Timothy J. LeCain

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The Men and Giant Mines That Wired America and Scarred the Planet

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FOR CHERÍ, CARINA, AND DANIEL

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Acknowledgments

When I was a boy growing up in western Montana, my parents took me and my four brothers to see the Berkeley Pit in Butte, back when it was still a pit and not a toxic lake. I can still recall the mixture of awe, excitement, and unease I felt at seeing that shattered industrial landscape, one so different and seemingly distant from our home in the green and pleasant Missoula Valley. First thanks must go to my parents, then, for introducing me to some of the major fault lines that divide the modern world and sparking an enduring fascination with big pits.

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Mass Destruction

ONE

In the Lands of Mass Destruction

He, in his own age, was almost as important a figure
as Mr. Jobs is in our age.
—A friend of the Jackling House

The wooded hills and elegant homes of Woodside, California, at first might seem an odd place to begin a book about mass destruction technology. On a warm early summer's evening in this fashionable community south of San Francisco, the air smells of fresh-cut grass and eucalyptus. A light breeze carries a hint of salt air from the ocean ten miles to the west and stirs the leaves on the tall coastal oaks that blanket the hills a dense green. Near the fork in the road where Robles Drive splits right from Mountain Home Road, there is a large tree-covered estate with an abandoned Spanish Colonial mansion—or at least what was supposed to look like an old Spanish Colonial mansion. It was actually built in the early 1920s for the copper mining tycoon Daniel Cowan Jackling, one of the most important mining men of the twentieth century and a key inventor of the modern technology of mass destruction. But standing near the house in the fast-fading western light, you would search in vain for a historical plaque or any other hint that a man due some measure of remembrance lived much of his adult life here at 460 Mountain Home Road. Dead now for more than half a century, Jackling seems to be as forgotten and inaccessible as his deserted mansion, veiled and locked away amid the fog and oaks of the Pacific coast.

1. Daniel Jackling built this elegant Spanish Colonial Revival mansion in the affluent community of Woodside south of San Francisco in 1926. Steven Jobs, the founder of Apple Computer, is the current owner. His efforts to tear down the mansion and replace it with a modern house have been stymied by historic preservationists. *Courtesy Woodside History Archives.*

For reasons that will become evident, it is difficult today to gain permission to visit the Jackling house. Yet old pictures show an impressive red-tile-roofed adobe house that sprawls over a large and elegant estate. Though the seventeen-thousand-square-foot home is not nearly so ostentatiously extravagant as William Randolph Hearst's San Simeon to the south, nonetheless its thick stucco walls enclose thirty-five rooms, thirteen baths, a custom-built Aeolian organ (a sort of player piano on steroids), and ubiquitous copper fixtures throughout—a nod to the original natural source of Jackling's wealth.[1] Inside, heavy dark oak beams support the ceilings, and decorative Spanish tiles grace the floors and walls. The effect is less authentic Spanish Colonial than 1920s Hollywood glitz. One suspects the fictional film star Norma Desmond would have found the home perfectly to her taste if it had been built on L.A.'s Sunset Boulevard.

Unfortunately, the years have not been any kinder to the Jackling house than they were to Norma Desmond. Unoccupied and largely neglected since the mid-1990s, today the mansion is showing signs of serious decay. The once brilliant white adobe walls are streaked with sooty black stains, and dry rot and mold have begun to invade the interior. In the music room the grand Aeolian organ still stands, its four tiers of black and white keys covered with layers of dust and dead leaves. Water pools on the Spanish-tiled floors, and the electric chandelier's faux candles bend at wild angles or hang broken from their sockets. Dank, gloomy, and slightly spooky, it would be a fine place to celebrate a memorable Halloween night. It is difficult now to imagine the famously elegant parties that Jackling and his wife, Virginia, once hosted here, to picture the movie stars, politicians, and other celebrities of the day talking and laughing beneath the brightly lit chandelier as the swelling music of the organ echoed through the tiled halls.

If the artifacts a society chooses to save from the past suggest what it wishes to remember, then those that it abandons to rot and decay may suggest what it would just as soon forget. Daniel Jackling died at his Woodside estate in 1956. Virginia followed a few years later. In the decades since, the house had several proud and doting owners and remained a much admired jewel of Woodside. By the early 1980s, though, the community found itself neighbor to the dynamic new economic hotspot of Silicon Valley, a boom that brought a new generation of the recently rich seeking convenient Arcadian sanctuaries. One of them was Steven Jobs, the computer whiz who made his fortune with Apple Computer. Jobs bought the Jackling estate in 1984 and lived there for more than a decade before he and his young family moved to a smaller home in nearby Palo Alto. Jobs eventually decided he wanted to move back to the spacious wooded estate, though not back to Jackling's quirky old manse. Instead, he proposed to tear down the Jackling mansion and replace it with a (relatively) smaller modern house. Jobs apparently stopped maintaining the house after about 2000, starting its decline into disrepair. Meanwhile, his plans to raze the mansion sparked controversy, and historic preservationists petitioned for an injunction to stop the computer magnate. In early 2006, a San Mateo County Superior Court judge agreed with the preservationists and ordered a halt to the project. Jobs, who now refers to the Jackling house as an "abomination," has offered to give it away to anyone who would move it to another site.[2]

The controversy over the Jackling house is hardly unique in a culture where the rush to embrace the future has long outpaced efforts to preserve the past. Yet the story also offers a deeper glimpse into the history of how Americans view nature, technology, and their own material environment, which is at the heart of this book. Even the preservationists fighting to save the house emphasize its architectural importance over its historical significance as Jackling's former home. George Washington Smith, a fashionable Santa Barbara architect famous for his Spanish Colonial Revival style, designed the house. An article in the local *Mercury News* captures Jackling's only secondary relevance: "It's protected because Smith was an important architect, even if most of his famous stuff is in Santa Barbara, and because Jackling was an important guy, even if most folks have never heard of him."[3] Even a letter from the California State Historical Resources Commission emphasizes the house's architectural importance, while adding almost as if an afterthought, "The property also derives its significance from Smith's clients, Daniel and Virginia Jackling."[4] Indeed, one journalist concludes that Jackling's connection to the house would best be forgotten altogether: "It's time to start calling it the Jobs House instead of the Jackling House."[5]

In the early years of the twenty-first century, it seems, the man whose technology provided the nation with billions of pounds of cheap copper was less worthy of remembrance than an upscale Santa Barbara architect who specialized in faux Spanish Colonial buildings. While Jobs and the preservationists may have fought over the architectural significance of the house, they seemed to agree that Jackling and his accomplishments were largely insignificant. In such careless or willful acts of historical amnesia are suggested the destructive ironies of modern technological America and its bizarre and often dysfunctional relationship to nature. Only a society utterly secure in its comfortable technological environment could so easily ignore its material foundations in the natural world. Earlier generations of Americans, living at a time when modern dichotomous views that separate humans and technology from a pristine concept of nature as wilderness were still emerging, had actually been much quicker to recognize the connections. During the first half of the twentieth century, American presses published numerous books on the history, extraction, and significance of critical modern raw materials like copper. Though sales and circulation figures are difficult to determine, presumably these publishers believed that a sizeable number of Americans were interested in these topics. The books were all uncritical in their celebration of the accomplishments of modern mining, and few mentioned the tremendous costs in both human and environmental losses. Still, in comparison to the modern distancing between the built material environment and the natural world, these earlier works are refreshing in their clear and unapologetic explanations of how technological society had its roots deeply planted in nature.[6]

Nearly a century ago, Thomas Edison was presented with a solid cubic foot of copper as a symbol of the natural raw material that had made his system of electricity possible—a story we will return to later in this book. In contrast, consider the irony of Steven Jobs today, a man whose fortune is also built on electronic machines—machines filled with copper parts and powered by electricity distributed on copper wires—attempting to tear down the house of a man whose own fortune came from providing that very copper. Perhaps Jobs is aware of this contradiction. If so, it does not seem to have influenced his feelings about the house. Regardless, this story of a California real estate battle points toward the way modern technological society often keeps us from recognizing our everyday dependence on raw materials extracted from nature.

As one of the relatively rare champions for preserving the mansion for its historic significance rightly notes, Jackling, "in his own age, was almost as important a figure as Mr. Jobs is in our age."[7] Perhaps this forgetting of connections and history is one of the ways we make the sacrifices demanded by modern industrial civilization a bit less painful. For Steven Jobs, minimizing Jackling's contributions to the modern world may be tactically useful, even if it means ignoring the fundamental connection between his own industry and Jackling's. But Jobs is hardly alone. It has long been psychologically useful for all Americans to ignore our own connections to the technology of mass destruction that provided us with cheap and abundant copper—the copper that carries the electricity that powers the computer used to write these words. The ease with which Jobs or any of us may forget or ignore our fundamental connections to the natural first source of our material world is a problem that lies at the heart of this book's story.

TWIN SONS OF DIFFERENT MOTHERS

To be fair, both Jobs and the preservationists were not unusual in their historical amnesia: Daniel Cowan Jackling may well be one of the more important men of the twentieth century that no one has ever heard of. Well before Jackling died in 1956 at his Woodside mansion, he had established one of the world's greatest copper mining companies, accumulated a sizeable personal fortune, and received numerous awards and honors. Decades earlier, President Woodrow Wilson had personally awarded Jackling the Distinguished Service Medal for his national contributions during World War I. In 1933, he received the John Fritz Medal, one of the engineering profession's highest honors and one Jackling shared with the more famous 1929 recipient, Herbert Hoover, the only mining engineer ever to become president. Nonetheless, Jackling's death passed largely unnoticed by most busy midcentury Americans. The *New York Times* ran a glowing though relatively brief obituary, and even his professional colleagues failed to really recognize and commemorate the true significance of Jackling's work. The relative silence was partly just a consequence of longevity: at the age of eighty-six, Jackling had simply outlived what fame he had once enjoyed.[8]

Americans are supposedly notorious for their historical ignorance, yet time and forgetting cannot fully account for Jackling's decline into obscurity. Contrast Jackling's passing with that of his close contemporary Henry Ford, a man whose own fame and fortune were founded on related (though not identical) principles and depended at least in some small part on Jackling's work. Born six years before Jackling, Ford lived nearly as long, and the two men passed through almost exactly the same stream of history. When Ford died in 1947 at the age of eighty-three, Americans and much of the rest of the world commemorated the Detroit automobile maker as if he were a beloved statesman or an honored war hero. Harry Truman, Winston Churchill, and even Joseph Stalin sent word of their deep admiration for Ford. Newspapers ran above-the-fold front-page stories.[9] The *New York Times* printed a long and adulatory obituary. Ford's career, the *Times* noted, "was one of the most astonishing in industrial history" because of "the revolutionary importance of his contribution to modern productive processes."[10]

Admittedly, at first glance a comparison between Ford and almost any other industrialist (except perhaps Thomas Edison) may seem inapt. Ford was one of the most famous businessmen of the twentieth century. Few could ever match the worldwide notoriety of the creator of the Model T, the assembly line, and modern mass production. Millions shared an oddly personal connection with Ford, thanks to their mass consumption of his company's cheap and reliable automobiles. He was the public symbol of a machine and a lifestyle many adored. However, it is precisely these two accomplishments—mass production and mass consumption—that should have closely linked Ford and Jackling in the public imagination. Jackling's accomplishment was to pioneer a third and closely related system, without which the other two would have been all but impossible: mass destruction, a technological system for cheaply extracting huge amounts of essential industrial minerals from the earth's crust.

Still, Jackling did not manufacture mass quantities of a popular consumer product like a car. Nor did he help to create the cultural meaning of such products through industrial design, advertising, and the other tools of modern mass consumption. Rather, Jackling's achievements were made in a much less public and prominent field, in an endeavor that has for centuries remained distant and hidden from the more obvious world of the urban factory or the boisterous marketplace. Jackling was a copper miner—a provider of one of the most important natural elements of the modern age. He perfected a technology capable of supplying immense quantities of copper that manufacturers subsequently transformed into wires for countless miles of power lines and parts for billions of cars, radios, and refrigerators. By midcentury, more than 60 percent of the world's entire production of copper was extracted using Jackling's system of mass destruction.[11] Other engineers adapted the technology to different minerals, and the same basic principles emerged in extractive industries as varied as logging and fishing.

I have chosen the term "mass destruction" to describe Jackling's technology only after much thought and debate, and use it advisedly. For most people, of course, these words evoke the mass destruction of human life and property, either through war or terrorism, and they are usually preceded by "weapons of." This is not precisely the meaning I wish to convey here, though I will argue that the past century's technological and ideological "advances" in the efficient destruction of humans were not unrelated to the efficient destruction of mountains. Indeed, this murderous sense of the phrase, with its echoes of Guernica, Hiroshima, and cold war Armageddon, may help to explain why it has not previously been used to define this type of mining. What mining engineer or company would want to suggest that their extraction technology was in any way analogous to weapons of mass human death?

No other phrase, however, better captures the essential traits of this transformative but often overlooked technology that was a necessary condition to the building of the modern industrial and postindustrial world. The term is also appropriate because it echoes the better-known concepts of mass production and mass consumption—both of which depended on mass destruction to supply the essential raw materials. As the antonym to the phrase "mass production," "mass destruction" suggests this close association, although from a strictly physical standpoint, mass production no more "produces" new materials than mass destruction "destroys" them. Both processes merely rearrange matter into new forms. Some might suggest the phrase "mass extraction" as a less pejorative label for the technology, but that term fails to convey one of the key properties of modern open-pit mining: its sheer destructiveness. Large-scale mass extraction of ores can be achieved without mass destruction. Big underground mines where skilled miners carefully select only the richest ores can produce massive amounts of minerals from some types of ore deposits. These mines merit the term "mass extraction."

Mass destruction was not, however, just a matter of size. Rather, as perfected by Jackling and others it was a means of increasing the *speed* of mining and thus achieving a certain narrowly defined type of efficiency. The enormous size of the operations was a necessary adjunct to using coal- and oil-powered machinery to dramatically increase the rate at which ore was extracted, moved, and processed.[12] As a result, mass destruction mines were so efficient that they could profitably mine ore deposits that would otherwise have been worthless. The phrase "mass extraction" also suggests a misleadingly neat, precise method of carefully removing ores, rather like a dentist extracting a rotten tooth. "Mass destruction" better captures the sheer explosive messiness of big open-pit mining and thus conveys some of the inherent environmental destructiveness of the technology. While I do not wish to exaggerate this destructiveness, neither do I wish to perpetuate the cultural tendency to ignore it—an example of yet another of those inconvenient truths that lay at the heart of modern material affluence and its accompanying "democracy of goods."

Daniel Jackling did not single-handedly invent mass destruction mining any more than Henry Ford single-handedly invented mass production. Ford, though, became the symbol of a technology and an era, while Jackling has been all but forgotten. Would Steven Jobs have even contemplated tearing down the Henry Ford house? Modern Americans, and perhaps people around the world, have generally been far less interested in remembering the providers of basic raw materials than the producers of shiny new objects of desire. This was not always the case. An earlier era once celebrated mining men as the keys to modern progress, and appropriately so. The story of the Jackling house, though, reminds us that one of the defining features of modern technological society is its tendency to distance us from the environmental first sources of our material world. As the historian William Cronon argues, the late nineteenth-century development of centralized corporate meatpacking in Chicago made it much easier for consumers to forget the living natural animals who became their dinner. "Meat," Cronon writes, "was a neatly wrapped package one bought at the market. Nature did not have much to do with it."[13] In mining, the connections between natural source and consumer product are arguably even more obscured and the moral questions even less evident.

Americans have a prejudice for production, finding tales of clever mechanical invention, production, and consumption more interesting than those chronicling the sources of raw materials. To a lesser degree, the prejudice has affected historians as well, and thus the stories we tell about the past. Consider one popular recent college survey textbook, *Inventing America: A History of the United States*, an otherwise superb text that emphasizes the importance of technological developments in the nation's history. Despite its focus on technology and industrialization, the text makes only passing references to the role of mining in post–Civil War American history. As in most American history surveys, the history of mining technology and business is relegated to a few sentences in a section surveying the late nineteenth-century development of the American West.

By contrast, *Inventing America* devotes nearly two pages to the story of Henry Ford and the automobile and includes pictures of Ford with his first automobile and of an early assembly line. Students reading *Inventing America* will learn that Ford's success lay in "improving the techniques of mass production" and that by 1920 factory sales of automobiles had risen to the mass consumption levels of 1.9 million a year. In the same section, they are also told how "homes and workplaces were lit by electricity," and men and women "communicated with one another through the telegraph or over the phone." Automobiles, electrical power grids, telecommunications—all the magnificently modern technological systems of mass production and consumption are powerfully and appropriately evoked. The words "copper" and "mining," however, make not even the briefest of cameo appearances, and they will scarcely appear again in the subsequent four hundred pages.

Copper and mass destruction mining did not cause the tectonic societal shifts of the modern era nearly so clearly as electric lights, cars, and the other technologies that used copper. The connections backward from a stylish new refrigerator with copper coils to a mine in Utah are not at all obvious. It is precisely this disconnect between human products and the environmental source of raw materials—between what we label "technology" and what we label "nature"—that needs to be closed if we are to better comprehend the dynamics of the modern world. All technological devices, from steam engines to computers, are made from nature and use natural properties and principles to operate. As Albert Einstein explained a century ago, humans neither create nor destroy matter but merely transform it from one state to another. In this sense, "nature" is always around us, and the separation between technological and natural environments can be seen as a powerful but misleading illusion.[14] The astounding ability of modern technology to reshape nature in so many ways creates the illusion that our world of cars, houses, and skyscrapers is utterly of our own devising, removed and separated from nature. As a result, many Americans have even gone to the opposite extreme and come to believe that true nature exists only in wilderness areas supposedly devoid of human effects—a view that Cronon has famously suggested was "getting back to the wrong nature."[15]

One goal of this book is to examine ways in which we might instead find our way back to something more like the "right nature," to a concept of nature that more clearly includes humans and their technologies in its definition. As scientists have shown in recent decades, there are really no environments left on the planet completely free of anthropogenic effects. Cores drilled in the Greenland Arctic ice sheet show traces of widespread atmospheric lead contamination from early Greek and Roman ore smelting, peaking between 500 BCE and 300 CE.[16] Two millennia later, greenhouse gases generated by human activities now affect nearly every ecosystem on the planet. Human technological systems have become so thoroughly integrated into environmental systems that there is nowhere on earth that has completely escaped our influences. It no longer makes sense to draw clear lines between technological and ecological systems. This is not in the least, of course, an argument against identifying and preserving areas where the human mark on the land remains less evident. The differences between Montana's Bob Marshall Wilderness and the city of Los Angeles are obvious. But for all its value, wilderness preservation offers no real solutions to the modern dilemma of managing a world of more than six billion people, most of whom would likely choose cheap and readily available electricity, cars, and refrigerators over wilderness preserves.

Fortunately, the choice need not be a zero-sum game, but only if we begin to see much more clearly how our technological environment is inextricably linked to our natural environment. Indeed, we would do better to learn how to think of the two as a unified whole or an "envirotechnical system," both because this reflects physical realties and because this analytical approach offers greater insights into preserving the best aspects of both wilderness and civilization. Consider how differently we might think if we could learn to recognize that nature was always around us, if every schoolchild knew the basic natural history of the metals in a car or the wood fiber boards in a house. Might the day ever come when we could see in a rap star's thick gold necklace not just a flamboyant cultural symbol of wealth and power but also the 360 tons of rock mined to produce the gold?

Or might an outdoor science school offer, in addition to discussions of the hunting habits of the great horned owl and the role of fire in serotinous pine tree propagation, lessons on the complex natural and social history of the trucks and SUVs that likely brought many of the students and teachers to the camp? In the modern envirotechnical world, developing a far deeper understanding of the technological may be the only realistic path to saving the natural.

BIG MINES, TALL STACKS

Though increased speed is at its heart, mass destruction mining is also big—so big as to defy easy description. Commentators often grope for words to convey the scale of open-pit mining operations, though neither words nor photos are adequate to the task. A favorite device to capture the stunning size of Daniel Jackling's Bingham Pit copper mine near Salt Lake City, Utah, is to note that it is one of only two man-made objects that can be seen by astronauts from outer space, the other being the nearly four-thousand-mile-long Great Wall of China. Dozens of articles, Web sites, and tourist guides reiterate this space-age superlative, even though a bit of thought suggests it is obviously not true. If the fifteen-foot-wide Great Wall is visible to space shuttle astronauts, who orbit at about 135 miles above the earth, then so are countless highways, airports, and dams. Likewise, scores of other pits and major excavations (think of the Panama Canal) around the world are equally visible at that altitude. Even the Bingham Pit is no longer the largest open-pit copper mine in the world, as that dubious honor has recently passed to the Chuquicamata Pit in Chile. Still, minor quibbles aside, the Bingham Pit unquestionably remains among the biggest single human-made artifacts on the planet. For a crew of astronauts on a voyage to Mars, the pit might well be among the last human-made features they could make out as the planet slowly receded in the distance. A fitting final symbol, given that the astronauts' technological home away from home in space would likely contain copper, aluminum, gold, and other metals mined in open pits.

Accurate or not, the popularity of using the Great Wall of China as a yardstick suggests the difficulty humans have in coming to terms with the size of the Bingham Pit and other products of mass destruction mining. Confronted with such a huge artifact—one that is literally beyond the normal human sense of scale and proportion—people simply grasp for analogies to the biggest thing they have ever heard of. Or is it that there is

2. Jackling's Bingham Pit mine south of Salt Lake City, Utah, in 1972. Currently three-quarters of a mile deep and two and a half miles wide, the Bingham Pit is one of the largest human-made artifacts on the planet. Each of the steplike benches is between fifty and eighty feet high. The tiny black dot slightly above the electric power pole on the left is an immense twenty-foot-tall steam shovel. *Library of Congress, Prints and Photographs Division, Historic American Engineering Record, Reproduction Number HAER UTAH, 18-BINCA, 1–1.*

something comforting in the comparison to a very long but nonetheless distinctly human-sized wall constructed centuries earlier, suggesting that the pit may not be such a jarring departure from past human experience after all? If so, the sense of comfort is unwarranted, as the Bingham Pit and its leviathan cousins far exceed the scale of any other single discrete human-made creations from the pre-twentieth-century era.

The best way to comprehend the Bingham Pit is to go there. Kennecott Utah Copper, a subsidiary of the international mining company Rio Tinto, owns and operates the pit today, and the company encourages visitors. The Bingham Pit viewing stand and visitors' center have been popular tourist attractions for decades. Looking southwest from central Salt Lake City, a visitor can easily spot the pit as a flat reddish-yellow gouge into the eastern flanks of the Oquirrh Mountains that run due south from the city and lake. It looks as if some massive explosion had annihilated several of the

Oquirrh peaks, leaving the range with a yellow-stained gap where the surrounding topography insists a forested mountain should be. Kennecott charges tourists a modest five dollars (all proceeds donated to charity, school buses are free) to drive up the snaking canyon road to the pit overlook. At 6,700 feet, the overlook is chilly even on a sunny day in early May, and gusts of gritty wind snap at jacket sleeves and the big American flag flying above the visitors' center. Undeterred, a few dozen people lean against the concrete barriers to peer down into the depths of the big hole, looking just like tourists gaping in awe at the Grand Canyon—though it is worth recalling that the Colorado River required millennia to carve its canyon, while the Bingham Pit is barely a century old.

Numbers may be inadequate to capture the scale of the Bingham mine, but they are nonetheless impressive. At its widest point, the pit stretches more than two and a half miles from rim to rim. From the highest point to the bottom, the pit is three-quarters of a mile deep, and the average depth is half a mile. Over the past century, more than five billion tons of rock and ore have been blasted out and removed from the mine. If the Burj Dubai skyscraper in the United Arab Emirates, the tallest building in the world as of 2008, were to be lowered into the pit, it would not even reach halfway up to the rim. Should the world ever decide to hide its major skyscrapers, the Bingham Pit is well up to the task.

If visitors to the pit take the time to tour the company museum, they will learn that the Bingham Pit was the creation of Jackling and his Utah Copper Company. A short film briefly explains the technological steps by which the low-grade ore in the pit is transformed into the pure copper for electrical wires, brass, bronze, and many consumer and industrial products. In a final dramatic flourish, curtains hiding a wall of windows open so the audience can once again look out over the pit that has provided so much of the material wealth of the nation. Neither the exhibit nor the film dwells on the environmental costs of the Bingham Pit, instead stressing Kennecott's attention to the issue in recent years. Massive amounts of copper, the exhibits seem to suggest, can now be had at little or no serious environmental cost. It perhaps goes without saying that Kennecott does not use the term "mass destruction" to describe the technology for making such impressive holes in the ground.

Jackling perfected the technology of mass destruction at Bingham partly because it was an interesting engineering challenge and partly because he wanted to achieve success and wealth—seventeen-thousand-square-foot mansions do not come cheap. But as free-market zealots are fond of pointing out, sometimes the self-interested pursuit of wealth actually can serve a greater public good, and the Bingham Pit was also an immense technological fix for what some saw as an impending crisis. During the early twentieth century, many mineral analysts had raised frightening alarms, predicting that the nation was on the verge of a severe copper shortage. Just as the process of national electrification was shifting into high gear, the well-known high-grade copper deposits in Montana, Arizona, and Michigan were beginning to decline. Jackling thought he had a solution to the crisis at Bingham: not the discovery of a new deposit—geologists had long known that there was an immense deposit of copper at Bingham—but the creation of a system for mining Bingham's low-grade deposit of disseminated ore. Mining experts had previously dismissed the Bingham deposit as worthless; all the numbers showed the copper would sell for less than it cost to mine. Jackling agreed this was true, *if* the big deposit was mined using conventional underground mining technology. But what if the speed of mining was greatly increased by digging down from the surface using high explosives and steam shovels to create a giant open pit?

This was Jackling's legacy to the world: a system of mass destruction mining as powerful as the system of mass production that Henry Ford and others were developing at almost precisely the same time. Jackling's idea could only have worked in the era of powerful but crude engines, energy-hungry steam, electric, or diesel monsters that could do the work of thousands of men or animals in a fraction of the time. Hydrocarbons, and later cheap hydropower, were the food that kept the mechanical muscles moving. Jackling's system demanded innovation at every stage of mining in order to speed the movement of raw copper ore from pit to concentrator to smelter. When it was all in place, the mountain of previously worthless rock at Bingham had been transformed into a bonanza copper mine that would eventually produce billions of dollars of wealth. The mine became so valuable that Jackling could build his Woodside estate, where he might sit in the elegant gardens and listen to his mighty Aeolian organ, perhaps congratulating himself on having helped to avert an impending copper crisis.

Although Jackling considered himself a conservationist of the efficient-use school, there is little evidence he gave any thought to the environmental costs of his achievements, which extended far beyond the obvious damage caused by the big pit itself. Indeed, the full consequences of open-pit mines cannot be understood without also studying the closely linked ore processing and smelting technologies. Mass destruction was a system of tightly integrated technologies, and the environmental effects of getting the copper out of the ore were often even greater than those of getting the ore out of the mine. Jackling pioneered the open pit, the real core of mass destruction, but he borrowed much of the subsequent ore processing technology from other copper mining operations. To understand these innovations and their consequences will require visits to other regions in the landscape of mass destruction as well. Put simply, big copper mines demanded smelters with tall smokestacks, and while Bingham had the biggest pit, Montana had the tallest stack.

To the casual traveler speeding by at eighty miles an hour, the Deer Lodge Valley must at first present the picture-perfect view of an idyllic rural Montana landscape. Cattle graze on rolling pastureland, green irrigated farms abound, and stately old cottonwoods crowd the banks of the winding Clark Fork River. Only the unusually sharp-eyed might notice the occasional patches of barren land and oddly colored soils scattered among the fields and river bottoms, a few brief dark notes in an otherwise cheery pastoral symphony. But as the road moves on past the small community of Deer Lodge, even the most inattentive will at some point spot the looming dark tower of the Washoe smelter smokestack in the distance, rising at the far southern end of the valley and looking rather like a photo-negative image of the Washington Monument. Move closer and the astonishing size of the 585-foot-tall masonry stack (the tallest of its kind in the world, and thirty feet taller than the Washington Monument) becomes apparent. As the highway skirts to the east of the stack, dusty barren hills border the road for nearly four miles. These are the forty-foot-high remnants of the giant Opportunity tailings ponds, industrial middens created by a century of copper processing.

A few miles later the highway turns east, the mountains crowd in, and the incongruous postindustrial landscape of the Deer Lodge Valley disappears in the rearview mirror. But drive another fifteen minutes up into the higher and smaller Summit Valley and the raison d'être of the Washoe smelter stack appears, an immense scar carved out of the town of Butte: the Berkeley Pit. Before Berkeley, the Anaconda Copper Mining Company obtained its ore from deposits beneath the city of Butte tapped by seven main shafts and thousands of miles of tunnels, some built nearly a mile beneath the surface. Beginning in 1955, however, Anaconda followed the example of Jackling's Bingham mine and shifted most of its operations to the mass destruction surface operation that became the Berkeley Pit. By the early 1980s, the twisting oval hole was almost 1.5 miles wide and 1,800 feet deep and had consumed a sizeable chunk of the city.

In 1982, the Atlantic Richfield Company (ARCO, Anaconda's corporate successor) shut down all mining in Butte and turned off the giant pumps more than half a mile below the city that had pumped ground water from the mines for decades. Soon the first puddles of water formed in the pit bottom. Then the puddles became a pond. As the groundwater continued to rise, resuming its previous natural level, citizens of Butte with a penchant for dark humor rechristened the flooding pit "Berkeley Lake." Some even staged a mass Hawaiian hula dance on its rim. But forget any images of cool limestone quarry swimming holes, much less white-sand Hawaiian beaches. The Berkeley Pit is a giant drain hole, the resting place of groundwater steeped through thousands of mile of subterranean passages, creating an acidic cocktail of heavy metal poisons. When a flock of migrating snow geese landed on the "lake" in 1995, more than 340 made the fatal mis-

3. The Berkeley Pit in Butte, Montana, began to flood after the underground water pumps were turned off in 1982. Currently over a thousand feet deep, the pit water is nearly as acidic as battery acid and contains a toxic brew of heavy metals. It must be constantly pumped and treated to prevent the further contamination of surface and groundwater reservoirs. *Photo by Timothy J. LeCain.*

take of lingering in the pit water for several days. Reportedly, the recovery of their carcasses was slowed because the birds' brilliant white feathers had stained the reddish-orange of the acid-laden water.[17]

As of 2007, the Berkeley Pit lake was more than nine hundred feet deep, and it is only the most obvious feature of the nation's largest Superfund site. The site also includes the immense underground mine workings, the nearby Anaconda smelter site and Opportunity tailings ponds, and a 126-mile stretch of the Clark Fork River. Cleanup efforts are under way and much progress has been made, but the task is daunting. At times, the only hope for a better future for Butte seems to come from "Our Lady of the Rockies," the brilliant white ninety-foot-tall steel statue of the Virgin Mary that benevolently gazes down over the town and pit from the high rocky spine of the Continental Divide.

The city of Butte has long inspired both awed contemplation and angry condemnation, whether because of the scale of the mining operations, the attendant environmental destruction, or some confused mixture of the two. Many of the historic political, economic, and labor upheavals that have periodically shaken this high northern Rocky Mountain city have been equally outsized, and almost all of them related in one way or another to the mining. In recent years, though, visitors are most likely to see the scarred landscape of Butte as evidence of some sort of environmental "original sin," the product of a greedy and rapacious mining company that stripped Butte of its mineral wealth and left behind a hollowed-out husk of a city that threatens to dry up and blow away in the high mountain winds. The author of one article on the environmental problems caused by the copper mining suggests the evocative imagery of "Pennies from Hell."[18] Another refers to the Anaconda as "the Snake" that killed the snow geese.[19] Another, perhaps a bit desperate to find an adequately nefarious analogy, concludes that the old Washoe smelter stack reminds him of the tower of Isengard, the fortress of an evil wizard in J.R.R. Tolkien's *Lord of the Rings*.[20]

Whether as "the richest hill on earth" or as home to the nation's biggest Superfund site, Butte has always inspired hyperbole. Condemning the Anaconda has also long been a popular Montana pastime, and the condemnation is generally well deserved.[21] A ruthless (perhaps even murderous) opponent of the mine workers' long struggle to unionize, an unapologetic manipulator of Montana politics, and a censorious master of much of the state's media, Anaconda ran Montana like a corporate fiefdom for a good part of the twentieth century. Given the Anaconda's crimes against Montanans, it has been tempting to explain the environmental carnage at Butte and Anaconda as simply yet another example of "the Snake's" irresponsible behavior. That story makes for good drama, and its lessons about the dangers of corporate hegemony and capitalist exploitation and commodification of nature are important and generally well understood. However, new evidence and theoretical approaches have increasingly suggested we should resist a too facile framing of Butte's environmental history as merely a morality play on the evils of early twentieth-century corporate capitalism. While containing elements of truth, such a simple declensionist tale tends to obscure other important aspects of the story that offer more useful lessons for understanding the human relationship to the environment. This other story that needs telling is one of arrogant overconfidence more than deliberate malice, of difficult trade-offs more than moral absolutes, about shared guilt rather than convenient scapegoats. Above all, it is a story about the dangers that come from thinking that humans and their technological systems are separate from nature and its ecological systems, and about the power and wealth that came from and propagated such illusions.

Jackling's pit would be the ultimate expression of this modern conceit, but to understand its roots demands probing deeper into the past and into the underground. Precisely because it initially demanded the creation of an underground world that was seemingly unnatural and separate from the living world above, the transition from underground to open-pit mining offers the perfect case study of this illusion that humans and their technological systems are distinct and separate from nature.

DEPTH ANALYSIS

In 1932, the cultural critic and historian Lewis Mumford went "underground" in the elaborate life-size mining exhibit at Munich's Deutsches Museum. He was so moved by his virtual experience of underground space that he later made mining and minerals a central theme in his influential 1934 history of the machine age, *Technics and Civilization*.[22] His basic argument was straightforward: mines and mining were instrumental to the process of early capitalist industrialization through their provision of coal, iron, and the other raw materials for power machinery. Mumford went beyond this, though, to argue that the mine was also a perfect allegory for what he viewed as the increasing artificiality of technological civilization, its distancing from the organic rhythms of the natural world. "The mine," Mumford writes, "is the first completely inorganic environment to be created and lived in by man." Fields, forests, and oceans, Mumford argues, "are the environment of life." By contrast, "the mine is the environment alone of ores, minerals, and metals. Within the subterranean rock, there is no life, not even bacteria or protozoa, except in so far as they may filter through with the ground water or be introduced by man."[23] Elsewhere in the book, Mumford elaborates the theme, noting that in mines, "day has been abolished and the rhythm of nature broken: continuous day-and-night production first came into existence here. The miner must work by artificial light even though the sun be shining outside; still further down in the seams, he must work by artificial ventilation, too; a triumph of the 'manufactured environment.' "

Mumford suggests a compelling if misleading idea here: the underground mine as a concrete expression of capitalist environmental and social relations. The unnatural inorganic environment of the mine, he concludes, fostered the equally unnatural and exploitative regimentation of mine workers. Capitalism and its destructive technology have broken the "rhythm of nature" every bit as much as a dead underground mine. There is much of value in Mumford's analysis, and this book will return to some of these same themes of artificial light and ventilation in a "manufactured environment." Likewise, Mumford is at his brilliant best in recognizing the importance of the mine as a metaphor for the modern world. As Rosalind Williams shows in her book *Notes on the Underground*, there are few spatial concepts seemingly more fundamental in human cultures than those that distinguish between "above" and "below," "inside" and "outside." Indeed, Williams argues that the fundamental spatial nature of the underground mine is the source of its appeal as a metaphor for modern existence: "It is the combination of enclosure and verticality—a combination not found either in cities or in spaceships—that gives the image of an underworld its unique power as a model of a technological environment."[24]

The unique physical nature of the subterrestrial mine, its sense of being an enclosed vertical world utterly apart from the normal human terrestrial worlds, explains its appeal to Mumford and others. In this view, the mine serves as the extreme expression of all that is human-made and therefore believed to be unnatural: the city, the factory, and the railroads and machines that invade a pristine countryside. Just as all human beings easily recognize the difference between the surface and the underground, so too is the difference between the natural and the technological supposed to be equally obvious and perhaps even instinctive.

Unfortunately, as is often the case with *Homo sapiens*, what is obvious and instinctive is often wrong, and that is the case here as well. Indeed, Mumford's argument was precisely backward. It was not the artificiality of the mine that led to environmental devastation, but rather the seemingly commonsense belief that Mumford himself was guilty of further propagating: that human beings and their technologies could ever be separated from the natural world.

One of the most destructive and dangerous ideas of the past century was that Americans (and others) could engineer a technological world largely independent from the natural world, whether that be a mine, a city, or a controlled and isolated industrial dead zone. Nature, of course, would still be the source of raw materials, agricultural products, water, and air, as well as a dump for the waste products of industrial civilization. Increasingly, however, these natural systems were believed to be mere cogs in the larger technological system, distinctly secondary subsystems that could be fully controlled, rationalized, and engineered for maximum productiveness. When problems or unanticipated consequences arose in the technological incorporation of these natural subsystems, such as declines in productivity or harmful pollutants, engineers and scientists offered new approaches and technological fixes that promised to either repair the system or erect an effective barrier between human society and any adverse natural effects. Either way, the technological appeared so powerful as to be nearly independent from the natural. Not coincidentally, the opposite idea that real nature occurred only in wilderness areas supposedly untouched by human technology emerged at roughly the same time, further deepening the illusory divide between the human and nonhuman world.

Having supposedly extricated themselves from nature, modern humans could think of the natural world they had left behind as a resource to be bent to their will, to be simplified, rationalized, and optimized to maximize human wealth, power, and safety. The many and undeniable accomplishments of modern science and technology were the result. Yet, as the political geographer James Scott demonstrates, this "high modern" technological regime also contained the seeds of its own failures. Both the natural and technological systems they had so confidently engineered proved far more complex than imagined, prone to unanticipated reactions and consequences. Simplified monocrop forests collapsed. Smog choked the life from cities. DDT killed songbirds and turned up in mother's milk. At the same time, the human-natural divide was used to justify and "naturalize" a host of other injustices, from the dominance of the supposedly "rational" male over the more "instinctual" female to the rule of the technologically advanced Western nations over colonial peoples viewed as closer to nature and thus "backward." As the environmental historian Richard White rightly notes, "who gets to define nature is an issue of power with consequences for the lives of working people, Indian people, and residents of areas defined as wild."[25]

Given the many potentially harmful effects of the dichotomous view separating the natural and artificial, the ecological and technological, any effective analysis of environmental and technological history must take pains to avoid validating this modernist illusion. Precisely because mining has so often been seen as inherently unnatural, it actually offers an ideal opportunity for exploring a different way of thinking about humans and nature. Rather than viewing the subterrestrial mine as the antithesis of the terrestrial "environment of life," as Mumford's dichotomy suggests, it is far more useful to think of the mine as a simplified environment. While less organic than many (though perhaps not all) terrestrial environments, it is certainly no less natural than the aboveground world, and modern science now even recognizes the existence of a subterrestrial biosphere.[26] Nor is the subterrestrial work of miners somehow less natural than the work of the farmer. Rather, in this concept of the mine, nature still very obviously exists, but it exists as part of a hybrid ecological and technological mining system. Significantly, this mining system is somewhat less complex and more easily managed than that of an industrial farm or a tree plantation. The mine is thus a striking example of a constructed human environment created by experts (engineers, managers, skilled miners) through their knowledge and limited mastery of subterrestrial space and ecology. Having developed the tools to measure, map, and control the underground world, these early "environmental engineers" created deep subterrestrial spaces that were seemingly distinct from traditional terrestrial human environments—the first such environments in human history. They were in part "manufactured environments," but Mumford erred in suggesting they were the antithesis of the organic, natural, living environments of the terrestrial world. To the contrary, they were inseparably linked to these terrestrial worlds, just as a city is linked to countryside.

In recent years, scholars studying the interactions between technology and the environment have begun to develop other analytical methods that avoid lapsing into these convenient but false dichotomies.[27] In January of 2000, several historians who had intellectual and professional affiliations with both the Society for the History of Technology and the American Society for Environmental History established Envirotech, a special-interest group for scholars working in both disciplines. Many of the scholars working in this and related areas have begun to develop a unique new method of envirotechnical analysis, an approach that challenges the misleading distinctions between humans and their environment. Indeed, as the historian Edmund P. Russell argued during a recent conference roundtable on the subject, "all technology is made out of nature," while nature constantly feeds back into human technological and social systems.[28]

Such an envirotechnical analysis does not deny the value or necessity of sometimes using more conventional categorical distinctions between technology and environment, human and nature. Indeed, our language itself is constantly forcing us back into these dichotomies. Even to use the term "nature" is immediately to raise in the minds of most (at least Western) listeners a concept defined by whatever is not human, not technological.[29] English offers no good word for that which is distinct from humans and thus affected by their technologies, but which also simultaneously includes humans and recognizes their technologies as being both derived from and embedded in nature. Absent such a much-to-be-desired word, to argue that "all technology is made out of nature" or that "humans are a part of nature" inevitably tends to re-create the old dichotomies even while the intention is to collapse them. The goal of envirotechnical analysis, then, is to demonstrate how this system that is both human and nonhuman, artificial and natural, technological and ecological, does actually exist even if our culturally constructed ideas and words often keep us from recognizing it.

The technologies of mass destruction that created the Bingham and Butte mines, their gigantic smelters, and the nation's largest Superfund site are ideally suited to just such an envirotechnical analysis. Here misleading dichotomies abound: surface and mine, terrestrial and subterrestrial, organic and inorganic, natural and artificial, environmental and technological—even female and male. Look closely, though, and these seemingly solid categories begin to melt into air, not only in a metaphorical or semantic sense, but also in a strikingly concrete and physical way. From an envirotechnical perspective, Bingham, Berkeley, and other such pits of mass destruction emerge from the depths of cultural and historical misunderstanding to reveal their true "nature" as enduring physical manifestations of the tremendous powers and the tragic limitations of the modern ideologies, societies, and economies that created them. Put simply, the pits of mass destruction are the embodiment of a human cultural, economic, and technological relationship with nature gone badly awry. Worse, as the size of these pits continued to expand and it became possible to profitably exploit even minuscule percentages of minerals, the line between the "mine" and the rest of the planet became ever more tenuous.

Increasingly, the landscape of mass destruction was not just in Bingham or Butte or some other distant and isolated place—it was all around us.

We will return to Butte and Bingham in the pages to come, as the two constituted a sort of yin and yang in the development of modern mining: one "the richest hill on earth," the other "the richest hole on earth." Visiting these sites in their modern state suggests the source of the basic question at the heart of this book: how did the historical forces unleashed during the past century produce such radically scarred and transformed landscapes? The answer lies with Daniel Jackling and the invention of mass destruction technology during the twentieth century. The forces that created the Bingham and Berkeley terrestrial pits, however, began at an earlier and (literally) deeper level with the late nineteenth-century development of the immense subterrestrial hard-rock mines of the American West. There, mining engineers first learned to use powerful new technologies to overcome natural obstacles, pushing nearly a mile below the surface of the earth, where they created new human environments in which they had seemingly taken control of many of the basic elements of life: air, water, and climate. From such triumphant engineering creations arose the sometimes arrogant belief that the complex terrestrial environment could be as mastered as easily as the simpler subterrestrial environment.

Such grandiose dreams of power and control ultimately faltered, as both subterrestrial and terrestrial worlds proved more difficult to master than first believed. Indeed, even as engineers learned to create deep hard-rock mines, they had little concept of the immense galactic and geological forces that had placed the minerals within their grasp in the first place. In mining, human technologies and natural forces were inextricably linked from the start, all the way from the stars in the heavens down to the extraordinary physical properties of ancient copper atoms buried within the earth.