILE GEOLOGY · I first learned about Javanese geology after turning a corner. I was in a taxi on the way to the airport in Surakarta, a medium-sized city in Central Java. As the taxi driver took a left turn, the road suddenly pointed in the direction of a cone emerging from the land, the summit was jagged, stone gray, half obscured by clouds.

"What is that?" I asked the taxi driver. "That? Oh, that is Merapi."

I soon learned that Merapi was a volcano, that it was active, and inhabited. Some people were saying that nearly one million people lived there. I also learned that a few years earlier, in 2010, it had erupted and killed a so-called gatekeeper who lived in a village close to the caldera. I read in the *Guardian* that there was a conflict between scientists and the gatekeeper because he had refused to leave the volcano during the eruption. The article referred to him as the volcano's "spiritual guardian."

My intuition told me that the people who lived on Merapi had things to teach those of us who did not live there. My hunch was that the extreme and unpredictable environment on Merapi was the future many of us are headed for as the climate crisis produces ever more uncertainty in natural systems. Merapi, too, is all about unpredictability, and people have been

living with it for centuries. It seemed to me that this was what people there could share wisdom about.

On my first trip up the flanks to the village of Deles, I met a man named Sukiman. He had an anarchist ethos and celebrated the volcano, with its caldera smoking only a few kilometers away. He embraced an ecological ethic of mutual aid between people, nonhumans, and the volcano. We discussed how he was caring for persecuted monkey communities that lived on the flanks of the volcano and provided early warning signals for eruptions when they fled before humans even sensed danger. He also advocated pesticide-free farming and planting native crops. Sukiman was well known in the region as an outspoken critic of government and as an advocate for disaster management reform. He even presented his case to the United Nations.

I came to understand that villagers in Deles, with Sukiman's encouragement, were self-managing their own disaster risk reduction and preparedness. They took advantage of their proximity to the caldera to take videos and photos of eruptions and later sell them to international media outlets, keeping the proceeds in a collective community pot dedicated for disaster relief. Communal savings were also created from voluntary contributions from villagers' harvests. Evacuations, Sukiman told me, were pitched as holidays, periods of reprieve from the boredom of everyday labor. The villagers were trying to build a communitarian ethos of mutual aid to manage the uncertainty of the volcano. Rather than fear the volcano, they shared an ecology, a cosmology even, of mutualism. This seemed promising—inspiring actually. Perhaps we, too, could learn how to thrive with the radical uncertainty of nature, even in its most extreme circumstances. Perhaps we could transform uncertainty into a vehicle for creating deeper forms of interdependence between society and nature. Maybe that is what residents on Merapi could teach us.

On that same trip, I also visited the village of Kinaredjo, where Maridjan, the "spiritual guardian" from the *Guardian* article, had died in the eruption of 2010. The destroyed parts of the village had been rebuilt, including a new mosque in the traditional wooden Javanese style. I met Maridjan's son, Asih, who had taken over the job from his father and who explained to me that he was continuing his father's work of undertaking annual pilgrimages to the volcano to give it offerings. In the village, a disaster tourism business had sprung up, taking curious passengers on Jeep rides to the hard, dusty, dried lava flows nearby. Kiosks were selling Kinaredjo tea, souvenirs, and T-shirts with Maridjan's face emblazoned on them. I was told that the Jeep business was so lucrative that some of the drivers had made enough money to open their own restaurants. The eruption had been devastating, but it also provided new economic opportunities and chances for regrowth.

It was on this visit that I learned of the richness of the stories about the volcano, the expansive pantheon of gods and goddesses and ghosts that live inside it and on its flanks. Keeping these stories alive and meaningful was crucial to Maridjan's and Asih's work as well as to devoted followers in the village and across Indonesia. Many Javanese men saw that Maridjan, before he died, upheld a tradition of so-called local wisdom, a quintessentially Javanese form of mysticism in which volcanic activity was inseparable from social and political orders and volcanic tremors and explosions signaled not just nature but also a society in duress.

Later, I began to spend time on leafy Cendana Street in north Yogyakarta, in the government volcano observatory. The observatory had its origins and mandate in the early twentieth century, when Indonesia was a Dutch colony, to monitor the volcano and warn the population of eruptions. Today, it is a high-tech, well-respected scientific volcano observatory. As scientists monitor the volcano from Cendana Street, there are also six outposts on the slopes and dozens of smaller, unmanned, transmitting stations. In the main observatory, there are nearly one hundred staffers. Some of them are on twelve-hour rotations, reading seismographs and overseeing television monitors. Tilt meters measure the deformations of the ground, and an assortment of other instruments surveil and record the volcano's every move and breath. During the eruption in 2010, observations went all the way from the slope of Merapi to Yogyakarta, Bandung, the presidential palace in Bogor, and the United States Geological Survey (USGS).

There were not only farmers constructing multispecies mutual-aid communities but also Javanese mystics, enterprising disaster victims, and scientists, each trying to make sense of the unpredictability of Merapi. Each of these groups often had very different stories to tell about the volcano. Scientists understood that it was part of the global plate tectonic system. South of Java, they reasoned, about five hundred kilometers away in the Indian Ocean, was a continental subduction zone, where the Australian plate was driving below Java and resurfacing on land through volcanic outbursts. They not only thought Merapi was the result of planetary evolution; they were also representatives of the state and public health officials dedicated to protecting the population. Yet, in Kinaredjo,

where Maridjan died, many villagers celebrated narratives that had been transmitted from before the colonial era and the establishment of any scientific observatory. For many residents on the upper slopes, volcanic activity was made sense of through references to stories connected to the founding of the sultanate in Yogyakarta in the eighteenth century; these stories suggested that the first sultan to rise to power and establish a kingdom in the sixteenth century had done so through arrangements (marriage and treaties) with deities in the volcano and the Indian Ocean. Living with the volcano demanded offerings and rituals because volcanic activity was connected to human moral and ethical behavior. What animated nature, according to stories in the observatory and in the villages, were different, seemingly exclusive, and contradictory forces. Sometimes those incompatible visions were held together in a fragile assemblage, sometimes by one person. I met Indonesian scientists who prayed to Allah in the observatory between meetings about the most recent seismograph readings. I met a white French seismologist who spoke excellent Javanese and fluent Indonesian, and who joined Javanese rituals with his Javanese partner. I met scientists who held that the theory of plate tectonics confirmed the origin stories of the Central Javanese sultanates. I drank tea with Javanese mystics trained as seismologists and with seismologists who meditated on the meaning of nothingness. One afternoon, I had a conversation with an observatory technician who had seen ghosts wandering around the observatory the night before. It is no surprise that people hold seemingly contradictory and inconsistent views, nor is it world-shattering to encounter it in Indonesia. It has long been a prevailing interpretation by Western and Indonesian intellectuals that Indonesian culture emerges from a long history of stitching together diverse cosmologies from centuries of cosmopolitan contact.

I began to split my time between the observatory and the village of Keningar on the western slope, a village high up the slope, similar to Deles. Keningar is subject to intense, widespread, and mainly illegal sand mining, where local and Indonesian migrant laborers dig at the residue of past eruptions, deposits of sand, ash, and stones. The mining was causing profound ecological destruction to the river valleys, agricultural land, and the water supply. It also gave rise to social conflicts and sometimes violence between environmentalists, farmers, and miners. Village activists responded with litigation and pushed hard and ambitiously on what they saw as a stressed and dysfunctional legal system. On top of that, they were also practicing spiritual activism, performing rituals, mysticism, magic, and spirit possession to fight corruption and drive the miners away.

Volcano scientists had a difficult time gaining respect in these circumstances. Many people in Keningar were suspicious of government officials, including scientists, suspecting that they represented, or were directly implicated in, government corruption—the same government that also failed to protect their rivers and landscapes from mining. Some scientists saw the "traditional practices" of ritual, magic, and spirit possession in Keningar as forms of folk culture, which they dismissed as voodoo and peasant superstition. At the worst of times, scientists, mystics, and activists were locked in holding patterns of mutual misrecognition.

I met a farmer in Keningar, Sukidi, a man in his eighties, who mediated local spirits. The spirits, he told me, were enraged by the mining, and if it continued there was sure to be an eruption, or at least a landslide. The volcano was talking back to the miners; it was in solidarity with activists and farmers. Sukidi told me that his friends often encountered volcano spirits in their dreams; when people died, their spirits went into the volcano. The mountain was social history materialized. Eruptions and landslides, the shuddering of volcanic earthquakes, were the gestures of rage-filled intercessions. Merapi had much to say; it was a matter of learning how to hear it.

This was what interested me in Keningar—Sukidi and his friends could help us live in the Anthropocene, an age of volatile and unpredictable nature constitutive of human agency, a period in which geology is woven with human culture, not only imprinted and inscribed by human efforts—cities, roads, and mines—but also haunted to its core in the very categories that describe geology and the sciences that study it. Anthropocene geology is also on the move, destabilizing the conventional boundaries between culture and lithos in an unceasing geological undermining. The animate geology of Keningar seemed to offer a new way into thinking the present more broadly by resolutely denying the conventional distinctions between stones and persons, human sociality and lithic substrate, politics and geology, and replacing them with a form of geological thought that is also always social thought, in other words, a political geology.

Making sense of the uncertainty of the volcano was inseparable from navigating ways of knowing, which in turn meant navigating multiple, sometimes competing, practices of mediation. Merapi was multiple indeed. Yet its fragments were bound together. What was certain was the

common magic of conjuring the hidden interior of the volcano and earth. As Bernard Siegert has argued, the often-assumed distinction between high-tech and folk-tech is condescending; they both, in their different ways, share the magic of conjuring invisible worlds.[1] The technologies of modern Javanese volcanology and mysticism conjure from felt tremors the constant churning of a plate tectonic earth renewing itself and the voices of restless spirits. What the magic of volcano science makes clear is just how flawed our contemporary narratives are about the disillusionment and disenchantment of the modern sciences. The earth sciences, in fact, have their ontological feet, as it were, in the magical act of conjuring hidden worlds such as the processes buried deep inside volcanic mountains or their gurgling magma chambers. And a volcano observatory is an utterly enchanted space, replete with idols (photos of volcanoes), daily rituals (reading seismographs or tilt meters), and an acknowledgment among volcanologists that they are witnesses to the utter mysteriousness of the earth's processes. Such acknowledgment runs counter to traditions of critical social theory that berate the sciences for banishing mystery from the world through rationalization, alienation, and instrumentalization. Contemporary attempts to revive the mysteries of geology through poetically inflected reflections on nature or poetic experiments with social theory often reproduce this misunderstanding: volcanology, and specifically volcanology in Java, has never been disenchanted; it has always been in magic-making collusion with mystical Islam, geological animism, socialized geology, possession play, ancestral obsessions, and other techniques of living with and through invisible worlds. This book is about these uneven, shifting boundaries, piggybacking, and unexpected collaborations. When we try to imagine how to live in a new geological epoch in which lithic and human processes seem uniquely conjoined, we are actually inheriting a much older conception of the earth. The rest of this book shows how that conception came to be and what it can tell us about living with the earth.

PLAN OF THE BOOK · Chapter 1 outlines the core ambition of political geology, which is to explore the intersections of politics, the geological sciences, cosmology, and culture. Political geology was inspired in part by discussions surrounding the Anthropocene and a turn across the humanities to grappling with geological agency. Yet, as the chapter shows, political geology, with its attention on the history of geological and earth knowledges, reveals how the Anthropocene debate in the geosciences was prefigured by Javanese spiritual geographies and volcanology for at least a century. The Anthropocene debate, in fact, belongs to the much older ambition in the geological sciences to question the boundaries between society and the earth, between *bios* and *geos*. The Anthropocene debate also signals a moment in which modern scientists are implicitly engaging much older ideas that have long been central to Javanese political philosophy, including the notion that politics is foundationally geological. The chapter then explores three significant volcanic eruptions and the colonial-political milieu that brought about the formation of volcanology as a modern science of governance in Indonesia.

Chapter 2 examines four geological maps of Java and the contexts of their production to explore how geological narratives of Java have changed since the late nineteenth century. The chapter traces how these maps represented Javanese volcanism and were tied to shifting scientific narratives of the earth's history. The chapter shows that geologists transformed their vision of Java as an island of natural and cultural antiquities in which volcanoes were the ruins of once great mountains, to a vision of Java as a young island in the violent throes of youthful earth-building. Adopting and adapting ideas of continental drift before many other geologists around the world did were key to this transformation. Combining oceanography with terrestrial geology was crucial to this new view, which later set the stage for the development of the theory of plate tectonics in the 1970s. The maps examined in this chapter were turning points in this new earth history.

Chapter 3 shows how the theory of plate tectonics landed on Mount Merapi. The chapter explores how the contemporary theory of the relationship between ocean and land was prefigured and enabled by Javanese spiritual geographies. The Central Javanese sultanates emerged through an acknowledgment that deities in the ocean and volcanoes were related to the sultans. Political power was made possible through these associations with chthonic deities. The theory of plate tectonics mirrored this belief structure. It was based on a radical shift in geological thought to understanding the exchanges between oceans and volcanoes as related. This chapter explores how these two visions fit together and the politics of their clashing and melding. It follows both the mystics and sultans as they gave offerings to volcano and ocean deities and the geologists as they, in turn, considered the mystical foundations of plate tectonics. The chapter describes these intersections in terms of *intercalation*.

Chapter 4 turns to the beginning of volcanology in the Netherlands East Indies and the anxieties of late colonialism. It traces the fate of the idea that medieval Javanese Hindu-Buddhist civilization was destroyed by a cataclysmic eruption of Merapi in AD 1006. This idea became a way to naturalize the end of a culture and to explain the rise of Islam. Colonial scientists in the twilight years of their own empire explored imaginaries of radical environmental change and cultural impermanence. Theosophists, Javanese nationalists, aristocrats, Sanskritists, philologists, and volcano scientists trudged up and down the slopes of Merapi looking for mystical communion with the earth.

Chapter 5 traces the origins of geopoetics in the work of the largely forgotten geologist Johannes Umbgrove in Java in the 1920s. The chapter shows how Umbgrove developed an aesthetic conception of geologizing that became an expansive notion of cosmic and terrestrial evolution. In his book *The Pulse of the Earth*, published in 1942, Umbgrove developed *geopoetics* as a means to describe his scientific method that connected the psyche to the galaxy. The earth, mind, and cosmos were understood as structured by polyphonic rhythms and cycles; geopoetics had nothing to do with poetry about rocks. This chapter explores how Umbgrove developed geopoetics not only on Javanese volcanoes but also in conversation with orientalists such as Paul Deussen, a friend of Nietzsche's and translator of the *Upanishads*. Umbgrove's influence went on to shape the early formulations of the theory of sea-floor spreading and plate tectonics in the 1960s. When Umbrgove's geopoetics became plate tectonics, it sought to create a vision of the earth as a system of creative destruction.

Chapter 6 considers the significance of volcano observatories as contact zones between volcanology, geopolitics, and the Javanese ethnonationalist mystical movement Kejawen (Javanism). The chapter explores the development and evolution of one observatory on Merapi that acted as a place where new technologies contributed to shifting conceptions of the human body, the earth, and communication. The chapter also examines how observatories were places through which the Indonesian, French, and other states could operate at rural frontiers to manage political crises. Kejawen had its roots in the late colonial spiritual geographies of Central Java, theosophy, and mystical Islam; and observatories became sites at which Kejawen practitioners struggled with imaginaries of the Republic, infrastructure, and volcanism. As much as observatories were architectures of the state, they were also places where scientists' and mystics' ideas about spatial and temporal proximity transformed each other.

ACKNOWLEDGMENTS

THIS PROJECT HAS MOVED AROUND A LOT · I have carried it, and it, in turn, has carried me. Parts of it were written in notebooks in Singapore, in a room in Jakarta, at a temporary desk with piles of old photobooks in the volcano observatory in Jogja, with final read-throughs in Central Sulawesi. There was the pleasant library with the quiet transistor radio at the Geological Survey in Bandung, and there were the rainy days on the deck by the cashew grove in Lombok. Many hours were spent in a *gubuk* on the edge of Mount Merapi getting away from the project, listening to the forest, and hanging out with Giyono. Cambridge, Sydney, Jogja, Malang, Surakarta, Kuala Lumpur, Hong Kong, London, Amsterdam, Tasmania, Glasgow, and the South Downs were some other places where bits and pieces or entire chapters were written, jettisoned, and rewritten. And on volcanoes, most often Merapi, but also Tangkunban Perahu, Idjen, Kelud, Merbabu, Rinjani, Vesuvius. All these topographies nourished this book and deserve thanks.

The conversations, friendships, and support (material and spiritual) that made this book possible are no less dispersed and long range. I will proceed chronologically. In Cambridge, where the project was conceived, it was nourished, challenged, and inspired by Ash Amin, Clive Oppenheimer, Michael Bravo, Simon Schaffer, and Andrew Barry. In Jogja, thank you to the Kunci community for the front-porch and dinner-table conversations. Elizabeth Inandiak offered me the little room on columns. Thank you, Sophia Hornbacher-Schönleber, for conversations and motorbike rides. Thank you, Mes 56. Thank you, Farid Rakun

and Ening Nurjanah, for the best of Jakarta all the time. I send warm gratitude to the following: the volcanologists who let me follow them around and join at their dinner tables, and all the people of Keningar for welcoming me and the long evenings on porches sharing stories and lessons in enchantment. In Sydney, Alison Bashford, Emily Kern, Jarrod Hore, and Naomi Parkinson helped guide the project in new directions. Three years with the New Earth Histories research program at the University of New South Wales (UNSW) were invaluable. Kasia Jezowska criticized and encouraged. Zeynep Oguz, Mira Asriningtyas, and Dito Yuwono championed the project, giving it energy when it seemed like it was going nowhere. Francesca Hughes and Jonathan Meyer welcomed us in London and provided escape in the hills of the Southdowns, away from a pandemic, to finish a final draft. Thank you, Nigel Clark, for encouraging the project from the very beginning at the Political Geology workshop at Cambridge in 2018 and for providing sage guidance through all its twists and turns. Jeffrey Malecki gave much needed copy-editing help. Courtney Berger at Duke University Press stuck with this and kindly guided it into the world. Anonymous reader two encouraged me to clarify the contributions of the project. Thank you to the production team at Duke for all of your careful work. Thank you, Seth Denizen, for—in one way or another—being in this conversation since the beginning when I told you about gatekeepers on Merapi while we sat on a stoop in front of a Hong Kong 7-Eleven. Finishing a book can be tiring and living with someone finishing a book even more so, not to mention frequently boring; thank you, Candice Chung, for your patience and, even more, your nourishment.

Earlier versions of some of the arguments in this book have appeared in different forms in the following: "Processions: How the Spiritual Geographies of Central Java Shaped Modern Volcano Science," *Indonesia* 113 (April 2022): 51–66; "A Javanese Anthropocene?," HKW *Anthropocene Curriculum*, April 22, 2022, https://www.anthropocene-curriculum.org/contribution/a-javanese-anthropocene; and "The Spiritual Geographies of Plate Tectonics: Javanese Islam, Volcanology, and Earth's New History," *New Earth Histories*, ed. Alison Bashford, Emily Kern, and Adam Bobbette (Chicago: University of Chicago Press, 2023).

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Unless otherwise noted, all translations are my own.

CHAPTER ONE

POLITICAL GEOLOGY AS METHOD

POLITICAL GEOLOGY · Political geology was created to bring together geology and politics in new ways. It developed largely within a milieu of geographers and was, in part, inspired by discussions surrounding the Anthropocene.[1] But political geology also resonated with conversations across the humanities with shared interests in the social life of geology and the geology of social life. Political geology attempted to extend those interests by foregrounding the *geos* in the geopolitical at the very moment when many contemporary geopolitical analyses had forgotten that the *geos* of politics was actual material: grounded geological processes.[2] Turning to a concerted analysis of the ways that the earth and geological matter became politicized dovetailed with emerging critical analyses of extractivism and modern state politics, which showed that the transformation of nature into a resource was a process that coupled epistemology and technology.[3] Political geology could then foreground the ways in which the geological sciences were perhaps some of the most profoundly significant sciences in shaping the modern world because they provided the knowledge that drove extractivism. There would be no carbon capitalism, in other words, if not for the geological sciences. It would therefore be a mistake to try to give an account of the history of that earth-transforming capitalism without explaining how the sciences

helped to define, prospect, and extract minerals, ores, and fuels. The political geology that is explained in this book, therefore, provides an expansive account of extractivism by explaining the social production of deep geological time, its context and controversies, and how it has been wrapped up with theology and cosmology. Extractivism, it might be said, is a cosmology. Providing such an account means acknowledging that the geological sciences were tools of European empire.

Yet, less obviously, those tools were also shaped or transformed by world knowledge traditions. This fact is rarely sufficiently acknowledged in critical literature on extractivism or the Anthropocene, where diffusionist models of scientific knowledge ("from the West to the Rest") are commonplace. The geological sciences are, in reality, cosmopolitan not only in the sense that they were developed by scientists acting in many parts of the world but also in the sense that there were (and continue to be) global traditions of geological knowledge independent of European or North American science. Moreover, those traditions helped author the standard European geological sciences. Modern geology, then, including the extractive sciences, is the product of global intelligence: encounters, brokering, and negotiation shaped them, not a linear dissemination.[4] While histories of the geological sciences have been amply told from the perspective of European and US scientists, it is less well understood how they were authored by actors conventionally understood as marginal, or peripheral, and then fed back to transform metropolitan ways of thinking. A multicentered vision of the movement of geological knowledge, with attention to the encounters, brokering, thefts, and gifts that produced it, can help complicate narratives that try to find redemption in local or indigenous counter-knowledges as resistance to extractivist modernity. Instead, the political geology in this book demonstrates just how long and winding the paths have been for many commonplace geological concepts; in fact, much global geological knowledge is local knowledge made planetary. The same ways of thinking about geology that Dutch colonial geologists encountered in Indonesia in the early twentieth century, for instance, then went on to create new Western scientific narratives about the entire earth. They were, in fact, even redeployed in new theoretical contexts to form the basis for the theory of plate tectonics while the local origins of the theory (and Indonesian intellectuals) were written out of the story. Part of the method of political geology is tracing these erasures, shifts of scale, and unexpected influences of geological knowledge to follow their transmission and how they end up enabling extractivist practices.

Much of the geology in this book is on the move and in the making. Unlike many other extractivist contexts in which the sciences stabilize and fix geology in place—turning it into a resource through quantification, spatialization, and mapping—volcanoes are completely different. They explode and melt and rumble. They cannot be approached or hacked away at like a gold or nickel deposit. Therefore, volcanic political geology is a different kind of politics and a different kind of geological knowledge. The core relationship to volcanoes in colonial Indonesia, as we will see, was not a form of extraction through stabilization—it was not about mining underground or scraping the surface—instead, it was about the management of volatile, unpredictable matter in space and time, of negotiating flows and rhythms and pulses to protect an extractive plantation economy. The thrust of geological knowledge about volcanism was not how to identify profitable ores, minerals, and fuels but, instead, how to anticipate a disaster, identify cycles and patterns of eruptions, and predict the future to protect plantation labor and better organize plantation land. Geologists thought about geology not as stable and fixed objects, nor according to the long and slowly transforming processes of geological evolution, but as a material that flows. Their goal was not to take geological material and transform it into a commodity but to negotiate its ability to suddenly move and destroy an already immensely profitable plantation economy; it was a political geology of choreography. They sought to bring society together with a mobile nature.

This eruptive political geology was often troubled by the porosity of the *geos* and *bios*. As Kathryn Yusoff and Elizabeth Povinelli have shown in their analyses of extractivist capitalism, the very categories—*geos* and *bios*, geology and biology, the living and the dead—are the product of a fundamentally cultural, political, and historical process. The geological sciences played a key role in shaping that distinction.[5] The drawing of the dividing line between *geos* and *bios* was not only a product of modern scientific categorization; it was also a profound political maneuver. By separating *biological life* from *dead matter*, things could be ordered into new hierarchies: mere *matter* could become extractable, exploitable, and fungible, while what was endowed with *life*, the organic, could be placed above and endowed with uniquely respectable values. The solidification of these categories lent ballast to imagined hierarchies between humans

and geological material; there could be no human exceptionalism without the privileging of the *bios* over the *geos*. (Some) humans were seen as uniquely different from and above the lowly matter of inorganic (dead) geological material. However, the political geology of Javanese volcanology since the late nineteenth century tells a more complicated story. The relationship between *bios* and *geos* in Java has consistently been seen as horizontal, porous, and fundamentally destabilizing. One reason for this was the relentless vibrancy of volcanoes; they seemed to express the liveliness of the earth itself. It was difficult for scientists and earth theorists on volcanoes to neatly parse out and privilege biological matter from dead, inorganic material. Were the volcanoes not alive? How could you not acknowledge the vibrant agency of a liquefying mountain? Indeed, even the geologist Johannes Umbgrove came to understand in the 1930s that the line between the *geos* and *bios* was porous, always on the move, and fundamentally elusive. He saw, too, that this realization was consistent with the cosmology outlined in the *Upanishads*, which in turn shaped the knowledge systems of the early Javanese kingdoms built on the volcanic plains where he had come to question the distinction between *geos* and *bios*. Hindu cosmology, Umbgrove thought, already showed that life was geological. The modern sciences, he argued, were only now catching up to that insight. Colonial volcanologists like Umbgrove were therefore ready to imagine a different kind of nature, one not burdened by the hierarchies of extractivism. Umbgrove's work belongs to an undercurrent in the modern geological sciences that has been generally ignored or forgotten by contemporary researchers interested in the Anthropocene and in the history of the geological sciences. Revealing this undercurrent can help complicate our narratives of the history of geology because it foregrounds scientists who were interested not in separating the living from the dead but instead in troubling their distinctions, in operating in the ambiguous spaces between biological and lithic life, where volcanoes could become persons and persons could transform into cold, petrified slabs hanging on the side of crater and known as lava tongues.

ATTENTION AND INDIFFERENCE TO JAVANESE VOLCANOLOGY · Given its significance to the history of geological thought, Indonesian volcanology has been surprisingly absent from global histories of geology. Martin Rudwick's pathbreaking histories of deep time zoom over the Indonesian archipelago and acknowledge the contributions of a few Dutch colonial geologists.[6] The large body of mostly well-known popular literature on the history of Indonesian volcanoes mostly omits the context, history, or politics of the science.[7] These omissions are less the case in the sociology and anthropology of volcanic disasters, where there is a larger body of literature on the social production of volcanic risk; yet, that scholarship rarely takes a long view, nor does it contextualize the political history of the geological sciences in Indonesia. Many scholars have recently turned to traditional and folk ideas about risk in Java in an attempt to question stadial, and often neocolonial, developmentalist approaches to disaster science; but it is still common to separate out science from Javanese spiritual traditions and set them in opposition to each other, as if their histories have been independent of one another.[8] No one has brought together the modern history of volcano science with Javanese spiritual traditions or shown how they made each other or depended on each other. The assumed divide between modern science and local knowledge is tenacious, even though it is not real. It is therefore not well understood how science and local knowledge not only shaped each other but also went on to inform broader geological narratives of the earth's history outside of Java. The comprehensive scholarship of Naomi Oreskes and Henry Frankel, for instance, on the history of the theory of continental drift and plate tectonics, acknowledges the work of "the Dutch School"—colonial geologists in the Netherlands East Indies in the 1920s and 1930s—but excludes almost entirely the role of Indonesians.[9] Their histories, like so many others in the history of the geological sciences, begin and end in Europe and North America, giving the impression that it is primarily people in those places who have shaped the global narrative of the history, structure, and origin of the earth. Excluding Indonesians from this story is not a minor omission; it is a familiar, Eurocentric move. Indonesia is the fourth most populous country in the world, in a region nearly the size of continental Europe; it was undoubtedly a crucial site for the development of the postwar geological sciences. Lewis Pyenson has been one of the few historians of science to appreciate the earth sciences in Indonesia, but his *Empire of Reason: Exact Sciences in Indonesia, 1840–1940* curiously excludes an account of volcanology, even though it was one of the "crown jewels" of colonial science.[10] Jean Gelman Taylor's *The Social World of Batavia: Europeans and Eurasians in Colonial Indonesia* gives an account of the role of science and *mestizo* cultures in Batavia, but only up to the turn of the twentieth century and also with scarce attention to geology and volcanology.[11] Rudolf Mrázek's masterful study of the existential crises of engineers in the late

colonial Indies, *Engineers of Happy Land*, focuses mainly on the period after Taylor's book ends, but it too only glances at volcanology.[12]

The scholarship on the history of volcano science in Indonesia, therefore, has largely been left to scientists to write. From the late colonial period, Georg L. L. Kemmerling, Reinout van Bemmelen, H. Albert Brouwer, Newman van Padang, and Johannes Umbgrove stand out for their efforts to document the history of their pioneering science. They published in technical journals, bulletins, obituaries, and scholarly monographs. In the postcolonial period, John A. Katili, Adjat Sudrajat, and Surjo stand out. The Badan Geologi Kementerian Energi dan Sumber Daya Mineral (Geological Agency of the Ministry of Energy and Mineral Resources) has also compiled a small number of excellent resources on the history of volcano science.[13] The aforementioned works were crucial sources for this book. In addition to this literature, a number of popular works by Indonesian volcano scientists were equally useful: Adjat Sudrajat wrote a hagiographic biography of the Dutch colonial geologist Reinout van Bemmelen, who also appears in chapters 2 and 4 of this book.[14] Sudrajat was perhaps the first volcanologist anywhere to write a popular novel in which a volcano played a leading role, *Prahara Gunung Galunggung*, which was published by the Badan Geologi (Geological Agency).[15] Sudrajat also wrote an introductory history of Indonesian volcano science.[16] One of the most prominent geologists of the postcolonial period was John A. Katili, who from 1952 to 1955 was also a columnist for the nationalist magazine *Mimbar Indonesia* (Indonesian platform), in which he discussed geological issues for a new postcolonial readership.[17] He later published several books in Indonesian and English on scientific issues and connected geology with national development. Between 1951 and 2008 he published more than 250 articles.[18] Sudrajat and Katili collaborated on a monograph about the eruption of Galunggung, near Bandung, in 1982–83.[19] Since the establishment of the Vulkaanbewakingsdient (Volcano Monitoring Service) by the colonial government in 1920, later renamed Vulkanologisch Onderzoek (Volcanological Survey), volcanologists have been some of Indonesia's most famous and outspoken scientists; their writings have helped establish the science at the heart of modern scientific culture and have engaged with the most pressing issues in the country. It is even more surprising, then, that English- and Indonesian-language scholars have paid little attention to this work. The marginalization of the volcano sciences is especially stark when compared with the overwhelming number of studies on the botanical and agricultural sciences in Indonesia. As one of the most volcanically active and densely populated places on earth, with one of the most influential traditions of earth sciences, this is a major oversight that this book attempts to rectify.

The line that now frequently separates geology from anthropology is a recent invention in Indonesia. When in 1931, Felix A. Vening Meinesz presented to the Royal Geographical Society in London his discovery of an ocean trench nearly eight thousand miles long, south of the Indonesian archipelago, he dedicated an entire lecture to his studies of Indonesian culture as seen from his submarine.[20] Philip Kuenen, a collaborator of Vening Meinesz's, was a geologist on the pathbreaking Snellius oceanographic expedition in 1929–30 to the eastern part of the archipelago. In 1941, he published *Kruistochten over de indische diepzeebekkens* (Crusades over the Indian deep sea basins); his "crusades," in this case, included his ethnographic studies of Indonesian culture, which he undertook when he was not measuring or taking samples from the ocean floor.[21] When Georg Kemmerling, one of the founders of the Volcanological Survey, undertook fieldwork to investigate volcanic craters in Java, Bali, and the Moluccas in the 1910s and 1920s, he repeatedly included descriptions of sacred sites, rituals, and prayers in his scientific papers.[22] Geologists prospecting for exploitable ores and minerals likewise wrote accounts of Indonesian culture that blurred the meaning of prospecting as a purely economic concern and that constituted a form of ethnology; finding sites for extraction was entangled with describing cultures. In some cases, geologists' work merged with travelogue and tourist diary, but it nevertheless indicated a familiarity and fascination with Javanese culture. Ideas about volcanoes and ideas about culture created each other in colonial Java.

In contrast to histories of Javanese volcano science, scholarship on Indonesian spirituality and religion is immense. No doubt, this has to do with the fact that Java and Indonesia have belonged to the cannon of western English-language anthropological fieldwork sites at least since Margaret Mead and Gregory Bateson landed in Bali in 1936. Later, the creation of Southeast Asian studies grew, in part, out of geopolitical fears over the spread of "Asian communism" and further established the Indonesian archipelago in the network of anthropologists' field sites. More recently, though, Indonesian anthropologists have begun to take over this role of studying Indonesian culture and belief systems. This book leans heavily on English-, Dutch-, and Indonesian-language accounts of spiritual and religious movements in Java from the early twentieth century up to the present. The exhaustive work of historian Merle Ricklefs on

the Central Javanese sultanates has been indispensable for this. I largely agree with Ricklefs's diagnosis that Central Javanese Islam was a "mystic synthesis" that brought together mysticism, local deities, a strong Muslim identity, and the imperatives of dynastic rule in a volatile volcanic landscape.[23] What I contribute to that frequently inspiring (and often intimidating) canon of Central Javanese historiography is to show how the mystic synthesis influenced, and in turn was transformed by, volcanology and modern scientific conceptions of the earth system.

This leads to my penultimate point about political geology as a method. As I mentioned above, one of the ambitions of political geology is to center the *geo* in geopolitics. In recent years, geographers have tended to engage with the agency of a multitude of nongeological nonhumans. This aligned with contemporary turns in geography, such as new materialisms and the emergence of the Anthropocene debates, that placed geological concerns at the center of the discipline but that less frequently considered geological processes themselves or the history of geological knowledges. I aim here instead for a political geology that not only contributes to a better understanding of geological material but also grapples with the culture of geological knowledge and the history of the geological sciences and their role in social life and the formation of political power. Undertaking this means historicizing and situating scientific concepts about the history of the earth, which are otherwise frequently taken for granted in current critical discourses about geology. Likewise, political geology may be able to address some geographers' perennial lamentations about the divide between human and physical geography. The gulf between the two could, perhaps, be mended by better understanding the production and social effects of the earth sciences.

Such ambitions for political geology were always, in some ways, running parallel to the venerable tradition of political ecology, which has one of its roots in the 1970s and 1980s in the work of Piers Blaikie, who among others, worked on the politics of geology—through soil erosion and land degradation in the "Third World."[24] The vast world of political ecology has not since lost sight of the politics of earthly material.[25] Yet, in the Indonesian context, scholarship has, I reiterate, not comprehensively considered the history of volcanology, the politics of the geological sciences, or their intersections with Indonesian knowledge traditions. Instead, political ecology in Java has tended to focus on the connections between botanical and political processes; and, because of this, political geology, as I imagine it, complements rather than eclipses—or worse, competes with—this tradition of political ecology.

A JAVANESE ANTHROPOCENE · The recent proposal to name the current geological epoch the Anthropocene signaled that geologists were recognizing that the border between geology and society had become porous. For many geologists, this was unprecedented. In the history of Javanese volcanology, however, it came as no surprise. As I mentioned above, blurring the boundary between geology and society has been crucial for Javanese volcanologists for more than a century. As volcanologist Reinout van Bemmelen put it in 1954, after more than two decades studying volcanoes, "Mountain building provides the very basis of our existence on earth."[26] He developed a form of volcanological determinism that placed volcanic processes at the center of cultural processes. Civilizations, he argued, could not be understood without also understanding the dynamism of the earth. Van Bemmelen's friend and colleague, Umbgrove, came to develop his complementary theory that sought to bring together civilizations, species differentiation, and consciousness with volcanic processes in *The Pulse of the Earth* (1942). Umbgrove drew on the term *Psychozoic*, as used by Joseph Le Conte, a geologist and physician, who in 1877 stated that he based the term on "the fact that Man, the specialist of spiritual and intellectual differentiation, appeared on the stage and began to extend his supremacy over the world."[27] Le Conte continued, "The geological importance of the appearance of man is not due only or chiefly to his transcendent dignity, but to his importance as an agent which has already very greatly, and must hereafter still more profoundly, modify the whole fauna and flora of the earth."[28] Umbgrove's use of the *Psychozoic* not only anticipated Anthropocene debates, it was also one example of how volcanologists in Java sought to account for the multiple directions of influence between geology and society. As both Umbgrove and van Bemmelen knew well, even the Holocene was so named in the first place because it reflected the emergence of human agriculture.[29] In Java, volcanology has long been social history.

The spiritual traditions of Central Java also acknowledged these blurry boundaries. The sultanates of Central Java, some of them formed in the sixteenth century, were understood to have been founded upon associations between sultans and deities in volcanoes through sex, marriage,

or friendship and acknowledged that sovereignty was conditional upon geology. Ritual processions and the giving of offerings to volcanic peaks by sultans, mystics, and scholars reflected the debts that society owed to geological deities. Not only was society dependent on geology for its existence; it owed debts to geology for its sustainability. Polities came into being through geological alliances. The relationship was not unidirectional, from nature to society, or through society imprinting itself on nature; rather, geology subtended society while social events persistently resulted in natural effects such as earthquakes and eruptions. Dutch colonial volcanologists were aware of these traditions; many were fascinated and even influenced by them. In fact, we know of many of these traditions because of the ethnologists, scientists, and geologists who recorded them.

The coproduction of sovereignty and geology persisted into the postcolonial period and became uniquely potent in the New Order between 1965 and 1998. This era was presided over by the dictator Suharto, who fashioned himself after the same Central Javanese sultans whom Dutch colonial administrators and ethnologists documented as having had sex with chthonic deities. When power was slipping from Suharto's grasp in the 1990s, for instance, he was rumored to have had a network of nearly fifty spirit mediums and magicians working for him.[30] He was also known to give offerings to the goddess of the Indian Ocean, Nyai Ratu Kidul, and to deities in Mount Agung in Bali.[31] He held, for instance, a ritual at Prambanan temple beside Merapi in which he buried a *kris* dagger in the ground to stabilize his political future; when the cosmos was out of order, so too was the political world.[32] When Kelud in East Java erupted in 1991, the tabloid magazine *Misteri,* which supported the regime, exclaimed that it was a sign that Suharto was coming as a "just king" in the time of the apocalypse to save the poor.[33] In the New Order, authoritarian political power was mystical and geological, and natural catastrophe was the result of social catastrophe. It is commonplace today to say that there is no such thing as a natural disaster; this was axiomatic for New Order authoritarianism.

Scholars have drawn attention to the contemporary legacies of this conflation of the social and the geological. Nils Bubandt has shown how the eruption of a mud volcano outside of Surabaya caused by exploratory drilling exemplified the Javanese Anthropocene.[34] Lapindo Brantas, an Indonesian oil and gas company, was prospecting for natural gas in 2006 when they caused an explosion. The explosion turned into an eruption of a mud volcano that inundated and buried the village of Balongnongo before earth berm walls could be hastily built to contain the leak. But the government, courts, and the walls were all ineffective, and the villagers became refugees when the company refused to acknowledge their responsibility. Supporters from all over Indonesia held protests and rituals, and Balinese priests ordered the provisioning of offerings. Jars of mud became souvenirs, and stones from the muck became potent objects. As Bubandt puts it, "The strange life of stones and mud speaks to a spectral moment in Indonesia in which geology is political, politics is corrupt, and corruption is haunted by spirits."[35] These intersections recalled how volcanoes in Java, whether spewing mud or lava, shuddering with earthquakes, studied by scientists, or proffered offerings by dictators, have long been sites at which the boundaries blur between the *anthropos, bios,* and *geos*. In fact, they have long constituted each other. Seen in this light, Java has much to teach those of us who are trying now to come to terms with how to live in an Anthropocene.

THE BEGINNINGS OF VOLCANOLOGY IN JAVA · Modern scientific volcanology has its roots, no doubt, in the global scientific interest in Javanese volcanism of the late nineteenth century. This is obviously because Java was (and still is) one of the most densely inhabited, volcanically active regions on earth. The spine of volcanoes at the center of the island had erupted hundreds of times between the late nineteenth century and early twentieth.[36] Some of the most famous eruptions of the last two centuries happened in Indonesia: Tambora in 1815 and Krakatoa in 1883. Unsurprisingly, Java was understood to be an important place to go to understand volcanoes.

Colonial Java at the turn of the twentieth century was also a plantation economy that relied on eruptions to fertilize the soil; yet, these same plantations also needed protection. The Netherlands East Indies grew and exported botanical products (spices, rice, tea, tobacco, medicine, rubber, teak, and cinchona) to European markets and made the Netherlands one of the wealthiest places in Europe. The natural sciences were also largely driven by efforts to manage and improve the local plantation economy, and because of this, Java was a world center for botanical knowledge.[37] The research stations and gardens at Buitenzorg and Bandung were at the forefront of plantation technologies, tightly networked with botanical centers in cities of the British and Dutch empires such as Amsterdam, Kew, Singapore, Ceylon, Sydney, Calcutta, and beyond. In the 1910s, cinchona

experimentation in Bogor was at the vanguard for its use in treating malaria, and Europeans throughout tropical colonies relied on it to not die. So too, rubber plantations were expanding across the island and fulfilling burgeoning industrial demand for rubber products, and palm oil was being newly experimented with as a lubricant for machine parts and a component in candles. The Pacific Science Congress was held in Batavia and Bogor in 1920, with more than two hundred scientists from the Pacific region learning about the state of science and engineering in the Indies. But plantations inevitably extended up the verdant slopes of volcanoes, where the higher altitude and cooler air provided excellent conditions for the cultivation of tea, tobacco, and teak. It was not only the crops that grew there that brought people into proximity with the volcanoes but the rivers too that threaded down from the craters and carried water into the lowlands and out into the oceans, connecting the tops of volcanoes to the flat lands. As Clifford Geertz succinctly put it, "Java [is] . . . a set of small-scale, richly alluvial galleries hemmed in by volcanic mountains."[38] The proximity of gallery to crater meant that eruptions were bound to have significant local and global costs.

Three eruptions around this time were significant. The first was that of Krakatoa in 1883, which was so huge and loud that it registered across the world. The volcano was in the strait between Java and Sumatra, at a distance from inland plantations but nevertheless so powerful that it destroyed many of them. More significant, at least for the authorities, was the interruption of trade from the Netherlands East Indies to Europe and Asia.[39] Ships stopped sailing and goods stopped moving. The possibility that such threats could recur spurred attempts by geologist Rogier Verbeek to systematically map for the first time all the volcanoes and their geological contexts in Java and Sumatra in an effort to diagnose future eruptions.

The second event was the eruption of Kelud in East Java, thirty-six years later, in 1919. A lake had formed in the middle of the caldera; it exploded out of the top and rushed down the slopes (figure 1.1).[40] A wall of mud and debris spilled into the market town of Blitar and overturned houses, lifted cars, and intercepted a train trying to escape the town. Corpses with their clothes torn off were later exhumed from the mud.[41] More than 5,000 people died, 135 square kilometers of plantations were destroyed, and 9,000 houses were ruined.[42] After expeditions to the crater to understand what happened, government engineers vowed to drill a tunnel into the caldera to drain the crater lake.[43] Such an undertaking required mining, rail, and road engineering expertise (figure 1.2). Drilling

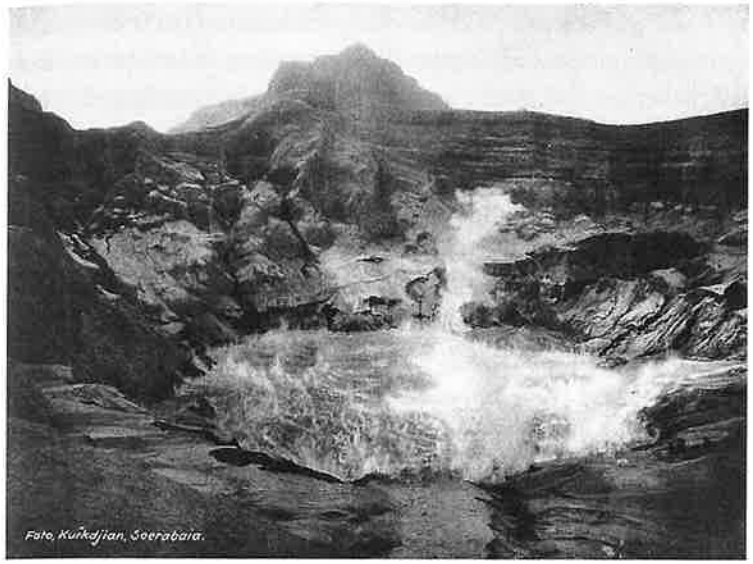

FIGURE 1.1 Kelud, showing its crater lake after an eruption in 1901. Georg L. L. Kemmerling, "De uitbarsting van den G. Keloet in den nacht van den 19^{den} op den 20sten Mei 1919," *Vulkanologische Mededeelingen* 2 (1921): 105.

FIGURE 1.2 Expedition to Kelud, hot lahar (pyroclastic mudflow) in the background. Georg L. L. Kemmerling, "De uitbarsting van den G. Keloet in den nacht van den 19^{den} op den 20sten Mei 1919," *Vulkanologische Mededeelingen* 2 (1921): foto 4.

into the wall of a volcano had never been undertaken in the Netherlands East Indies (or perhaps anywhere, for that matter), and it presented a series of challenges, not least the heat inside the crater walls and the danger of drilling into a hot lake from below it. It was also the first time the authorities had attempted to directly intervene in volcanic processes to shape an outcome favorable to their plantation economy.

Another consequence of the Kelud eruption was the establishment of a government-run Volcano Monitoring Service dedicated to monitoring the islands' most disruptive volcanoes.[44] The authorities resolved to incorporate modern scientific monitoring and communications with the populace into colonial government policy, which motivated a recognizably modern, cosmopolitan form of volcanology. The small group of scientists who participated in this were mainly mining or military engineers and geologists. They began to publish bulletins of their observations and studies that soon circulated among geologists trying to define volcanology as a new and modern science in the United States, Japan, and Europe. The formation of the Volcano Monitoring Service, later the Volcanological Survey of the Netherlands East Indies, institutionalized volcanology in the East Indies. Volcanologists such as Berend G. Escher, Charles E. Stehn, Georg L. L. Kemmerling, Reinout van Bemmelen, Johannes Umbgrove, Maur Neuman van Padang, Louis Rutten, Gustaf Molengraff, and others were often not only volcanologists (the term was not even greatly in circulation at the time); they were also economic geologists, prospectors, engineers, or stratigraphers. Volcanism, though, became the prism through which they came to understand a broad range of geological problems. For many of them, their principal theoretical preoccupations became the origins of volcanoes and, in turn, the planetary and historical processes that created them. In other words, they were fascinated with *orogeny*—mountain building. They frequently understood volcanic processes as the engine of lithospheric evolution, which placed them at the vanguard of European and US debates about geological history because they were sympathetic to notions of drifting continents proposed by Alfred Wegener in 1912. Most American or European scientists were dismissive of "continental drift," but geologists in the Netherlands East Indies developed innovative concepts to rethink planetary history. In other words, Javanese volcanoes became the model through which scientists understood the entire earth. For this they would retrospectively be called the Dutch School.

The third important eruption was that of Merapi in 1930. Volcanologists had built a permanent watch station there after the eruption at Kelud, an effort of the Volcanological Survey. It was a flimsy hut located on a hill called Maron and included telescopes and what appears to have been the first seismometer on a volcano in the East Indies (figure 1.3). The massive eruption washed the hut away, buried the seismometer, displaced thousands of people, and destroyed nearly forty villages (figure 1.4).[45] In response, scientists regrouped and planned a much more durable observation station at Babadan, to the west of the caldera, which included a bunker that could withstand the clouds of superheated gasses and flying boulders. The bunker contained a new seismograph and soon became part of an expanding network of observatories on Merapi's southern and southwestern flanks. What was new was the installation of telephone and telegraph cables linking the observatories to the lowland market towns. The communications network was far more extensive than at other observatories, and it accelerated communication from the top of the caldera to urban centers while also importing lowland technologies into rural, often impoverished, villages. Observatories thus became architectural outposts of the state and contact zones between colonial scientists and rural cultures.

Volcanology emerged in Java because of these three eruptions, and it then became an established mechanism of colonial governance. As volcanologists frequently put it, their aim was to protect people and property. But the new interest in monitoring helped volcano scientists acquire resources—offices, transportation, assistants, funding—to greatly extend their efforts. And the first generation of state volcanologists used all the techniques at their disposal; they wrote detailed case studies of eruptions based on observatory records and site visits, and they drew on eyewitness accounts and photographed, measured, sketched, and described eruptions. Whole new apparatuses of knowledge-construction were brought to bear. After the eruption at Kelud, for instance, Kemmerling compiled a report of nearly 120 pages for the Dienst van het Mijnwezen in Nederlandsch Oost-Indië, Vulkanologische Mededeelingen (Bureau of mines in the Netherlands East Indies, Volcanological Reports), with engineering diagrams and exquisite photographs by Kurkdjian studios, one of the Netherlands East Indies' most prolific photography studios that also made landscape portraits for tourists. By the 1920s, the volcanologists had support from the military to fly airplanes and conduct aerial surveys of eruptions and their effects, compiling vast archives of aerial caldera photos from every angle (figures 1.5, 1.6, and 1.7). As Susie Protchsky has observed, aerial photography brought together military with scientific

FIGURE 1.3 The first monitoring post on Mount Merapi at Maron hill, beside Blongkeng River, March 1920. *Post Maron bij K. Blongkeng, Maart 1920*. Courtesy Balai Penyelidikan dan Pengembangan Teknologi Kebencanaan Geologi archive.

FIGURE 1.4 Photograph from 1931, surveying the destruction of Demong village from the Merapi eruption of 1930. *Kroon verwoeste dessa Demong met graven en vliegenhuisje*. Courtesy Balai Penyelidikan dan Pengembangan Teknologi Kebencanaan Geologi archive.

FIGURE 1.5 Military aerial survey of Mount Merapi, December 22, 1930. *Militaire luchtvaart, afd. top en zuidflank G. Merapi*. Courtesy Balai Penyelidikan dan Pengembangan Teknologi Kebencanaan Geologi archive.

FIGURE 1.6 Military aerial survey of Mount Merapi, December 1930. *Militaire luchtvaart, afd. bovengedeelte van het gloedwolkgebied met de groote bocht in het Blongkeng ravijn*. Courtesy Balai Penyelidikan dan Pengembangan Teknologi Kebencanaan Geologi archive.

FIGURE 1.7 Lieutenant Wegner at Tidar airfield, Magelang, 1933. *Lt. Wegner voor het vliegtuig op het vliegterein tidar bij Magelang*. Courtesy Balai Penyelidikan dan Pengembangan Teknologi Kebencanaan Geologi archive.

modes seeing, and volcanology became an integral form of territorial knowledge and control.[46] By the closing years of the Dutch colony in the late 1930s, volcanologists had constructed a visual culture of volcanoes, established modes of practicing fieldwork, and pursued ambitious theoretical frameworks that were uniquely integrated with the plantation economy but extended to the entire history of the earth.

As materially grounded as colonial volcanology was, it was also mythical, theological, and cosmic. Answering why a volcano erupted eventually led to questions that expanded beyond the visible to bigger questions about the region and, often enough, about the cosmos. Indeed, the most theoretically ambitious volcanologists, who often became the most influential, coupled observation with attempts to situate Indonesian volcanism in the history of the evolution of earth. Brouwer, Kemmerling, van Bemmelen, and Umbgrove engaged with prevailing geological theories that suggested volcanoes were created by a cooling, shrinking earth that buckled at the surface and created explosions. But many questioned this orthodox narrative and wondered whether volcanism was the result of the surface of the earth sliding horizontally. Perhaps, they asked, drift caused mountains to build and magma to emerge from below. Engaging these debates put Dutch colonial volcanologists at the heart of European geological controversies, and Vening Meinesz, van Bemmelen, and Umbgrove (as we will see in chapters 2, 4, and 5) developed complementary yet unorthodox positions. Van Bemmelen developed a theory of *undation*, which posited huge waves traveling through the earth's surface, that he vigorously defended until his death in 1983, even though there was very little uptake of the idea by his contemporaries. Meanwhile, Umbgrove posited cosmic rhythms of mountain building, climate change, and species diversification that recurred in 250-million-year cycles, corresponding to the time it takes earth's galaxy to rotate. Umbgrove and van Bemmelen wondered whether geologic and biological time was cyclical, occurring in rhythmic "pulses," and if so, whether pulses could be predicted like seasons but in deep time. For both, volcanology was a science that made cosmic order and disorder, crisis, and catastrophe legible in the landscape. At the same time, at the foreground of their cosmic geology was the question of the place of humans and geological determinism. They wondered to what extent humans were a product of geological processes, and whether the coming into being and passing away of civilizations was rooted in planetary-wide processes of mountain building. Were cultures also tectonic?

Indonesian volcanoes taught colonial scientists to see the earth in new ways. And so did Indonesians; Javanese political geology enabled European scientists to think differently about the relationship between culture and the lithosphere. The purpose of political geology as a method, therefore, is to stay close to these acts of translation, movement, and transformation in earth knowledges and to map the ripples of their political effects. Not only does political geology place Indonesian knowledge at the center of modern earth knowledges; it also enables us to destabilize conventional narratives about the geological sciences.