SueEllen Campbell

With Alex Hunt,
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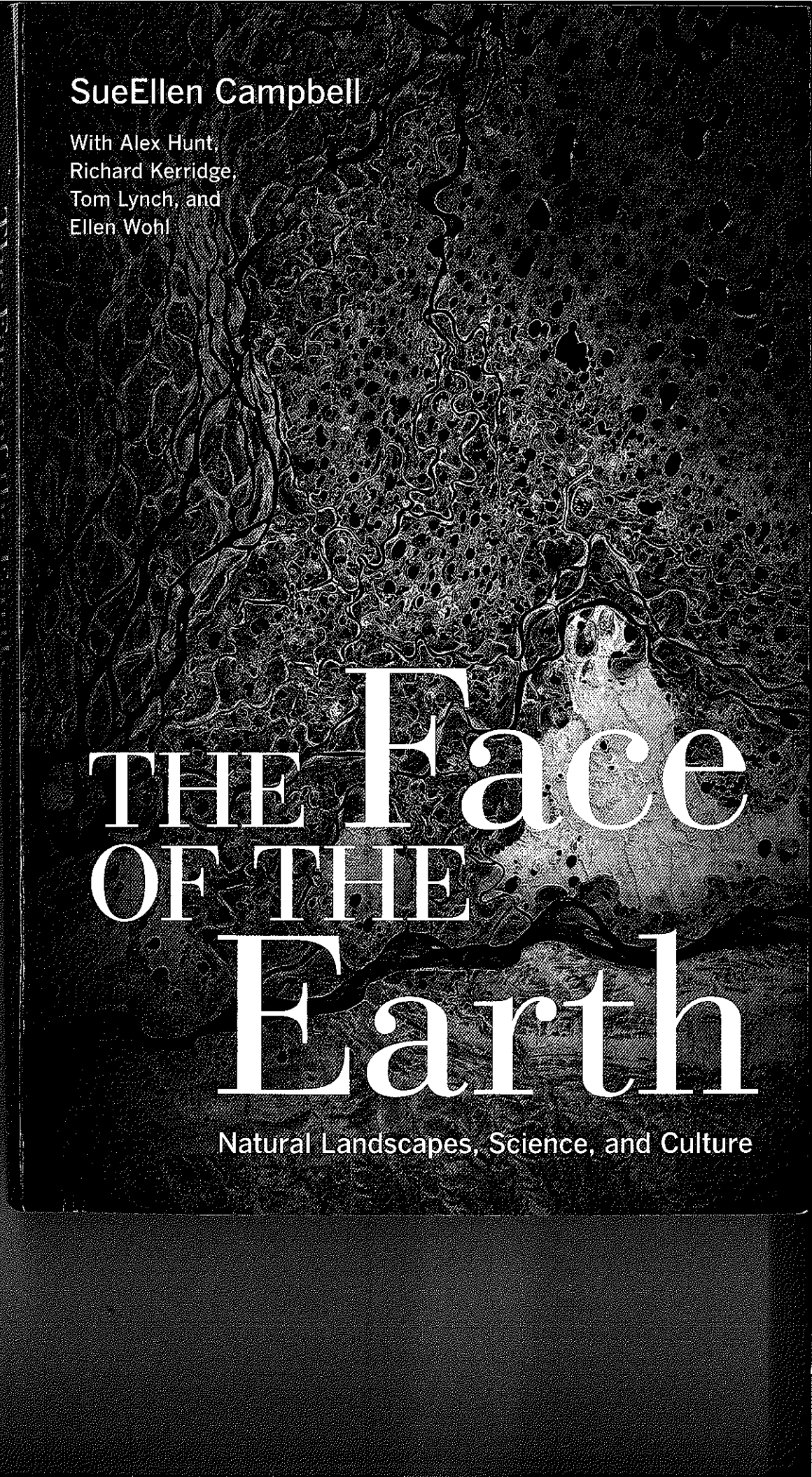

# The Face of the Earth

## Natural Landscapes, Science, and Culture

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bers beneath the volcano that the ground above them collapses into that space, creating a caldera (from the Spanish for cauldron). The eruption of New Zealand's Taupo less than two thousand years ago created a caldera that now holds Lake Taupo; Kilauea's former lava lake visited by Isabella Bird and Mark Twain was in another. Scafell in England and Glen Coe in Scotland are very old calderas. The steep walls of Tanzania's Ngorongoro Crater have helped protect its extraordinary wildlife. American examples include Crater Lake in Oregon and two less visible instances near Santa Fe, New Mexico, and in Long Valley, California. Much of Yellowstone National Park is a caldera, and the lingering heat from its last superexplosion about six hundred thousand years ago is what fuels its hydrothermal features; entering Yellowstone's gates, visitors are given a map on which the caldera rim is marked. The 1883 explosion of Indonesia's Krakatau created a caldera (and a particularly deadly tsunami), as did the eruption of Santorini about 1600 B.C.E. The effects of the latter event on Mediterranean cultures may have been considerable. Geologists, archaeologists, and historians have speculated that it may have contributed to the decline of the Minoan civilization and provided the basis for numerous legends, including the story of Atlantis and possibly some of the region's many stories of catastrophic floods.

Such speculations bring us full circle, in a way, returning us with yet another twist to the age-old interplay between what we might simplistically call material and nonmaterial explanations of our world. We have seen how the earliest natural philosophers moved away from traditional methods of explaining geology with the stories provided by myth, legend, and religion and toward what would become scientific methods. Today, we may reconnect these modes in the other direction, recognizing that myth and legend may have some scientific value and using the tools of scientific geology to renew our understanding of some of our culture's most fundamental stories.

### ◈ ON THE SPOT: APPROACHING CHAITÉN VOLCANO

*Fred Swanson*

Today's the day—the start of our weeklong field expedition into an unexplored landscape, southern Chile's Chaitén volcano. Quiet for nearly ten millennia, it erupted less than a year ago, sending ash eastward across Patagonia and into the southern Atlantic, and

in the months since, still restless, it has pushed up a massive dome that nearly fills its old caldera. With my ecologist buddy Charlie Crisafulli, I've come here to learn more about the ecology of volcanic explosions, and to test some of the lessons we've learned from three decades of study closer to home at Mount Saint Helens.

We've traveled hard to get here, and now, finally, poised on the bridge into the town of Chaitén, we get our first full view of the looming volcano. Just a few miles north up the Rio Blanco, it's a big, dusty mass of rubble. Puffs of steam from vents dot its sides, and a plume rises a few thousand feet straight up before bending northward with the winds. The river below us is a braid of many channels wandering across a plain of gray silt and sand—evidence of the sediment-charged floods that have moved down the riverbed, inundating the forest along its sides and then the town. For a few minutes we watch several massive bulldozers working on dikes to protect what's left of the town, but they can't really do much: it's sitting at the mouth of the gun barrel, squarely in the sights of the next flood or mudflow.

I had imagined a crucial decision at this point in our trip: crossing the bridge commits us to engaging directly with the volcano. The possibility that a new mudflow could wipe out the bridge, cutting off our supplies and our retreat, seems very real. I worry too about how close the roads—and our own sense of safety—will permit us to get to the blast zone. But of course, now that we're so close, we can't stop.

Just over the bridge we find the town of Chaitén nearly deserted. Despite the government's efforts to relocate its five thousand citizens, about seventy holdouts remain. Abandoned dogs roam the streets, and horses graze on the tall grass in the city square. Gritty gray ash lies several inches thick on every horizontal surface, except where passing cars and trucks have blown it aside. Houses close to the river are scarred by mud lines halfway up the first story. Vultures perch atop an empty A-frame, and crudely lettered slogans (in Spanish, of course)—"Madam President, you violated all the rights of a people who will not die"—protest the government's reactions.

Our destination is the northern flank of the volcano, the point of closest access. We drive through lush rain forest, then suddenly catch a glimpse ahead of completely dead forest beneath the dirty steam cloud drifting from the dome. Soon we're stopped where deep

gullies cut by streams draining the northern flank slice the road. A ten-minute hike takes us through a towering forest of standing dead trees and into a blown-down forest. The world is gray except for a few sprigs of foliage sprouting on surviving plants and many hard-to-see brown, yellow, and orange mushrooms budding from rotten wood. Rocks clattering down the dome less than a mile directly upslope remind us of the instability of the scene and the potential for further explosions. The air is full of the slightly burned, organic smell of wood stewing in the fresh volcanic deposits, a scent that takes me back to the Mount Saint Helens landscape I walked the first summer after her 1980 eruption.

We get down to work. Charlie is an intensely inquisitive naturalist with a craving for critters—he knows them all. Although we're both lanky, bearded, seasoned volcano nuts, we couldn't be more different in how we set to work. Charlie focuses on collecting—plants go into the plant press, bugs in the vials, soil and new ash into the plastic sample bags. This means he hunkers down and examines a few spots intensively. Ultimately, stories will tumble out of his samples and data. By contrast, as a geologist, I like to move quickly across the land and assemble stories from observations along the way. I scribble notes and sketches, emphasizing interactions between geological processes and the biota, and jot down questions I'll think about later. So Charlie and I compromise and adopt a blend of fast reconnaissance with hourlong periods of focused site sampling.

In the blast zone, less than a year after Chaitén's big eruption, we discover many signs of life. Amid the gray, prostrate tree trunks we find bright green, knee-high clumps of bamboo and other hearty plants sprouting from rootstocks buried by less than a foot of rock debris left by the blast. Some species of toppled trees are sending out a few green sprouts, but other species don't have this capacity. The blast zone is loaded with dead wood, both from before the eruption and because of it, so I'm not surprised to see many types of mushrooms, fruiting bodies of the extensive network of fungal mycelia spread throughout the feast of rotting wood below the surface. I'm reminded of the small pebbles I saw dangling from spiderweb mycelia on the wall of a shallow pit I dug in blast deposits ten days after the climactic eruption of Mount Saint Helens. I realized then that this fungus, adapted to germinate after heating by forest fires, had penetrated a vast blast-zone area in less than two weeks. Maybe the same thing happened here at Chaitén.

Cross-country travel in this landscape is made very difficult by the endless fascinating distractions and the physical challenges of a forest laid flat. Usually my long legs are a big advantage in moving across rough ground, but in the parts of this volcanic area most littered with fallen tree limbs and stems of shrubs, we're almost swimming through the tangle. Our shovel, packs, and camera gear are repeatedly snagged, bringing us to awkward and sometimes risky halts. And in short order we're covered with ash shaken from every stem and leaf we touch; we're as gray as the landscape. The chance to catch a breath is welcome; to trade muscle work for mind work in this fascinating landscape is a treat. Why is the bright red flower here? How much clatter are we hearing from rockfall from the dome; is it giving us a warning? What is the fate of that expanse of forest on the distant ridge—is it dead or will another crop of foliage emerge and green the landscape again? We're not very disciplined; if we were, we might miss something very important. This stuff we call fieldwork taxes all our skills and energies.

In the slant of evening light, Charlie and I finally call it a day, exhausted but abuzz with thoughts of the live volcano, the changing ecosystem, and the people of Chaitén. This wild, noisy, fragrant, dangerous landscape has really focused my attention. And as I've learned from other field adventures, today's images and ideas will provide a lifetime of reflections. ◈

## HOT SPRINGS AND GEYSERS

One simplified way to describe what happens in volcanoes is to say that this is how heat escapes from the inside of the planet, as part of the very long, very slow cooling process that began when the universe first formed. Heat always wants to rise, even when it encounters barriers. Kircher's illustration of the fire houses of the interior captures this fact. His diagram of the subterranean interactions of fire and water captures another related fact: as the natural philosophers thought (though not exactly in the ways they thought), internal heat does encounter underground water, and water may increase the explosiveness of volcanic eruptions. Heat also alters water, and we experience the results on the surface in the form of such features as hot springs and geysers.

Some warm and hot springs derive from geothermal gradients—that is, water that descends far enough into the earth to become heated simply by increasing pressure and temperature and then rises quickly