VISIT TO A COMFORTABLE CALDERA

Bruce Finson

(NEWBERRY)

Photographs by the author

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WE HAD driven halfway around the rim of Crater Lake, stopping now and then to peer down the steep lava slopes at the jewel-blue water, to feel the hardness and texture of the volcanic rocks near the road, and to take pictures of the fantastic erosional buttes and spires. We had found it difficult to do anything but gawk; Crater Lake is astonishing in the suddenness of its steep appearance after the winding climb through green forests with dim white snow patches interspaced among the trees. We did not stay long at the rim. Our purpose was not to do a detailed study of this most famous caldera, but to get a quick view of its overall shape and feeling for comparison with its almost equally-huge but less-known neighbor to the north, the Newberry Caldera, largest of the ice-age volcanoes east of the Cascades.

It had been a long day of exploring. My camper—a converted delivery van—held two tired children and a restless dog. We had left Mount Lassen in the morning, stopped for a brief hike through Burney Falls canyon, and driven around three sides of Mount Shasta on our way to Oregon. Near Klamath Falls we had stopped while a heavy hailstorm beat a thunder of steel drums on the car roof. And on the way up the slope to Crater Lake we had stopped for a pleasanter purpose—a midsummer frolic in the snow. Now we had seen Crater Lake, however briefly, and at the moment wanted nothing more than a comfortable campground for a night's rest before going on to the Newberry area. We found our campground by the warm waters of Diamond Lake, just a few miles north of Crater Lake National Park.

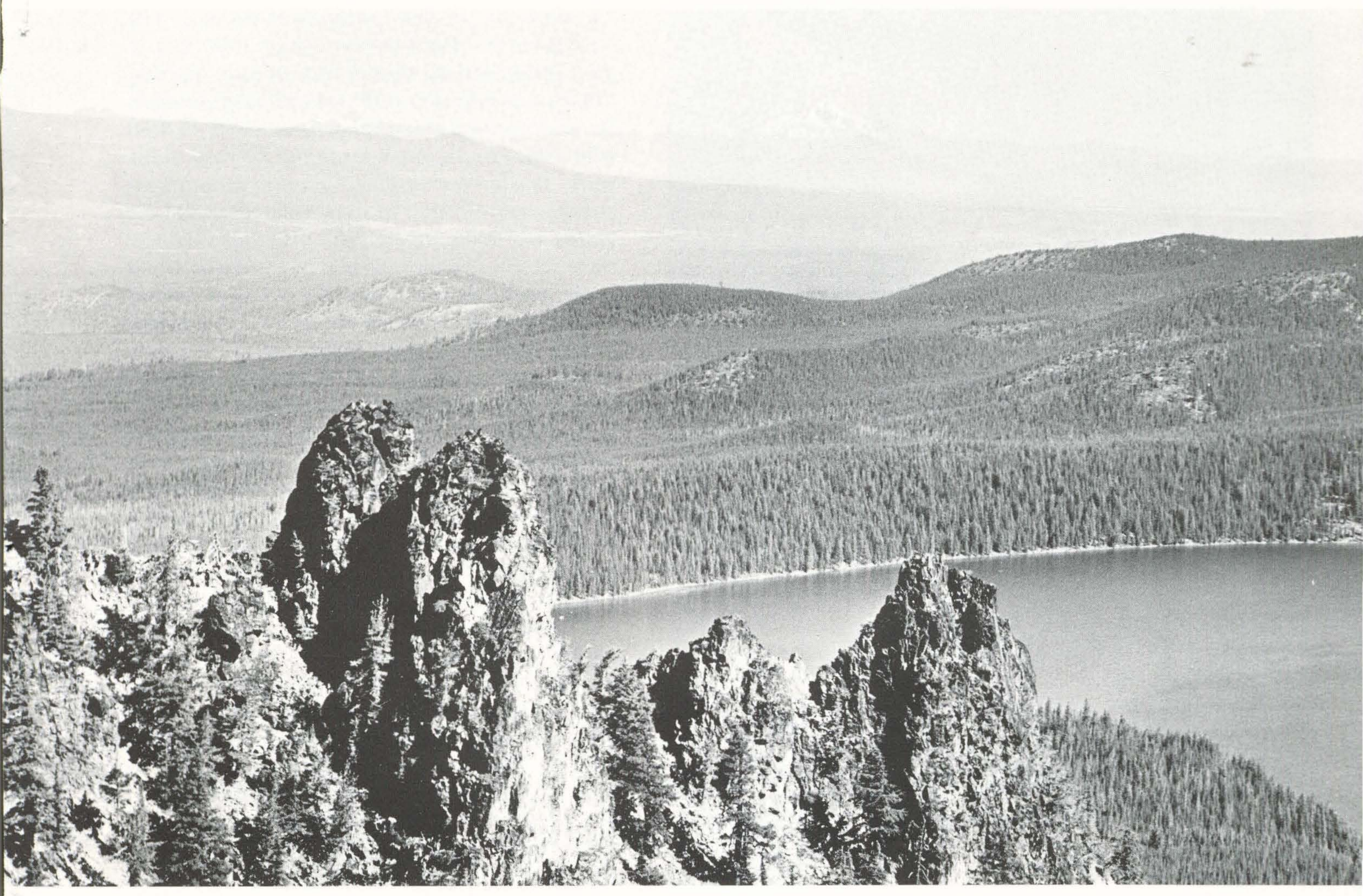
In the morning, after a sunrise swim with pumice chunks for water balls, we broke camp and drove through national forest land on U. S. 97. In an hour we were at the turnoff to the Paulinas, about five miles north of Lapine and twenty-five miles south of Bend. We filled up on gas and water, checked our camping provisions, and headed east on the good blacktop road. Our elevation at the turnoff was 4200 feet; the guard station at Paulina Lake, inside the caldera, was only twelve miles away but 2100 feet higher, at 6300 feet.

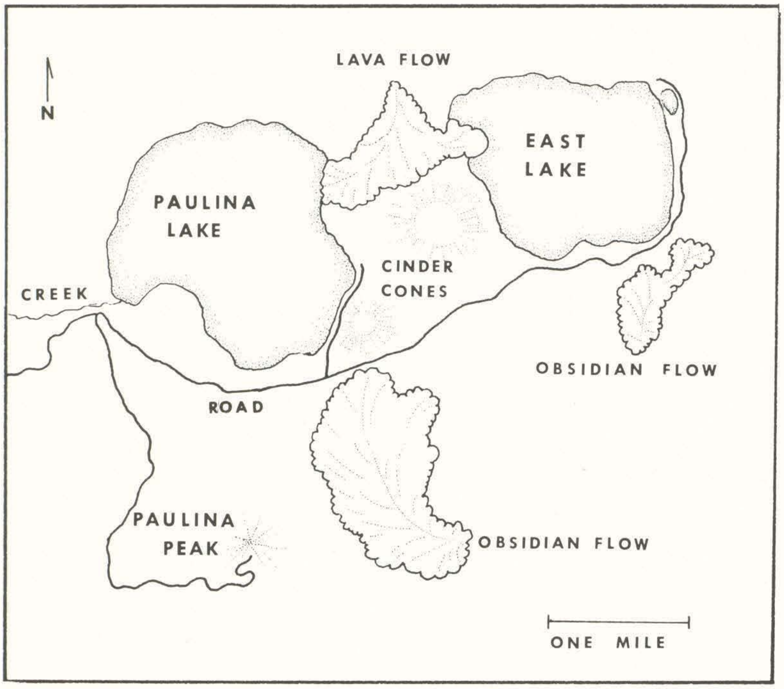
For the first couple of miles the road was level.

Above, Paulina Peak, highest point on the rim of Newberry Caldera, rises steeply to 7900 feet, 1500 feet above the crater lakes. This view is from East Lake. Right, on Paulina Peak are jagged spires of eroded lava. The first row of hills beyond Lake Paulina is the caldera rim, at most places only a few hundred feet high. Cascades peaks in background.

Then, just inside the border of Deschutes National Forest, the road began to climb. We crossed a stream, but did not realize at the time that this was Paulina Creek, outlet from the crater lake, on its way to join the Little Deschutes River just across the highway. The road was not a steep one; Newberry is a shield volcano, formed by many liquid outpourings of lava, and its form is that of a shallow dome rather than a steep mountain like Shasta or Lassen. So the drive up to the lake was a steady meandering climb up the gentle slope of the shield, with many bends and turns as we passed around one or another volcanic protuberance. But the steadiness of the climb, and the everchanging views of forest and sky afforded by the winding road, gave us the feeling that we were climbing onward and ever upward to a high and distant place, and brought us an awareness of the hugeness of this old volcano. It measures twenty-five miles across at the base; and the peaks and crags left when it collapsed into itself make a landscape feature distinctive enough on the Deschutes Plateau that it has been given its own name—the Paulina Mountains—as if it were a separate mountain range.

Finally we were at the top, then over the edge and looking down into the huge caldera. We were not much above the level of the lake, as the road comes in from the west through the only break in the steep caldera wall. It is through this break that Paulina Creek has its outlet, the water flowing only a short distance before it tumbles over a waterfall into the gorge of the river we had crossed on our way up. Although we could not see the entire caldera from our parking place by the guard station, we had a sense of quiet spaciousness as we looked across mile-wide Paulina Lake to the steep hills on the other side. To our right was the row of overlapping cinder cones that divided the caldera in half and hid landlocked East Lake from our view. Paulina is a fishing resort, having been stocked with trout in 1910, and there are commercial lodges as well as public campgrounds within the caldera. But we had arrived in midmorning, long past the hour of intense angling, and the lake had the sleepy peace of midday in midsummer. Coming over the lip of the caldera to this quiet lake with its forested slopes, we felt as if we had arrived at a separate world, a large and open



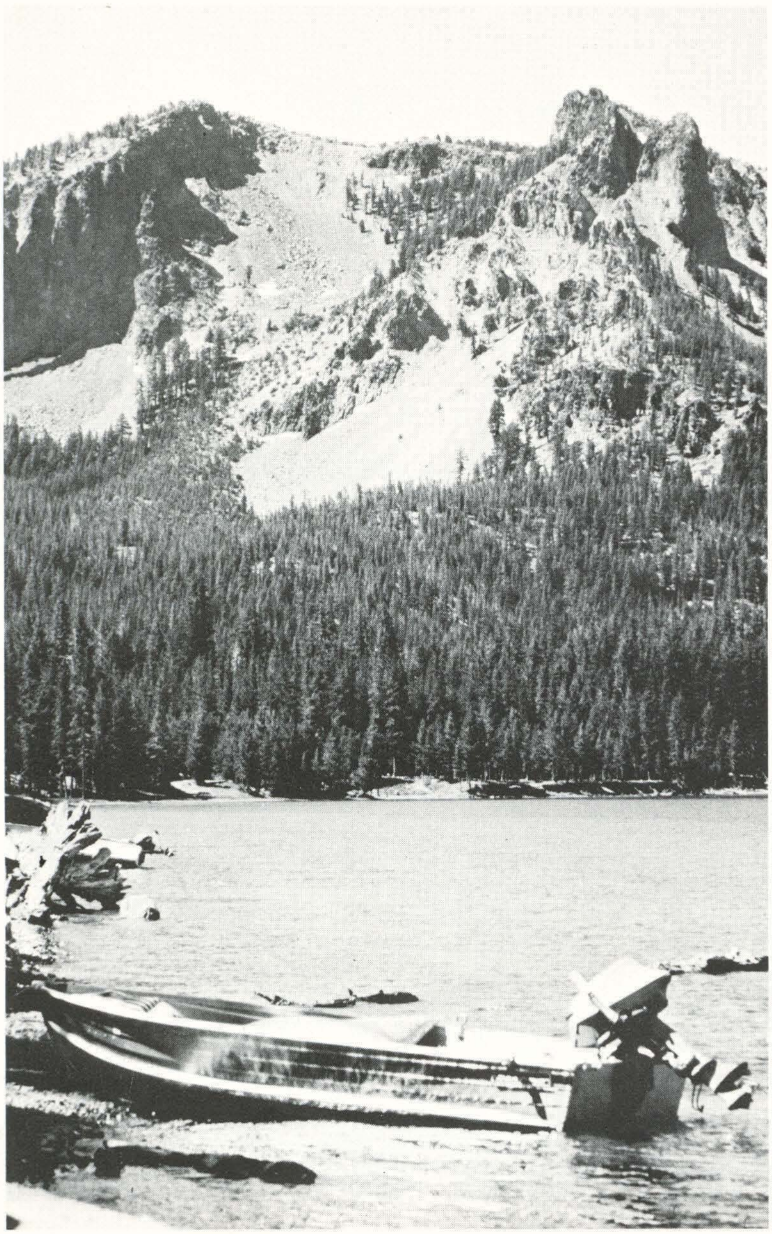


world with a wide sky, but a world that had its definite boundaries in the form of the encircling hills. This crater would make a good Shangri-La.

We drove along the road of the lake for a mile, then turned into the campground on the east shore. The row of cinder cones separating the lakes was right at our backs, directly south was the large obsidian flow, and beyond that the steep ruggedness of Paulina Peak. Most of the hills forming the caldera rim are only a few hundred feet high, but Paulina Peak reaches up to 7897 feet, 1500 feet above the lake. There is a winding road to the top, and we planned to try it the next morning as one of several short geological excursions to make during this visit.

We spent the rest of the day in family camping activities—a swim in the lake, a walk to the falls and the gorge below it that the river has carved deep into the layered lava flows of the volcano's flank, then dinner and an evening of star-watching and meteor-counting.

In the morning, after breakfast and camp clean-up, the camp and lake were still in shade. To the south, Paulina Peak glowed yellow in the early light. We made up our minds that the drive to the top would be our first excursion of the day. The road from the guard station climbs 1500 feet in three miles, and we figured that an early-morning drive would help a tired old radiator stay refreshed. So we drove back along the shore of a lake studded with fishing boats, and turned onto the road to the peak. In a few hundred feet the road changed from paved to gravel, but it was well maintained and the curves and slopes were gentle. After about a mile that changed, and the road began to snake back and forth, getting narrower and steeper as it twisted around volcanic outcrops on the way to the top. Naomi and Rachel were looking out the windows, urging me excitedly to look at the ever-enlarging view of the countryside below. I decided to postpone my viewing until I was no longer driving, lest the car and I fall into the view. I didn't want to stop to look, either, because then the radiator might heat up too much. So I confined my looking to passing glances at several rugged spires of black rock, perhaps fifty feet high, that the road curved around. From a distance these looked a little like burned-out trunks of trees, and I noticed a certain place where I could park on the way down to get good pictures of the spires. We curved and twisted up the steepness for another mile, and then, suddenly, the slopes fell away on both sides and we were at the top. There were a parking area and fire lookout below the peak, and we all got out to walk and look.



Left, Paulina Peak. Newberry Caldera combines volcanic landscapes with a peaceful fishing resort. Above, map of the central portion of the caldera. Road coming in from the west makes access easy to the lakes, the obsidian flows, and the peak.

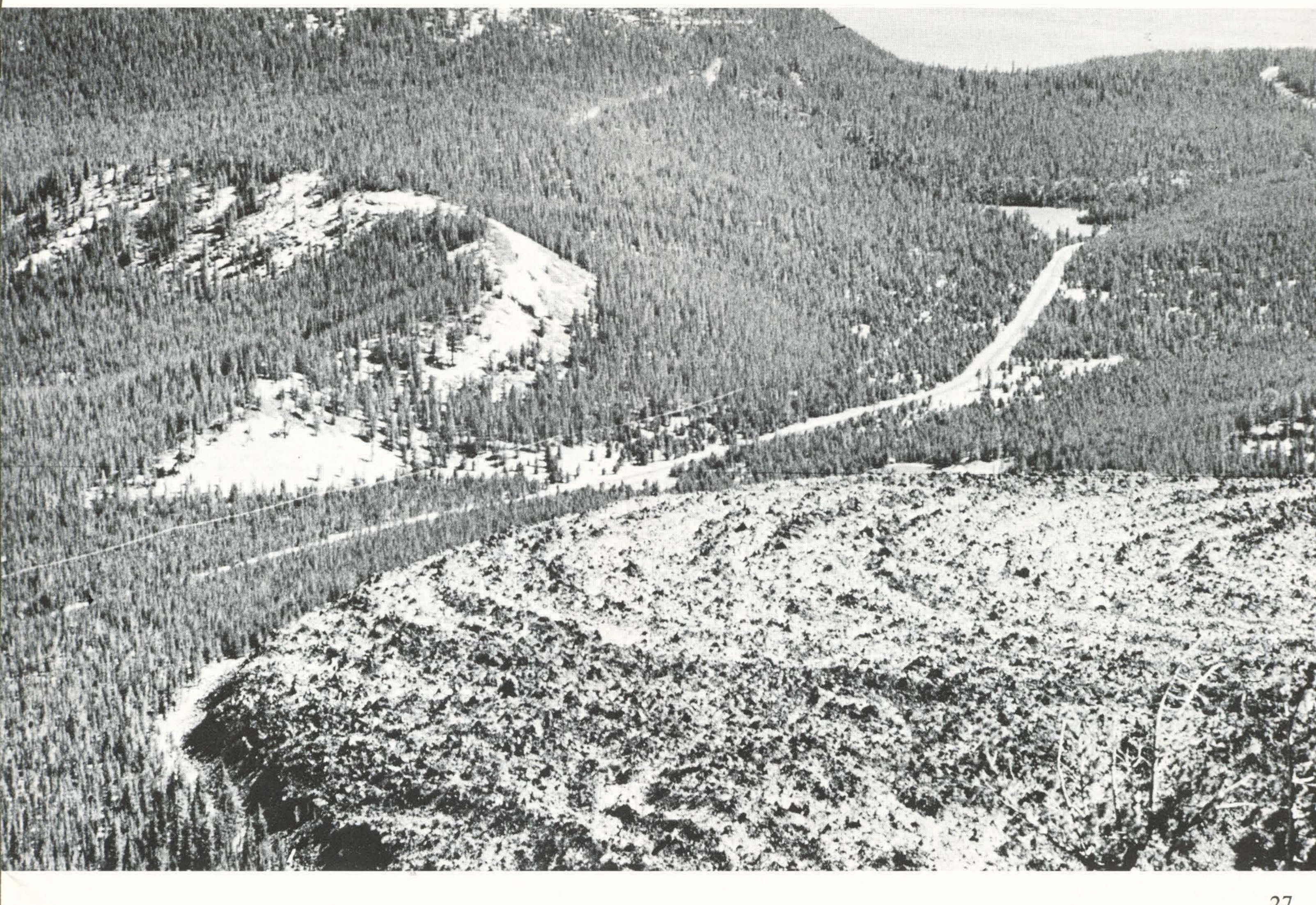
Paulina Peak sticks up about 2000 feet from the surrounding plateau, and from it we could see not only the caldera and the two lakes, but also a wide-stretching view of eastern Oregon. Looking west we could see the Cascades, with snow-capped peaks spaced almost evenly along the horizon. Although the Newberry volcano was active during the Pliocene and Pleistocene, the same as the Cascades volcanoes, it is not actually a part of that mountain chain, but rises from the Deschutes Plateau near the eastern foothills of the Cascades.

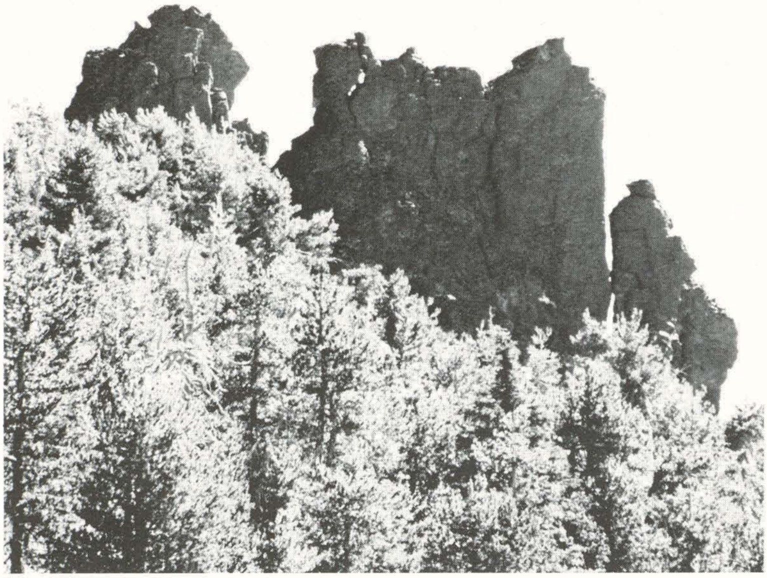
We turned and walked along the path at the edge of the cliff. Looking north to Paulina and East Lakes, we could see for the first time the overall shape of the four-by-five-mile caldera, and the surrounding walls of the caldera rim. The rim is fairly even in height in most places with the exception of the peak where we were standing and the low place in the place in the west where the creek flows out. The row of forested cinder cones dividing the lakes looked like a series of sand castles in green, dividing a child's play-pond in two.

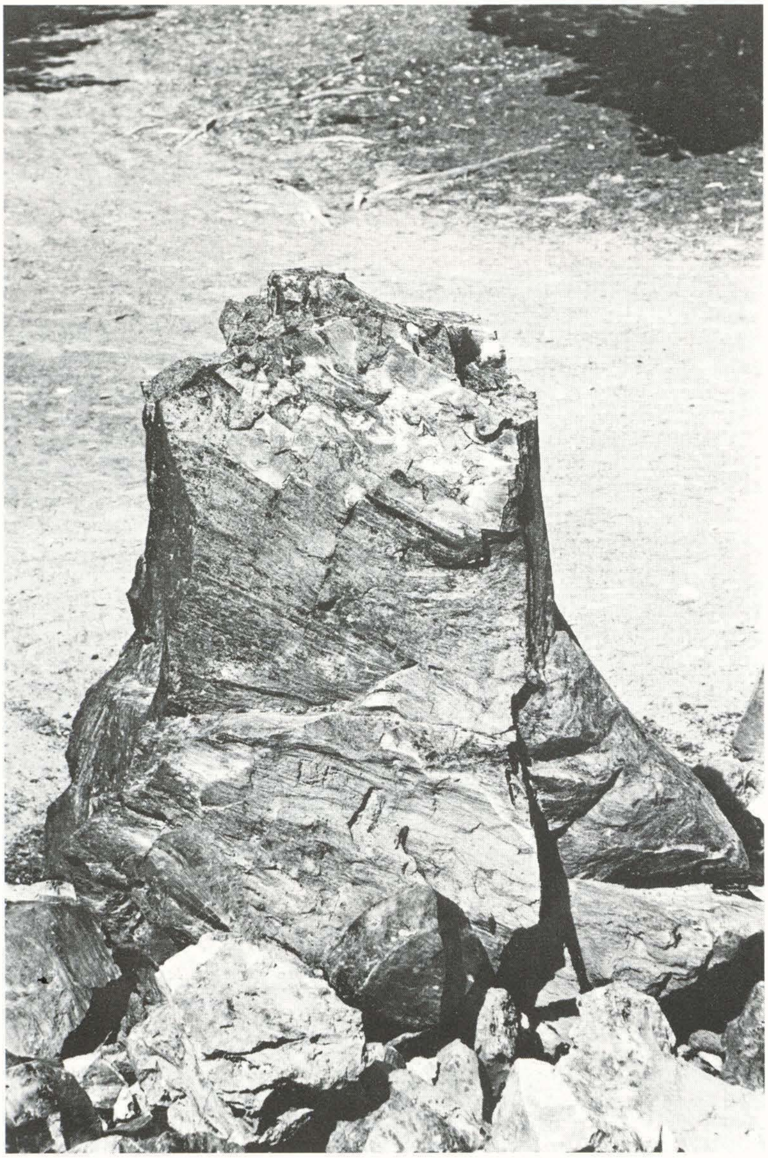
Walking along farther, we looked down the cliff to the east for a view of the large obsidian flow, which is about a mile long. The surface of the flow was far from even, but undulated in little ridges and valleys that formed a semicircular pattern curving around with the front of the flow, focussing inward toward the source. The history of the flow was contained in this pattern, and could be read like a book. The flow had started at the base of the cliff on which we stood, almost a mile to the east of us, and had curved west and then north, reaching almost to Paulina Lake before it stopped. The flow was bare of vegetation, and was probably quite recent, perhaps two thousand years old. It must have been one of the last events in the formation of the present-day landscape of the caldera.

The catastrophic events that formed this caldera took place about 20,000 years ago. At that time the volcano would have been an impressive sight, a huge circular mountain sloping gently upward to ten or twelve thousand feet. It had been formed over many thousands of years by numerous flows of liquid lava. Some unknown occurrence,

In the depression east of Paulina Peak is an obsidian flow about a mile long, extending almost to Paulina Lake. Seen from above, the pattern of obsidian ridges indicates the development and direction of the flow.



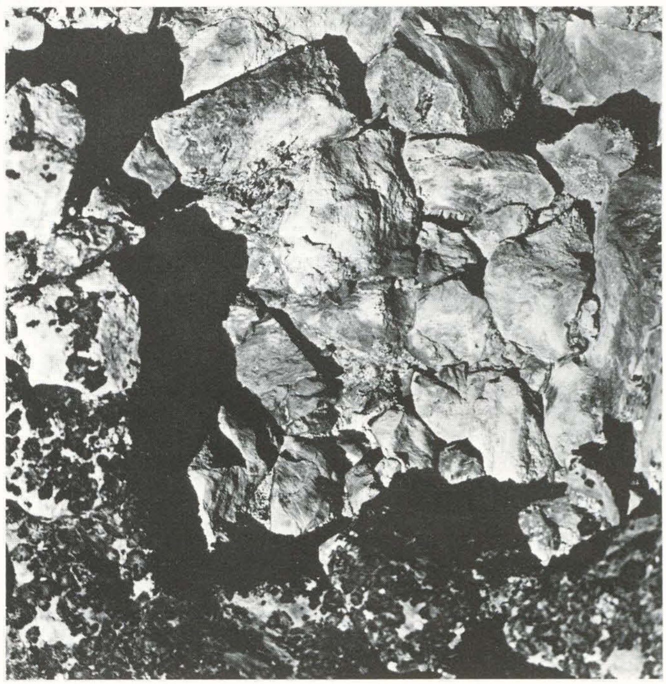




perhaps an earthquake, triggered the climatic event in its life. Concentric fissures formed in the lower slopes and let much of the magma flow out from under the peak onto the surrounding plateau. The top of the mountain, deprived of support, collapsed into itself to form a caldera. Twenty millenia of erosion, soil formation, and plant growth, along with later eruptions that divided the caldera and its lake in two, shaped the landscape of today. Newberry is a dormant volcano, not a dead one. Hot springs are still active in East Lake.

The evidence for this violent history, as interpreted by vulcanologists, was spread out before us on the landscape. In fact, the evidence is the landscape. I explained the story to my daughters as we stood there, pointing out various features as we talked, and assured them and myself that the Newberry volcano was not about to erupt again. We continued our walk around the parking area, and came to the southern edge. Here we could look out over the outer flanks of the mountain and see a few of the 200 small cinder cones and other volcanic features, such as spatter cones, fissures, and lava casts of trees, that dot its sides. Then, geology tour finished, we climbed up the last hundred feet of the peak to stand for a moment at the top and take one another's pictures with the peaks of the Cascades like ice-cream cones in the background.

On the way down we discussed the places in the caldera that we had seen, and made plans for the rest of the day. We would go for a close look at the obsidian flow, then drive on to East Lake and see what we could find. We stopped several times on the way down to take pictures of volcanic spires and the view of eastern Oregon. In a few more minutes we had driven all the way back down the inner slope



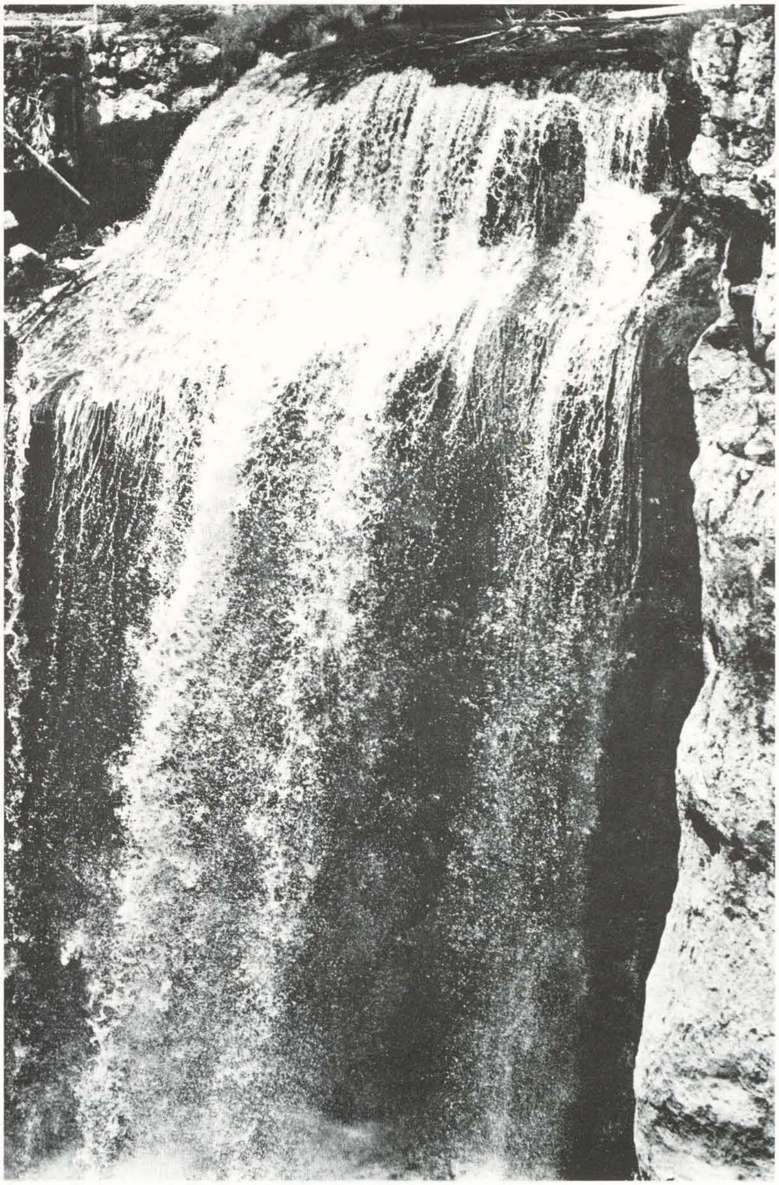
Top, on the outer slopes of the caldera, especially along the drive up to the peak, numerous volcanic formations can be seen, including many small cinder cones and isolated spires of lava such as this wall-like formation. Above, a fine specimen of obsidian from the main flow. Right, lava rocks on Paulina Peak.

of this cup-shaped mountaintop and were at the bottom of the cup again, by the lake. We drove back to camp for a snack, then on a little way to the place where the obsidian flow comes down almost to the road. Beyond the parking area we walked through the trees to the edge of the flow. When we came out from the trees we discovered that there was a strip of open land about thirty feet wide all along the edge of the obsidian hills. This area was covered with small chunks of obsidian, and I guessed that the heat from the molten flow had killed the trees for that distance beyond itself, and that the intermittent rain of black glass falling down from the front of the flow over the years had kept trees from starting again.

We crossed this region, and stood at the edge of the obsidian. The front edge of the flow was very steep, and we had to crane our necks to get a good look at the top, fifty or more feet above. Huge chunks of glittering black rock were piled one above the other, looking as if they might fall at any moment. We were standing at the snout of the flow, and we turned left and walked up the cleared swath along the edge for about a quarter mile. The ground sloped up steadily. To our left were green trees, to our right a steep wall of black glass boulders, shining under the hot sun. The side of the flow curved around to the left ahead of us, so that much of the obsidian was directly ahead. We could see hills and hummocks and tiers of obsidian — acres of it — rising one above the other, higher and higher to a sawtooth horizon, dark and sharp-edged against the deep blue of the sky. It was a natural version of a going-to-the-sun temple, only in this case it was a going-to-the-fire. We felt pulled by the upwardness of these hills, urged to climb the obsidian steps and make our pilgrimage over sharp glass to the volcano.

Reluctantly we turned away, and went on to East Lake. The map showed a little pond at the edge of East Lake near that campground, and we wanted to see the pond. When we parked, Naomi and Rachel and Shep got out and ran ahead toward the water, while I strolled through the trees, kneeling down now and then to examine the rocks on the ground—a mixture of pumice and a denser dark red rock I did not know. While I was examining the rocks I heard a shout from my daughters: "Daddy! Tadpoles and polliwogs! Come and see!" I stood up and ran out of the woods and across a field toward the pond, stepping over and around lumps of pumice that ranged in size from golf balls to basketballs. When I got to the edge they showed me a shallow place with water-weeds and hundreds

Near the caldera rim, Paulina Creek Falls drops into the gorge the creek has cut into the lava flows from ancient Newberry Volcano.



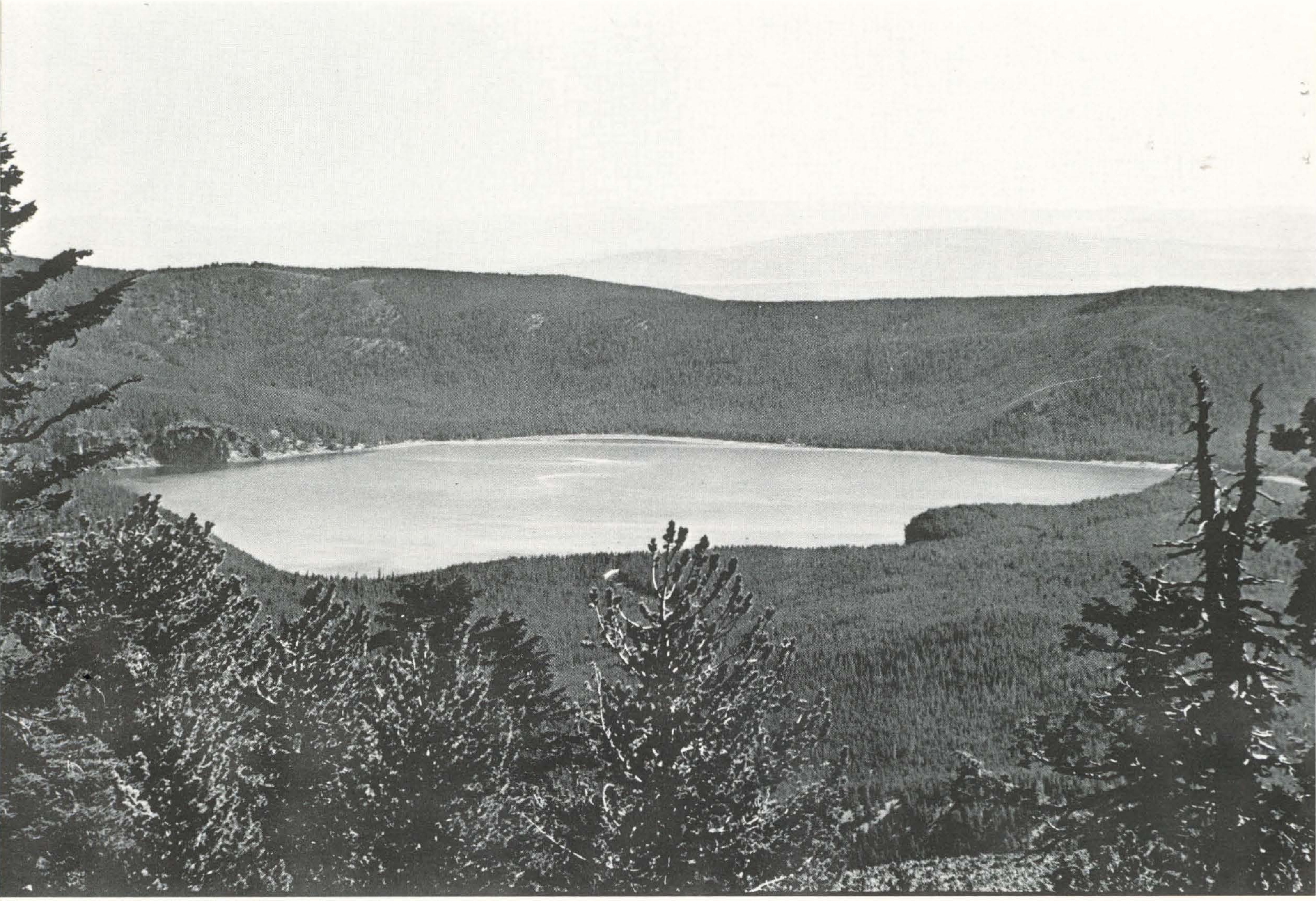
of black tadpoles, clustered so thickly they hardly had room to swim. We took pictures of them through the clear water, discussed whether we should try to capture some and take them home, decided against that because I outvoted everybody, and then walked on to explore farther.

A long sand ridge about five feet high divides the pond from the lake. We walked upon it and looked about, studying this half of the caldera. Southwest across the lake we could see the entire side of the mountain we had driven up earlier that morning. To our right was a cliff bordering the lake, and beyond it the snout of another lava flow that extended into the lake. This flow was lightly sprinkled with trees. Perhaps it had occurred earlier than the obsidian flow, or, more likely, it was of a rock that decomposed into soil more readily. Directly west across the lake was Little Crater, the largest of the row of cinder cones. This hill had a forested crater at the top—we had been able to look down upon it from Paulina Peak. The cone of Little Crater is quite symmetrical, and is placed right in the center of the caldera. Although this cone developed some time after the collapse of the volcano, and had nothing to do with the formation of the caldera, its position is such that it gives the impression of being not only the center but also the focus of the circular creation surrounding it.

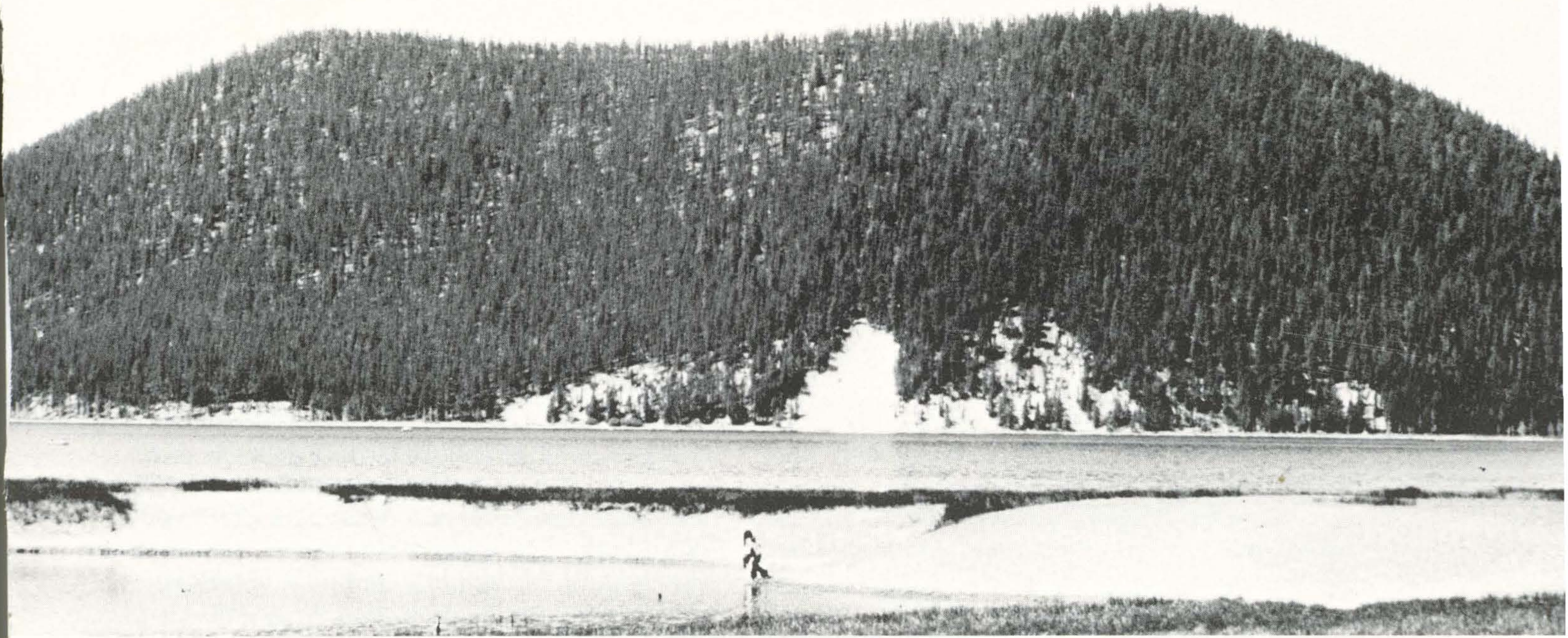
By now it was mid-day. We were hungry, hot, and tired. Naomi and Rachel had had enough of geology, and Shep, who had spent most of the morning lying patiently on his bed at the back of the camper, was eager to be running and playing. So we went back to camp for lunch, and I decided to let dog and children stay there while I did some more exploring and picture-taking. They had tent and food, one another to play with and a lake to wade in, so I was sure they would be comfortable.

Back at East Lake I walked through another campground, with campsites scattered between the lobes of the other, smaller obsidian flow. The obsidian here differed from that of the main flow. That had been black and glossy; this was gray, matte-surfaced, and rougher-textured, with many tiny bubbles in the glass. Some of it was even frothy with bubbles, and was hardly obsidian at all, but a transitional form between that and the lightweight pumice.

Across the road from this campground was a boat landing, and the ranger had told me that there were some hot springs near the shore a few hundred feet west of the landing. I walked along the shore and came upon a group of boys who were throwing chunks of pumice into the lake to watch them float. They had heaved a large chunk out, and were



East Lake and the caldera rim,
as seen from Paulina Peak. Unlike
Paulina Lake, East Lake has no outlet.



throwing smaller pieces at it. I asked them if they had seen the hot springs, and they didn't know what I was talking about. When I explained they got excited, and wanted to know more. I told them a little about the geology of the caldera, assuring them that another eruption was not imminent. They offered to join the search for hot springs, and we walked along the shore together. In a little while I saw what I was loking for—bubbles coming up out of the water just offshore. We took off shoes and socks and waded out. From the edge of the lake for about fifteen feet out, and extending perhaps fifty feet along the shore, the water was dotted with myriads of bubbles, rising and popping. The water was warm to our feet. We knelt down to feel the places where the bubbles were coming from, just oozing up through the sand of the bottom. Holding our hands over some bubbly places, we felt the warm water push up between our fingers. We walked back up the beach, and I decided to dig down. The surface of the sand was comfortably warm, but only a few inches down it was as hot as bathwater. The boys wanted to know if it got boiling hot a few feet farther down and I told them I didn't think so, but that the magma heating the water was probably hundreds of feet down. They were disappointed, but decided to dig anyway. I was ready to return to camp, having seen the hot springs. So I started back to my car, leaving a group of boys eagerly digging a large hole in the beach to make themselves a hot sand-bath.

My volcano exploring was over; I had studied as much as I could of this caldera in the time avail-

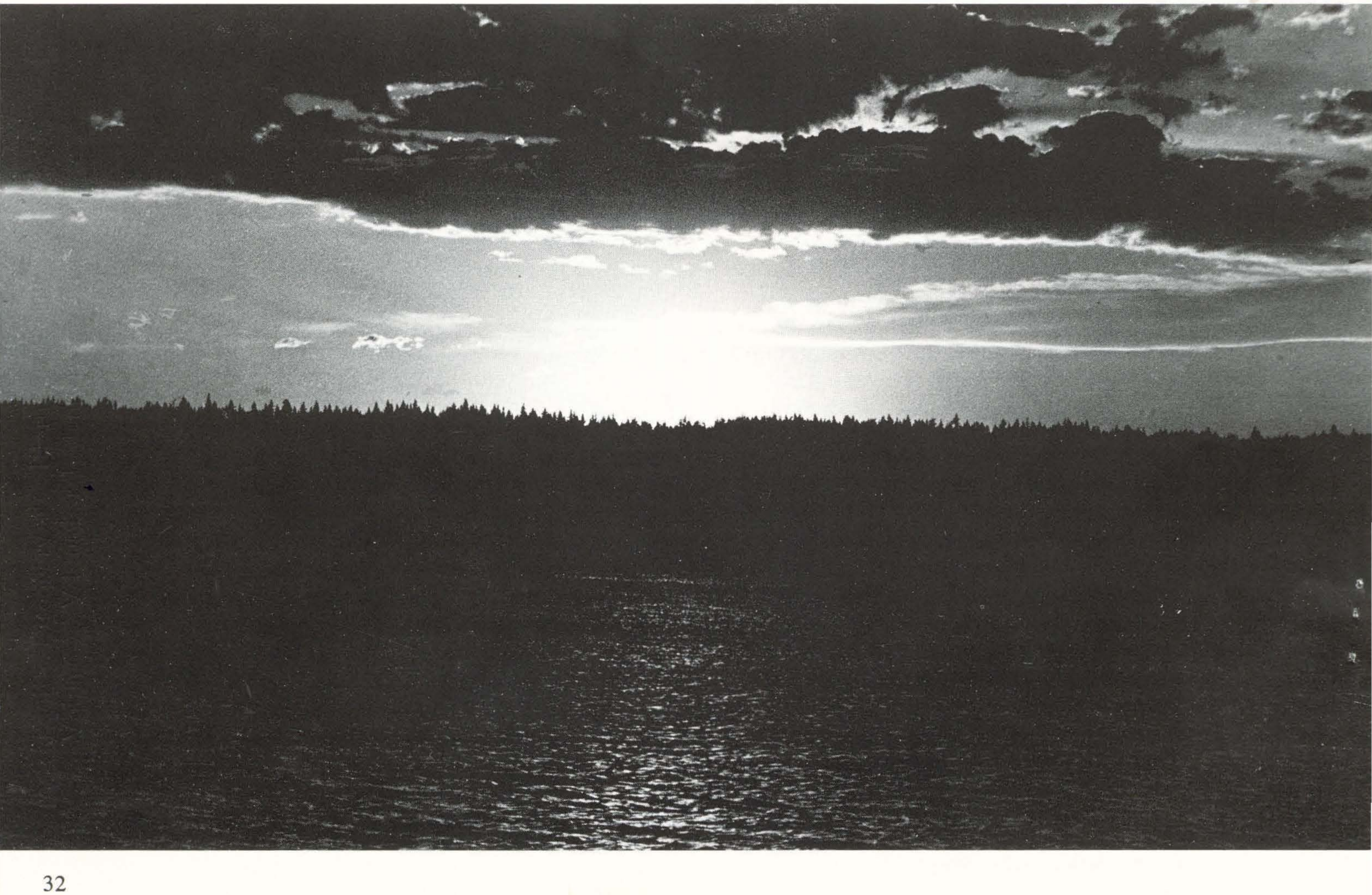
Top, the largest of the cinder cones dividing the caldera, as seen from East Lake. In the foreground, separated from the lake by a sand ridge, Naomi and Rachel are tadpole-watching. Above, the population explosion of tadpoles that all of us found so intriguing.

able, in the midst of a family vacation. I returned to camp, and the girls and I spent the remainder of the afternoon wading and snacking and lazing in the sun. We all felt gentled to peacefulness within this private circular world. Soon the lake grew cold, and as sunset and evening chill came on we built a fire, barbecued a steak, baked potatoes in the hot coals, and roasted marshmellows in the flames. It had been a long and exciting day. After dinner, children and dog played in the dusk while I typed up my notes of the day's excursions. We were all ready for sleep early, and we packed all our gear in the camper so as to be ready for an early start south next day.

I awoke at dawn, clambered over a sleeping family and into the driver's seat, and started the return trip. As I drove along the winding road down the long gentle outer slope of the volcano, I mused on our visit, and the contrast between the Newberry and Crater Lake calderas. Crater Lake is steep, rugged, and dramatic, a spectacle to visit and wonder at. Newberry is gentle and forested, a comfortable sort of caldera for a restful vacation. Both are calderas, formed by the same process—the collapse of a volcano when the supporting magma beneath flowed and erupted away. But they were as unlike as brothers or cousins—members of the same family, and showing a family resemblance, but utterly different in temperament. We had enjoyed both, but we had especially enjoyed our days at the bottom of the Newberry caldera, living for a time inside an ancient volcano.

By the time I turned onto highway 97 toward Lapine, sun, children, and dog were all up. After almost a week of camping, from Lassen to Newberry, we were ready to return south to San Francisco and home. We wanted to enjoy the comfort of a good meal cooked for us, so I pulled in at a truck stop. We all revelled in a huge breakfast of bacon and eggs, plenty of toast, and hot chocolate. The air in the restaurant was hot, steamy, and snug, filled with the strong smells of bacon, coffee, and tobacco, the clatter of sturdy crockery, and the conversation of the truckers. I lingered over my coffee, warmly accepting the comforts of civilization again. But soon the girls urged me out, eager to get going on the final leg of our trip home, by way of Lava Beds National Monument and the Medicine Lake Highlands. By this time we were all volcano buffs.

Sunset over Newberry Caldera.



Obsidian Hydration Dating Applied to Basaltic Volcanic Activity

Since our original work on dating volcanic events in the Newberry craters (*1*), we have examined many hundreds of thin sections. The latest results reinforce most of our previous conclusions (*2*).

We do not believe that the fumarolic activity referred to by Higgins and Waters (*3*) has significantly influenced our results. If fumarolic activity had been a complicating factor, we should have found thicker hydration for samples from Big Obsidian flow, where the hydration thickness ranges from 0.9 to 1.1 μm. In addition, we should find a continuum of hydration thicknesses for samples that had different exposures to fumarolic activity. Instead, we find discrete thicknesses of hydration, corresponding to the discrete events that created the obsidian surfaces. Evidence of alteration is easily detected in thin sections, and such sections were rejected.

The Central Pumice Cone flows consist not only of a flow that plugs the vent and is now in the bottom of the symmetrical crater, but also of obsidian flows in the walls of the crater both above and below the vent. The results show consistently that the flows in the center of the cone have hydration thicknesses of 2.9 μm. Other flows in the Central Pumice Cone, particularly some later airfall material, have hydration rinds as thick as 3.6 μm. In our original publication (*1*), we used a hydration rate of 5 μm^2 per 1000 years. This rate was one that we had found for some archeological obsidian artifacts hydrating in southern Montana. In a more recent report (*4*), we used a hydration rate of 3 μm^2 per 1000 years, as derived from archeological material buried in southern Oregon. From temperature measurements which we are making on obsidian exposed to the atmosphere as well as obsidian buried in archeological context, it appears that the hydration rate is more rapid for exposed obsidian than for buried material. This is logical because the rate of hydration is quite temperature dependent, and exposed material is heated by the sun, which causes it to hydrate much more rapidly than buried material. The point at issue here is really the actual hydration rate rather than the influence of hydrothermal activity on the obsidian. As mentioned, hydrothermal alteration can easily be identified on these thin sections; where present, it has made measurement of the hydration thickness extremely difficult, and accordingly such sections have always been rejected. The consistency of the thicknesses of hydration on samples collected from various parts of a flow would rule out the influence of hydrothermal activity since it would not have acted uniformly on all specimens. The hydration rate of the exposed obsidian may be as high as 5 or 6 μm^2 per 1000 years. If so, the age discrepancies mentioned by Higgins and Waters disappear: if a rate of 5 μm^2 per 1000 years is used, the Central Pumice Cone flow would be about 1700 years old—the age that Higgins and Waters wish to assign to it. The East Lake fissure material also referred to by Higgins and Waters would then be of approximately the same age: its hydration thickness was 3 μm, and the rate of 5 μm^2 per 1000 years would give an age of 1800 years.

An alternative explanation of the age discrepancies may be found in the assignment by Higgins and Waters of the Central Pumice Cone vent as a source of the pumice eruptions 1700 years ago. But it should be pointed out that within 3 km of Central Pumice Cone there are at least four other vents, any one of which could have been the source of the pumice and ash. It is possible that the vent was in an area now covered by the Big Obsidian flow, which is less than 400 years old.

We think that much of this argument will be resolved when temperature measurements being made in the area allow us to calculate the rates of hydration of obsidian so as to date these flows more precisely.

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2. I. Friedman, in preparation.
3. M. W. Higgins and A. C. Waters, *Science* **176**, 1259 (1972).
4. I. Friedman and N. V. Peterson, *ibid.* **172**, 1028 (1971).

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Betty Meister
1719 Evergreen St.
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(503) 269-9110

OCT 04 1994

Dear Mrs. Meister:

Here is the information you requested. It would be best to use the information written in my letter to you as opposed to what is in the enclosed article due to copyright infringements concerns.

There is currently no limit on the amount of obsidian one can collect from public lands for personal use. Use of mechanical equipment is prohibited. However, commercial use of any amount of obsidian collected from public lands will require a permit issued by the Bureau of Land Management, Prineville District Office. The District is asking people to maintain their collecting activities to existing quarry areas or within drainages (see attached letter/map) to minimize impacts to other resources. Note: There are three grandfathered mining claims for obsidian in the vicinity of Musser Reservoir where mechanized equipment is used at certain times of the year.

Glass Buttes is mostly public lands administered by the BLM, although private lands do occur (again see attached map). As such, it is subject to multiple use by the public, including grazing. Other uses on this particular piece of public land include rock hounding, mining (for other than obsidian and chalcedony), camping, hunting, research and education.

The best access to Glass Butte is at Obsidian Rd (mile post 77) off Hwy 20, or from Stauffer Rd. off Hwy 20 just west of Glass Buttes which takes one to the south side of the mountain.

The BLM has future plans to develop an information sign for the Glass Buttes area. For now, however, those wanting information on Glass Buttes should contact the Prineville District Office prior to arrival. Contacts at the District Office include:

John Zancanella (archaeologist) 503-447-8735
District Office Receptionist 503-447-4115

If you have any further questions please don't hesitate to contact me at 503-447-8735.

Regards, John K. Zancanella

VIA Rock Chip REPORTER

John K Zancanella