



THE GRAVEL PAGE

The most frightening crimes have no witnesses except the ground on which they were committed. And from that alone forensic geologists illuminate cases in a way that would impress Sherlock Holmes, the science's first practitioner.

BY JOHN MCPHEE

"You have come up from the south-west, I see."

"Yes, from Horsham."

"That clay and chalk mixture which I see on your toe-caps is quite distinctive."

"I have come for advice."

"That is easily got."

"And help."

"That is not always so easy."

"I have heard of you, Mr. Holmes."

FOR sixteen years, I have had on my desk petri dishes full of Platte River pebbles. They call to mind, among other things, kidnappings and murders—call to mind Sueyoshi Ku-

saba, Adolph Coors, the late Enrique Camarena. They call to mind Sherlock Holmes (as in the lines above, from "The Five Orange Pips"). They call to mind Karen Kleinspehn, Cecily Garnsey, Ronald Rawalt, James Swinehart. They call to mind Jimmy Doolittle, Joseph Corbett, Ken Lohman, Clarence Ross. And they call to mind always—as year follows year—the fact that I have not yet written this piece. The pebbles work these varied effects especially when they are wet. Worn, pitted, stream-rounded, they are without lustre when

they are dry, but if you pour a little water on them, as I do from time to time to keep them alive, their colors brighten and shine. I took them from a gravel bar in Nebraska, near the river's right bank, not far from the hundredth meridian. From thirty-six thousand feet, as one passes over, the Platte there resembles a braid of cable. Its channels among the gravel bars are so numerous that the river is two miles wide. Choked with rock, the Platte cannot transport its load in any but an awkward way, so it subdivides and loops and braids, and hunts

for passage through its own bed. From an altitude of thirty-six centimetres—we were lying prone, elbows down, chins in hand—the assembled gravel, like a New Hampshire boulder field, could be seen for what it was: unique sculpture from distinct terrane in widely separated distant worlds.

I was traversing the continent with Kleinspehn, a sedimentologist who was then a graduate student at Princeton University and is now a professor at the University of Minnesota. Choosing stones from the gravel bar, she was trying to guess where they might once have been bedrock. She picked up a stone of graphic granite—so called because its interlocking crystals develop in a manner that suggests writing. She said, “This is a real diagnostic pebble. If there’s no graphic granite in the Laramie Range, it did not come from there.” The Laramie Range, of the Wyoming Rockies, was only the most direct and obvious source of pebbles in a region of possibility at least the size of Italy, for the streams of the modern watershed were not the sole carriers; from numerous directions, there were ancient vanished rivers to be considered. In the core of the Laramie Range are the large slow-cooled crystals of a bright-pink granite called Sherman. Many of the pebbles beneath our eyes seemed surely to be Sherman granite, more than three hundred miles from where they had started. There were banded cherts and burgundy cherts. (“I have no idea where they came from; there are Mississippian cherts around the Black Hills.”) There were gneisses, schists, and hard shales. There were foliated metamorphics, quartzites, quartz crystals (“from vein quartz in any rock—for example, from the Medicine Bow Mountains”). There were pebbles of red-bed sandstone. In the nineteen-thirties, a Nebraska man was indicted for stealing sheep from a ranch on Red Mountain, which is about twenty miles southwest of Laramie. Pleading not guilty, the defendant said that he had bought the sheep in Nebraska. In the sheep’s wool were grains of red sandstone—Triassic red sand of the Chugwater formation, the rock of Red Mountain. Samuel H. Knight, of the Geology Department of the University of Wyoming, testified

at the trial. There is Chugwater under Nebraska, yes, but it’s hundreds of feet down.

I had read Raymond Murray and John Tedrow’s textbook of forensic geology. Looking up contemplatively from the fast-moving Platte across a floodplain that ran off the curve of the earth, I realized that the concatenated pebbles Kleinspehn was describing not only were of varied provenance but also were, in macrocosm, directly analogous to the mineral assemblages that might be found, as dirt, on the skin or clothing of a hastily buried corpse. Detective work is what geologists do. In the long series of geological writings that I had undertaken, if I were to get into forensic geology this bar on the Platte River would be a place to begin.

I collected a sack of gravel and shipped it home. Over time, those prompting pebbles on my desk would send me off to unexpected places—to the Dakota Hogback in Jefferson County, Colorado, for example, and to the Pikes Peak granite, farther south, and to the archives of the National Air and Space Museum, in Washington, and to the Materials Analysis Unit of the Federal Bureau of Investigation, also in Washington. The pebbles would draw me back to Nebraska—to the state geological survey, in Lincoln—and, by odd coincidence, to the river they came from, beside which lives a special agent who is an F.B.I. geologist.

At the state survey, I learned from the stratigrapher James Swinehart that Kleinspehn, despite the fact that she was only passing through, had been right at least nine times out of ten. In a sense, these pebbles were Swinehart’s specialty. His expertise is in the Cenozoic paleogeography of western Nebraska. As I spilled before him what had been the contents of the dishes on my desk, he picked up the stones one by one, turned them in his hand, and occasionally looked closely at them under magnification. As he sorted them, he remarked that the line of maximum glacial advance lay east of my gravel bar, so there would be no agates from Minnesota, or greenstones, or the like—no evidence gathered from that direction. The sources would lie west and southwest, simplifying the situation by narrowing

the field to a hundred thousand square miles. Taking two dark pebbles in the palm of his hand, he said they were acidic volcanics out of calderas in or beyond Rocky Mountain National Park—probably from the Rabbit Ears Pass area, near Steamboat Springs. To be geographically more specific, if you needed to be, you would have to analyze individual crystals under the microprobe, identifying major elements and trace elements.

Those Colorado calderas are four hundred airline miles from the river bar where I found the pebbles. How could he feel confident that that was where they came from? He had seen them before, he said—seen them uncounted times. “I started out as an art-history major,” he continued. “I learned the language. Someone asks you, ‘How do you know that’s a Vermeer?’ It’s like your grandmother walking down the street.”

When Swinehart had finished sorting my collection, he was not surprised to see that the pink-feldspar Sherman granites were by far the largest group. In any attempt to pinpoint distant geographies, they would be less useful than, say, the Rabbit Ears volcanics. Sherman granite is the core not only of the Laramie Range but also of mountains in Colorado. Sources of granite, generally, are in “larger bodies and are therefore not as diagnostic.”

Holding up a handful of sugary-textured fine-grained stones, some with green chlorite, Swinehart said, “These quartzites are almost surely from the Medicine Bow Mountains. They’re very distinctive gravels, weathered out of a quartz-pebble conglomerate, in which the pebbles flattened. The matrix has recrystallized, and so have the edges of the pebbles. The Medicine Bow quartzites are so unusual in this geological situation that you can say just where they came from.”

While a garden-variety granite might be hard to pin down geographically, if something in an assemblage is unusual the assemblage as a whole becomes useful. A banded ironstone from the Seminole Range had travelled well over four hundred miles. It was two thousand million years old and it looked like petrified mahogany, a piece off the leg of a Steinway. “There’s not a lot of it,”

Opposite: The suspect (left) under arrest for the murder of Adolph Coors III. Geology tied him to the landscape of the crime.

he said. "But when it shows up it's a bull's-eye."

He did not know the name or home address of everything. He set aside a little pile that he referred to softly as "others."

"Others?"

"Ferrocryptomungite."

He had learned the term from an aeolian-sand expert in Denver, he said, and it meant, "It's ugly. You don't know what it is. And you hope it will go away." If you very much needed to know, you would make a thin section—a bit of rock ground to a thinness of three-hundredths of a millimetre and placed between microscope slides, from which its components, translucent, transparent, would flash their signature colors. If you were still unsure, you would do chemical analysis—"digest it and look at major ions." You could use an X-ray fluorescence spectrometer to measure the chemical composition, and a microprobe to see the composition of each mineral. To see a single crystal's chemistry, which might tie it to a source area, you would use ion-laser probes or induction-coupled probes. "You'd want to see at least a thin section before you'd publish it or take it to court," he went on. "Keep in mind—what questions are you really going to ask of these rocks?"

It may be comparatively simple to deal with a boulder, a cobble, a pebble, a granule, but when you fine down through grades of sand and reach the level of clay and silt, the degree of difficulty rises. "When you get below medium sand, you're off into chemistry-land. You'd better have a good reason for asking that question, because it's going to cost plenty to answer it. With separate feldspars, for example, you would need to look at the isotopic composition. That isn't cheap."

In choosing one pebble at a time and ascribing to it its place of origin, he was reversing a procedure more commonly applied to rock assemblages as a whole. I mean, if I had committed some unthinkable crime and run off to Florida and those pebbles had been found strewn about in my van Jim Swinehart or someone like him could have determined the provenance of each pebble in the group—and the distance of transport, and the presence and absence and percentages of rock types—and told

anyone who needed to know that I had perpetrated whatever it was on a gravel bar in the main stem of the Platte River west of the line of glacial advance and east of the hundredth meridian. What works macroscopically works microscopically as well. Mineral grains and microfossils can narrate a story. A police officer fails to report for work in Harrisburg, Pennsylvania. His private automobile is found in Virginia, its trunk full of blood. The officer remains missing. Harrisburg police search the region for several days and come up with nothing. They turn for help to the F.B.I., which collects the officer's car and turns it over to Special Agent Ronald Rawalt, a geologist. With his petrographic microscope, not to mention his common sense, Rawalt studies the car. He sees a heavy buildup of soil in one wheel well and inside a bumper, and notes that the soil was wet-deposited. He sees also that the car was driven over pavement with water on it between the deposition time and the time the car was recovered. The soil is of one consistency, not the mottled layering from different locations that would usually be found under a fender. Someone stepped on the accelerator and spun the tire in mud. Like Rawalt, the Harrisburg police have assumed from the beginning that the soil in the wheel well is from a place where the body might be found. They just wonder where to look.

Going through the washed minerals, Rawalt finds microscopic fragments of glass beads and of yellow reflective paint and white reflective paint. The beads could be from any stretch of road, but the presence of both white and yellow paint suggests a hill or a curve. He finds microscopic asphalt. He finds black slag. He knows that Pennsylvania historically has bought slag from its iron smelters and coal-fired furnaces, crushing it for use as an anti-skid on highway curves. He also finds an assemblage of microfossils. He looks them up in a textbook of micropaleontology. The book includes maps. So unusual are these fossils that the pyritic limestone they come from outcrops only in two highly confined localities, one of them in Appalachian Pennsylvania. The limestone in Pennsylvania is just a narrow stringer that comes down off a mountain and crosses a

country road south of Harrisburg. Rawalt calls the Harrisburg police. He mentions the road and tells them to stop at a rising curve where both yellow and white paint are present and there's not enough room for a whole car to get off the pavement. Since the missing man is heavy, look a short distance downslope. Next day, the police call Rawalt: "We got him. He was there, under a pile of brush."

"A sort of volcanic pit, was it not?"

"Exactly," said I.

"Did you notice the soil?"

"Rocks."

"But round the water—where the reeds were?"

"It was a bluish soil. It looked like clay."

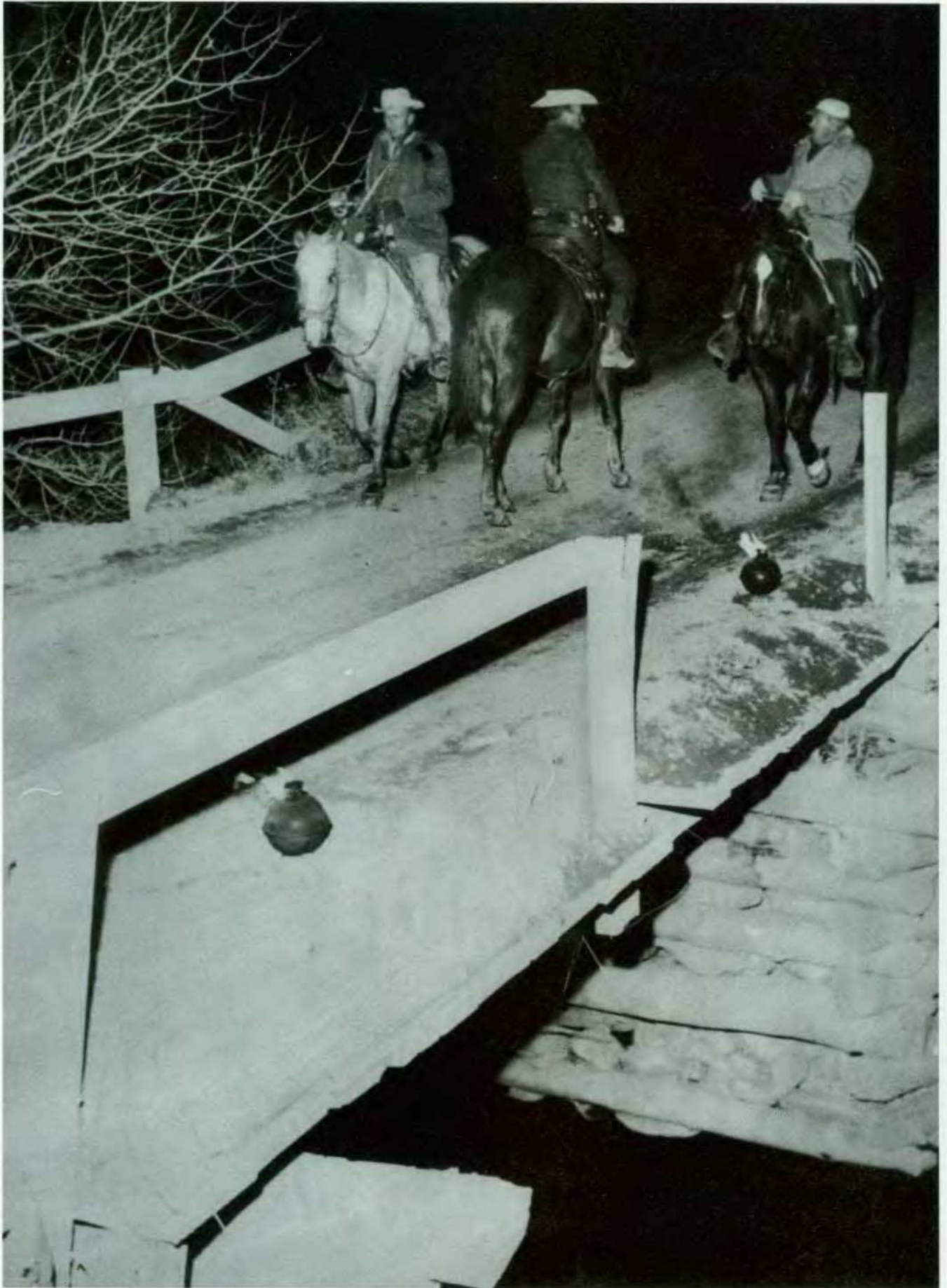
"Exactly. A volcanic tube full of blue clay."

"What of that?" I asked.

"Oh, nothing, nothing," said he, and strolled back to where the voices of the contending men of science rose in a prolonged duet.—*The Lost World.*

F.B.I. geologists look first at color, and then at texture. Next they wash the soil and do the mineralogy. They collect "alibi samples," "alibi soils." If you have said that the mud on your skirt came from your back yard, they will collect soil from your yard to prove that it did or did not. About half the work of the Materials Analysis Unit has to do with geology. The rest has to do with things like glass and paint. Bruce Hall, the special agent who is the unit's chief in Washington, points out that forensic geology is broader than the name implies, because it includes chemistry and physics as well. It also includes, in growing numbers, people who testify about environmental impacts and the causal aspects of landslides. For my purposes here, the topic remains concentrated in military puzzles and egregious crimes.

Hall once spent a couple of days on Staten Island collecting alibi samples after a "soldier" in the Bonanno crime family put five dismembered bodies in several graves with a shovel. The shovel was found with bits of soil on its kick plate. Hall collected alibi samples from every place on Staten Island to which an alibi had been—or might be—asccribed. He matched the mineralogy from the bits of soil on the shovel to the mineralogy of the gravesites. With equal care, he unmatched everything else. "You've got to be right every time," he



The crime scene at the wooden bridge over Turkey Creek, where Adolph Coors disappeared.

says. "There's no being wrong once in a while."

During the Cold War, the British traitor Kim Philby used a trowel to bury a hot camera in woods beside the Potomac River in Great Falls, Virginia. Years later, he evoked the scene in his autobiography, mentioning his fear of F.B.I. surveillance. After leaving the woods but-toning his fly, he went home and "fiddled around in the garden with the trowel." Apparently, he understood the potentialities of forensic geology, for he continued, "As far as inanimate objects were concerned, I was clean as a whistle."

Some years ago, I asked Chris Fiedler, an F.B.I. geologist, if he could think of a case in which the relevant rock had come in a size class larger than mud, silt, or sand. He remembered a time when the F.B.I. was investigating a group of potential terrorists thought to be moving explosives from safe house to safe house in Eastern states. After a suspect vehicle passed through southern New Jersey, a large rock was observed near an intersection of roads. The F.B.I. wondered if the rock was a marker. They reasoned that the potential terrorists would assume that they were being followed and would use a lead car that was free of incriminating cargo. The lead car would set large rocks in predetermined places to inform a following

car that things were so far so safe. Large rocks are about as common in South Jersey as bent grass on the swells of the ocean. South Jersey, above bedrock, is fifteen thousand vertical feet of unconsolidated marine sand. This rock was out of place, erratic, alien. The F.B.I. took it to Washington. It was a garnet schist, and in the schist was the mineral staurolite in a form sufficiently unusual to eliminate a lot of territory. A metamorphic petrologist at the Smithsonian Institution thin-sectioned the rock and determined that it came from a definable area in the highlands of western Connecticut. F.B.I. agents went there and began asking questions under the outcrops of garnet schist. They found the hideaway they were looking for. In it was evidence that ultimately led them to a safe house in Pennsylvania, full of explosives. The road had been circuitous, and that was the end of the line.

"It is evidently a case of extraordinary interest, and one which presented immense opportunities to the scientific expert. That gravel page upon which I might have read so much has been long ere this smudged by the rain and defaced by the clogs of curious peasants."—*The Hound of the Baskervilles.*

IN Denver, years ago, Walter Osborne (an alias) bought a canary-yellow four-door Mercury sedan that had be-

longed to a couple whose name appears only as a black rectangle in F.B.I. files released under the law of freedom of information. The car was exceptionally clean. The old owners had washed it often, and they washed not just the paint and chrome surfaces, where dirt would show, but also the undercarriage, hosing everything from springs to wheel wells. Osborne was fastidious himself. He was an alkyd cooker at a Benjamin Moore paint factory, a job he did with highly commended care. He was on the night crew with one other person, had access to the factory offices, and—before he left—was able to remove every paper trace of his background.

Osborne had come to Denver to enrich himself through a single bold endeavor. Always thorough, he was not hurried. For several years, he made plans. Bank robbery had been his earlier choice, but after studying the field he came to the conclusion that there was not enough money in it. (He was close-mouthed in general, but he did confide that much to a fellow-worker.) He decided instead that he could realize the kind of wealth he had in mind if he were to kidnap the chairman of a brewing company. His attention focussed on the patterns of custom at a modestly large house on Steele Street, in south Denver. He had all day, every day, to watch it. Adolph Coors III was the person he meant to abduct.

Osborne was who knows how close to choosing his moment when large vans appeared on Steele Street and the Coors family providentially moved. Privacy and insulation from any form of celebrity were what Ad Coors and his wife, Mary, wanted most for their four children—all teens or under. And so they had decided to try living on a fairly secluded ranch near Morrison, closer to the Rocky Mountain front, where they could go off on horseback when they wished to, on long anonymous rides. The change of milieu probably added about a year and a half to Ad Coors' life, but, inevitably, Osborne followed them.

The ranch was tucked into the morning shadow of the Dakota Hogback, a narrow, sinuous, phenomenal freestanding ridge that protrudes from the plains and



"He's the alpha gopher—the other guys are just gofers."

parallels the mountain front for hundreds of miles. With its platy peaks, the ridge mimics the great mountains it borders. Cretaceous in age, it suggests not so much a modern razorback as the protruding spine of an unending stegosaurus. Dakota sandstone forms the high sharp parts, and these are underlain by gray, green, and maroon clay stones, shales, more sandstones, and limestone. A dirt road traversed the rising ground between the ranch and the ridge, and then crossed the ridge through a stream-cut gap. If you drove on that road—as Ad Coors did routinely on his way to work, as Osborne did in his yellow car—you were driving on the eroded, pulverized components of the Dakota Hogback.

Cecily Coors, at sixteen, often rode alone on the hogback, and often with her father. He was a tall man in his mid-forties with a wide grin and a quizzical near-sighted look behind his flesh-colored glasses. He was, in fact, so nearsighted that he would be—according to his ophthalmologist—lost without his glasses. In Cecily's irrepressible athleticism, her love of outdoor sport, she was much like him, and she raced him flat out down trails in Aspen, flew with him in the company plane, went to Bears games with him in Denver. (One day, a good deal later than these scenes, she would be ranked third among downhill skiers in the United States.) There was a right-angle bend in the dirt road close to the hogback, and a wide flat space where a car could pull off. She passed by there on her way through the scattered junipers and up the sage-covered slopes. The yellow car was there, and there again. She would stop her horse and ask the driver if he wanted something. He thanked her, no. "He was always very friendly," she said recently, standing at the bend in the road. "We saw him a lot—up on our property. He had a very distinct face. He had, to me, a small face—with sunglasses. He always had a rifle with him."

They would have been prescription sunglasses, for Osborne was extremely nearsighted and could not have seen much of anything without them. She took him to be a hunter, a deer poacher,



"Let me tell you what it's like to be seven in this city."

as her mother did on the several occasions when she, too, noticed the yellow car. Deer poachers scouting deer from automobiles were common in that country, never mind that it happened to be a game preserve. At least once when Cecily was riding with her father, they met Osborne at the bend.

Two miles from the ranch, on the east side of the hogback, was a wooden one-lane bridge over Turkey Creek. Almost every workday, Ad Coors crossed that bridge soon after eight in the morning—as Osborne had come to know. After Osborne decided that his planning was complete, he arrived at the bridge before eight one winter day, turned the yellow car around, backed up, and blocked the bridge on what would be, to the arriving Coors, the opposite side. Coors, listening to the radio in his International Travelall, left his ranch, went through the gap in the hogback, and turned north. Dressed, as he was, in a billed cap and a nylon windbreaker, not a suit, he would not have been taken for the chairman of a significant corporation on his way to his office. His tie, though, was secured by a clasp in the shape of a ski, and the ski was monogrammed "A C III." In his right rear pocket was a white handkerchief with maroon stitching: "A C III." On

his key chain was a small silver penknife engraved "A C III." A label in his trousers said that Hickey-Freeman had "customized" them "expressly for Mr. A. Coors, III." His wristwatch was a Patek Philippe, Genève. He wore white deerskin gloves from Gokey. The tie—dark blue, with small white rings and red dots—was from the Aspen Country Store. The windbreaker was from Abercrombie & Fitch. He approached the bridge, got his two front wheels on it, and stopped in puzzlement, blocked by the yellow car. He seems to have rolled down his window and shouted something. He got out, closed the door, and faced Osborne—a heavy-shouldered man, with myopic eyes under a brown fedora. Neither man ever told this story, but evidence would carry the narrative. A woman whose house was several hundred yards away heard loud voices. If they were coming from the bridge, Ad Coors was resisting, reacting to whatever Osborne might have said. The clash became physical. Both men's hats fell past the bridge railing and landed at the edge of the stream. Coors' eyeglasses came off his head and ended up in the water, a lens broken. Gun muzzle in Coors' back, Osborne seems to have tried to march him across the bridge toward the yellow car. Coors probably

made a sudden move that electrified Osborne's nerves. The woman who had heard the shouting voices now heard gunfire. She would say it was the sound of lightning hitting a tree. Another woman—two and a half miles away, hanging laundry on an outdoor clothesline—heard it, too. Blood fell on the bridge railing and, in larger quantity, on the bridge. The yellow Mercury left the scene—digging out, leaving tracks, dirt flying.

Osborne's plans unravelled. In days that followed, he did not respond to responses to a typed ransom note that he sent to Mary Coors. His victim died. Burdened with a corpse, the yellow Mercury went south, outboard of the mountain front, and then, on an unpaved road in Douglas County, turned west and began to climb. There had been no snow in some time, and what there was had been scraped away. The road seemed to be made of muddied dust. Pink-feldspar dust. The dust was granite. If you were to collect such dust and do an analysis of it, it would look very much like granite. Compared with the source bedrock, the dust would be deficient in iron and magnesium, that's about all. The minerals break down at different rates. With altitude, the road became pebbly with granite, the hue brighter. It was old rock, ten times as old as the rock in the Dakota Hogback, but, as Colorado granites go, it was singularly and anomalously young. It was Pikes Peak granite—a geology that stands alone, and can write its name in dust. This was ponderosa country, its colors green and pink. At seven thousand two hundred feet, the yellow car turned in at a dump used by the Shamballah Ashrama, Brotherhood of the White Temple. Well beyond the mounded trash, the body was left in the forest. It would not be discovered—the fate of Ad Coors would not be learned—for seven months.

Returning to essentially clean pavement, Osborne now went east. Apparently, the next unpaved surface he drove on consisted of black slags and drifted sands on New Jersey's best-known barrier island. He all but hid the yellow car in some tall spartina grass near a large municipal dump. There, on the eighth day after the confrontation at the wooden bridge, he soaked the interior

with gasoline and tossed in a lighted match. The fire was hot enough to melt some of the window glass. From the dump, it is only a fifteen- or twenty-minute walk to Mediterranean and Baltic, Park Place and the Boardwalk, and the rest of Atlantic City.

The F.B.I. gave a breathtaking performance in figuring out who Osborne was—assembling his story in dozens of ways, of which geological insight was just one. Something like thirty special agents worked on the case in Colorado, and a great many around the country. They learned that he was thirty-one—



blue eyes, brown hair, a hundred and seventy pounds, six one, Caucasian. They learned that he had bought a .32 by mail order from Dakin Sporting Goods, in Bangor, Maine. They learned that he had practiced with his guns on targets at the Coors rifle range, near Golden. They learned that as a light and occasional drinker he preferred Coors. (They seem not to have learned that Ad Coors was allergic to beer.) They learned from their lab in Washington that the ransom note was probably written on a Royalite portable typewriter. A miner in the hogback, annoyed by frequent vandalism, said he tended to notice lingering cars, remembered a yellow Mercury, and was pretty sure that its license began with an AT and a 62. They attempted to do surveillance on each Mercury in Denver in the State of Colorado's 6200 series (colors were not listed), and they failed to locate only one. It was registered in the name of Walter Osborne, of 1435 Pearl Street, Denver. It had been bought from Hack Sells on the Little Lot, a dealer in Denver. A salesman confirmed the transaction and said the car was canary yellow. They learned that Osborne had worked at the paint factory. Although records were missing there, people remembered a number of things about him, including the fact that some five years back he had worked in Los Angeles for an ice company. The F.B.I. found the ice company, where Osborne had joined a union. Asked by the union to name a beneficiary for a life-insurance policy, Osborne had declined, saying that his parents were dead. Asked, then, to name a friend, he named Joseph Corbett, Sr., and gave an address in Seattle. Meanwhile, the lab in Washington matched

a fingerprint on Osborne's first Colorado application for a driver's license to a fingerprint filed under fugitives from justice. It belonged to Joseph Corbett, Jr.

An F.B.I. agent in New Jersey, reading a description of Osborne's car, remembered the blistered hulk near the Atlantic City dump. He checked its motor number. The F.B.I. in Colorado learned that Osborne could be an incautious driver. Two weeks before he ended the life of Ad Coors, he had been stopped by an officer of the Colorado State Patrol for crossing a yellow line and passing a truck at the crest of a hill. This was a few miles from the bridge that became the crime scene. When the policeman asked him what he thought he was doing, he answered flatly, "I got tired of waiting." After the F.B.I. learned that alias Osborne had paid his fine with a money order, they went to the National Check Cashing Company, which operated only in greater Denver, and went through four hundred thousand money orders. Of interest to them were five. They learned that he had ordered several sets of Monte Carlo handcuffs from Big Three Enterprises, on Sixth Avenue, in New York. Also cashed in New York was a money order that he had mailed to Kline's, on East Forty-second Street, a subsidiary of Prince Enterprises that handled only one product: leg irons.

The F.B.I. went to May D & F, a Denver department store, whose label was in "The Cruiser"—the suspect's brown fedora. May D & F also sold Royalite portables, and, because typewriters have serial numbers, the store routinely recorded purchasers' names and addresses. Remarkably, a sales clerk remembered a cash sale that occurred four months before the crime. He looked through his files. The buyer was William Chiffins, of 1735 Pennsylvania Street, Denver. At the conclusion of the interview, the investigating agent showed the sales clerk five pictures. Did one of them resemble the buyer? That one, said the sales clerk, touching the likeness of Joseph Corbett, Jr.

Corbett had served in San Quentin and had later escaped from Chino. Second-degree murder. The F.B.I. knew that already. Reviewing the roster at San Quentin, they noticed that when Corbett was there Arthur John Cheffins was

a prisoner, too. They learned from Cheffins that it had been his job to give I.Q. tests to fellow-prisoners. He remembered that Corbett had scored 148. It had also been Cheffins' job to give social-fitness tests. Corbett told Cheffins that he admired the intellect of Friedrich Nietzsche—especially the sentiment "Might makes right." If he said things like that, Cheffins advised Corbett, he could not give him much of a grade in social fitness. Corbett replied, "Look at Nagasaki. The only thing that was important was the result of the bomb."

Alias Osborne was seen at his apartment at five-thirty the morning after the scene at the bridge. In a locker in the basement he left a gasoline can, a two-burner Coleman gas stove, a nest of aluminum pots. In his apartment were two tent poles and a twelve-piece picnic set. All these things came from Sears. Figures had been added up on the carton that held the picnic set. A clerk at Sears remembered jotting down the figures, and remembered the buyer. He had come in after Christmas. He had inquired about a discount because the goods were out of season. The clerk asked why he wanted such equipment at that time of year. Corbett said, "I like to camp in winter. I'm going to camp this winter in the mountains."

Corbett was at large more than eight months. Meanwhile, the F.B.I. removed layers of material from under the fenders of the burned yellow Mercury and established the sequence of deposition. They collected four hundred and twenty-one "knowns"—Colorado earths of as many provenances—with which to compare "the questioned stuff." The analysis was assigned to Richard Flach, who, with a colleague nearly two decades earlier, had established forensic geology as a function of the F.B.I. Seven months after the crime, a pizza-truck driver who went target-shooting at the Shamballah Ashrama dump discovered the Hickey-Freeman trousers labelled "expressly for Mr. A. Coors, III." The engraved penknife was still in a pocket, and so was the maroon-monogrammed white handkerchief. The tie clasp and knotted tie and the Abercrombie & Fitch windbreaker—bullet holes in the back—were some distance away. Coors' wristwatch and gloves were separately found the next day. A few weeks later, the F.B.I. at last found Corbett: they

pulled him out of a hotel in Vancouver, British Columbia, and walked him through the legal wickets that returned him to Colorado. When asked about the Coors kidnapping, he would fold his hands, lower his head, and resolutely say nothing about it. He was tried in Golden. He denied the presented story and never confessed. In the completed mosaic of evidence were enough solid items to condemn him many times over; the role of the geology was to tie him to the country.

While careful at all times to cover his tracks, he had been writing his itinerary on the bottom of his car. There were four depositional strata. The fourth and outermost contained the sands, silts, paper fibres, cinders, glass wools, and black slags that surround the Atlantic City dump. The sands of this fourth stratum were rounded and marine. All sand grains of the three inner layers were sharp and fresh. They contained the pink feldspars of the Pikes Peak gran-

ite, the pink feldspars of other Front Range granites, the light-gray quartzose sands of the hogback's Dakota Group, the varicolored sandstones, limes, and clays of the Morrison Formation. Richard Flach, now retired in Florida, refers to the oldest and innermost layer as "the odd man out, except that it could be related generally to the Rocky Mountain Front because of the pink feldspar." He goes on to say, "The second layer related to the country around Coors' ranch. It placed Corbett within a couple of miles of the crime scene. That is, it was consistent with the minerals of that locality, consistent with his being there. The third soil was from near where the body was found."

It was Flach's case—the testimony his to present. Flach was a geology-and-botany major from Northwestern University. The chief defense attorney was a graduate of the Colorado School of Mines. He attempted to discredit Flach, to impugn his competence. This led to



"We don't use the Congressional Budget Office. We have our own figures."

a moment when an assistant defense attorney said, "I don't think he's qualified."

The judge said, "Sit down. He's qualified."

Corbett was sentenced to life imprisonment. The F.B.I. sent out a press release citing the "major importance" of the geologic evidence. Flach agrees softly: "It carried a little weight."

Corbett now lives free. Coors' daughter Cecily Garnsey lives with her husband in a community of town houses arranged for privacy but very close together,

where small patches of lawn are decorated with little blue signs mentioning to intruders the prevailing security system. She accompanied me along the mountain front and up to the high ground of Shambalah Ashrama, where she had never been. Under the ponderosas there, the big crystals of the Pikes Peak granite were crumbling like pink sugar. The air was warm, dry, at seventy-two hundred feet. She wore tennis shoes, tan shorts, a blue sleeveless canvas blouse, and pearl earrings. She was as trim as she had been

on downhill skis. Shell casings of every calibre were all over the dump. Shoulder to shoulder, a score of special agents had walked here for days collecting her father's remains. She asked, almost of herself, "Didn't he bury him?" The dump was an ugly moment in beautiful terrain. After taking it in slowly, she described one of her sons, recently graduated from college, who had worked summers for the Arapahoe County police. "He's such a Sherlock Holmes person," she said. "He is waiting to get into the F.B.I."

BALLOONS OF WAR

*What value did the War Department place on the Geological Survey's studies of world terrain?
A lot, especially when balloon-borne bombs started exploding in America.*

For a long time he remained there, turning over the leaves and dried sticks, gathering up what seemed to me to be dust into an envelope, and examining with his lens not only the ground, but even the bark of the tree.—*The Boscombe Valley Mystery.*

JAPAN in 1944.

After a free-balloon flight test near the end of September, Technical Major Teiji Takada, of the Ninth Army Technical Research Laboratory, took a walk on the Ninety-nine League Beach, at Ichinomiya. Satisfied with the test, of which he was in charge, he simultaneously rejoiced in the temporary relief from pressures applied by his military superiors and began to concentrate on another question. "The only thing left for further study was the planning of how to meet the requirement of huge amount of sand on the beach," he later wrote. (The translation, done six years after the war, is by Ken Suda, of the Central Meteorological Observatory, in Tokyo.) "After the balloon has disappeared in the blue sky, I walked about on the sand beach, picked up a handful of sand at several places to wrap it in a piece of paper and putting it in my pocket, went down the sand dune in the evening dark feeling the chill of autumn wind."

It had been a long two and a half years since B-25s from the American carrier Hornet, under the command of Lieutenant Colonel James Doolittle, bombed Kobe, Nagoya, Yokosuka, Yokohama, and Tokyo, agitating the Japanese populace, embarrassing the military, and set-

ting in motion the free-balloon project that was now about ready. It was intended specifically as retaliation for the Doolittle raid. The unmanned balloons were meant to carry fire bombs and high-explosive bombs to the homeland of the United States and drop them there to kill people, destroy structures, and start forest fires. The preparation had consumed so much time because the technological problems were acute. This was not a simple matter of loading up some bottled germs and floating them over Russians in Manchuria, as the Japanese had once done. These balloons had to travel more than five thousand miles. In sunlight they would rise and in darkness fall. With excessive rising and falling, they would fail their mission. They would also fail their mission if they leaked too much hydrogen. They should not drop their bombs until they reached North America. Bombs away, the balloons should then destroy themselves.

In addressing and fulfilling each requirement, Technical Major Takada and his numerous colleagues at the research laboratory and their boss—Major General Sueyoshi Kusaba—were creating an intended instrument of terror, the world's first intercontinental ballistic missile, a Japanese V-1 with twenty times the range, if not the accuracy, of the German rocket. The jet stream was not yet called by that name, but the great strong current of the winter air—in its sinuosity and remarkable velocity—had been the recent discovery of the Japanese, and the jet

stream, they calculated, could drive a large balloon to North America in three days. You could find the high wind at and above thirty thousand feet. With an altimeter and a battery, you could cause gunpowder to ignite and jettison ballast when a balloon, cruising, descended to thirty thousand feet. They tested that successfully. With an altimeter and a valve, you could get rid of hydrogen if the sun were to expand it to a critical extent. You could program the valve to release hydrogen at thirty-eight thousand feet. That, also, they tested successfully. Within these designated altitudes, in the jet stream, a balloon would go through x cycles in y hours, expending z pounds of ballast. Now the balloon is over the United States. The ballast is gone. The next discharge of gunpowder releases the bombs and lights a sixty-four-foot fuse that dangles like a shroud line from the balloon's equator. For eighty-two minutes, the fuse shortens, and then it ignites a flash bomb that blows up the envelope. Mission accomplished, missile destroyed. To carry all that gear, the balloon would need a lifting capacity, at sea level, of one thousand pounds. You could do that with a diameter of ten metres.

At first, the balloons were made of conventional rubberized silk, but there was a way to make an envelope that would leak even less. An order went in for ten thousand balloons made of *washi*. Produced in rectangular units not much larger than a road map, *washi* was paper, derived from a mulberry that was much



Who was launching the balloons? It was inconceivable that they could have travelled five thousand miles.



"And one for the old prostate."

like American sumac. Practically impermeable and very tough, it represented a step backward to a higher technology, like a bark canoe. In three or four laminations, the paper was glued with devil's-tongue flour. Devil's-tongue is a Japanese potato. Workers stole the paste and ate it. Many workers were high-school girls, whose fingers were nimbler than the fingers of any other class of people. They were told to wear gloves, to keep their fingernails short, and not to use hairpins. They assembled the paper in many parts of Japan. They had no idea of the purpose of their work. When scuttlebutt suggested the truth to them—that they were making *fusen bakudan* that would fly all the way to America and ignite fires—they laughed. Large indoor spaces were required for the envelope assembly—sumo halls, soundstages, theatres—but somehow secrecy was preserved.

Before preparations were complete, B-29s attacked the home islands, and the balloon project that had begun as an act of revenge became an act of desperation. At last, the balloons were ready. The jet stream was ready. The order came down to release at 0500 on November 3rd. Ichinomiya, on the Chiba Peninsula, east-southeast of Tokyo, was one of three launch-

ing sites. Major Takada watched as the products of ten years' research and two years' labor were let go, one by one. In his words, "The figure of the balloon was visible only for several minutes following its release until it faded away as a spot in the blue sky like a daytime star."

The Military Geology Unit of the United States Geological Survey was established in June of 1942, six months after the Japanese attack on Hawaii and virtually at the same time that work was beginning in Japan on the intercontinental balloons. The Geological Survey people had imagined that geological knowledge could help the military effort, so they made up a sample folio of information useful to an invading army, randomly choosing Sierra Leone as a model. They located water supplies, strategic minerals, and places where road-building materials could be obtained. They described the terrain. According to Kenneth Lohman, who was one of the original geologists in the section, "The War Department bought it hook, line, and sinker," but the utility of such folios would be greatly reduced by a distinct and unexpected problem: "The military, we found out, couldn't read a topographic map." Presented with contours, depressions, noses,

and reentrants on a flat sheet of paper, the military people tended not to see terrain in three dimensions. Therefore, as the geologists began making folders on strategic settings all over the world, they developed terrain diagrams—pen-and-ink sketches of landscape as if from a low-flying plane.

Ken Lohman is ninety-eight years old. I met him when he was ninety, and interviewed him in, among other places, a hospital room in Virginia, before I had to suppress my interest in forensic geology in order to spend a number of years on the geology of California. When I next telephoned Lohman, to inquire about renewing our talks, he was ninety-seven. He said—a little more than firmly, and with emphasis on the first and third words—"Where have you been?"

I went to see him at his home, in Fairfax Station, Virginia, near Washington. A few years ago, he stopped going regularly to his office at the Survey. I found him, as before, engaging, direct, humorous, and amiable. He speaks in a strong low-register voice. He is tall and large-framed, and his hair is now for the most part fringe, superthin on top. He is out of the habit of a bourbon-and-water every night before dinner, a Martini at the Cosmos Club before lunch on Fridays. He has thick eyeglasses. He peers at you from behind the glass like a teller from a cage.

"We worked eighteen hours a day," he reminded me, speaking of the war years. "We practically slept on the job. We helped the military pick landing beaches. We were looking for places with shallow water near shore, not a shelving beach or a cliffy shore. No quicksand." They worked in the Interior Building, only two physical blocks but two thousand political miles from the White House, for the Geological Survey at that time had a long way to go to please, if not placate, the sitting President. As geologists of the day would tell you, Roosevelt didn't like the Survey. First, Her-

bert Hoover was a geologist, a mining engineer. Second, Roosevelt had a special interest in the properties of the water at Warm Springs, Georgia, which he had found therapeutic for the polio that had stricken him in 1921, and as early as 1927 he had written a request to the Survey for a study of the Warm Springs water, seeking an analysis of its obviously distinguished chemistry. The Survey replied that you could find similar water in the pipes of an average city. In a consequent exchange of letters, Roosevelt expressed considerable annoyance. When he became President, his request for a thorough study acquired mass. Foster Hewett, of the United States Geological Survey, was named leader of a team that went to Georgia. There—to Hewett's surprise—he encountered a German consultant. This was Doktor Paul Haertl, managing director of Bad Kissingen, consultant also to Saratoga Springs. Even while Hewett was making the scene, Roosevelt was seeking a second opinion.

The American and the German conferred. At one point, Doktor Haertl asked Hewett, "Are you studying the gas that comes from the water?"

Hewett answered, "We are."

Haertl said, "Have you examined the shape of the bubbles?"

Hewett's pupils doubled in size. He said, "No, we haven't."

Haertl said, "Oh, you must examine the bubbles. Some bubbles are round, but others are square."

Hewett (all this would appear in U.S. Geological Survey Bulletin 1589) said, "Do I understand that you know places in Germany where the bubbles issuing from water are square?"

"Oh, yes, Mr. Hewett," Haertl said. "The bubbles of gas at Bad Kissingen are square. You see, Mr. Hewett, when you put your arm in water that contains gas, bubbles appear on the flesh. Now, if these bubbles are round they produce no effect, but if they are square they have the effect of stimulating the nerves of the skin. It is extremely important that you determine whether these bubbles are round or square."

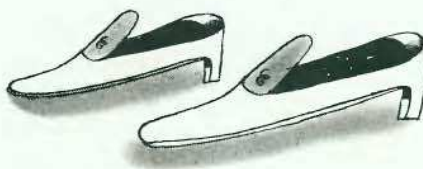
Hewett spent two and a half years studying Warm Springs, and concluded that the magic fluids were "ordinary rain water without exceptional physical or chemical properties." It fell on Pine Mountain, followed a bed of quartzite

to a depth sufficient to heat it, and came up along a fault. After this information was printed in his report, a bound copy was sent to the White House. It was not acknowledged.

Ken Lohman commented, "There was a period of about six years in the thirties when no one was hired by the Survey. Roosevelt wanted to believe the German, who said the bubbles came up in the water and the corners scratched your skin. That was just bullshit."

When the Survey's Military Geology Unit began its work, it consisted of Lohman and five others in a very small corner of the Interior Building's fifth floor. "In no time, it was two hundred, and we had the whole floor," Lohman said. These geologists all had broader backgrounds in the science than geologists would tend to have in later years—a fact that fit the spread of war. By year-end 1944, they had contributed several hundred major studies across the whole spectrum from invasions to defenses, reconstituting, at the White House, the Survey's lost prestige. Their principal link with the military was Colonel Sidman Poole, G-2—"a fine man," as Lohman remembers him, "a bit on the pompous side, as colonels usually were." One day early in the New Year, "Poole came in with a couple of little bags of sand. Very much hush-hush. People who weren't classified couldn't even get into the place. Poole wanted to know where the damned sand came from."

Balloons had been sighted, explosions heard, from California to Alaska. Something that appeared to witnesses to be like a parachute descended near Thermopolis, Wyoming; a fragmentation bomb exploded in bright-red flame; shrapnel was found around the crater. Actually, the paper balloons were shaped much like our hot-air balloons that float in the morning and evening sky, and were about three-quarters as large. As is detailed in Robert C. Mikesh's "Japan's World War II Balloon Bomb Attacks on North America," a P-38 Lockheed Lightning brought down a paper balloon near Santa Rosa, California, another was seen over



Santa Monica, and bits of *washi* paper were found in the streets of Los Angeles. Two paper balloons were recovered in a single day in Modoc National Forest, east of Mt. Shasta. Near Medford, Oregon, a balloon bomb exploded in thirty-foot flames. The Navy found balloons in the ocean. A P-47 Thunderbolt brought one down in the Aleutians. Balloon envelopes and other apparatus were found near Kalispell, Montana; Lame Deer, Montana; Nogales, Arizona; Estacada, Oregon; Stony Rapids, Saskatchewan. Balloons came down at Fort Simpson, on the Mackenzie River, in the Northwest Territories; and at Marshall and Holy Cross, Alaska, in the Yukon-Kuskokwim delta—failing, like so many others, to destroy themselves.

Under the headline "BALLOON MYSTERY," *Newsweek* of January 1, 1945, told a story about two woodchoppers who found the balloon at Kalispell. On January 2nd, an item appeared in the *Times* under the headline

BALLOON IN OREGON
Like That Found in Montana
It Is Laid to Enemy Origin

The Office of Censorship sent out an all-points memorandum to newspapers and radio stations asking them to make no mention of balloons and balloon-bomb incidents, lest the enemy be encouraged to release even more.

Where conventional balloons would have a hanging basket, the *fusen bakudan* had a cast-aluminum four-spoke wheel festooned with sandbags, like bulbs pendant from a chandelier. The sand device developed by Technical Major Takada was an automated hopper. For the most part, though, the sand was precisely weighed in amounts of as little as three and as much as seven pounds, and wrapped in paper identical to the paper of the envelope, snugly secured with twine. These ballast units were programmed in pairs for sequential release by the battery-and-altimeter gunpowder method, always getting rid of two bags at once, on opposite sides of the ring, so as not to tilt the envelope and risk losing gas. Most of the ballast was gone by the time a balloon crashed in North America, but a few sandbags were found. And the War Department asked Colonel Poole if his geologists could tell where the sand came from.

Remember, it was inconceivable that the balloons had travelled five thousand

miles from Japan. American Military Intelligence was no more prepared to believe that than were the high-school girls who were gluing the paper in numerous parts of Honshu. It was thought that the balloons must be coming from North American beaches, launched by landing parties from submarines. It was thought that the balloons might also, or alternatively, be coming from the submarines themselves. It was thought that the balloons might be coming from German prisoner-of-war camps, or from Japanese-American relocation centers. They might even be coming from small Pacific islands. Possibly their purpose was to transport enemy agents. Poole handed over to the geologists several cupfuls of sand.

One close look and they eliminated North America. Everything was wrong. It was not our sand. Chemically, petrologically, it was not the sand of the mid-Pacific, either. The geologists, with their polarizing microscopes, their dark-field stereoscopic microscopes, their X-ray diffraction cameras, settled in for a tighter view. Ken Lohman was more or less in charge. He is a micropaleontologist and a specialist in diatoms, a class of microscopic algae. He was not discouraged by the palmful of sand that was given to him. "It was enough to work on, anyway. I stewed up the stuff, and I got more than a hundred species of diatoms." The sand had obviously come from a beach. It contained a mixture of recent diatoms and fossil diatoms, and that, to Lohman, meant beach sand. The geologists read the papers of Hisashi Kuno on orthopyroxenes from volcanic rocks, which dated only to 1937 but had quickly established him as one of the world's most gifted petrologists. His paper on Hakone Volcano was the most detailed study ever made of that kind of rock. Reading Kuno in the light of the mineral percentages they were seeing in the sand, they eliminated chunks of

country. Julia Gardner was a paleontologist whose most concentrated experience was in small mollusks. She put the ballast under her microscope and looked at pieces of small mollusks. She looked as well for coral. You can identify coral even if it is smaller than a sugar grain. There was no coral—not a hint of coral. Coral doesn't

grow in cold water. Along the coasts of Japan, the northern boundary of coral comes near the latitude of Tokyo. It approximates the thirty-fifth parallel. Gardner was eliminating the southern third of Japan.

Clarence Ross—mineralogist, petrologist—found nothing granitic in the mineral assembly. His son Mac Ross, himself a Survey mineralogist, recently remarked to me, "If the sand had derived from a garden-variety granite, it would have been difficult to trace, or impossible, but it contained an unusual suite of minerals." His father and the others looked at geologic maps of Japan, and eliminated all beaches north of the thirty-fifth parallel where streams reached inland to granite bedrock. That done, the search became more subtle. The assemblage included hypersthene, augite, hornblende, garnet, high-titanium magnetite, high-temperature quartz. Most remarkably, the hypersthene was fifty-two per cent of the total. Even allowing for wave concentration of this heavy mineral, so large a percentage was quite unusual. The hypersthene and the augite would be of volcanic origin. Augite is typical in volcanic rocks, hypersthene a good deal less so. The hornblende and the garnet were metamorphic, so you'd have to see both volcanic and metamorphic rocks

upstream from the beach. The high-titanium magnetite was igneous in origin. In Mac Ross's words, "The assemblage does look a bit strange. The high-temperature quartz suggests melts that you would expect from lava flows. You wouldn't find that in Hawaiian basalts. Shards of glass in the sands also speak of lavas. There's no mica. As euhedral crystals, hypersthene grows in a melt. The crystals are then erupted. They are frozen into a volcanic glass. What follows is the weathering out of the glass. How it got to be fifty per cent is strange. There's so much hypersthene that you'd have to have a local igneous rock that was not all that common."

Patiently, exhaustively, Clarence Ross searched the literature, studied the maps, and related the rock types to his own petrologic descriptions. He was a large, imposing man with a mane of gray

hair. His son says of him, "He had a professorial manner. There was no trivia. Small talk was beyond him. He was forty-nine when I was born, so in some ways he was like a grandfather. When he came home, he always smelled of immersion oils." Mac's wife, Daphne, remembers her father-in-law as "a forthright person with a dominant personality, a perfectionist, who didn't take fools lightly." Ken Lohman describes him as "an oddball guy, not sociable, a damned good man on rocks, without much interest in anything else," and says, "His stuff was definitive."

Kathryn Lohman, who had been a specialist in foraminifera for Texaco, looked through the ballast sands for these single-celled microscopic creatures with calcareous shells. Forams are highly varied, fairly ubiquitous, almost wholly marine, and have been around more than five hundred million years. Kathryn found quite a few of them that had been described north of Tokyo and on the east coast of Japan. On this planet, they occurred nowhere else. "She went to the Smithsonian and got papers from Japan," Ken Lohman told me. "Her forams were just as definitive as the diatoms were." When I asked him to describe her, he said, "Anything I say would be colored by the fact that I was very much in love with her. She was very good-looking. She played the piano beautifully. I played the violin. We never had a harsh word in fifty years. It was easy to like her. She was friendly."

Kathryn was born in Canada, grew up in Winnipeg. I had asked the question in their living room, she gone now thirteen years, he aged ninety-seven. As I looked around the room, I saw fresh newspapers, copies of *Physics Today*, copies of *Science News*. A headline on a geological publication said, "Gulf's Mahogany Find Excites Explorers." There was a church-model Hammond organ and eleven speakers—five for the Hammond, six for the stereo. Spread out on a table were his Beethoven sonatas, his Beethoven concertos, his Haydn symphonies, his copy of Jules Verne's "A Journey to the Center of the Earth." Outside were his hundreds of azaleas. He remarked out of nowhere that he was expecting momentarily a load of mulch.

I concentrate here on Ken Lohman because he is an eminent, arresting sci-



entist, and because he is alive. "In 1993, I developed an irregular heartbeat," he said, evidently reading my mind. "It was very scary. You could die from it. But I'll never go to another nursing home. God Almighty."

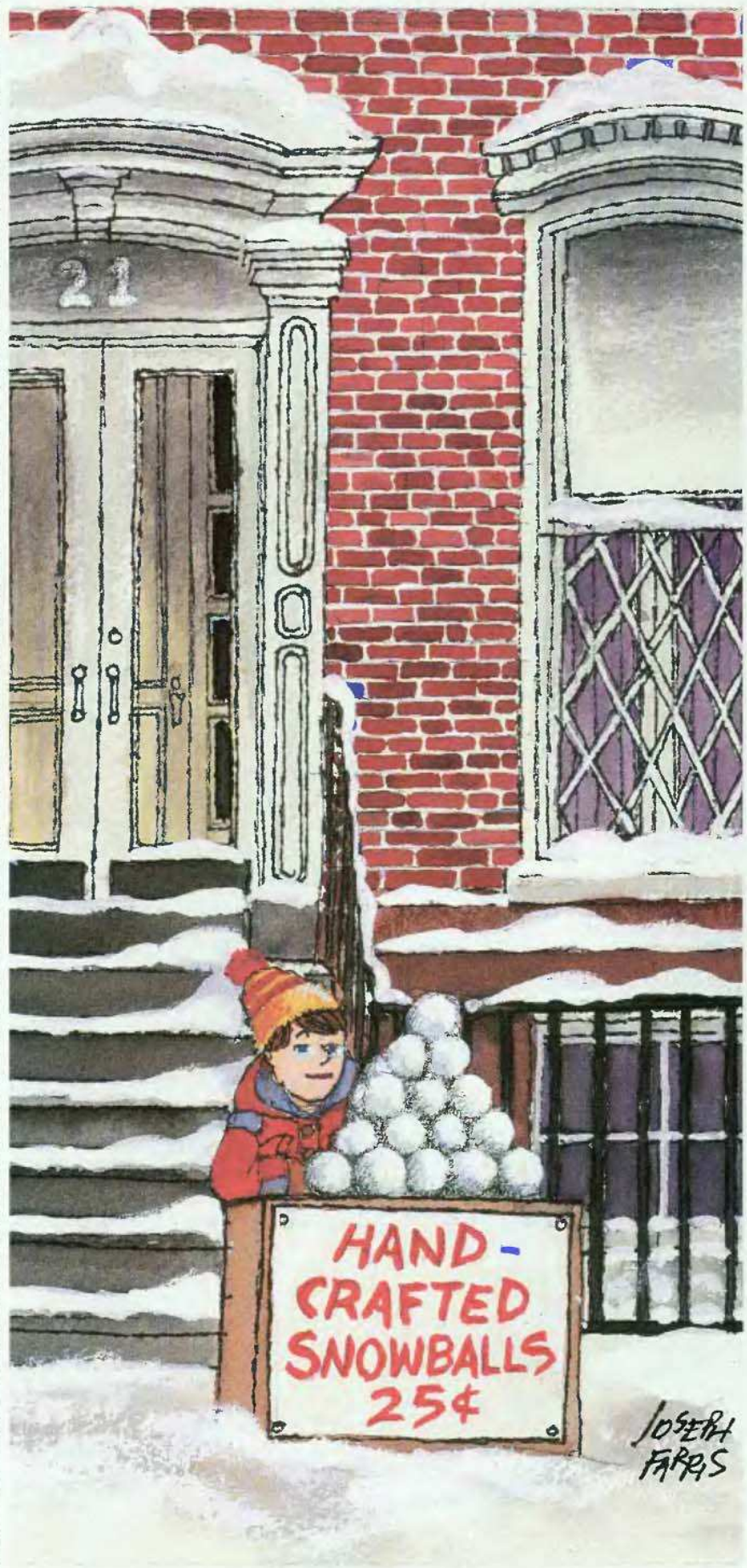
Here and there on the walls were pictures in rich color—a third of a metre wide—of intricately patterned circular objects that came close to resembling Buddha's gongs. They were diatoms, magnified seven thousand three hundred times. In my notes somewhere was the first description he gave me of these creatures on which he had centered his life's work: "They're just damned interesting things to look at. They're beautiful. They're useful fossils, Cretaceous to Recent. Hydrosilica, $\text{SiO}_2 \cdot n\text{H}_2\text{O}$ —the same composition as opal. There are no opals before the Cretaceous, and no diatoms before the Cretaceous. There's no connection, but it's interesting. The average size of a diatom is forty to sixty microns. A big diatom is two hundred microns."

A micron is a thousandth of a millimetre. I remarked that a Princeton professor of geology had told me that all the diatom experts in the history of the world have yet to look through their first teaspoonful of diatoms.

Lohman said, "That is wrong. It's more like a tablespoonful."

There are three hundred genera of diatoms and twenty-five thousand species. "I've had seventy-five years of looking at these buggers. You get to recognize them. You know two or three thousand species just like that. You can take a look at a slide and say, 'That's Middle Miocene.' Lake-surface diatoms are totally different from bottom ones. Diatoms live on ice floes. They live in hot springs. There are twenty-one million diatoms per cubic inch of diatomite. In one litre of seawater are a hundred thousand to one million diatoms. The water is clear—it doesn't even look cloudy, they're so small."

Lohman dropped out of Caltech after his freshman year. He learned photography. Johns Manville hired him to photograph diatoms for advertising purposes. Johns Manville mined diatoms. ("All the sugar you have ever eaten has been filtered through diatoms.") He also found a job as a chemist. His chemistry was from Hollywood



High School and the freshman year at Caltech.

One day, his boss said to him, "Do you have a Ph.D. from Harvard?"

Lohman said, "I don't have a Ph.D. from anywhere. I don't have an undergraduate degree."

The boss looked oddly pleased.

Lohman asked him why he had said "a Ph.D. from Harvard."

The boss said, "Your predecessor had a Ph.D. from Harvard and he wasn't worth a fart in a high wind."

Lohman eventually went back to Caltech—a freshman in 1916, a sophomore in 1926. He completed his undergraduate degree and did graduate work there to the master's level. When he was working in the Military Geology Unit during the war, he did not yet have a Ph.D. In the nineteen-fifties, on leave from the Geological Survey, he would return to Caltech to complete it.

As the research went forward on the fifth floor of the Interior Building, balloons continued to arrive in North America. Near Klamath Falls, Oregon, a snowplow plowed into one. Balloons came down in or dropped their bombs on Bigelow, Kansas; Holstein, Iowa (incendiary explosion); Nelson House, Manitoba; Oxford House, Manitoba; Waterhen Lake, Manitoba; Fort Chipewyan, Alberta (in all, four balloons landed around Lake Athabasca); Hay River, Northwest Territories (bits of envelope, two unexploded incendiaries, seven sandbags beside the Great Slave Lake); the Brooks Range (two); Echo, Oregon (now in the National Air and Space Museum); Walla Walla, Washington; American Falls, Idaho (bomb burst in air, fragments were found); Kadoka, South Dakota; Pyramid Lake, Nevada; Delta, Colorado (explosion, shrapnel); Desdemona, Texas; Laguna Salada, Mexico; Grand Rapids, Michigan; and—the longest known flight, ending in a shower of incendiary fragments—Farmington, Michigan, ten miles from the center of Detroit.

"I should have got a Purple Heart," Ken Lohman told me. "I was working so hard I got hemorrhoids. They'd find another balloon. Poole would come in with another handful of sand."

The fossil diatoms—their number and variety notwithstanding—were all Pliocene in age, and that removed from consideration a great deal of parent rock. In an 1889 paper by the French paleon-

RADIATORS

Not theirs the stove's inflammatory drama,
or the refrigerator's frosty glamour,
or the trim, glazed hauteur of window frames,
but the warmth of the first, the erectness of the last.
Standing by a window, we feel on our knuckles a kiss
of heat like a dog's nudge, and remember that
the room lulls our blood not by accident but
by basement-based thermodynamic plan.

With their thick fins and many spines these cast-iron soldiers stand at attention in the least obtrusive corners, like museum guards, sleepy and dull, in rooms of glowing treasure—ourselves. Their weeping, whistling valves declare a love of us that makes them throb and simmer; they call out for our praise for their fidelity, but we scorn them like monarchs born of the sun.

—JOHN UPDIKE

tologists Jacques Brun and Joannes Tempere, Lohman found descriptions of diatoms identical to the ones in the ballast sands. The research area of the Brun and Tempere paper was around Sendai, on the Honshu coast northeast of Tokyo. He also read papers by "Japanese diatomaniacs," who described the same fossils on the same coastline. Brun and Tempere covered forams, too, and they were the forams that Kathryn Lohman was finding in the ballast sand. Taking these things together with the discoveries of Clarence Ross and Julia Gardner, the Military Geology Unit, which had already narrowed its focus to the northerly thousand miles of Japan's eastern coasts, now narrowed that by eighty per cent. More scientific literature, more sand, more study of geologic maps, and they were ready to be specific. They told Colonel Poole that the sands seemed to have come from one or both of two locations, roughly two hundred miles from each other. Only because of the coral line, the geologists slightly favored the more northerly site—the great beach of Shiogama, close to Sendai. To the other site the minerals were even more closely matched, but the coral line was so near that if it was the launching place of the sand under their microscopes they would expect to see a trace amount of drift coral, and none was there. The southerly site was the Ninety-nine League Beach at Ichinomiya.

Joseph Conrad's Charlie Marlow, sailing down the coast of Africa on his way to the heart of darkness, passed a French man-of-war anchored near "the edge of a colossal jungle so dark-green as to be almost black, fringed with white surf." The French ship was firing its guns. "There wasn't even a shed there, and she was shelling the bush. . . . In the empty immensity of earth, sky, and water, there she was, incomprehensible, firing into a continent." Only in the postwar's lengthening hindsight did Japan's balloon campaign reach the metaphorical status of that French warship. General Kusaba launched more than nine thousand bomb-laden paper balloons. It was his hope and expectation that ten per cent would complete the flight to North America. Physical evidence of some three hundred of them was found on the North American mainland. A reasonable estimate is that a thousand made the crossing. Only two landed in Japan—one on northern Honshu, one on Hokkaido. No damage. In the end, the balloons represented the enemy's fourth and last and most sustained attack on the United States mainland in three years and eight months of war. In February of 1942, Japanese Submarine I-17 shelled an oil field up the beach from Santa Barbara, and damaged a pump house. In June, Submarine I-25 shelled a coastal fort in Oregon, damaging a baseball backstop.

In September of 1942, the I-25's crew assembled and launched a Yokosuka E-14Y-1—a small float plane—that attacked Oregon. Its incendiary bombs ignited small fires on a ridge of Mt. Emily. The balloon campaign killed six Americans, all in an instant. Five of them were Sunday-school children. A minister and his wife took them on a fishing trip in southern Oregon, east of the Cascades. The minister was some distance away when his wife and the children came upon a balloon bomb. They called to him in excitement, and a moment later were dead.

All through that fall and winter, airplanes scrambled in pursuit of the balloons, but the airplanes were singularly unsuccessful. Lightnings, Hellcats, Thunderbolts, Corsairs, they literally were not up to it, and they destroyed fewer than twenty, only two of them over the United States. In altitude and sometimes in speed, the paper balloons were beyond the reach of American interceptors. On the coast of Washington, the Fourth Air Force set up a balloon early-warning line—Cape Flattery to Queets to the mouth of the Columbia River. One result of a secret meeting of military planners on January 17, 1945, was this classified statement: "Should balloons approach in hours of darkness, visual observation will not be effective." Frequently, pilots reported balloon sightings and the balloons turned out to be Venus.

Japanese propaganda broadcasts mentioned great fires and an American populace in panic. One broadcast said that five hundred casualties had occurred. Another broadcast raised the figure to ten thousand. Several million airborne Japanese troops were said to be ready to follow the balloons. The woman and five children who died in Oregon were the only American mainland casualties of the Second World War.

Geologists would develop some hyperbole of their own, especially after the war, when stories about the accomplishments on the fifth floor of Interior enriched the scientific conversation. Of the three balloon-launching sites, Ichinomiya was nearest to Tokyo. The two others—Nakoso and Otsu—were scarcely ten miles apart and about a hundred miles up the coast from

Ichinomiya, in the direction of Shiogama, the survey's other suggested beach. So far so true. Not without encouragement from Colonel Poole, the geologists tended to make a memorable story even more memorable. After the Survey's sand analysis, according to Ken Lohman, "Jimmy Doolittle went over and bombed hell out of the place." He said Poole told them that in so many words. He said, "We had all kinds of classified information. It wasn't in the newspapers, don't worry. Doolittle came up from Okinawa and bombed hell out of the whole area. The Japanese general was crestfallen." From geologists over the years, I've heard many versions of the same remark: "Photoreconnaissance showed the plant. Jimmy Doolittle bombed the bejeezus out of it, and there weren't any more balloons."

B-29s destroyed two of the three hydrogen plants that supplied the balloon project. Jimmy Doolittle was there in spirit. General Kusaba was indeed disappointed—a sentiment he expressed in person to a visitor from the United States Geological Survey late in 1945. By April of that year, Kusaba had spent nine million yen on his balloon campaign. In the military structure were people higher than Kusaba who considered that a very great waste of yen. He was ordered to give up the launchings. "Many factories which were manufacturing various parts of balloons were de-

stroyed," he later told a reporter. "Moreover, we were not informed about the effect of this weapon throughout the wartime. Due to the mentioned hardships, we were compelled to cease operations." The American press, in its way, had been as effective as the B-29s, for what Kusaba needed in order to impress his superiors and keep his project going was proof that the people of the United States, in dread of the balloon missiles, were in psychological disarray. From the American press Kusaba had nothing to show. After the deaths of the children in Oregon, the War and Navy Departments in Washington at last broke the silence of censorship with press releases informing the public of the danger. Headlines quickly bloomed, some in full eight-column width: "JAP BALLOONS REACH COAST" (San Francisco *Chronicle*), "NIP BALLOONS HAVE LIT IN WEST, ARMY REVEALS" (San Francisco *Call-Bulletin*). Soon Smilin' Jack—comic-strip aviator, lantern-jawed Lindbergh—was encountering paper balloons. But they were just newspaper balloons. The real ones had stopped coming.

The coast around Otsu and Nakoso, backed with granite highlands, had been considered unlikely by the Survey as a site for launchings. To Lohman and his colleagues, being right on one site and missing the two others was a matter of zero



"We're looking for the kind of bad taste that will grab—but not appall."

discomfort. "We always got the same kind of sand," he told me. "The samples we had were all from the same beach."

In a magazine article in 1953 Lincoln LaPaz wrote, "Scientists studying the balloons in this country (I was one of them) believed that the next step on the Japanese war plan, scheduled for the fall of 1945, was to be a balloon-borne bacteriological attack." A university cosmologist, LaPaz during the war had

been technical director of the Second Air Force Operations Analysis Section. About the atomic bombs exploded over Hiroshima and Nagasaki, he wrote, "Some people talked about how inhuman we Americans were. If they had only known what we avoided! I don't know how much influence the anticipated Japanese balloon offensive had on President Truman's decision to use the bomb, but it seems reasonable to

guess it was a factor in his consideration."

On March 10, 1945, a paper balloon that had crossed the Pacific Ocean, the Olympic Mountains, and the Cascade Range descended in the vicinity of the Manhattan Project's production site at Hanford, Washington. The balloon landed on an electric line that fed power to the building containing the reactor that was producing the Nagasaki plutonium, and shut the reactor down.

DEATH OF AN AGENT

How dangerous was it for an agent in the D.E.A. to be working with the Mexican police? A teaspoon of dirt taken from a dead man's body told the story.

"Well, Watson, I will not offend your intelligence by explaining what is obvious. The gravel upon the window sill was, of course, the starting-point of my research. It was unlike anything in the vicarage garden. Only when my attention had been drawn to Dr. Stern-dale and his cottage did I find its counterpart."—*The Adventure of the Devil's Foot.*"

WHEN the textbook "Forensic Geology," by Raymond C. Murray and John C. F. Tedrow, appeared, in 1975, its jacket copy lavished credit on Sherlock Holmes as the progenitor of this branch of the science. The text within was more restrained, and ascribed the credit to Conan Doyle. It quoted Dr. Watson on Holmes' knowledge of geology: "Practical, but limited. Tells at a glance different soils from each other. After walks has shown me splashes upon his trousers, and told me by their colour and consistence in what part of London he had received them." But the textbook's authors—professors of earth sciences at Rutgers University—were too serious to lean on the wisdom of the detective himself, and did not quote him. If they had, they might have increased—even more than they did—the number of geologists in the F.B.I., all of whom have the book. For the most part, they are F.B.I. geologists as a result of reading it. Chris Fiedler, for example, who started out doing clerical work for the Bureau, happened to have geological training. After he came upon Murray and Tedrow's textbook, he had himself transferred to the lab.

The Geological Survey and the Smithsonian stand ready to help. The F.B.I.

prefers the Smithsonian. Not only is it just across Connecticut Avenue but it is also generous in donating its time and effort, whereas the Geological Survey might present a stiff bill. Once a suite of minerals has been washed and sorted out, it can readily be presented to people like Daphne Ross for powder X-ray diffraction, Eugene Jarosewich for the electron microprobe, Sorena Sorensen for cathodoluminescence. A cathode-ray tube shoots electrons into a sample, and, in Sorensen's words, "images the presence of trace elements." She remarks on her astonishment at the role mineralogy can play: "You can fingerprint soil samples from a crime scene. You see how special two rocks a hundred metres apart can be."

For some F.B.I. geologists, Connecticut Avenue could not be called convenient. Ron Rawalt lives on the South Platte River, in North Platte, Nebraska, where he and his wife have three children and ten acres. "I like walking around out there. The gravel is definitely of granitic origin: a lot of tourmaline gravel, a lot of feldspar—the white and the pink feldspars, the cleaved crystals. It's just a pretty sand and a pretty gravel. With that are all your micas that are inherently associated with your granites. It's a sparkling bed through the water, all the flat faces reflecting the sun."

Rawalt is a large, competent, confident man of the sort you'd expect to encounter if you were a halfback running a football. He has full cheeks, green eyes, and curly brown hair down over his forehead, flecking gray. His shirts

button down. His suits are conservative, and rumpled from the road. He has a dark tie with Disney characters on it playing golf. Years ago, he testified in a Mississippi assault trial after police reluctantly mailed soil samples to the F.B.I. The police had accused a man of stalking a former girlfriend and shooting her through a window of her house, maiming her, after which, they surmised, he ran a mile to his car. The Mississippi police sent Rawalt a number of soil samples without saying which was which or where any of them were from, or telling him much of the story. They included samples from under the car. They included soil from the knee of the defendant's pants, which he had apparently smeared when he fell, running. Rawalt's report singled out the knee stain and matched it to the topography. It labelled the other samples and described the actions they implied. When he arrived in Mississippi to testify, a sheriff generously said to him, "You convinced us. You separated the soils and you told us which soil came from the wheel rut, and you also showed that a mud puddle was splashed on afterward. And out of all those soil samples you picked the one that showed where his knee slid on the side of the hill. You convinced us."

Rawalt said, "What did you think I was going to do—lie for you?"

His name is pronounced "Ray Walt." He was born near Chadron, Nebraska, southeast of the Black Hills. ("I grew up playing in the White River Oligocene north of town, digging fossils.") At

Chadron State College, in 1971, he wrote his senior thesis on the recataloguing of fossils. While he was doing graduate work in geology at Colorado State University, he heard that the government was looking for geologists to do mineral studies in Vietnam. He applied, was accepted, and then found out that "government" meant "C.I.A." and that the relevant geology was in enemy territory. He applied instead to the F.B.I.

was kidnapped in Guadalajara. It had been a street abduction in noonday sun, and witnesses said that two vehicles seemed to be involved—a Volkswagen Atlantic and a Mercury Gran Marquis. A month went by while the White House, the State Department, and half the agencies in Washington put great pressure on the Mexican government and the Mexican Federal Judicial Police to find the agent and resolve the case. Fi-

story was repeated. In early morning, he went out to his mailbox for the newspaper, and stood there absorbing what it said. The footage from the scene had showed bodies lying on the ground and covered with sheets. To him it seemed obvious that someone had dumped them there, because they were not being excavated from a burial site. It was reported that the bodies had soil adhering to them and, with respect to the ground around



When the Mexican government displayed the bodies it found, a geologist watching TV noticed that something was wrong.

The Justice Department's Drug Enforcement Administration was established at about the same time. Over the years, the D.E.A. would make frequent requests of F.B.I. geologists. "An airplane is found abandoned someplace. They want to know if it took off from a sandbar in a river in central Colombia, based on the sands there. Sometimes we've been able to do that, from soil on the underside of the aircraft that got kicked up in the wheel-well sand." In 1985, Rawalt was working at the F.B.I. in Washington when a D.E.A. agent

nally came the day when the television news was full of revelation. The bodies of the American agent Enrique Camarena Salazar and Alfredo Zavala Avelar, a pilot who helped him do clandestine surveillance, had been found on a ranch in Michoacán. There had been a shootout between police and a family named Bravo—small-scale drug runners, who owned the ranch. Every person on the ranch was killed in the raid—husband, wife, three sons. An M.F.J.P. officer had been killed. Rawalt watched the television coverage, and watched again as the

them, the colors were not the same. The dirt on the bodies was dark, the soil of the ranchland light. "The authorities' side of the story was that the Federales, the M.F.J.P., had received a tip on where Camarena's buried body—that was the key word, 'buried' body—would be located. And they went there and found the bodies. Case solved and closed. This was a premier case. We wanted that body back. Alive or dead, we wanted Camarena back. The Mexicans had to come up with a way of returning the body in such a way that it would take the



"O.K. Will somebody please bring me up to date?"

pressure off of them and get our government off their back. The Mexican federal police 'solved the case' through the location of the bodies and the execution of witnesses who would have said, 'We don't know anything about it.'

Rawalt called F.B.I. headquarters and asked the switchboard to connect him to the United States Embassy in Mexico City. Eventually, he got through to a sleepy man—possibly an assistant to the Ambassador—and told him he felt that he could prove through the soil alone that Camarena had not been buried at the Bravo ranch. He believed that he could prove as well that the site of exhumation was nowhere near the Bravo ranch. He just needed the minerals—samples of the soils. He added, "I think it's an absolutely transparent ploy by the Mexican government to placate us. That's my goal—to show a coverup."

The Camarena story was extensively covered in every news medium, and it also served as the structural framework of an exhaustive study by Elaine Shannon called "Desperados: Latin Drug Lords, U.S. Lawmen, and the War America Can't Win" (Viking, 1988). A television movie was made from her book. Needless to say, I don't intend to encapsulate either the film or Shannon's

five hundred pages but merely to offer as a supplement the details of the forensic geology. Trials resulting from the Camarena case continued into the nineteen-nineties. The United States, doing all it could to bring accomplices before American juries, arrested people north of the border when opportunities arose. Eight were tried on charges that included murder. Forensic evidence of various kinds resulted in seven convictions. Until the trials were over, Rawalt and his geological colleagues refused all interviews about the subject.

"Next thing I know, it's Monday morning and I'm up in my assistant director's front office and he wants to know where I got this theory of a coverup. He has heard from the Department of State, and he is asking me to explain where I am getting this all-encompassing knowledge from that I am making these phone calls to Mexico. I admitted what I had done. He said, 'It would be nice if you would let us know before you make these wild calls. It's been discussed at the White House. But it seems like people agree that you've put your finger on what's going on, and if you think you can do something it's your case. You're going to be going to Mexico as soon as the soil samples get back here and you can do a

comparison. Pick your team—anybody you want. D.E.A. will cooperate. They'll get you in and out of the country.'

The samples were collected in the Guadalajara morgue by an F.B.I. agent named Jack Dillon, posing as a D.E.A. agent. From Camarena's skin, and from his clothing nearby, Dillon took about a teaspoon of earth. Camarena's body had been found in a state of advanced decomposition. In arid ground, dehydrating, it had begun to undergo the process known as mummification. The skin resembled leather. In his skull was a double concave fracture, resembling broken glass. Because of his ability to cultivate informants, Camarena—young, beefy, garrulous—had been one of the D.E.A.'s most effective agents.

In Washington, Rawalt looked at the samples. As he had read in the newspaper, the soil from Camarena's body was dark. It was actually wet. Adipose tissue had come through the skin and had caused the soil to stick together in small lumps. Moisture darkens soil, of course, and he needed to give the D.E.A. correct guidance on color, which he could not do without removing the fatty tissue from the minerals. Chemists at the F.B.I. had an oxygen plasma-reduction unit. In Rawalt's words, "It rusts body tissue. It causes carbon to rust. It replaces the oxygen radical for the carbon radical, burns the carbon radical off, and leaves a light-gray powder. It decomposes body material." A lump of the soil from Camarena's body spent eight hours in the plasma-reduction unit. "They've got oxygen set up with a pump, and they're evacuating the atmosphere, and doing all kinds of stuff, and—lo and behold—the thing came out ash gray. That was from the oxidation of the tissue. I used these little air pumps for dusting off optics. You could sit there and blow the gray away and see the soil underneath it. By systematically reducing the lump, a little bit at a time, and blowing the tissue away in the form of gray dust, I got down to the soil color. I'd never done that before, and to my knowledge it's

never been done again.” Color contrast was what had caused him, in the first place, to telephone the Embassy in Mexico City. Now, oddly, the contrast turned out to be the reverse of what had been reported. The rock of the Bravo soil, cleaned for inspection, was a globular obsidian, very dark greenish gray. The soil off the body was a sharp tuffaceous vesicular glass, tan to white in color. “There was a world of difference between the two. You didn’t have to look at them for their mineral composition to know that these things were not even remotely close.”

Rawalt, of course, did look at them for their mineral composition. The intended contribution of the forensic geology was to help guide the investigation, and to provide trial evidence if there ever was a trial. His immediate goals were to disprove the statement by the Mexican government that the Bravo ranch was the place where Camarena died and to suggest, if possible, where the body might have been buried. To do all that, he’d need more than contrasting colors.

The Bravo soil of Michoacán was no less volcanic than the soil on the body, but the volcanoes were different. The Bravo minerals were much coarser, heavier-grained, sluglike, rounded, and dirty (from trace substances trapped in the glass). There was not nearly as much ash. The globularity of the grains spoke of slow deposition in a sedimentary basin, of water deposits interlayered with ash flows from intermittent volcanic events. The soil from Camarena spoke of mountains.

Roughly ninety-eight per cent was tuffaceous windblown rhyolite ash. Rawalt’s attention would settle on less than one per cent. The ash was very clean, high in silica, angular, vesicular. It had come out of a volcanic explosion as a fluid and had cooled suddenly as it sailed through the air. It could also be described as airfall pumice. Among the minor components of the Camarena soil were a notable concentration of bixbyite, blacker than coal, and a pink glass of exceptional depth and richness of color. (“I’d never seen anything quite like it, except in candy. I had worked with pink garnet, pink zircons—they don’t look the same.”) Less in quantity—and therefore of greater forensic value—were two kinds of cristo-

balite: opalized and clear. You might wander all over central Mexico occasionally finding one or the other form of cristobalite. You’d be getting pretty warm if you found two. The cristobalite crystals were elongate and faceted—clear polygonal columns. Octahedrons. To Rawalt, they resembled branch coral. They had developed in the volcanic explosion when, as molten material, they were forced into the vesicles in the tuffaceous glass. “It’s like filling a straw. And then it cools slowly, insulated by the glass, and it goes back into a crystalline state. The reason some is opalized is that there’s a high percentage of water in it when it is crystallizing. A lot of the glass in Camarena’s stuff actually had the cristobalite still inside it. Weathering mechanics can break the tuff, and then the cristobalite is freed. But a lot of the tuffaceous rhyolite glass had cristobalite still within it. You could see the vesicles full of cristobalite. For us, it was the big indicator.”

Rawalt went to the library of the United States Geological Survey, in Reston, Virginia, and studied maps and scientific papers that related to the region of Guadalajara. He was looking for rhyolite sources in high ground, which for central Mexico was to some extent like looking for pavement in New York City. But you started with that, and then used the bixbyite, the cristobalite, the rose glass to narrow it down. His colleague Chris Fiedler once outlined the problem by saying, “Initially you have the whole country of Mexico in which to find where a teaspoon of soil came from.” In the *Journal of Volcanology & Geothermal Research*, Rawalt found a thirty-one-page paper by Gail Mahood, then of Berkeley, now of Stanford, on the “Geological Evolution of a Pleistocene Rhyolitic Center—Sierra La Primavera, Jalisco, Mexico.” With its maps, charts, and cross-sections, it widened his eyes from the abstract onward. It described the types of sedimentary soil he was looking for: the airfall pumice, the caldera-lake sediments that would contain the pinkish material.



He went to the Smithsonian to review with the mineralogists there the results of his mineral studies. He was referred to a young woman who had done volcanological field work in the Guadalajara area and was at the Smithsonian at the time. As Rawalt began to explain the mineralogy he was working with, and mentioned the unusual hue of the rose glass, she immediately said that she recognized what he was talking about and that the minerals were specific to a Jalisco state park called Bosques de la Primavera. “She said, ‘This is Primavera-park soil. This red-pink-type glass that you’re talking about is a result of a third-event caldera formation. It was not extensive. It was confined just to the park and its slopes—the mountain itself.’ And then we take the map, and she highlights the outcrops of rhyolite that will be upslope and in general conjunction with the mineralogy I’m looking for.”

Not long after Rawalt turned in his results, he was called to the assistant director’s office and told that he and three forensic scientists in other disciplines were to go to Mexico as soon as possible. “That meant, ‘Do not go home and pack. Go to the airport right now. D.E.A. is waiting. They have an aircraft in Dallas. They’re going to take you in.’ We picked up stores from the disaster squad—clothing and stuff—downstairs. I took a small microscope, sufficient chemicals, cleansing solutions, and instruments. In Dallas, we got on a D.E.A. aircraft. It was a twin-engine turboprop, but its ground speed was about five hundred miles an hour. We hit the border and that pilot put that plane right on the desert, and we flew down under the Mexican radar. We went into a canyon a lot bigger than the Grand Canyon. We flew below the rims of other canyons, too. We landed in Guadalajara. We did not have permission to come into the country. F.B.I. was not allowed in the country. D.E.A. was. We were not to admit our identity. The D.E.A. bribed the Mexican customs officials—paid them cash not to look in our bags and not to ask who we were and why we were there, paid them cash just openly, right there at the airport.” The twin-engine turboprop had been seized in the United States. It had belonged to a Mexican drug trafficker of the first order, whose name was Rafael Caro Quintero.

Rawalt stayed at the Hyatt Regency, in downtown Guadalajara. On his first

night there, an officer of the Mexican Federal Judicial Police knocked on the door of his room. Rawalt opened the door. The M.F.J.P. man greeted him warmly and told him that he was in charge of making sure that Rawalt and the others were comfortable. "He wanted to know what I wanted. Did I need a little cocaine? Did I need a woman? Did I need a young boy? What did I want? He was to get it for me. I told him he had the wrong room and shut the door in his face."

A connotative beginning with Mexican authority. In the concentrated effort to solve the case of the American agent, the Drug Enforcement Administration's principal official colleagues were local, state, and federal Mexican police, not to mention government ministers and the Federal Security Directorate, or D.F.S. (D.F.S. = C.I.A.) As Elaine Shannon's "Desperados" documents thoroughly, especially with reference to Mexico, there was not a government agency, in law enforcement or otherwise, that did not in some way repose in the drug economy. In the war on drugs, it was impossible to tell from a uniform which side the wearer represented. With respect to who was and who was not being enriched by drug traffickers, the collective personnel in the list above were like shaken salt and sugar. A D.F.S. badge could quell inquiry anywhere in the country. The drug traffickers easily bought D.F.S. badges. "It's the top form of identification," Rawalt once said. "They paid millions and millions of dollars for their people to be issued these badges, so they could run through the country with impunity. They didn't have to worry about anybody stopping them." They could snatch an American agent off a street, hold him prisoner, torture him, crush his skull, and dispose of the body, even in the presence of "authorities." More than one M.F.J.P. officer was to tell Rawalt that Camarena had died of natural causes.

The intense American interest shown in Camarena's disappearance seems to have been baffling from the Mexican point of view. Others had vanished who were presumed American agents and much less fuss resulted. Americans had gone into Mexico never to be heard from again, and the news media did not seem to care. Scarcely a week before Camarena was kidnapped, a couple of Ameri-

cans named Alberto Radelat and John Walker happened into a traffickers' party in a Guadalajara restaurant. The traffickers took them for D.E.A. agents infiltrating the neighborhood and tortured them and killed them. This had not produced a similar hue and cry. Eight weeks earlier, four American missionaries going door to door in Guadalajara had lifted the wrong latch. Drug-enforcement agents in California had been known to pose as geologists, so who was it that these missionaries were working for? They disappeared and their bodies were not to be found. In all, six American presumed agents had been killed by the traffickers in recent weeks. So why were the White House, the State Department, and the American press creating so much pressure now? "When this firestorm hit, the Mexicans didn't understand what was going on," Rawalt says. "They had killed seven, and we were interested in just one." In Guadalajara, Rawalt was asked in English by a mid-level officer of the M.F.J.P. to explain to him what the problem was. "I explained to him that in our country when you kill a law-enforcement officer it incenses the American public and becomes an important case. When you kill a federal agent, it incenses the American public. And we don't stand for that. He said he could not understand what the big deal was, because, he told me, in the M.F.J.P. they lost about two hundred officers a year in drug shootouts and retaliation murders. To them, it was a way of life."

It was believed that Camarena's unauthorized flights over marijuana fields in Chihuahua had led to incendiary raids and the destruction of a crop worth three hundred million dollars. The two marijuana-and-cocaine traffickers who had lost the most were Rafael Caro Quintero (former owner of the airplane that carried Rawalt under the rimrocks into Mexico) and Ernesto Fonseca Carrillo. From Day One, they were seen as the principal perpetrators of Camarena's disappearance. On Day Three, Caro Quintero had left Mexico, seen off at the airport by Armando Pavón Reyes, *primer comandante* of the M.F.J.P., who, it turned out, received three hundred thousand dollars for letting him go. When the American firestorm was burning high and the White House was calling and the State Department was calling



and the American press was swarming, a hundred Mexican troops surrounded a house where Fonseca was staying in Puerto Vallarta. A deafening gunfight began. It went on and on. It did not stop until the traffickers ran out of ammunition. When the smoke cleared, no one on either side had been hit. Fonseca, thereby captured, was jailed but not charged. A SWAT team snatched Caro Quintero from a villa in Costa Rica. Fonseca, of raptor face, was said to be a billionaire. The boyish curly-haired Caro Quintero could not have been worth more than five hundred million. They were incarcerated together in Mexico City in large comfortable rooms, where they kept fighting roosters and an arsenal of guns, gave parties with visiting female friends, and had their own chefs. In Rawalt's words, "They were being maintained by the Mexican government away from access by the American government."

Rawalt showed the D.E.A. investigators his maps and charts and mineralogy, and told them about the cristobalites and the rose glass. "These guys are— They don't know what I'm talking about. But they were convinced enough." With his hand in motion over a Jalisco state map, he said, "Here's where the guy was buried, right around this park. This is where we look. We don't go there, because this is where he is going to be." The most immediate effect of the mineralogy was to enable the D.E.A. to confront the Mexican government with evidence that the body had been moved and that the M.F.J.P.'s story of Bravo ranch was a fiction. When, or if, the true burial site was found, it would be up to Rawalt to match exactly the minerals of the site to the teaspoon of earth taken from the body—to present the forensic evidence matching body to grave. The D.E.A. had hypnotized a witness who had seen Camarena being beaten in a car heading south beyond the Guadalajara *periférico* (beltway). Under hypnosis, he remembered a part of the license plate. The D.E.A. wanted Rawalt to go south. "But the geology didn't match. It was not the right kind of soil. I did not have these large rhyolitic extrusions influencing the soil factors. We spent minimal time down there." Mexican television and newspapers were full of the story, and people were calling in and writing in to say where Camarena had been held and where he had been buried, and even to

report seeing him alive. The tips on burial sites included Cancún, the Chi-huahuan desert, and scattered stations along the primary cocaine-marijuana route through the west and north. The D.E.A. wanted Rawalt to check out these places. Rawalt resisted such coverage as often as he could. ("I'm convinced from the geology that we've got the area located. For me to convince myself to look somewhere else, I've got to duplicate what I already know is in their back yard. And killers are lazy. Why would they take a guy clear to northern Mexico to get rid of a body?")

He went first, of course, to the Bosques de la Primavera, a fire-swept country, arid six to nine months a year, where pine needles are exceptionally thin. Michael Malone, who had flown with him from Washington and was an expert in things like carpet fibres and hair, went along to assist him and to be with him if trouble should arise. The M.F.J.P. did not know that they were out there, let alone that they were F.B.I. "We were not to go anywhere without an M.F.J.P. escort. That was part of the rules of engagement, so to speak. We didn't trust them. We were well armed."

Malone and Rawalt had a pickup. In likely places, they put the tailgate down, and Rawalt set up a lab. "I could use a nonpolarized scope and immediately make a determination based on the cristobalite. If I'd been using some of the other indicating features, I would have had to have a pole scope to identify the minerals. I did have a small pole scope, but I was using ambient light. We had no power sources that we could hook up that scope to. The easy indicator was the cristobalite. We might pick thirty samples. We'd wash them up. We'd take a quick look at them under the microscope. For one reason or another, we'd eliminate them. What we tried to do was ballpark an area. We were looking for those key cristobalites and rose-colored-glass features. We started on the mountainside, up high. In soft soil, we started getting samples from the surface and a foot down and two feet down, looking for these things. I eliminated roughly four hundred soil samples. They just weren't the same. They were close. We had the type of glass. In some of them we had cristobalites—but not as much as we needed. Or we'd have rose glass with no cristobalite. Or we'd have the glass

CONGRESSIONALLY MANDATED THEMES FOR THE DAYTIME TALK SHOWS



"WIVES WHO MAKE ASPIC WHEN THEIR HUSBANDS ARE AWAY"



"IS MY BRIDGE PARTNER PSYCHIC?"



"I MARRIED A LOVABLE LUG WHO MAKES ME COFFEE"

but we wouldn't have the rhyolite. And we had to have them all. We did ditches, ravines, sides of roads. We went clear into the hot springs." In three days, they covered about twenty square miles. The Forest of Primavera was a few thousand square miles.

An informant told the D.E.A. that a Mercury Gran Marquis was sealed up behind a fresh wall of adobe across the front of a residential garage near the southern boundary of the park. Rawalt and four other F.B.I. agents went there and did a crime scene. There was blood in the car. Hair on a floor mat and on the back of the front seat matched hair that Jack Dillon had removed from Camarena in the morgue. The car derived from one of Caro Quintero's Mercury-Ford dealerships. Rawalt looked for the story that might be written on the undercarriage, but all he found were fine silts from numerous locations.

They went to Michoacán for a wider test of the Bravo ranchland. The ranch house was not a prototype of Mexican rural architecture. It had barred windows, gun slits, and walls half a metre thick. It was a fort. There were enough big bullet holes in the walls to house a flock of purple martins.

Malone and Rawalt were assigned, as "D.E.A. agents," to check out various addresses associated with Fonseca and Caro Quintero. On such missions, the M.F.J.P. was supposed to accompany

them. "By their actions, the M.F.J.P. told us how dangerous it was. When we'd go to a search, they'd disappear. They might escort you up there, but when it came to going into a house or going into a compound they disappeared. They were there for our protection, and to help us, yet they were absolutely working a hundred and eighty degrees from us at all times." Balking, the M.F.J.P. would point out the need for a search warrant. ("Don't even mention Mexico and a search warrant in the same breath.") The M.F.J.P. also warned that the houses and compounds could be full of *pistoleros*. Approaching a walled compound, Rawalt, Malone, and a couple of D.E.A. agents would knock, and when no one answered they'd open the place and gingerly go in. "We're talking about a fifteen-bedroom mansion with indoor pool, outdoor pool, and a twelve-foot-high wall—a compound with lights, and cameras on the corners, encompassing three to four acres, with big interior vegetable gardens, and servant quarters—like a small Alamo. We're armed to the teeth. I had a MAC 10—a little submachine gun—and a 9-mm. pistol. Mike had a handgun. When you're out, you're dressed with a machine gun and with a handgun. You were told that in essence you cannot trust anybody but the D.E.A. Your life is at danger. Do not go to dinner. Do not go for a job without going in groups. An easy way to

tell the good guys from the bad guys down there was by the armament they were carrying. M.F.J.P. officers are very open about to whom they owe their allegiance. If you're carrying an AK-47 rifle, that rifle comes up through Central America to the drug traffickers. That's where they get their weapons, and they pass the weapons on. One of the first things we looked for with the people who were supposedly guarding us and helping us was the type of weapons they were carrying. Here's an M.F.J.P. officer, and look what he's carrying—an AK-47. This is just flaunting the fact that he is there protecting the people in the drug trade—he's a traffickers' *pistolero*, he's also an M.F.J.P. officer. Time was danger down there. You hit a trafficker's house and the trafficker knew it—through the M.F.J.P. or through the peons who were working there who had taken off when we pulled up. Wasted time could mean a carload of *pistoleros* coming down the road for a gunfight."

In one compound, Malone was doing his fibre collecting and Rawalt his soil sampling when the M.F.J.P. appeared. Seeing that no one had been killed and no *pistoleros* were present, they entered the house. For three hours, while Malone and Rawalt went on collecting and sampling, the M.F.J.P. systematically rifled the place. They stole all the liquor, the food in the pantry, the television sets, and the parabolic dish off the top of the house. They took clothing, shoes, silverware. They pried a safe out of a wall. Rawalt and two D.E.A. agents were working in an upstairs room when a shot was fired. All three hit the floor, imagining forty *pistoleros*. Silence. Guns drawn, they got up warily and looked around. They looked out a window. The M.F.J.P. had shot a pig. They were putting it into the trunk of a car. A whole line of cars was there, bumper to bumper, trunks open, being loaded with household goods.

One day, the federal paradoxical police informed the D.E.A. that they had learned where Camarena had been held. The address was in central Guadalajara—881 Lope de Vega. Rawalt and Malone were asked to do the crime scene, as part of a D.E.A. team. When they arrived, NBC, ABC, and CBS were on the curb. There were trucks with dishes pointed at the sky. Rawalt recalls



"You look as if you don't expect fireworks, you act as if you don't expect fireworks, you say you don't expect fireworks. But something tells me you expect fireworks."

his reaction when he first glimpsed the house and compound: "It's a logical place to hold a person. Because what's it look like? It looks like a jail." The walls were eighteen-inch adobe. Every window was blocked by white-painted iron bars. The doors, inches thick, were reinforced with metal strapping. After the house, courtyard, guesthouse, arcade, and swimming pool came a tennis court bordered with jaguars. These were not motorcars. They were living black and spotted jaguars, in six cages. Also beside the tennis court was a Volkswagen Atlantic with no license plates.

Indoors, fresh paint was on most of the wall space, entombing fingerprints. Rooms had been swept spotless. The main power line had been cut. "They knew we processed with vacuum cleaners—they'd seen us doing it at other houses. We put on heavy gloves and spliced the ends—hooked those babies together and taped them up with evidence tape." Still no power. The fuses, which were of the screw-in type, had all been removed. This was late in the day, light fading. Rawalt put copper coins in the fuse sockets and rammed them in with the wooden handle of a mop. Every coin welded. The lights now worked. They turned on their vacuum cleaner.

The lawn had been completely raked, but a pile of leaves had been left there. Among the leaves was an order to the commandant of the M.F.J.P. to supply ammunition to the drug traffickers. The water in the pool was opaque. Rawalt explored the bottom with a broom handle. It was overrun with bottles and cans. Water would not erase fingerprints. Rawalt asked the M.F.J.P. for a pump from a firehouse. The M.F.J.P. said no. He found a pump in the pool house, rigged it up, and started it. An M.F.J.P. officer kicked the pump into the pool. Before anyone could return with another pump, the pool had been emptied and scrubbed.

The guesthouse was a cell within a fort, with its own barred windows and a half-inch boilerplate door. The vacuum cleaner picked up hair from the guesthouse carpet that would match Camarena's. In the bathroom, the lower six feet of tile was bright and clean. The tiles above were grimy. Among traffickers who sought information or confession from a captive, a routine method of torture was Tickle the Bone. Icepicks are

run into knee joints, elbows, vertebrae, and elsewhere and then scraped on the bone. There was the Pepsi Challenge. Rawalt's description: "Tie a person to a chair, shake up a bottle of Pepsi, and shove it up the nose. Shooting that into your lungs under high pressure gives you the sensation of drowning. You'll confess to anything. Yet there's no scars or marks. I asked one of the M.F.J.P. officers if they really used that treatment, and he says, 'Of course not. We don't use Pepsi or Coke. They stain your clothes. We use seltzer water.'" An informant eventually told the D.E.A. that a doctor had assisted in the interrogation of Camarena. The doctor had used painkillers, so the traffickers could stretch out the beating and questioning. After a dry-cleaning bag was used to suffocate Camarena and take him near death, the doctor would be there to revive him. Rawalt found a cleaning bag in a closet, and an acid bottle as well. Evidently, the prisoner had been burned with acid.

Rounding a stair landing in the main house, Rawalt suddenly felt an M16 in his stomach, prodding. He was prodded to admit that he was not a D.E.A. agent, that he was really from the F.B.I. He didn't admit.

On the day of Camarena's abduction, an M.F.J.P. officer had used the Volkswagen to pick up some dry cleaning. He was given a dated receipt. He slipped the receipt under the weather sealing of the VW's trunk, where Rawalt now found it. In the trunk was blood that matched Camarena's and two strands of his hair.

In a drain beside the tennis court, Rawalt noticed a license plate folded in half. He asked for a crowbar to lift the grating. Alarmed and hostile, an M.F.J.P. officer refused. A crowbar was improvised, and the grating was lifted. The M.F.J.P. radioed for backup. The Americans photographed the license plate. Federales came in force and demanded the plate. Rawalt refused. He describes the situation as "a classical Mexican standoff," and continues the story: "Their guns were off their shoulders. I was told by our legate, 'You have no choice, turn it over to them.'" Beyond the caged jaguars Rawalt noticed *pistoleros*, their guns trained on him. Mike

Malone, seeing the confrontation, had begun to worry about losing collected evidence. While the M.F.J.P. and Rawalt were squared off by the pool, Malone was loading evidence into a D.E.A. truck. An agent drove the truck to the American Consulate and locked the evidence in a vault.

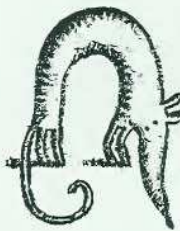
SOME months earlier, a representative of a California aerospace company had approached the F.B.I. in behalf of the company's French consultant, Loic Le Ribault. The representative said that Le Ribault was the head petrologist for the French national oil company, had his own aerospace group, and was very wealthy. He wanted to get into forensics, because he could do things to solve cases that other people could not do. Show him a few grains of sand and he could tell you where they were from. He had tried to interest the national crime laboratories of France and Great Britain but had failed. He felt sure that if the F.B.I. showed interest others would follow. He called his work exoscopy.

The F.B.I. said, "A few grains?"

Le Ribault's representative said, "Test him. Just test him. Give me three samples."

While the man waited, the F.B.I. geologists—Fiedler, Rawalt, and others—conferred. Into a pillbox they put some ash from Mt. St. Helens. Into another they put alluvium from a river delta in South Carolina that related to a recent murder. What to put into the third pillbox? Across the hall were some girders from the Marine Corps barracks that was bombed in Beirut. Rawalt remembered noticing that dirt had been blasted into the girders. He scraped some out and boxed it.

A few weeks later, a spiral binder arrived from La Teste de Buch, a town in the Médoc. The cover said "Exoscopic Study of 3 Samples of Sands, by Loic Le Ribault." It was vintage stuff, so good it was hard to swallow. The F.B.I. had collected samples of Mt. St. Helens ash from all over the West to record size and particle distribution and depositional cycles, because the ash would become a factor in soils at crime scenes. Le Ribault's study said that Sample 1 was Mt. St. Helens ash and had been deposited on an angle within a hundred miles of



the volcano. "He hit it within a couple of miles," Rawalt says. "We called the senior resident agent who collected the ash and said, 'Where'd you get it?' He says, 'It was on the hood of my car. I was parked out there on a slope.'" Sample 2, according to Le Ribault's report, came from a river basin in the American Southeast and with geologic maps of sufficient scale the location could be pointed out. The third sample was baffling, the report admitted, and what follows here is Rawalt's paraphrase of what Le Ribault wrote: "It's a pyroclastic event, a deposit under extreme force—an explosion. It can only be a short time since the deposition of this grain on a vertical surface. I have no idea where this one comes from, because the only place I can match this mineral grain to—any place in the world that I can find—is in the Bekáa Valley in Lebanon, and of course the F.B.I. does not do cases in Lebanon. So I have no idea where it comes from." After the F.B.I. geologists had finished reading the report, someone said, "We need to talk to this man."

Rawalt remembers Le Ribault as "a short little guy, early fifties, very jovial, with sharp features, who talked a mile a minute." Le Ribault brought an interpreter with him to the F.B.I.'s Forensic Science Research and Training Center, in Quantico, Virginia. In a scanning electron microscope, he looked at quartz from Camarena's body—ordinary quartz, out of the rhyolite. He blew it up ten thousand times and read the sign on its surfaces. Water dissolves quartz, slowly but certainly. Water leaching into soil dissolves some of the quartz in a mineral grain, and as the silica-rich solution dries off it recrystallizes. In supermagnification, you can see the subcrystallization, as the surface change is called, and as the subcrystallization varies it tells varying stories. If it is all over the grain, the grain was deposited in water. If it is on the top of the grain at such-and-such an angle, the mountainside was steep there. "He'll take a single grain and tell you the angle of deposition, how long it's been there, and where it comes from," Rawalt continues. "He also looks at the solubility of the quartz, and he looks at the surfaces to see how much they've been eroded by water. From his experience, he can tell you the nature of the exposure to environmental factors, and from his experi-

ence he makes a conclusion. The knowledge of how quartz dissolves and recrystallizes is the basis for his whole exoscopy science."

During the week that Le Ribault spent at Quantico, earth samples kept pouring in from the D.E.A. in Mexico—all negative. Standing before the scanning electron microscope—on its screen a quartz grain like a large map—Le Ribault said, "You have a rhyolite outcrop up a slope."

Rawalt said, "Yes, we've already figured that out."

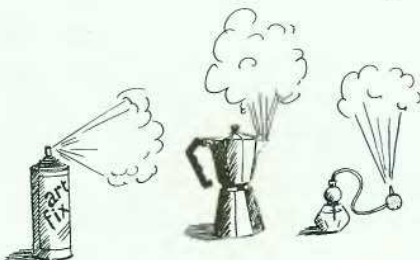
Le Ribault had been given three of the samples that Rawalt had collected in the Forest of Primavera, as well as earth from Camarena's body. On a map Rawalt showed Le Ribault where he had collected the samples. Le Ribault said, "You're there, but not quite. You're at about the right elevation in the park, and at about the right angle of slope on which this quartz grain was deposited. The style of deposition and the depth are right. You're there, but you're not there. These are from an area washing north. The burial site was in an area washing south." Le Ribault continued, "This rhyolitic-base sand was deposited by water. It was deposited around four to five feet deep. The crystallography says that it came from a draw. The slope of the draw is less than ten degrees. Shade predominates there. When you go back, it may help to note that the outcrop this sand derives from is four thousand feet above the site where the body was buried."

Le Ribault made a large contribution to Rawalt's confidence and, with regard to the story that Camarena had been killed and buried at the Bravo ranch, he underscored the Mexican farce. At increased volume, the D.E.A. could repeat to the M.F.J.P. that their scenario was phony. The D.E.A., in need of continuing guidance from the forensic work of the F.B.I., pleaded with the Mexican government to let Malone and Rawalt return to the country as acknowledged

F.B.I. agents—Rawalt to continue working in the Bosques de la Primavera. No response was forthcoming. Then a D.E.A. agent in Mexico called Washington to say, "We have Radelat and Walker's pit, or are going to." The D.E.A. had a new informant, who said he could show them where the car had been parked when the bodies of the Americans had been carried into the forest. The assistant director of the F.B.I. Laboratory appealed directly to the Attorney General of Mexico to permit Rawalt and Malone to return. The Attorney General's reply was that Rawalt could come but Malone could not. Rawalt speculates that the Mexicans were made especially uneasy by Malone's carpet work—his vacuum cleaner, his hair-and-fibre work—but could not imagine being inconvenienced by anything a geologist might do.

The site was on a southerly slope in Primavera, up a thoroughfare that resembled a mule trail more than a road. A short distance into the forest was a draw, a wash, its gradient less than ten degrees. It was shaded by tall trees. To the immediate north, and four thousand feet above, were extensive rhyolite outcrops. The rainy season had arrived. The air was densely humid and hot. A stench of human and animal decay was high enough to jam the throat. A horse rotting there looked like a balloon. The M.F.J.P. were already on the scene, with backhoe. Its bucket had disassembled the bodies of Radelat and Walker as it scooped them out. The digging had reached about five and a half feet down when Rawalt arrived. Seeing the backhoe, he thought, Nice forensic tool. Some ribs, vertebrae, and tissue were still in the pit. Rawalt removed them by hand. The M.F.J.P., a dozen in number and dead drunk, were engaged in a competitive game that involved cutting down the fine-needle pines with machine guns. Ammunition was everywhere. So potent were the smells of lead, cordite, powder, and decay that Rawalt had instantly developed a headache.

He supposed that Camarena and the pilot, Zavala, had been buried on top of Radelat and Walker. To compare mineralogies, he took soil samples from ground level down to the bottom of the pit. He set up his microscope and looked. At five feet, there was only a slight difference from the mineral suite off Cama-



rena's body. "There was a little bit too much iron content in that pit. A small lens of iron-rich sediment ran through there from an old dry streambed."

When the D.E.A. had called Washington to report on their latest informant, they had said that he knew where people had left the road carrying Radelat's and Walker's bodies but did not know exactly where the bodies were buried. There might be a need for dogs. The F.B.I. does not have cadaver dogs. Rawalt called a training center and learned the whereabouts of America's five best teams of cadaver dogs. From Tuscaloosa, Alabama, a team was soon in the air. On the ground in Primavera, they were initially useless. "Cadaver dogs work hungry," Rawalt explains. "They locate a cadaver because they like the smell and they like the taste. Their reward is to eat part of the 'proud flesh'—the remains. So they work hungry. The dogs that first day were just listless as hell. It turned out someone had fed them. All the dogs were just gorged on dog food."

Cadaver dogs work singly as well as hungry. On the following day, the first dog released showed attention to a small depression some yards up the draw from Radelat and Walker's open grave. The animal dug a little. It did not give a clear signal, but a new pit was worth trying. The pervasive odors of dead bodies made it all but impossible for a dog to be unambiguous about a location so near. During the digging, Rawalt took samples at ground level and down through six or seven soil horizons. As the depth of the pit approached five feet, there was fresh high smell. If this was where Camarena had been buried, the opalescent and the clear cristobalite would be present in equal amounts. Under his microscope, as sample followed sample, that is what he saw. Given the two cristobalites, in balance, the next indicating feature would be the rose-colored quartz. It had the rhombohedral shape of a sugar crystal. He even wondered if, somehow, sugar was what he was looking at. He culled out some crystals and tried to dissolve them. They would not dissolve. What he was seeing in his microscope was not candy. "Almost pink-red, usually a negative crystal, it was just brilliant." The slight difference was no longer there. He was matching the soil that Jack Dillon had removed from Camarena's body in the morgue. ♦

PORTFOLIO BY ANNIE LEIBOVITZ

SHOWGIRLS

ONE of the unwritten laws of Hollywood is "If you build it, we will come." In 1931, the Empire State Building was completed; in 1933, King Kong clambered up it. So it is with Las Vegas, which by the end of 1994 had transformed itself from Sin City to a kind of Slot Machine Disneyland. What the Mob had built, the corporations had rebuilt; where once crook-nosed goons had cavorted among the fleshpots, now kids played on thrill rides while their parents squandered the bank account at the roulette tables. The old Las Vegas was tawdry and crass, but there was nothing like it anywhere else. Now something extraordinary has become rather ordinary. And last year several movies, good and bad, contemplated the change: "Leaving Las Vegas," "Casino," and "Showgirls" were, in varying degrees, laments for a city's lost romance.

Yet tatters of that romance remain. There are still casinos that don't pretend to be amusement parks. And there are still showrooms where, every night, customers watch the sort of vulgar, eye-popping musical production numbers that Vegas used to be famous for—where the ordinary becomes extraordinary again. That is what the following portfolio of photographs by Annie Leibovitz is about. The women in these pictures are performers from the "Jubilee!" show at Bally's Hotel and the "Enter the Night" show at the Stardust. Except for the woman in the first pair of pictures, they are married; two of them have children; all of them work six days a week, two shows a night, for a salary ranging from around five hundred to eight hundred dollars a week.

They call themselves "showgirls," which means that, unlike "dancers," they perform topless. In exchange, they get flashier costumes, greater prominence in the show, and an extra fifty dollars a week. Their feathers alone can cost as much as five or six thousand dollars, and bearing them with the proper liquid hauteur around the stage's

runway, or *passerelle*, requires a particular skill. "We have a special showgirl walk," Narelle Brennan, the woman in the fourth pair of photographs, says. "You keep your whole body to the front, and your legs are crossing. You can't have any open legs." Susan McNamara, in the first pair of photographs, adds, "In these Vegas shows, they want that feeling that you're untouchable. It's 'Here I am, look at me, but I'm not for you.' It's fun, because it's not a side of me that I am in life."

In life, she, like the other women here, is a trained dancer; she spent three years with Nevada Dance Theatre. The woman in the second pair of pictures, Linda Green, danced with the Harkness Ballet. She is the only member of the original cast of "Jubilee!" who is still in the show, and there are not many companies that would have allowed her to keep working as long as she has—she is now forty-two. Narelle Brennan, who is Australian, trained for ten years in ballet, tap, jazz, and Highland dancing. In fact, the only one who doesn't regard herself as a serious dancer is Akke Alma, the woman in the third pair of photographs.

Alma, who is Dutch, is familiar to Las Vegas habitués, because her likeness adorns the tail of one of Western Pacific's airplanes, and billboards all over town proclaim her "A Showgirl for the 21st Century." Alma speaks five languages, takes correspondence courses in Dutch law, and is married to a film professor at the University of Nevada; she starred in his most recent short film. "Onstage, it's not only about dancing," she says. "It's about personality"—by which she means what used to be called "sex appeal." The showgirls of the 20th Century view themselves somewhat differently. "I wear these big white feathers at the end," Linda Green says. "And I look at people and they're looking up at me, and I see tears in their eyes sometimes. The way it's lit and sparkly—they're looking at me like I'm this brilliant white angel."

—STEPHEN SCHIFF