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THE NATIONAL GEOGRAPHIC MAGAZINE

OUR GREATEST NATIONAL MONUMENT*

The National Geographic Society Completes Its Explorations in the Valley of Ten Thousand Smokes

By ROBERT F. GRIGGS

DIRECTOR OF THE KATMAI EXPEDITIONS OF THE NATIONAL GEOGRAPHIC SOCIETY

FROM the first accounts of the explosion of Katmai Volcano, in Alaska, in June, 1912, it was clear that it must rank among the dozen greatest historic eruptions. Nevertheless, these early narratives contained no accounts of the events of the eruption itself, but were confined to the description of its effects at great distances.

Closer inspection was not needed to establish the rank of the eruption, for it was evident that a cataclysm which buried towns a hundred miles away under a foot of ashes, whose concussions were so loud as to excite the comment of people at a distance of 750 miles, whose explosions threw such a quantity of dust into the upper atmosphere as seriously to diminish the intensity of sunlight for many months throughout the whole Northern Hemisphere, must have been among the greatest known to man.

Yet, tremendous as must have been the outbreak that produced such effects, it has gradually become certain, as the expeditions sent out by the National Geographic Society have explored the country round about, that the explosion of Katmai itself was by no means the most remarkable feature of this tremendous eruption.

It is too much to claim that the evisceration of Katmai was only a subordinate outbreak consequent upon the main disturbance, yet it is certain that before Katmai blew up another eruption, itself of the first magnitude, had already occurred at a distance of some miles from that volcano.

EXPLOSION OF KATMAI MERELY FINAL ACT IN THE ERUPTION

However the relative importance of the eruption giving rise to the Ten Thousand Smokes as compared with the explosion of Katmai may be judged, it is certain that the disturbance did not begin, as would naturally be supposed, with the big explosion. That was rather the closing act in the drama, the sequel to eruptions from the floors of valleys at a considerable distance from Katmai.

This is proven by the fact that the

*Members of The Society will recall that the Valley of Ten Thousand Smokes was discovered by a National Geographic Expedition. The reports of The Society's six Katmai expeditions contain all the information that has been published covering the district. (See the NATIONAL GEOGRAPHIC MAGAZINE for January, 1917, and February, 1918.) These accounts gave such clear evidence of the unparalleled interest of the region that, by proclamation of the President of the United States, it was promptly added to our National Park System as the Katmai National Monument. (See NATIONAL GEOGRAPHIC MAGAZINE for April, 1919.)

The only comprehensive account of the eruption was likewise prepared by a National Geographic Society Expedition and published in The Society's Magazine in February, 1913.

Photograph by R. F. Griggs

THE HEADQUARTERS OF THE NATIONAL GEOGRAPHIC SOCIETY'S LATEST KATMAI EXPEDITION DURING ITS STAY IN THE VALLEY OF TEN THOUSAND SMOKES

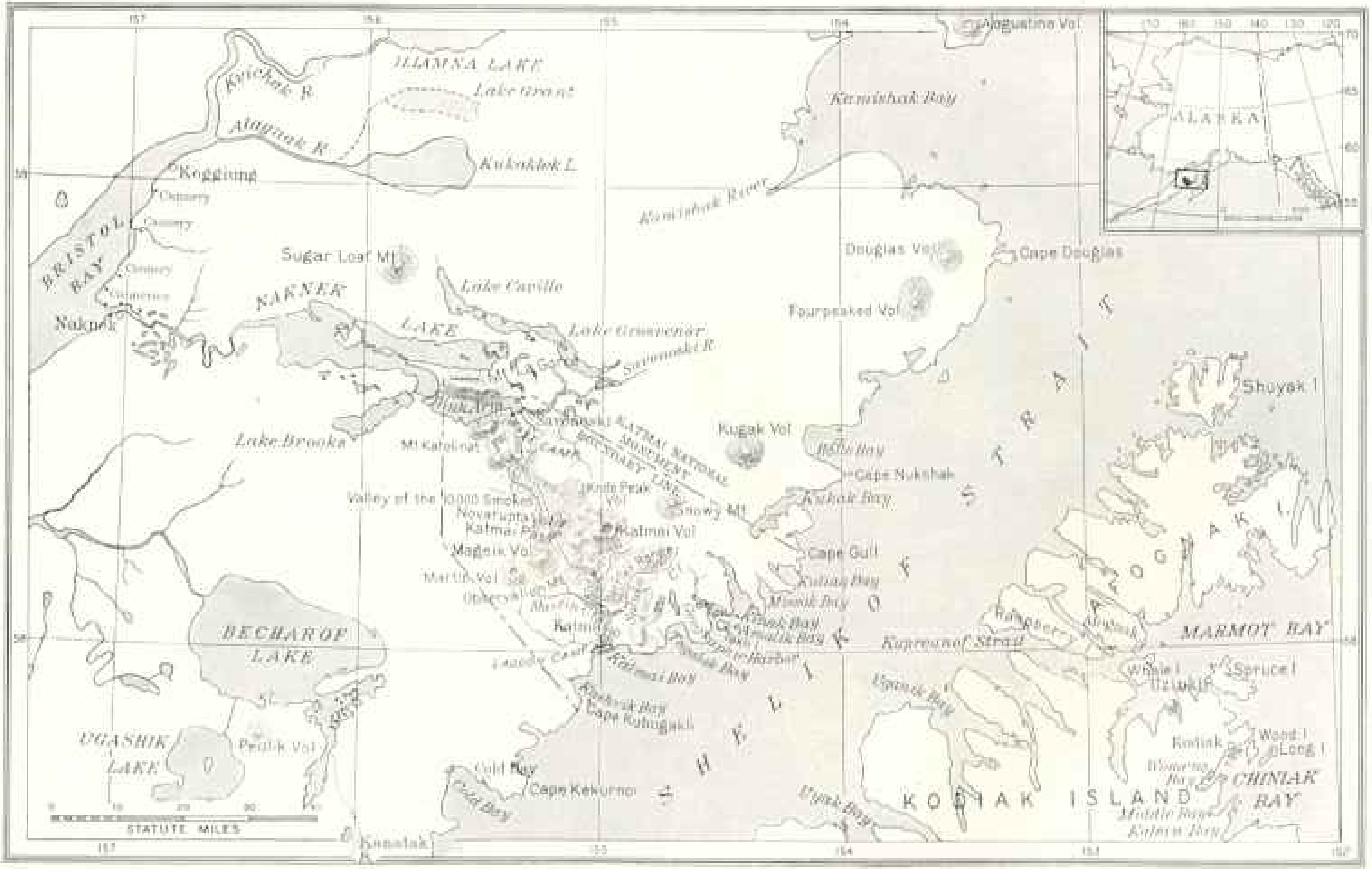
This is Baked Mountain Camp, with Mount Martin in the background. Before the eruption this was a green valley. Many travelers have camped beside a bunch of bushes that formerly stood near the middle of this picture, but at an elevation much lower than the present surface, for the valley was here filled many feet deep by the flow of incandescent sand (see page 241).

Photograph by E. C. Kolb

EVERYTHING FOR BAKED MOUNTAIN CAMP HAD TO BE LUGGED IN ON MAN-BACK FROM OUTSIDE THE BURNED AREA, A DOZEN MILES AWAY (SEE PAGE 228)

Photograph by J. D. Sayre

THE BASE CAMP IN THE FOREST AT THE HEAD OF NAKNEK LAKE, WHERE, SUPPLIED BY POWER DORY, THE MEMBERS OF THE EXPEDITION WERE ABLE TO PROCURE "ALL THE LUXURIES OF CIVILIZATION" (SEE PAGE 243)



Drawn by A. H. Bumstead

A MAP OF THE BASE OF THE ALASKA PENINSULA, SHOWING THE MAJOR FEATURES OF THE KATMAI DISTRICT AND THE ADJOINING COUNTRY

The National Geographic Society's Katmai expeditions have surveyed more than 3,000 miles of hitherto unmapped country and, in addition to scientific studies of Katmai Volcano and the Valley of Ten Thousand Smokes, have added Geographic Harbor, Lakes Grosvenor, Coville, and Brooks and Mt. La Gorce to the map of North America (see text and illustrations, pages 286 to 292). The dotted area is the Valley of Ten Thousand Smokes. The territory covered in the large map is indicated by the small black rectangle shown in the inset map of Alaska.

stratified ash from Katmai everywhere lies on top of the deposits of this earlier phase of the eruption, showing, of course, that the latter had already been poured forth before Katmai blew up (see p. 224).

The discovery of the Ten Thousand Smokes, as described in THE GEOGRAPHIC, furnished the first suggestion that there were other phases of the eruption of greater interest than the explosion of Katmai; but any understanding of what really occurred in those days of early June, 1912, involved so much study that it has not been possible until now to give any clear idea of the real nature of the eruption, and even yet there is much that must be left to conjecture, although the general features stand out fairly clearly.

The task of interpreting the events of this great eruption has been much the more difficult because, so far as can be found, nothing resembling it closely has ever been recorded before.

Since there were no witnesses of the catastrophe, we are limited in framing our account of its events to deductions from the study of its effects on the surrounding country. Indeed, it is hardly probable that any observer would have survived to tell the tale if he had been near enough to see what actually happened.

It will be understood, therefore, that our account must of necessity be made up of reasonable inferences and necessary conclusions from evidence left behind rather than of the narration of a series of observed events, and it must be read in this light.

A GREEN VALLEY SUDDENLY TRANSFORMED INTO A NEST OF VOLCANOES

Some time before the beginning of the terrific explosions whose sounds first announced to the world that an eruption was in progress, a host of small volcanoes burst open in the floor of the green valley through which ran the Katmai Trail. The date is unknown, but was probably near to the first of June, 1912 (see page 271).

In the very formation of these vents, the eruption presented a feature unusual in volcanic phenomena; for this was no reawakening of dormant vents, such as constitutes the vast majority of eruptions, but rather the formation of new volcanoes in areas where none had existed previously. If there had been nothing else remarkable about the eruption, this alone would have set it off as a noteworthy event.

These new volcanoes consisted simply of holes blown through the floor of the valley, not of hills or mountains with craters at their tops. How many of them there were or how they may have looked and acted when they first burst open, we have no means of knowing, but there is reason to believe that they constituted literally a host in number, and that they consisted at first merely of lines of craterform holes blown through the floor of the valley, resembling, perhaps, the close-set shell-holes of a battlefield, though, of course, much larger than the craters produced by the explosion of even the biggest shells. Whatever their original appearance, it is certain that soon after their formation they began to throw out ash and pumice in enormous quantities.

A SPECTACLE THAT PASSES THE POWERS OF THE IMAGINATION

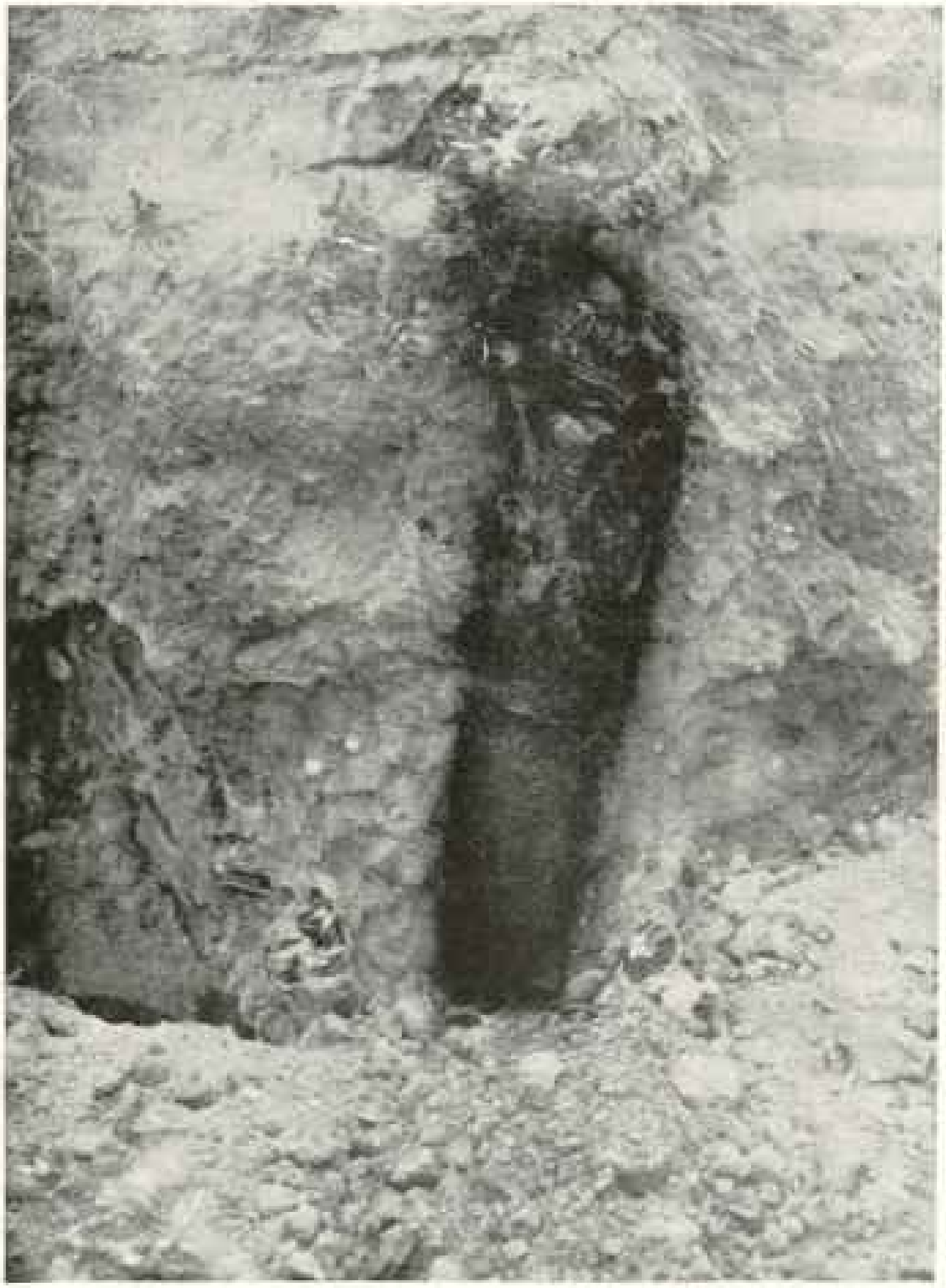
The Ten Thousand Smokes, wonderful as they are at their best, can give no idea of what the valley must have looked like in this initial stage. In addition to myriads of fumaroles, probably greater than any that now remain, scores or hundreds of vents must have been belching forth incandescent material in veritable torrents of fire.

Prodigious quantities of red-hot solids and liquids, sand and stone, masses of fluid or semifluid lava, issued from the vents and poured out on the ground, following the slope in rolling, tumbling fiery torrents that consumed everything they touched.

In the first stage, if one could have seen it, many separate volcanoes would have appeared in different parts of the valley, each pouring forth its own contribution to the general chaos.

From each there was probably a great black cloud rising to a considerable height in innumerable, ever-expanding, lobulated convolutions. From analogy with other eruptions, we may suppose that electrical displays of weird grandeur accompanied the clouds rising from the various vents.

On careful observation it would have



Photograph by L. G. Folsom

PROOF THAT THE VALLEY OF TEN THOUSAND SMOKES OPENED BEFORE KATMAI BLEW UP

Beneath the three layers of ash from Katmai is seen the massive sand-flow, which must already have run its course before the ash began to fall. This picture was taken close to the terminus of the sand-flow. The charcoal log, a foot in diameter, is striking evidence of the heat still retained by the sand 10 miles from the head of the flow at Novarupta (see page 220).

become evident that the source of the cloud was the mass of incandescent material around the vents. It was in fact produced by the gases that boiled out of the mushy semi-molten lava. The quantity of gas given off was so great that the whole mass of lava was puffed up into frothy pumice and entirely disrupted into small fragments by the expansive force of the escaping gas.

If any other of a score of valleys in the vicinity had been the seat of the disturbance, it would probably be impossible to gain any information of its character before the eruption, for the whole country roundabout was an unexplored wilderness; but, as it happened, the eruption occurred in the one valley of the district about which something was known; for this particular valley was the route by which a well-known trail crossed the Alaska Peninsula from the Pacific to the Bering Sea.

For ages past this trail had been an inter-tribal highway between Katmai Village, on the Pacific, and Sabanoski, at the head of Naknek Lake, whence passage downstream to the Bering Sea was an easy matter. More recently it was much used by both Russians and Americans, so that there are many men still alive who traversed the valley and camped within its confines before the eruption (see p. 220).

It is certain that none of these travelers, among whom was at least one able geologist, ever suspected that this peaceful valley might become the theater of such an eruption.

There was no indication of volcanism outside the chain of old volcanoes forming the axis of the peninsula, and these had not been active for ages past, except for occasional smoking.

The valley was overgrown, up to an altitude of nearly 1,500 feet, by a dense forest of spruce, poplar, and birch, broken only by ponds and tundras in the

low places. Above the timber-line there was still abundant tundra vegetation, with occasional clumps of bushes close up under the volcanoes themselves.

Except for the ancient lava flows poured out at the head of the valley from these old volcanoes in prehistoric times, the rocks of the valley are not volcanic, nor even igneous. They consist rather of horizontal sedimentary strata, of sandstone and shale, full of fossils of marine shellfish of Jurassic age.

While a geologist might have predicted an early eruption from Katmai or from Mageik, the possibility of such a cataclysm as broke loose in the floor of the valley would never have occurred to him.

Photograph by Frank L. Jones

KNIFE CREEK CANYON

The streams have cut most curious sinuous canyons into the stiffened mass of the sand-flow. Although in places these canyons are a hundred feet deep, they do not cut through the flow to the soil beneath, except in the lower part of the valley.

STORY OF THE ONLY EYEWITNESS

Although the pass was frequently crossed by travelers, there was no permanent settlement in the valley. About halfway up, however, was a group of native huts known by the name of Ukak. These seem to have constituted a sort of hunting lodge, used by the natives of the village of Savonoski, for the valley was formerly the abode of abundant herds of caribou, as well as moose, bear, and fur-bearing animals.

Warned by preliminary disturbances, of whose character no clear account is given, beyond the statement that there were frequent earthquakes, "American Pete," chief of the Savonoski natives, had gone to Ukak to remove his gear and was on the trail when the eruption occurred. He was thus the only human being who had any opportunity of observing what happened in the valley.

This fact gives an unusual interest to his story, since, meager as it is, it constitutes the only scrap of direct evidence concerning the beginning of the Ten Thousand Smokes that can ever be secured. He was interviewed by Mr. P. R. Hagelbarger, of the 1918 Expedition. At that time he was an old man, in the last stages of tuberculosis, and it was difficult to get him to talk freely.

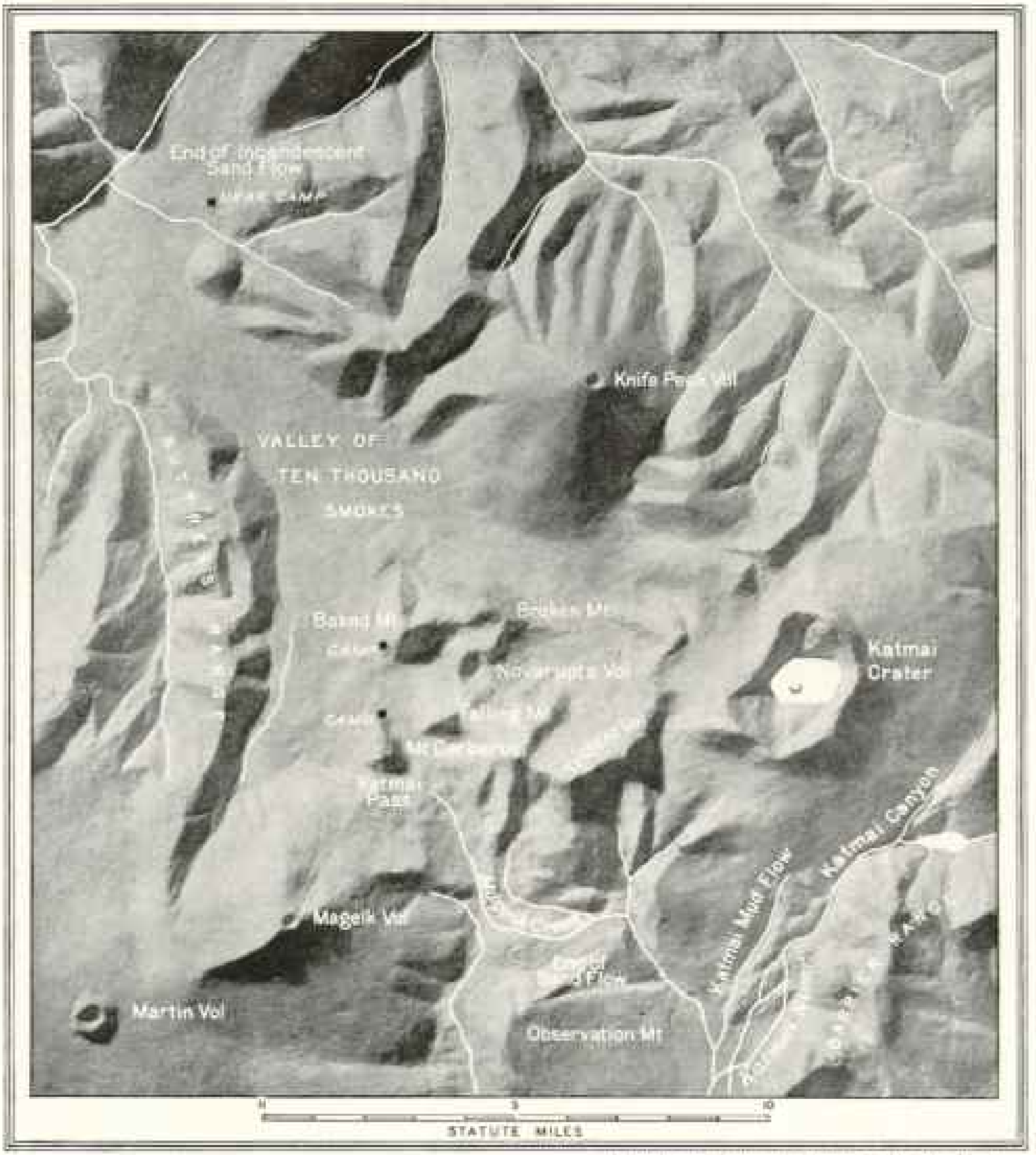
"The Katmai Mountain blow up with lots of fire, and fire come down trail from Katmai with lots of smoke," he said. "Me go fast Sabanoski. Everybody get in bidarka [skin boat]. Helluva job! We

THE EDGE OF THE CHARCOAL FOREST ABUTTING UNINJURED TREES ABOVE THE EDGE OF THE ONCE FIERY TORRENT (SEE PAGE 229)

Photographs by R. F. Griggs

STUMPS OF TREES BURNED OFF BY THE HOT SAND-FLOW; EXPOSED BY EROSION

Near the terminus of the flow, where this picture was taken, the sand had so far cooled as not to burn the trees clear to the ground.



Photograph from a model by A. H. Bumstead

A MODEL OF THE VALLEY OF TEN THOUSAND SMOKES AND THE VICINITY

The illustration shows the old volcanoes, the character of the incandescent sand-flow, and the base camps of The Society's parties. The fumaroles are omitted. Sculptured by A. H. Bumstead from a survey by the National Geographic Society's Katmai expeditions.

come Naknek one day; dark; no could see. Hot ash fall. Work like hell. Now I go back every year one month, maybe, after fish all dry, and kill bear. Too bad! Never can go back to Sabanoski to libe again. Everything ash. Good place, too, you bet! Fine trees, lots moose, bear, and deer; lots of fish in front of barabara [house]. No many mosquitoes! Fine church. Fine house. Naknek no good."

Realizing the importance of the testimony of this man, Mr. Hagelbarger endeavored by questioning to elicit further details, but none were to be obtained. He and his associates were too badly frightened and too much concerned with "fleeing from the wrath to come" to make any detailed observations. He must have left Ukak before the eruption was fairly under way. Indeed, it is probable that

Photograph by P. R. Hagelbarger

THE EDGE OF THE HOT SAND-FLOW

The lower ground, exposed in the drainage gulley, was originally covered with forest like the bank on the left. Here and there a burned stump remains to show what happened when it was overflowed by the hot sand. The destruction shown in the right half of the picture is complete and total (see page 229).

he could not have escaped if he had been a little later.

Ordinarily stories of "fire" in connection with eruptions are to be discounted, for it is generally the flow of molten lava rather than the flame of combustion that has been seen. But in this case Pete's statement that "fire come down trail from Katmai" is literally true; for the red-hot ash and pumice thrown out on the ground started fires of such intensity that they swept over the adjoining mountain sides, consuming every vestige of vegetation throughout the area surrounding the upper valley.

So completely were the plants destroyed in this area that there remains today not a scrap of charred wood or other evidence to indicate their former presence. Around the head of the valley all plants were completely consumed and their ashes long since scattered.

Along the far side of the valley, where the fires were somewhat less intense, the roots of the former abundant vegetation remain in the soil, but the fire made a clean sweep of everything above ground.

On account of the complete destruction of everything combustible, whatever we needed at our camps had to be carried in on man-back from outside the burned zone, a dozen miles away.

The ordinary outdoors man can hardly realize the barrenness of the valley as to everything which he expects to find anywhere. Every tent-pole and every walking-stick had to be lugged in from a distance, with the expenditure of no little time and energy. So simple a thing as providing stakes to mark the fumaroles under special observation required a very considerable amount of forethought and labor (see page 221).

If it had not been for Nature's fires, it would have been impossible for us to cook. It was, of course, out of the question to carry in fuel for any sort of a fire.

Long before the fires that consumed the surrounding vegetation had time to run their course, the masses of incandescent fragments accumulating round the separate vents coalesced until they covered the whole area of the valley, converting it into a single fiery torrent of seething, swirling masses of red-hot sand and rock, which soon began to roll down the valley under gravity.

Before it finally came to rest, this fiery

Photograph by P. R. Hagelbarger

LOOKING ACROSS THE SAND-FLOW NEAR ITS TERMINUS

This illustration is panoramic with the picture on the opposite page. The massive character of the flow and its relations to the undisturbed forest covering the hills beyond its reach are evident. The fiery torrent consumed everything it touched (see page 241).

torrent ran down the valley for about 17 miles. Even at that distance it was so hot that, although it no longer utterly consumed the forest nor started fires up the mountain sides beyond its reach, it still reduced every stick it touched to charcoal (see page 224).

The charcoal forests, uncovered where the streams have later cut into the substance of the cooled and stiffened flow, are extremely impressive witnesses of the fiery avalanche that overwhelmed them—far more striking than the utter barrenness of the upper valley, where the work of destruction was so complete as to leave the imagination powerless to reconstruct the original scene.

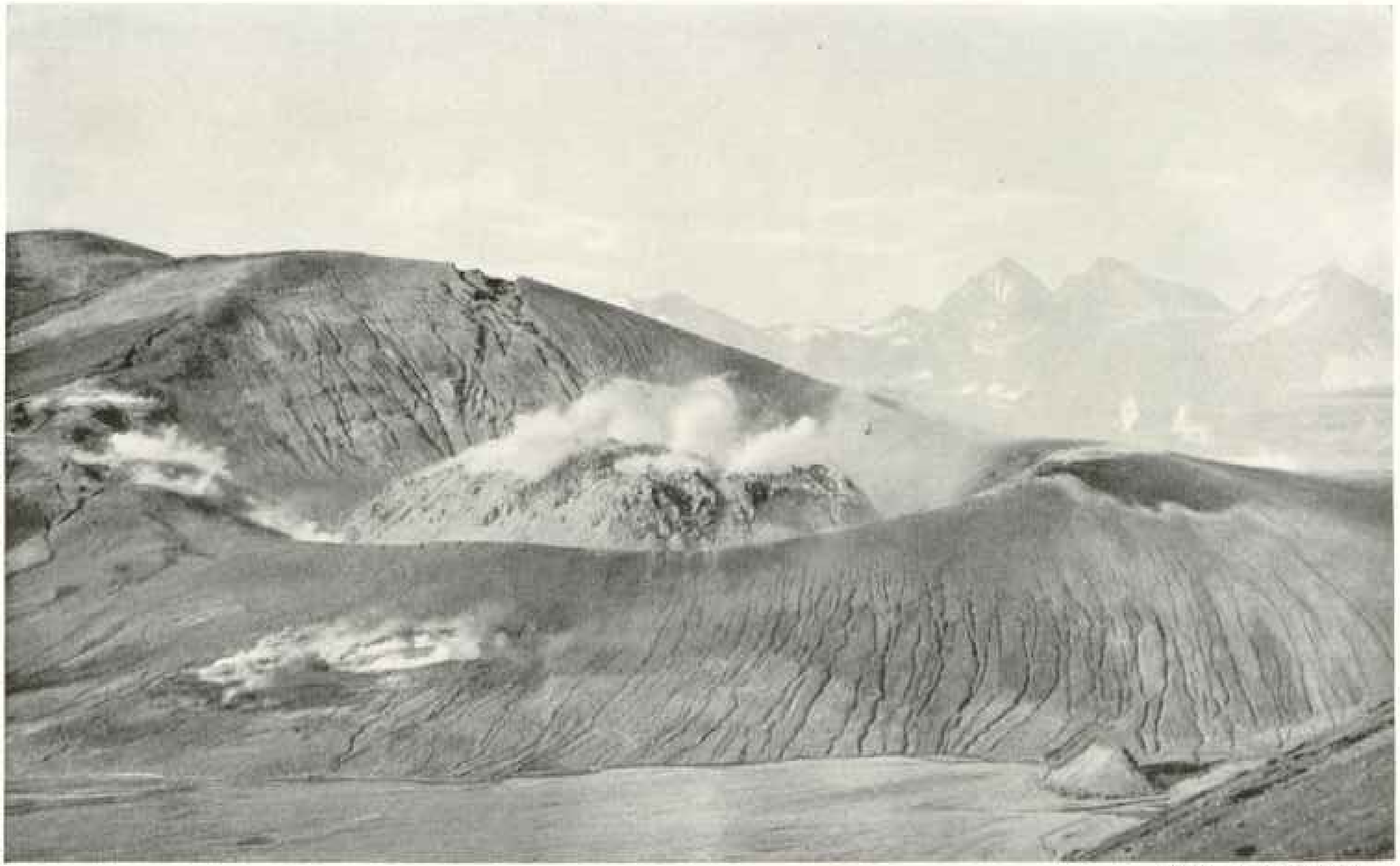
ESSENTIALLY DIFFERENT FROM A LAVA FLOW

In many places one can see the trunks of the overwhelmed trees standing where they grew, rooted in the ground, but turned to columns of black charcoal. Such charcoal logs are sometimes a foot in diameter. In other places the mat of vegetation that originally covered the ground is preserved as a conspicuous stratum of charcoal on top of the old soil (see pages 224 and 226).

Although the description will undoubtedly call to mind the condition of an ordinary lava flow, this fiery mass cannot be properly compared with a stream of molten lava, for it differed from a lava flow in many essential particulars. Although undoubtedly liquid in the beginning, it did not long remain so, for the escaping gases promptly converted it into a suspension of innumerable solid fragments buoyed up by the enormous quantities of gas which were being given off from within their substance.

The physical behavior of the resultant fluid was very different from molten lava, for lava under the most favorable circumstances is a viscous liquid, moving slowly, like stiff tar, whereas such a suspension may run like water.

Had the quantity of gas been less, the material might have remained a liquid lava of the conventional kind and hardened into solid rock on cooling, but the heavier constituents were so completely disrupted that on cooling they became ash and pumice similar to that formed in the typical explosive eruption. When the flow came to rest and cooled down, therefore, it became a fine-grained friable tuff, easily cut into by running water, rather



Photograph by E. C. Kolb

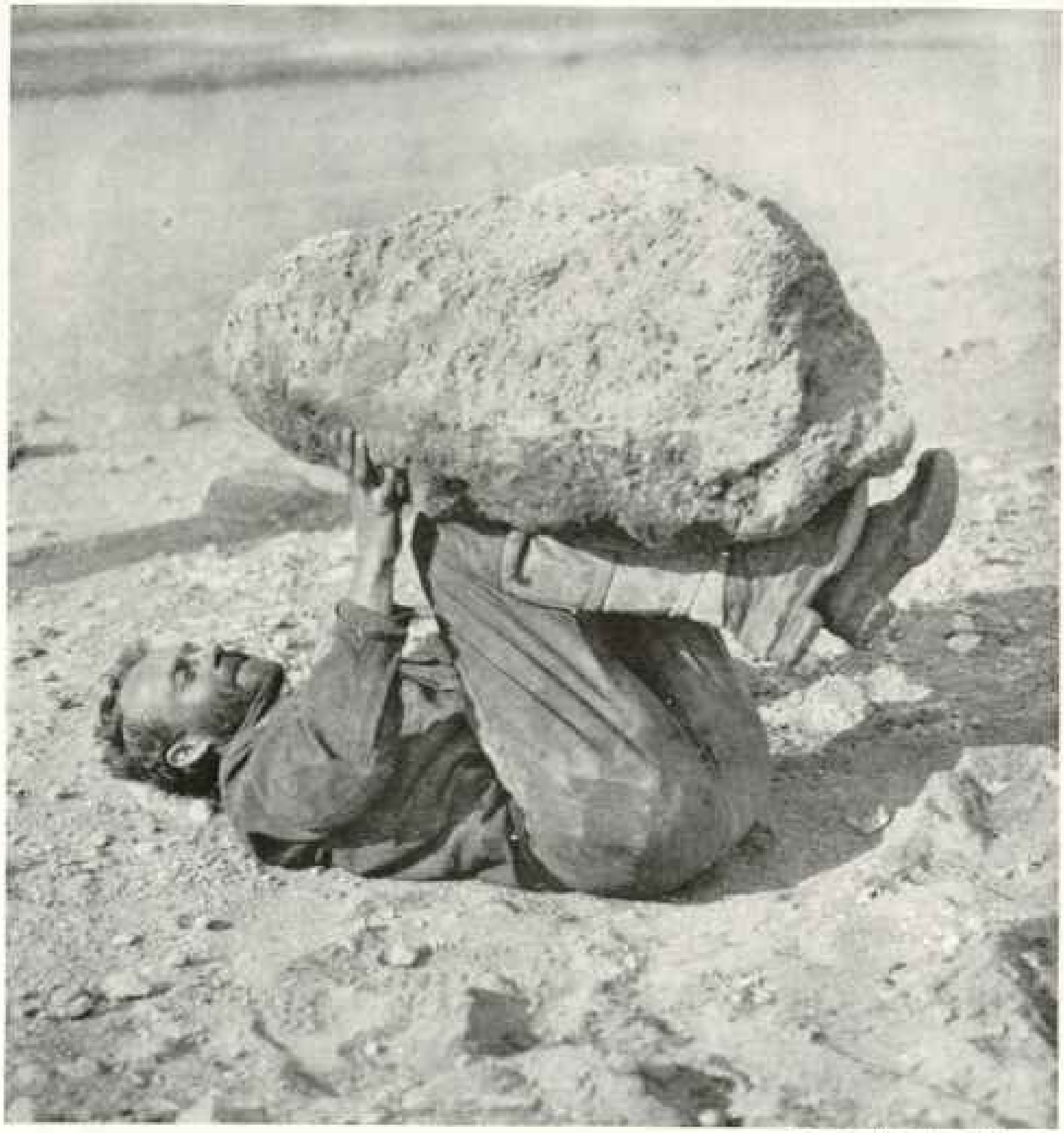
NOVARUPTA FROM THE SLOPE OF FALLING MOUNTAIN

The central lava plug is surrounded by a ring of material thrown out in the explosive stage with which this volcano began its existence. It is probable that a considerable fraction of the incandescent sand came from this vent (see text, page 223).

Photograph by E. C. Kolb

LOOKING ACROSS A CORNER OF THE VALLEY OF TEN THOUSAND SMOKES FROM THE RIM OF NOVARUPTA

Novarupta appears to be the climax of the activity of the valley. There are many large and impressive fumaroles near by. It is a significant fact, however, that none of the extremely high temperatures have been found in this vicinity.



Photograph by L. G. Folsom

KOLD IN THE RÔLE OF SAMSON

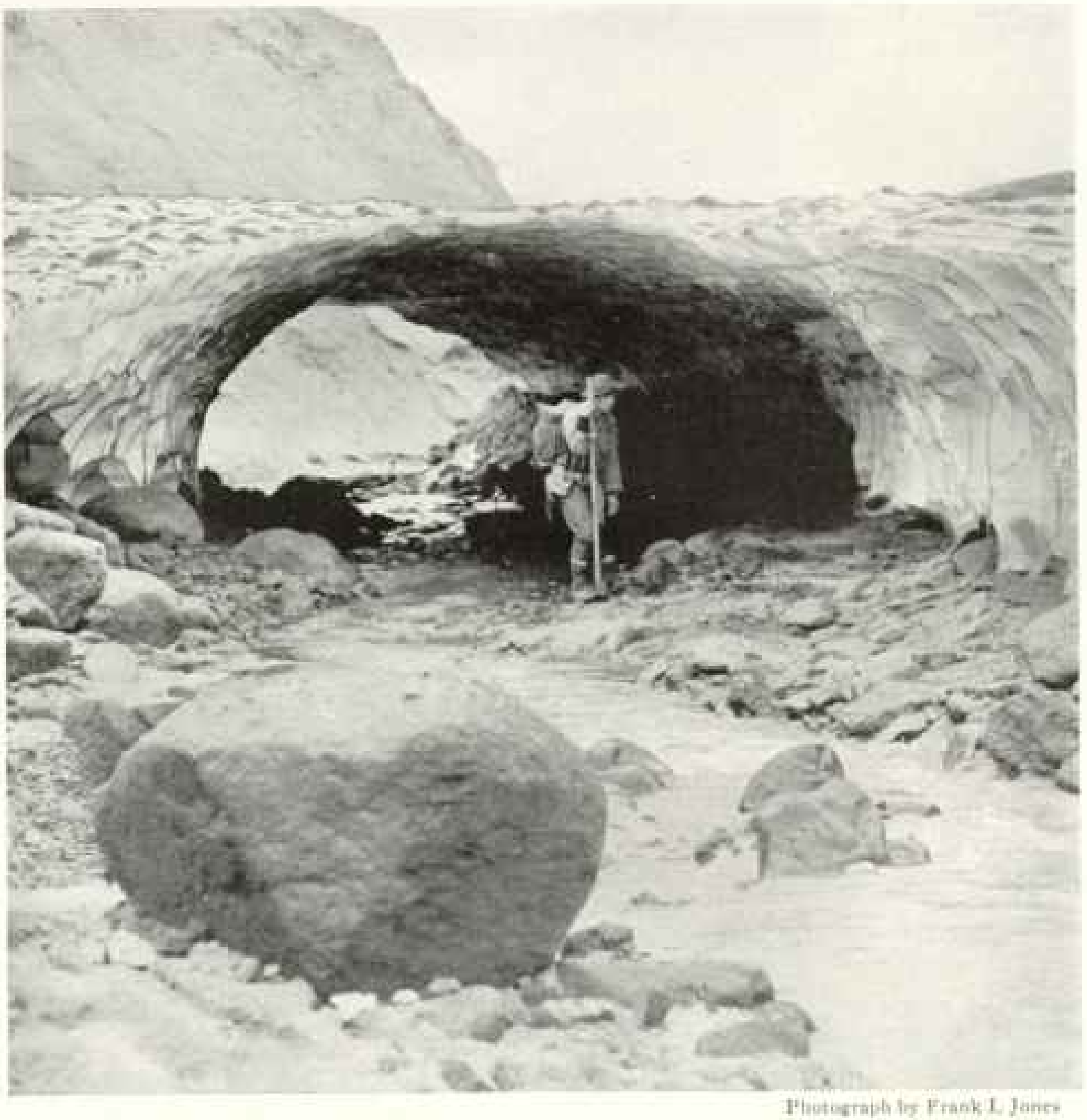
Balancing such a "rock" in the air is not so much of a feat as it appears, for the mass is a chunk of pumice blown so full of bubbles by the gases of the eruption that it might float on water. Such large pieces of pumice are confined to the vicinity of Novarupta. All the ejecta of Mount Katmai itself are very finely divided because of the greater violence of its explosion.

than the solid rock of a hardened lava flow (see page 225).

VALLEY SURROUNDED BY "HIGH-SAND MARK" OF THE FIERY TORRENT

One of the most conspicuous features of the valley as it stands today is the clear-cut margin of this great mass of once incandescent sand, which stretches in a practically continuous high-water mark all around its margin. The continuity of this "high-sand mark" shows clearly that the incandescent mass was not poured down one of the adjacent mountain sides into the valley, but must have originated from vents within its confines. This is clearly evidenced by many additional facts which cannot be detailed here (see page 220).

During the whole period of flow the mass was probably kept in a state of constant turmoil by the continued evolution



Photograph by Frank L. Jones

A STREAM FROM A HOT SPRING MADE THIS NATURAL BRIDGE OF SNOW

Hot water emerges from many openings in the valley leading up to Katmai Pass. These ancient hot springs were well known to the natives. They constituted almost the only sign of volcanic activity in the district before the eruption of 1912.

of gas from the substance of its solid components.

After the forward motion had ceased, explosions continued for a time, tearing great yawning holes in the surface of the smooth valley floor—the present craters which dot its surface. Some of these are isolated; others stretch out in long lines like beads on a string, indicating probably the seat of fundamental fractures in the rocks beneath. In other places they are so thickly peppered over the surface as to coalesce and form compound nests of craters. Two of these measure half a mile in diameter (see page 246).

The explosions responsible for the valley craters were insignificant in violence as compared with the great outbursts of Katmai, for all the debris fell in the immediate vicinity, no recognizable quantity having reached the sides of the adjacent mountains. Still, explosions capable of tearing up pieces of ground half a mile square and upheaving them in a series of fountains of red-hot rocks thrown in all directions would, from the human standpoint, form about as awe-inspiring an exhibition of titanic forces as can well be imagined.

The fiery flow at its height must indeed

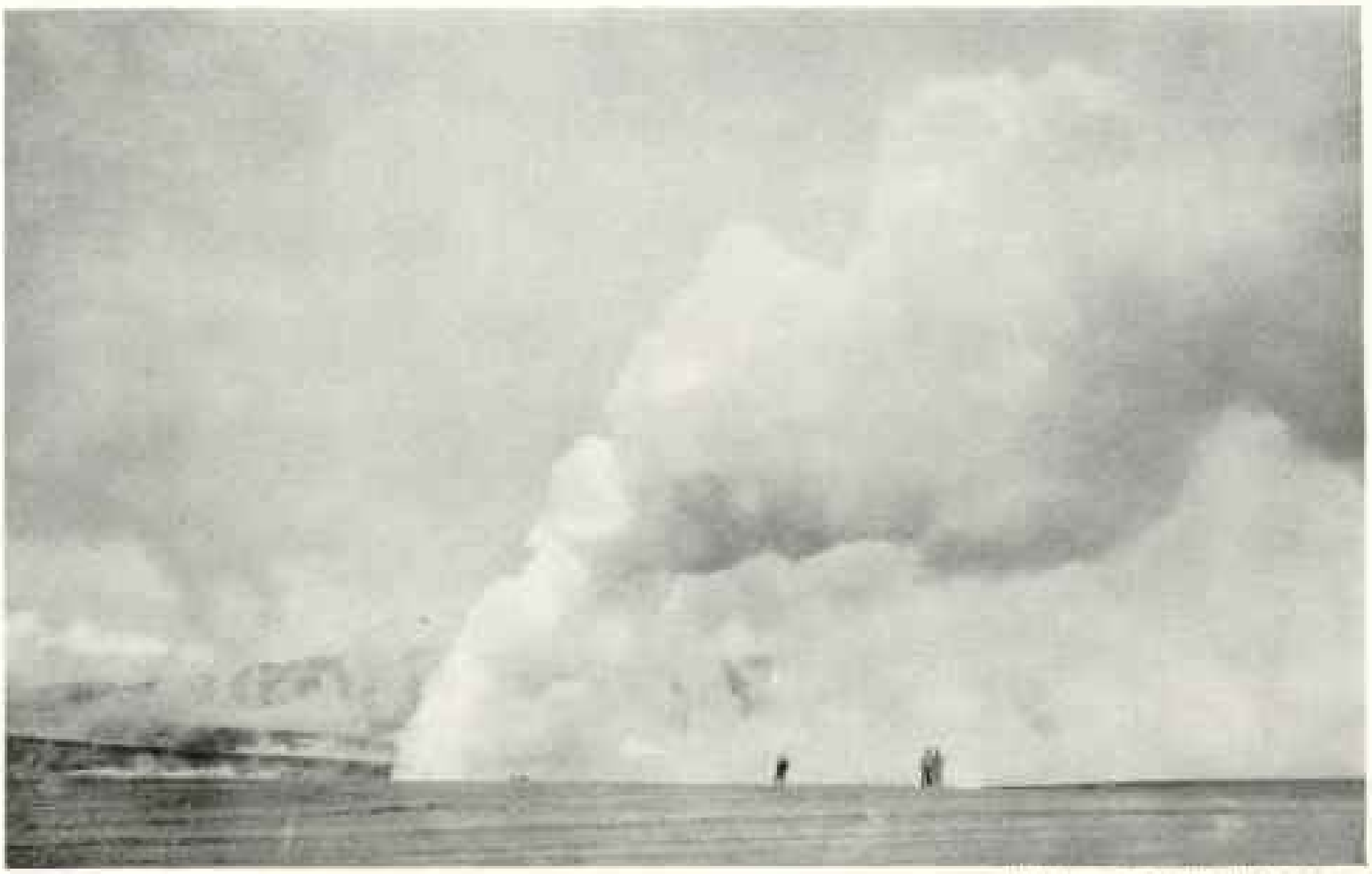
Photograph by E. G. Zies

DROPPING THE THERMOCOUPLE INTO A DEEP HOLE

Photograph by Frank L. Jones

CHEMISTS PREPARING TO COLLECT THE GAS FROM ONE OF THE FUMAROLES

A complete knowledge of the gases given off by the fumaroles could not fail to add greatly to our understanding of the problems of volcanism.



Photograph by R. F. Griggs

APPROACHING ONE OF THE BIG FUMAROLES

Photograph by E. G. Zies

STEAM RISING FROM HOT SPRINGS IN THE LOWER END OF THE VALLEY

These streams were running cold in 1917 and 1918. At that time the hot-springs of 1919 were fumaroles, whose steam escaped into the air without warming the surface waters.

FRYING BACON OVER A FUMAROLE

It is hard to appreciate the situation from a still picture. The steam is so hot and dry, as it rushes forth, that it is perfectly clear. The pressure was so great as to lift the frying-pan high in the air. It had to be held down against the outrushing steam (see page 262).

Photographs by E. C. Kolb

OUR DRINKING POOL AT THE MOUTH OF A SNOW CAVE

By moving the tents a few feet back or forward, we could obtain any desired floor temperature. Only a few rods beyond the tents was our cookstove.

A BONFIRE KINDLED BY WATER (SEE PAGE 250)

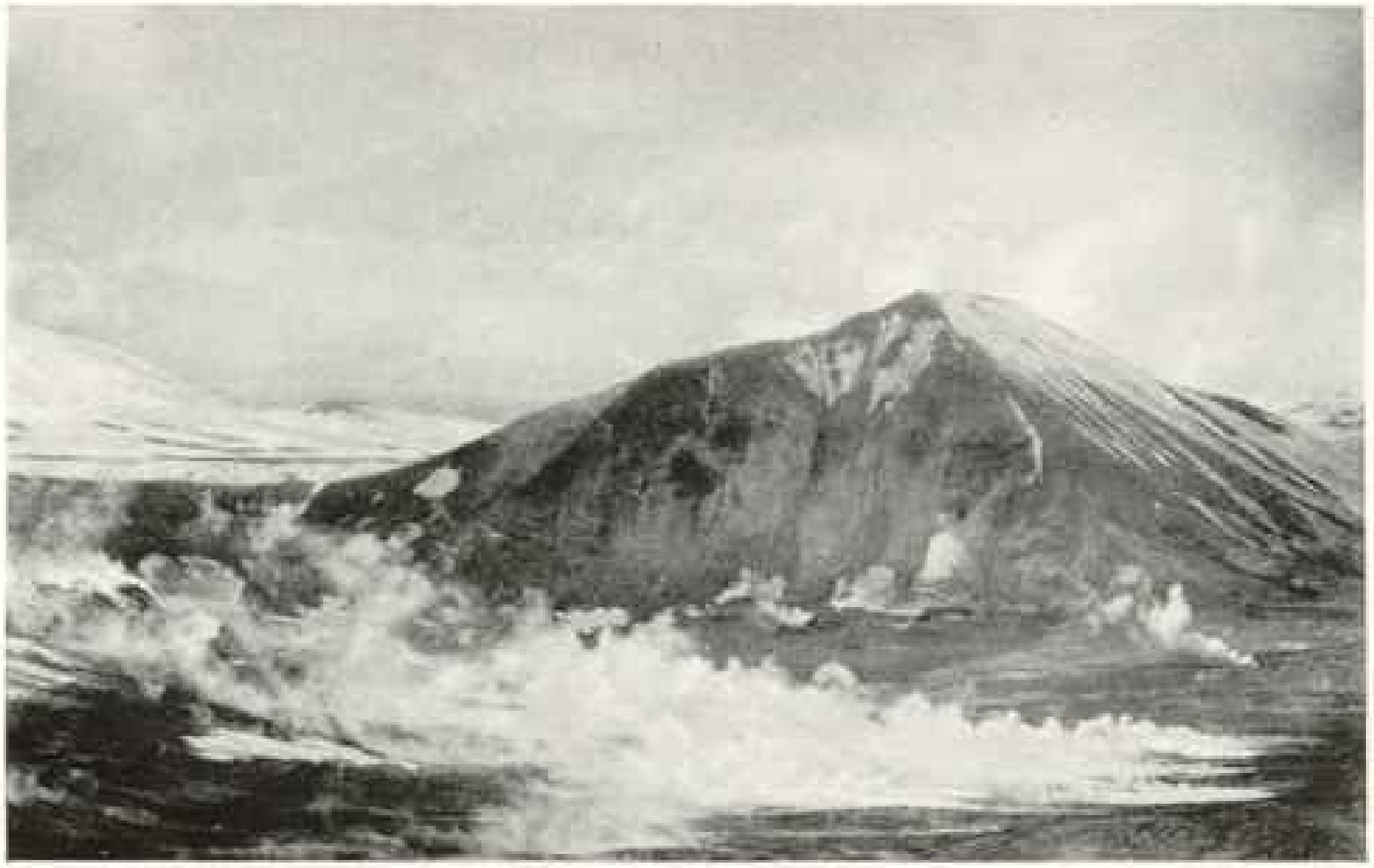
One of the fumaroles was so hot and dry that shavings burst into flame after being plunged for a moment into its hot vapor. Since this consisted of almost pure steam—that is to say, water—what we really did was to kindle a fire by poking a stick into the water. Temperature measurements by the geophysicists showed that it was 645° C. (nearly 1200° F.).

Photographs by R. F. Griggs

FUMAROLES AT THE CORNER OF BAKED MOUNTAIN

We all wanted to come down at night and see if the throat of the fumarole shown in the upper illustration was *red hot*, but no one cared to try to find his way around in the dark.

THE FLAG OF THE "GEOGRAPHIC" IN THE VALLEY OF TEN THOUSAND SMOKES



Photographs by R. F. Griggs

FALLING MOUNTAIN FROM ACROSS THE VALLEY

Avalanches continued their galloping succession down the gouged-out face of Falling Mountain with quite enough frequency to satisfy the newcomers, although they were a little less regular than in 1917 (see text, page 248).

Photograph by R. F. Griggs

ONE OF THE GAPING FISSURES ALONG THE MARGIN OF THE VALLEY

Photograph by Frank L. Jones

MOUNT MAGEIK FROM BAKED MOUNTAIN CAMP

The towering form of Mount Mageik, with its pillar of cloud rising high in air, is a landmark for the whole region. It stands directly across the head of the Valley of Ten Thousand Smokes.

Photograph by R. F. Griggs

STEAMING FISSURES NEAR NOVARUPTA

Photograph by J. D. Sayre

LOOKING DOWN INTO KATMAI, THE GREATEST ACTIVE CRATER IN THE WORLD

A single step would plunge the man on the edge to destruction. The crater rim is as sharp as a gabled roof. Inside the slope is almost vertical.

have presented a spectacle, if it could have been seen through the impenetrable black cloud that rose from its surface, far surpassing the weirdest image of the infernal regions ever conjured up by poet or preacher in an effort to picture the place of everlasting torment.

The spectacle presented by this tremendous outflow of incandescent sand was not seen by human eye. But even the stiff, cold mass lying on the ground where its movement ceased is one of the most impressive features of the Katmai National Monument (see page 228).

A CUBIC MILE OF INCANDESCENT SAND

Not only did the flow continue down the main arm of the valley toward Naknek Lake for 17 miles, but it also ran back across the divide behind Novarupta Volcano and completely encircled the Broken Mountains, coming down a side valley under Knife Peak to join the main flow again several miles downstream. More surprising yet, a quantity of it was poured out high up in Katmai Pass, whence it ran both ways, sending one tongue down to the base of Observation Mountain on the Pacific side of the range, while another flowed down into the main valley between Cerberus and Falling Mountain (see map, page 227).

Its greatest length is thus 20 miles, while its greatest breadth is 9 miles. The total area covered is 53 square miles.

Over most of this area the depth of the flow is so great that no indication of the original height of the ground remains. It is impossible, therefore, to estimate the thickness of the mass. Only around the edges and near its terminus can one find any stream canyons or fissures that cut through it (see page 229).

The deepest canyon exposes a section about a hundred feet thick, but there are the best of reasons for supposing that its thickness must be much greater than that over the larger portion of the valley. It seems quite safe to estimate its total volume as greater than a cubic mile!

A cubic mile of incandescent sand! The figure is so large as to pass comprehension. If a gang of contractors with steam-shovels should start to load it onto flat cars, they would find that before they had finished they would have filled a train that would reach entirely around the world and still leave a considerable pile of it untouched.

Pulverized as it is, the material may justly be compared with crushed stone, for in composition it is similar to granite. If it had been permitted to crystallize deep down in the interior of the earth, it would have become granite.

In seeking to gain some conception of the magnitude of the operation by which it was produced, we may inquire how long it would take our stone-crushers to pulverize a similar mass of granite into road-making material. The answer is that the sand flow is equivalent to the output of all the stone-crushers in the United States for a period of one hundred years!

OBJECTIVES OF OUR LAST EXPEDITION

In piecing together a narrative of the events of the eruption that gave birth to the Ten Thousand Smokes, we have in a certain sense put the cart before the horse, for the sifting of evidence that has made the preceding account possible required a large amount of time and study.

The various aspects of volcanism described by previous expeditions are so exceptional and so helpful to an understanding of many puzzling problems of the volcanic mechanism that I felt our findings were too important to stand alone without corroboration by other observers. The scientific world would indeed be justified in some skepticism over such remarkable reports until they were independently confirmed by other observers.

After a survey of the field, it was decided that no other organization was so well equipped to handle some of the varied problems encountered as the Geophysical Laboratory of the Carnegie Institution. Accordingly, this institution was invited to send a party with the National Geographic Expedition of 1919, under a coöperative agreement, whereby the National Geographic Society undertook to assume the field expenses of the party, while the Geophysical Laboratory agreed to work up the results on the return.

The production of a moving-picture record of the wonders of the region occu-

Photograph by L. G. Folsom

THE ONLY WOMAN WHO EVER BEHELD KATMAI CRATER

Mrs. Griggs, spurred by an unconquerable optimism, climbed through the fog all the way, while a party of the men lingered behind, waiting in vain for a break in the clouds. She was rewarded by coming into clear air just before reaching the rim, but some of the men went home without having ever beheld this wonder of wonders.

pied almost as important a place in our plans as the more technical scientific observations. Still pictures at best can give only an inadequate conception of the place. But the motion pictures brought back by the expedition, showing the majestic rolling columns of the big volcanoes, the sizzling fumaroles, and the leaping salmon, are the next thing to a view of the marvels themselves. The members of The Society, some of whom have had opportunity to see these films, will be glad to know that such a record of these unique phenomena has been preserved.

The activities of the expedition were so varied in 1919 that the men were kept scattered at different camps throughout the season. It thus happened that some of the men hardly saw each other during the whole summer. Folsom, for example, did not meet Sayre until August 21, when the season's work was almost done.

At no time were all the members of the expedition assembled on one spot. The largest group was assembled at Kodiak, after the field season (see page 258): but there were three faces missing, for Jones had been compelled to leave early and Jacob, with Ralph Hagelbarger, had returned through the Bering Sea with a cargo of specimens too heavy to be carried over the pass.

PERSONNEL OF THE EXPEDITION

There were nineteen of us in all: The Director; the Geophysical Party, consisting of Dr. E. T. Allen, chemist; Dr. C. N. Fenner, petrologist, and Dr. E. G. Zies, chemist; Prof. J. S. Hine, of the Ohio State University, zoölogist; J. D. Sayre, topographer; Paul R. Hagelbarger, topographer; Emery C. Kolb, of the Grand Canyon, motion-picture man; Frank I. Jones, of Portland, Oregon, color photographer; Lucius G. Folsom, assistant to the Director; A. J. Basinger, Ralph Hagelbarger, Richard E. Helt, William L. Henning, Harry E. Jacob, August E. Miller, Julius Stone, Jr., H. N. Wallace, and Charles Yori, assistants.

It would be hard for any one who was

Photograph by E. C. Kolb

MOUNT MAGEIK FROM THE ASH FLATS

The elderberries and bunches of grass have come up through a heavy blanket of ash and pumice.

not along to realize how these men worked for the success of the expedition. No task, however difficult or disagreeable, was too great, whenever it was recognized that it was for the good of the expedition.

Many of the tasks for which there were volunteers in plenty would have been altogether unreasonable in the eyes of any except men who were there for the love of overcoming difficulties.

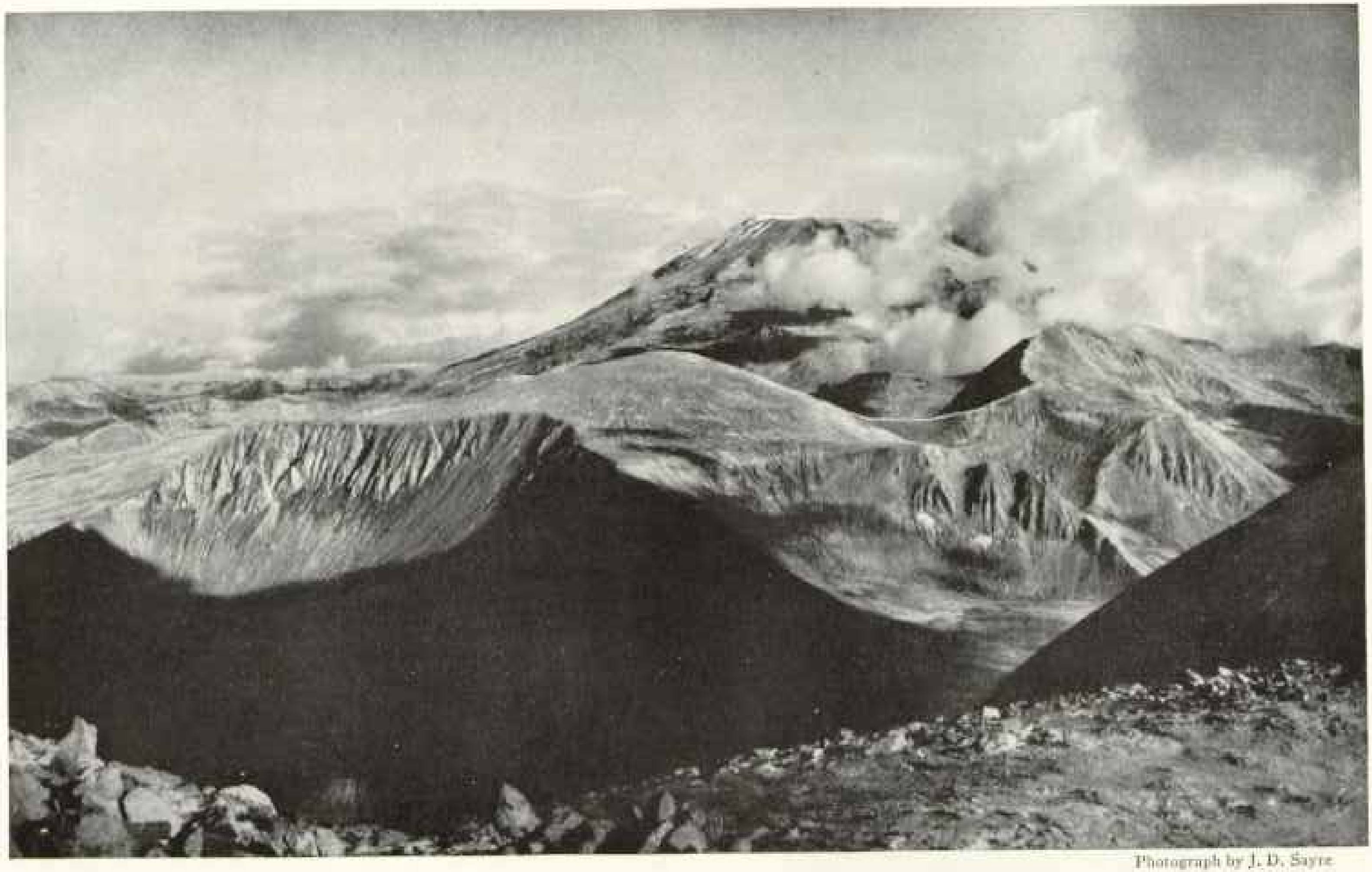
In addition to the regular members of the expedition, visitors were received for the first time. The first "tourist" to visit the Katmai National Monument was Rodney L. Glisan, of Portland. Later in the summer the wives of the three members of the expedition whose families were at Kodiak—Mrs. Griggs, Mrs. Folsom, and Mrs. Kolb—also came across and visited the valley, thus proving that, despite the necessarily primitive conditions, the place is by no means impossible for women (see page 242).

"LINING" SUPPLIES UP THE RAPIDS

Although there was some uncertainty in advance as to the possibility of "tracking" our supplies through the rapids by lining the boats, it had been decided that the chances were favorable to success. When the Naknek section of the expedition, under the leadership of Sayre, arrived, they found the river extremely low—so low that there was considerable difficulty in getting the boats over the bars.

Nevertheless, it was found that as much as 1,500 pounds could be tracked up in a single load, which was far more than we had dared anticipate. At the time, the low water, with its shallows, was considered a considerable handicap, but, as we found later, to our sorrow, it was extremely lucky for us that there was no more water.

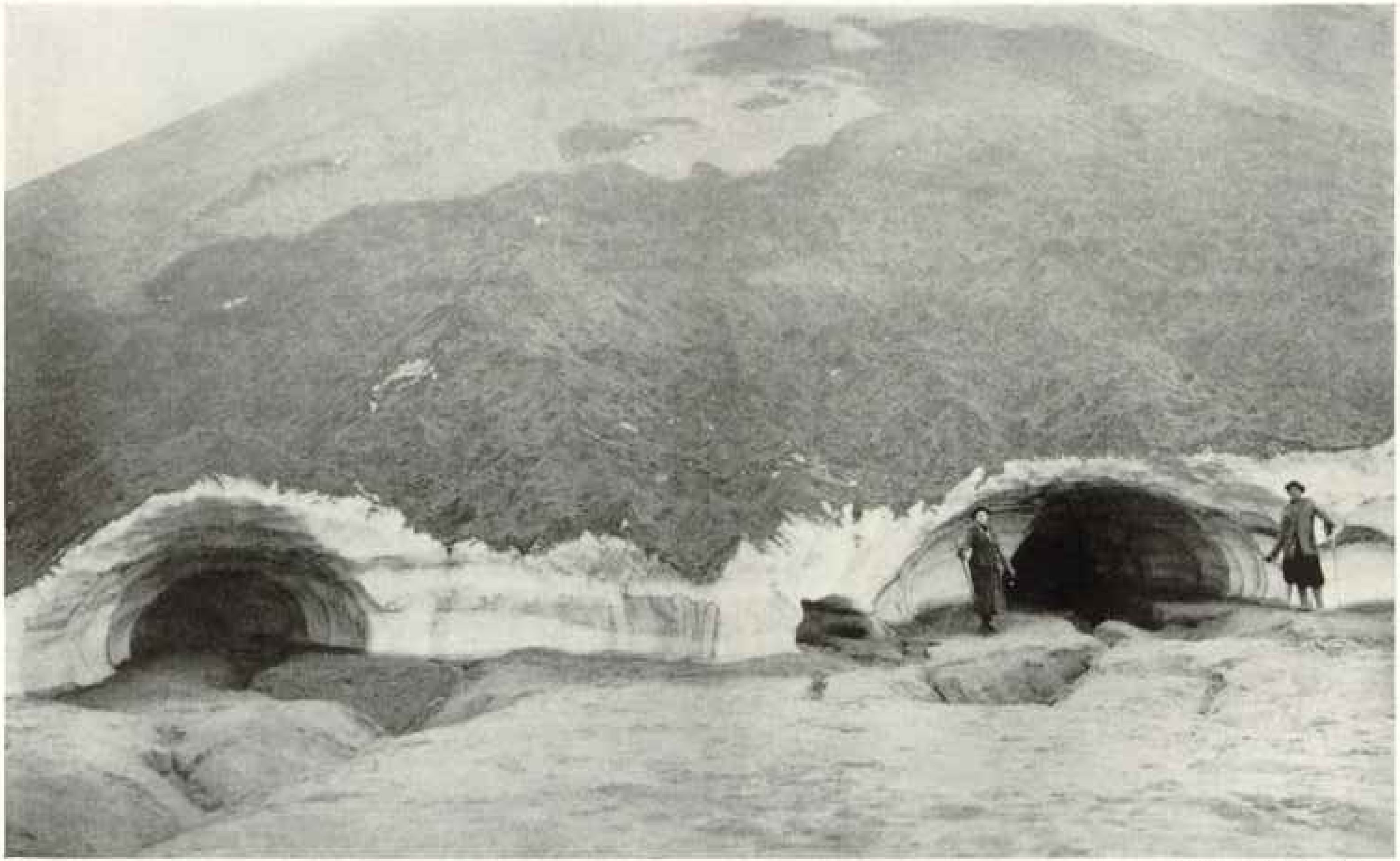
Any one who has tried it knows that lining a boat through swift water is hard work. It took three men, two on the towline and one to fend off, at the bow of the boat, and in many places the water was so swift that the combined efforts of all three were barely sufficient to move it against the swift current. Yet, with all its difficulties, a day of this work is much easier than a day with a pack on one's



Photograph by J. D. Sayre

KNIFE VOLCANO, WHICH OVERHANGS THE NORTHERN ARM OF THE VALLEY (SEE MAP, PAGE 227)

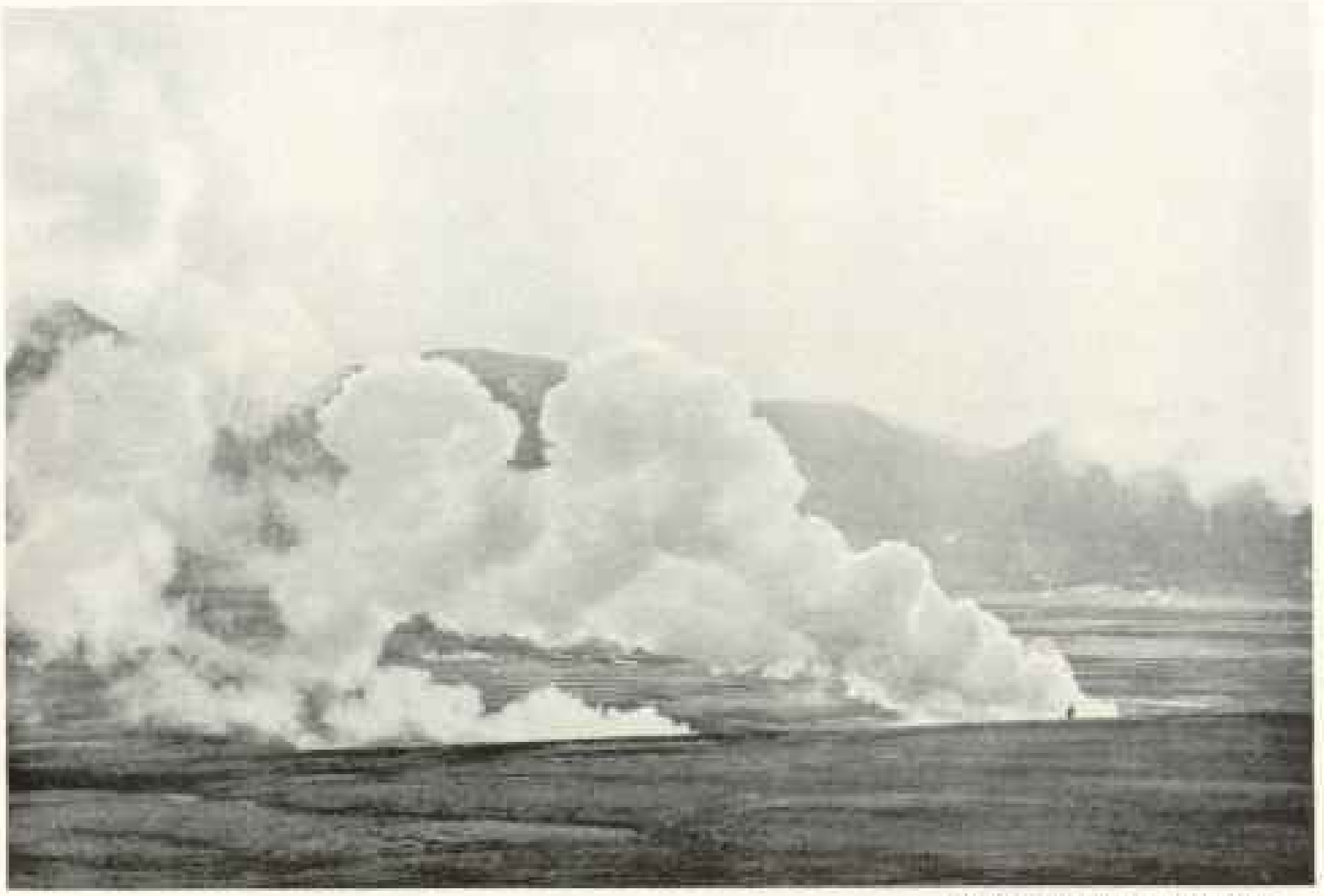
This volcano is the highest mountain in the Katmai region, overtopping Mageik and all the rest by several hundred feet. It is not at present active, but the snow melts off its flanks sooner than from any of the other mountains round about. Prior to the National Geographic expeditions, this mountain was not known as a volcano, nor had it ever been photographed.



Photograph by E. C. Kolb

AN ASH-COVERED SNOWDRIFT ON THE EDGE OF THE VALLEY OF TEN THOUSAND SMOKES

The heat from the ground melts out great tunnels in the snow. The water coming out from under the melting snowdrift is sometimes actually warm to the touch.



Photograph by Frank L. Jones

FUMAROLES IN FRONT OF BAKED MOUNTAIN CAMP

Photograph by R. F. Hoit

ONE OF THE MANY CRATERS IN THE SAND-FLOW

The presence of these craters is evidence that explosions occurred after the general body of the hot sand-flow had come to rest. The whole surface of the east arm of the valley is pitted with craters like this. Many of them are the seats of vigorous fumaroles.

back; and, besides, one has the satisfaction of knowing that he has accomplished three times as much.

But when the wished-for high water came we found that it was another story. Later in the summer the river rose three feet, covering all the shoals and rising up over the grassy bank. Then we had our troubles, sure enough.

The last time we tried the rapids was when Kolb, Helt, and I had gone down to Naknek to attend to some business at the cannery, late in July. We found at once that the increased swiftness of the water far outweighed the advantage of greater depth. In many places where we had been able before to find good footing on the bare gravel bars, we were now driven to cling to the steep, slippery bank with water, too swift to stand against, racing beneath.

Many were the places where, in spite of our best efforts, we slid off into the river with a splash. If there had not been two of us we could never have held the line, much less hauled the boat forward; but when one fell, the other held, often having to take a turn around one of the tree trunks, which were otherwise unmitigated nuisances, as we clambered under and around their leaning branches.

But, to our surprise, we found the worst going along the comparatively level grass banks, where the water, working among the clumps of grass roots, had eaten away great holes which could be neither seen nor avoided.

As we went pushing along, shoulder deep in the tall grass, splashing through shallow water, we would suddenly drop clear out of sight into a little pocket of a hole deeper than it was wide. Out again, over a yard of resistent grass roots, and then plump into another hole!

In places there were stretches of upward of a hundred yards where the ground was honeycombed with holes of this sort. Long before we reached the head of the swift water we were dog tired, but there was nothing to do but keep on.

Toward the end our incentive to keep going was the knowledge that if we could only stick to it a little longer we could go ahead across the lake on the morrow without further occasion for getting wet—no small matter when we had only one change of clothes and no chance of drying out.

We were surprised to find that the season was later on the south side of the peninsula than on the Bering Sea side. We had feared that the lake might not break up in time to permit Sayre's party to reach the head of navigation at the appointed date. But, as it turned out, it was we on the other side who were delayed. It was the first day of June before we were ready for a try at the pass and the valley beyond.

FIRST TRIP TO THE SMOKES

The calm of the early morning, which had induced us to believe it a suitable day for the attempt, gave way soon after we had started to squalls of rain, sleet, and snow, which, driven by fierce cold wind into our faces, made us almost sorry we had started.

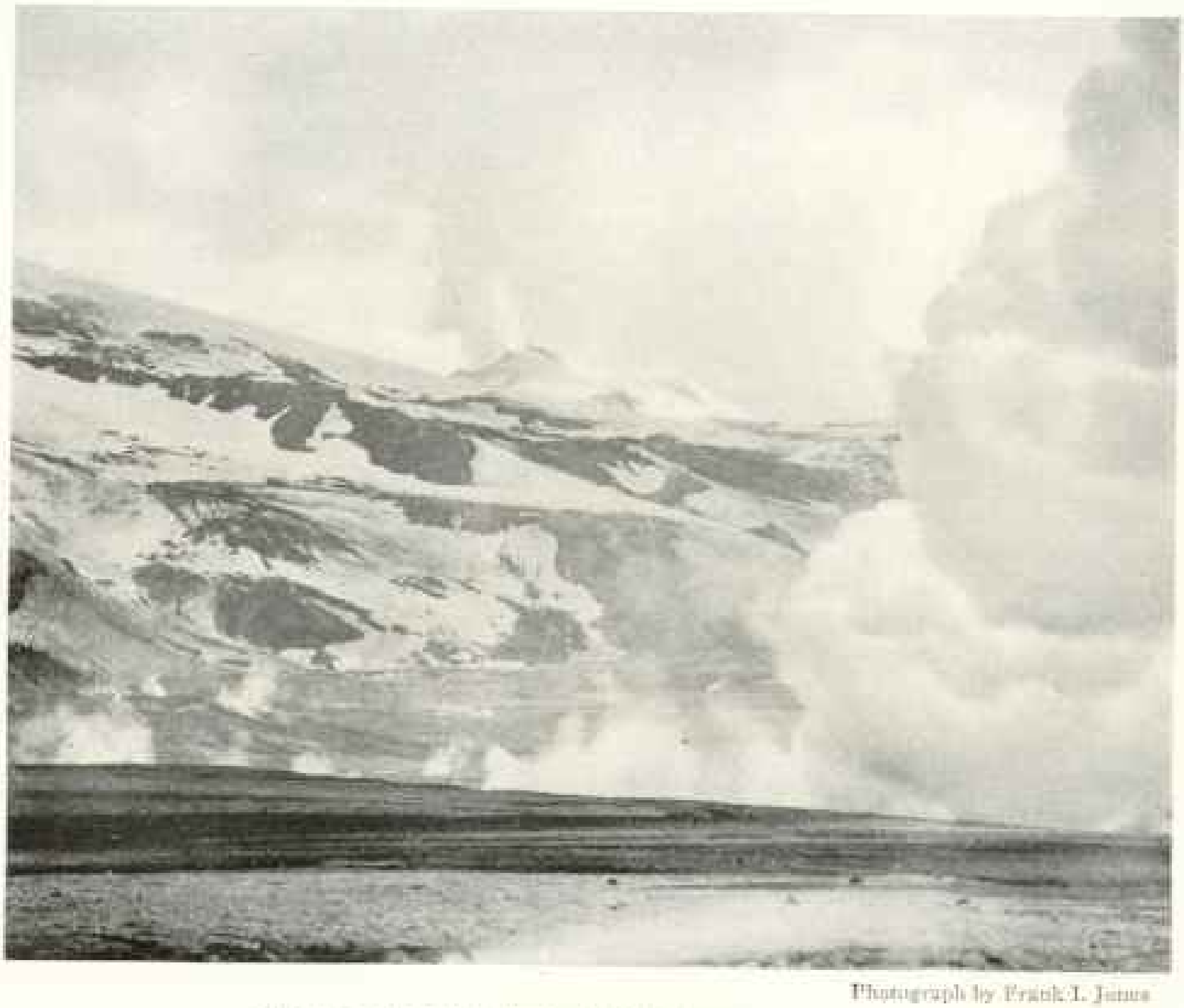
Everywhere, except on the lowlands close to camp, the ground was covered with soft, wet snow, through which we had to plow our way, sinking halfway to our knees at every step.

In the monotony of the weary grind up hill we scarcely realized how hard we were working until, coming to little patches of bare ground where we could swing out free, we felt as though we had suddenly taken wing, so great was the relief.

As we neared the pass our nerves tightened with expectancy—Kolb, who alone was with me, wondering whether the thing would after all be as wonderful as the stories; and I, my mind full of the picture of that memorable day two years before, when I had taken leave of my wonderful valley, anxious to see what changes time had wrought.

When we reached the pass we found the upper flat all blanketed with snow. The little twin fumaroles that had first beckoned me into the valley were nowhere to be seen. I knew that they had maintained faithful watch all through 1918, but I could not help wondering whether they had really gone out or whether they were merely overcome by the mass of snow that had drifted over them.

I peered over the rise, half a mile be-



Photograph by Frank L. Jones

MOUNT MARTIN FROM BAKED MOUNTAIN CAMP

The crater is thirteen miles distant in a straight line. After leaving the first slopes, five miles away, our path led entirely over ice and snow. Some of the glacier-work was extremely hazardous (see text, page 267).

yond, that hid the valley itself. Nothing was to be seen. Had it, too, succumbed? But, as I looked, a puff of vapor rose up and joined the clouds above. No, the Smokes were still there.

Saying nothing to Kolb, for I wanted him to be taken by surprise, I pressed on. But the puffs kept coming, another and another, so that it was not long until he saw one for himself. When finally we surmounted the rise and looked over, there they lay, spread through the whole valley, exactly as when we first beheld them. No snow there! (see pp. 237, 272).

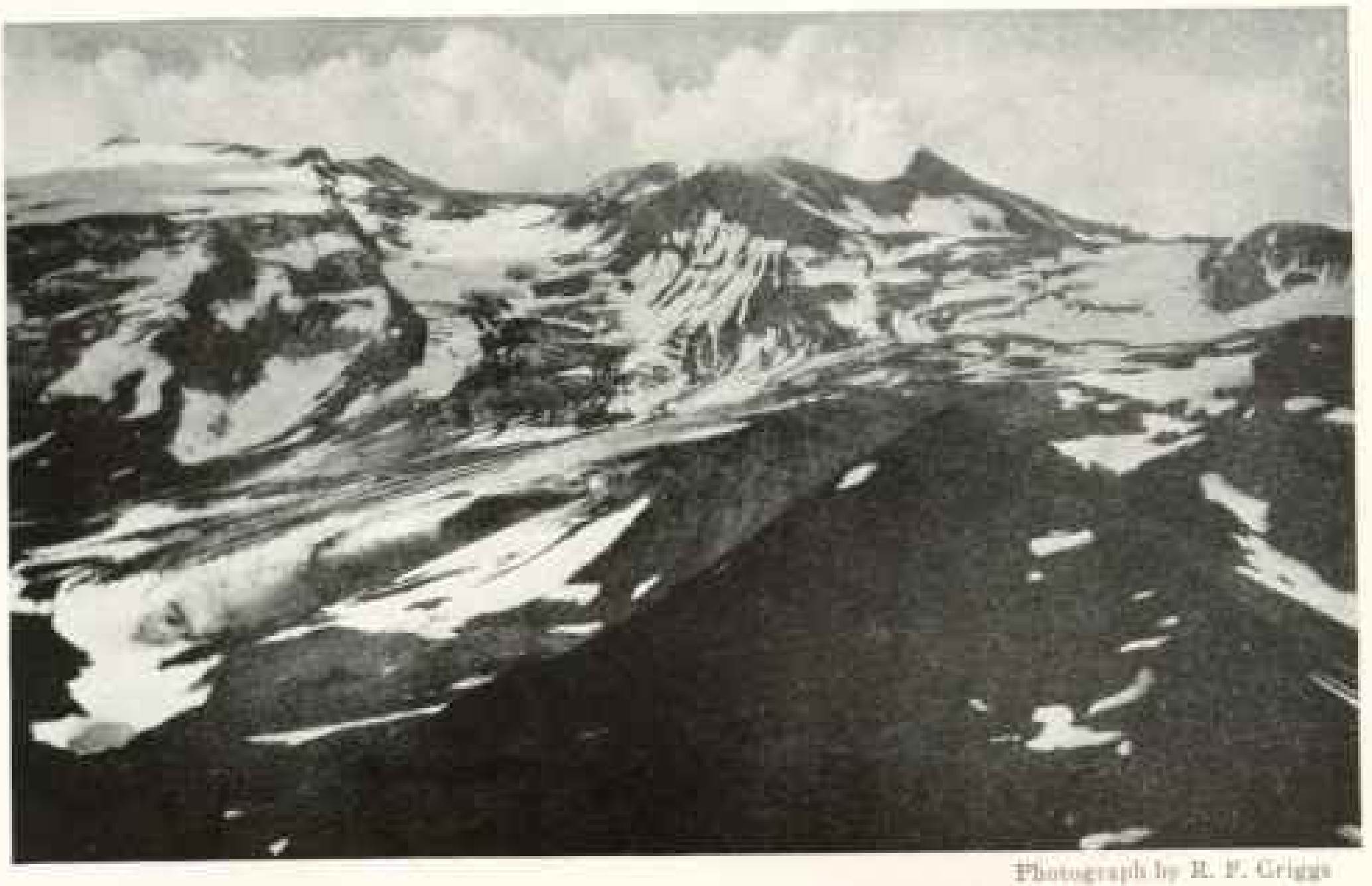
THE TEN THOUSAND SMOKES IN 1919

What a contrast to the snow-covered valley leading up to the pass! Except for a few patches in cool spots around the margin, it was as clear and bare as in midsummer.

The general appearance of the valley was the same as it had been in 1916, when first discovered, but after we had had time to examine it somewhat in detail, we could observe some slight indications of a slackening of activity around the edges. The little fumaroles between Cerberus and Mageik, at the head of the valley, of which there were about a hundred in 1916, 1917, and 1918, were reduced to two or three in 1919.

At the foot of the valley a large number of springs of boiling water had started up in areas where there had been nothing but steam previously. The temperatures of some of the fumaroles in the same area were markedly lower than the year before (see page 235).

Falling Mountain, likewise, though active enough to satisfy the newcomers, did not shoot forth its avalanches with



Photograph by R. F. Griggs

MOUNT MARTIN FROM THE PACIFIC SIDE

Three times we climbed this volcano and once descended inside its crater, but in our attempt to study it we were baffled by the fog, which each time shut down and kept us from seeing what we sought to observe (see text, pages 269 and 270).

quite the same frequency as in former years. The old volcanoes—Katmai, Trident, Mageik, and Martin—also were less vigorous than in 1916 and 1917.

It is by no means certain, however, that this indicates that the activity of the region is dying out. The big volcanoes, which alone were known at that time, had a similar slackening in activity in 1915. We could not be certain that year whether Katmai was active at all, and the steam from Trident could not be seen except under favorable atmospheric conditions. But the two following years the activity of both these vents increased measurably, so that no one would have questioned the reality of the steam clouds issuing from them.

Whether the slackening of the activity of the valley vents observed in 1919 was simply such a temporary fluctuation or whether it represented a permanent quieting down can only be judged by the future. In either case, there is no reason to expect any sudden extinction of the Smokes, for the changes observed were so slight that we could not be certain that there was a real slowing down of activity until after many days of observation and comparison.

Although some signs of a diminution of activity were detected around the edges of the valley, the geophysicists found temperatures very much higher than any that had been measured before—higher, indeed, than any of us had believed to exist in the valley.

MELTING LEAD AND ZINC IN THE FUMAROLES

It was late in the season before any of these hot places were discovered, and all felt that if only there had been more time certainly more hot ones and probably others with even higher temperatures would have been found; but the increasingly bad weather put a stop to further efforts in that direction.

Well do I remember the excitement when Dr. Allen, coming in late one evening, announced, "Three times have we melted zinc this day." They had found three widely separated fumaroles with temperatures above the melting point of zinc (419° C., 784° F.). The hottest of these was practically five hundred de-

Photograph by R. F. Griggs

THE "DEFENSES" OF BAKED MOUNTAIN CAMP

Profiting by several sorry experiences, Yori finally shored up the tents so thoroughly as to bid defiance to the winds, but it was no use. The condition of the camp when the next storm cleared away is shown on the opposite page (see text, page 279).

grees centigrade (496° C., 915° F.). This was found in a fumarole where the steam broke through a myriad of small holes in the roof of a bridged-over fissure.

The volume of gas coming from any one of these was so small that it could be approached as closely as might be desired. One could readily reach into the hole with the end of a foot rule held in his hand. Within five seconds the stick would begin to smoke violently, and when drawn out its end would be a glowing coal. In less time than that a bar of lead tied to the stick slumped down and melted away (see color plate, page 275).

KINDLING A FIRE BY PLUNGING A STICK INTO WATER

Even this performance was eclipsed next day when the chemists came in, reporting several temperatures far above 500° C.; the highest was 645° (nearly 1200° F.). This was measured in a small orifice, not over two inches in diameter, located at the bottom of a crater-like pit eight or ten feet across. It was so inconspicuous as never to have excited the curiosity of observers, although it was but little removed from the trail which we used constantly as we traveled up and down the valley. The gas, which appeared to be almost pure steam, was, however, so blue as to arouse Dr. Zies' suspicion and so resulted in the discovery of its temperature.

If it had not been located at the bottom of a pit, this fumarole also might have been reached with a foot rule, but on account of its situation it was not quite so accessible.

When we put an aluminum cup into this steam it was quickly softened, so that it could be cut with a knife like pewter; yet it showed no signs of fusion, for the temperature was still somewhat below the melting point of aluminum. The tinned handle was vigorously attacked by the gas, but the body of the cup itself was neither corroded nor tarnished in the least degree.

Then we cut the end of a walking-stick into a brush of shavings and thrust it into the steam. Instantly it began to smoke and char, but nothing further happened until we jerked it quickly into the air, when it burst into flame. We had,

Photograph by R. F. Griggs

THE WRECK OF BAKED MOUNTAIN CAMP

Nearly a thousand feet of cordage had been used in lashing the poles together to resist the weather. The wreck was so heavily drifted over by flying pumice that it took the combined strength of two of us to peel back the fallen roof and get at the duffle on the floor.

therefore, the very curious sensation of kindling a fire by plunging a stick into water (see page 237).

A RED-HOT FUMAROLE

All of the high temperatures measured were found in such relatively small and inconspicuous fumaroles as these, rather than in the big vents, which would at first impress any one with their tremendous heat. The real temperature of the gas in the big vents when it first emerges is probably quite as high as in the little ones, but the wide-open throats which the force of the escaping gases has blasted out permit the emanations to cool down considerably before reaching the surface.

On this account the biggest and most impressive vents, those which are actually delivering by far the greatest quantities of heat, are seldom more than two or three times as hot as ordinary steam. Their temperature, although far beyond that ever found in a steam-boiler, and so high that the steam is perfectly dry and transparent as it comes forth, is yet far below the kindling point of wood.

In the hottest vent the steam is not only so dry as to show no signs of condensing for a long distance, but is so highly heated that in the dark the orifice from which it comes must glow with a faint redness. Indeed, one could almost call it "red-hot steam"; but by reason of its transparency no glow would be visible in a small body of it.

All of us would have liked to see a red-hot fumarole, and there was much talk of going down to the vent to observe it at night; but when it came to making the trip no one was exactly ready to undertake the job, for none cared to try to pick his way among the fumaroles in the dark! (see page 237).

BEARS INVESTIGATE THE FUMAROLES

In the seven years since the formation of the fumaroles, the country round about has gradually become populated by a new generation of bears, which, having grown up in the vicinity of the valley, have come to regard it as one of the normal elements of their world.

When first discovered, the active area was as absolutely devoid of living creatures as can be imagined. The next year

Photograph by L. G. Folsom

SORTING OUT THE WRECKAGE AFTER THE STORM AT BAKED MOUNTAIN

We looked and felt very much like rag-pickers on the dumps, but among the wreckage were many of our most cherished possessions (see page 285).

we found the track of a single bear which had ventured to cross the valley. But in 1919 bears were frequent visitors, comprising, indeed, the only tourists that had yet visited its confines. Not merely here and there, but in many places, their tracks were to be found all through the valley. It was not the work of any single bear, nor made at any one time, for the tracks were of many sizes, showing that most of the bears of the region probably enter the place from time to time.

They were not satisfied with merely crossing through the steaming areas, but were apparently attracted in some degree by the Smokes. Their tracks were often to be found close around the largest vents, even far up toward the head of the valley, where they were many miles from any possible food. From their behavior, indeed, it seems not at all impossible that they may have been attracted by the warm ground and have sought out good places to enjoy the heat, just as a dog stretches out in the hottest place behind the kitchen stove.

But we could not assure ourselves on this point, for we never caught sight of them in the valley, and the ground around the big fumaroles is baked so hard by the heat that only claw-marks remained to show where bruin had walked. If he lay down, his shaggy coat left no mark on the hard crust, so we could not follow all his activities.

BRUIN STARTS A FUMAROLE OF HIS OWN

It was not unusual to find tracks of a bear leading straight up to one of the large vents, where he had evidently stopped to peer into the mysterious hot hole. In one of the steaming areas Hagelbarger found places where the hot ground had evidently excited the bear's curiosity, for he had dug into it with his claws until he started a small fumarole of his own.

The appearance of a cloud of steam under his claws as he broke into the hot crust must have provided bruin with a great surprise, but it did not scare him away, for he was not satisfied with a single experiment; he tried again in several places, each time digging down till he started the steam.

Photograph by E. G. Zies

UKAK CAMP

The refuge to which we fled during the storm at Baked Mountain (see text, page 279).

Photograph by W. L. Henning

EROSION IN VOLCANIC ASH

We cut off the top of this tree in 1917 at a then convenient height above the ground. So much ash has washed out in the ensuing years that the cut end now stands nine feet above the ground.

Photograph by Frank L. Jones

A JOB FOR A TIGHT-ROPE WALKER

THE BRIDGE OVER MARTIN CREEK

All the materials for color photography were in this pack; if Jones had slipped there would have been no illustrations in color (pages 271 to 278) to show the members of the National Geographic Society. Some of the boys hesitated a long while before trusting themselves on those wet, slippery logs. I am proud to say, however, that when Mrs. Griggs came to it she marched right across, just as though it were a yard wide.

LUPINES COMING UP IN AN AREA OF DEEP ASH

Photograph by R. F. Griggs

FRUITING LUPINES GROWING IN DEEP ASH DEPOSITS

These plants are the most successful pioneers in the process of revegetation, because, on account of their root tubercles, they obtain nitrogen from the air, while most other plants are dependent on organic compounds. The vigor of the plants and the abundance of the fruit in the Katmai region afford ample evidence that soil conditions are not unfavorable in areas where plants are not killed by sand blast.

Photograph by R. F. Griggs

SAND BLASTS HAVE STRIPPED THIS ALASKAN WILLOW OF ITS BARK

All of the season's growth has come from the buds on the lee side of the twigs.

In addition to the bears, which never entirely deserted the region about the devastated country, many other forms of animal life are coming in.

On one of the little ponds we found not only several loons, but two or three pairs of golden-eye ducks, geese, and even a swan, which contributed an element to our larder that had been sadly lacking in former years; for we were thus permitted to enjoy swan cooked by the steam of the fumaroles. Better meat was never served at any table.

On the hillside round about, ptarmigan were nearly always to be found, while there were a number of colonies of ground squirrels, each with several hundred individuals, like a "town" of prairie-dogs. To complete the fauna were many short-tailed mice, busy about their affairs as they worked along the ground with little heed to the footsteps of the approaching explorer.

THE MARVELOUS COLORATION OF THE VALLEY

For the author, one of the most interesting incidents connected with the expedition was the wonder of the new members of the expedition when they saw for the first time the marvels of which they had read. While it was generally agreed that the pictures and descriptions had given them a fair idea of the Smokes themselves, they were unanimous in their opinion that the printed account conveyed no adequate conception of the coloration of the valley.

The previous articles had, to be sure, stated that the ground was painted with "all the colors of the rainbow," and that the "fissures were baked bright red for miles at a stretch"; but somehow it was imagined that these must be wild exaggerations rather than literal statements of fact.

COLORS BRIGHTER THAN THOSE OF THE GRAND CANYON

No one was more impressed with the colors than Kolb, who, having lived for years on the brink of the Grand Canyon, was not oversusceptible to striking colors. Along with most people, he had supposed that the canyon represented the climax of nature's colorings and had never expected to see anything more brilliant.

The color is, however, so altogether different in character from that of the canyon that the two cannot be properly compared. In the canyon it is in the distance that the color is most remarkable. In the valley it is in the foreground. There are no bright and sharply contrasting masses of rock in the walls of the valley. On the contrary, the valley it-

self, seen under the heavy clouds which usually cover it, is apt to convey an idea of somber coloring. But, when one comes up to the fumaroles, he is almost overwhelmed by the indescribable riot of color (see page 273).

The colors of the canyon are almost entirely due to the wonderful atmosphere and the brilliant light which floods its recesses. Under such leaden skies as usually prevail in the valley, even the canyon itself would show to very poor advantage. The reason why the valley fails for the most part to show much color at a distance is due in large measure to the fact that all the colors of the spectrum lie close together, so intermingled as to blend into neutral grays or browns when seen from a distance. But, while thus largely losing their effectiveness at a distance, the colors are for this reason all the more striking when seen close up, for then each is heightened by contrast with the other (see page 273).

The throats of the fumaroles and the ground around them are most often burned into some of the various shades of red which are familiar in the different tints of brick in common use. Sometimes it will be a light, pinkish tone; again a bright scarlet; or, in still hotter places, rich crimson passing into purple and black in some of the very hottest vents (see page 278).

With such deep-burned purple patches is frequently associated a bright orange deliquescent incrustation of the greatest richness. These two colors are most often found together in fumaroles bearing so high a concentration of acid as to have eaten away all soluble constituents, leaving spots of purest white silica standing in most pleasing contrast with the purple and orange.

In some places considerable areas are leached out to a gleaming white by the acid fumes. When to this are added faint tinges of pink and yellow, there results a beautiful flesh color of the greatest delicacy. Again, the ground color of red, white, or gray may be overlaid with copious deposits of pure yellow sulphur.

Bright colors are by no means limited to the large and vigorous fumaroles. Over many hundreds of acres in the valley, where steam is everywhere seeping up from beneath, the ground glows with the most brilliant colors imaginable. Sometimes it is black with the character and consistency of asphalt. This grades through various shades of blue into delicate light pearl grays or alternates, as

Photograph by R. F. Griggs

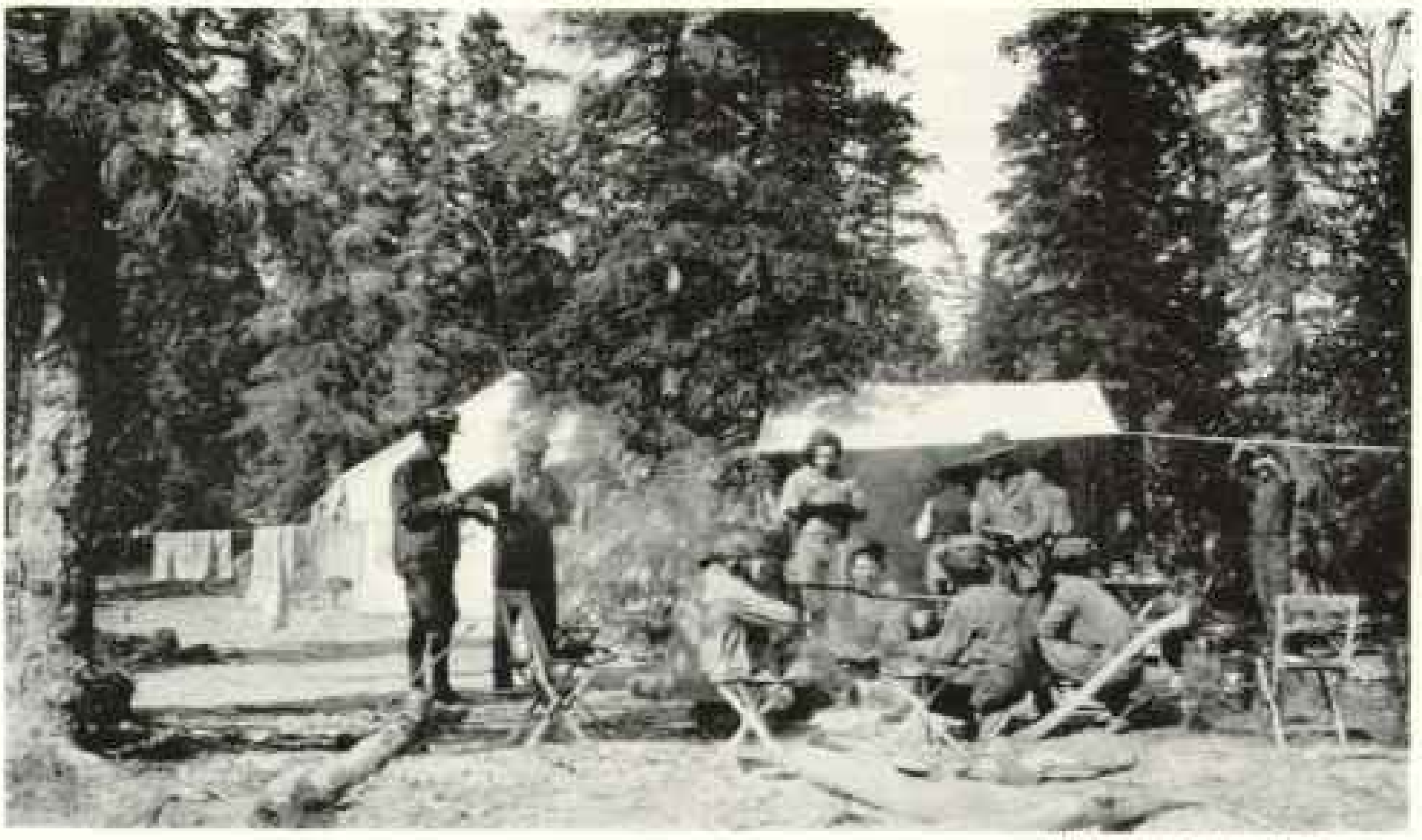
THREADING A WAY THROUGH ONE OF THE CANYONS IN THE SAND-FLOW

The sand-flow fills the Valley of Ten Thousand Smokes (see text, page 241).

Photograph by Mrs. E. C. Kolb

THE LARGEST GROUP OF THE EXPEDITION ASSEMBLED IN ONE PLACE

Three men—Jones, Jacob and Ralph Hagelbarger—had left before the others came together. From left to right are Helt, Sayre, Paul Hagelbarger, Kolb, Yori, Griggs, Folsom, Fenner, Allen, Miller, Zies, Hine, Wallace, Basinger, Stone, and Heming.



Photograph by R. F. Griggs

THE BASE CAMP IN THE FOREST AT THE HEAD OF NAKNEK LAKE

We were much surprised on finding such forest within a dozen miles of the Smokes. A fox used regularly to bring her little family to our garbage pile, and Wallace shot a bear on the bench in front of camp. The Katmai National Monument is destined to become one of the great game preserves of the world (see text, page 285).

the chemical conditions change, with the various shades of red, while round about are the more ordinary ochraceous yellows and browns (see page 275).

SHOES DAUBED WITH VARIEGATED MUD AS FROM A PAINTER'S PALETTE

After a trip across such an area one's shoes, covered with the parti-colored muds, take on a resemblance to an artist's palette daubed with all possible colors in a confused medley. The fine-grained mud is indeed so similar to artist's pigments that it may be readily used as a substitute for them. With no other materials than mud from the valley and a piece of canvas from a ruined tent, Mr. Kolb painted several pictures that excite the interest and admiration of all who see them.

Where the ground is not too hot to prevent their growth, such places are covered with a layer of bright green algæ, adding the last color needed to complete the spectrum.

One of the most striking color combinations in the whole valley was produced by the growth of such algæ in one of the great conical craters whose general ground color was a bright orange ochre. In another place I came across a trail made a few days previously, where the depressed tracks had served to collect a little water which had so favored the growth of algæ as to make the tracks stand out green against the general brown surface. Occasionally, too, the incrustations have a coppery green color, but such deposits were never seen in quantity.

In other places one can find the most astonishing combinations of reds and blues and yellows by digging into the loose ground in the vicinity of a fumarole. The brilliancy of colors of such freshly exposed blocks is indeed quite beyond belief. One can simply stand and marvel at the never-ending variety of shades he uncovers, for each block is different from all the rest (see page 273).

But to convey by verbal descriptions any adequate conception of the gorgeous coloring is impossible. Even pictures colored as carefully as might be on the ground would not do, for the most gaudy mixture of colors that could be daubed over the canvas would not surpass the shrieking effects presented by our impressionistic artists as their idea of the coloration of the most drab and somber landscapes; wherefore, many would doubt the accuracy of any painted pictures.

Ever since I first beheld the wonderful display of colors in the valley, I have been extremely anxious to have them recorded by color photographs which should present what we had seen without the possibility of the personal equation entering in.

The problem was by no means easy of solution, for the obstacles to successful color photography, which are difficult to overcome at best, become greatly intensified in such a region as the Ten Thousand Smokes. The plates are sensitive to the adverse climatic influences, and must be guarded from the hot, damp ground with the most jealous care. The dust clouds which are frequently stirred up by the wind are so all pervasive that it is extremely difficult to keep things clean, and dust is much more serious in color photography than in ordinary black and white work, for, while films can be changed just before exposure, plates must be loaded beforehand.

On a black and white picture it is easy to touch out a spot, but in the Paget color process, which we used, any imperfections on taking-screen, plate, or viewing-screen must remain a permanent blotch on the picture.

THE COLOR PHOTOGRAPHS

Success in ordinary photography is dependent on one's ability to coördinate two or three mechanical processes—shutter speed, diaphragm, etc.—and at the same time to watch the subject and take the picture when conditions are just right. But in color work the number of mechanical factors is greatly increased, and the demands of artistic conception by the operator are greatly increased. It is, therefore, a rare man who can do such work successfully in the rough-and-ready conditions under which we were forced to live.

The difficulties were so great that I felt it wisest not to make any promises in advance of what could be done; but the results are so beautiful and preserve the natural colors with such perfect fidelity as to reflect the greatest credit on Mr. Jones for his careful patience and his artist's

vision (see color plates, pages 271 to 278, inclusive).

LIFE AT BAKED MOUNTAIN CAMP

When we first camped in the valley, in 1917, we were so overawed by its volcanoes that our guiding maxim was "safety first"; but when we returned in 1919 we were willing to take a chance and experiment with things we had not dared attempt before.

At the suggestion of the photographers, the camp was placed at a corner of Baked Mountain, close beside some of the biggest vents in the valley, in a situation that commanded magnificent views of Mt. Mageik and Mt. Martin, and was at the same time convenient of access from all directions (see map, page 227).

Although this position proved untenable, as we afterward found from a series of disastrous experiences, it permitted camera men to secure some magnificent photographs which could not otherwise have been obtained. Pictorial conditions in the valley are so dependent on fleeting light effects that one cannot hope to obtain the pictures he wants except by camping on the spot and rushing out with his camera at favorable moments.

The light is usually best either early in the morning or late at night. Our most successful pictures were taken at these times. The Alpine glow on the volcanoes reproduced in its natural color on page 277 is limited to a few moments after sunset, which in July occurs about 10 p. m. in the valley.

ACID FROM THE "COOK-STOVE" EATS THE POTS

As far as the conveniences of the camp were concerned, this location was all that could be desired. The big fumaroles in front furnished any degree of heat that might be needed for cooking, while the snowdrift directly behind the tents supplied an abundance of good water, as well as facilities for refrigeration.

The different situation required methods of cooking somewhat different from those we had employed previously. We soon found that it was impossible to hang a pot down into the fumaroles here, as we had done before. The steam from this group of fumaroles was highly charged with acid (either hydrochloric or hydrofluoric), which in the course of a few minutes attacked the rope to such an extent that it fell to pieces when we tried to pull out the pot. More embarrassing still was its effect on the pots themselves, for it was not long before they developed holes where the fumes had eaten away the aluminum.

Instead of attempting to hang the pots into a fumarole, therefore, we dug holes in the hot ground and banked up the steaming earth around them. The different holes we used stood at different temperatures, so that we were able to vary our procedure according to the results desired (see page 278).

If on leaving in the morning we wished to provide supper against our return, or if we wished simply to keep a pot warm, we would select a "slow" hole; but if we were in a hurry for something, we would put it into a hot place, where it would boil away vigorously.

In the hottest places our food would burn up if left too long, just as when cooked over a fire; but a pot could be left indefinitely in the slow holes without harm.

Once, when driven out by storm, we found the oatmeal that had been put on for breakfast in prime condition on our return two days later. The wind had been so fierce as to bury the pot entirely in drifting pumice, so that it had to be dug out with a spade; but it was none the worse for having simmered away nearly ten times as long as intended.

With no temperature at our command greater than that of ordinary steam, we had been compelled in 1917 to limit our menu to boiled dishes; but the range of temperature at Baked Mountain was great enough to provide any sort of cookery we might desire.

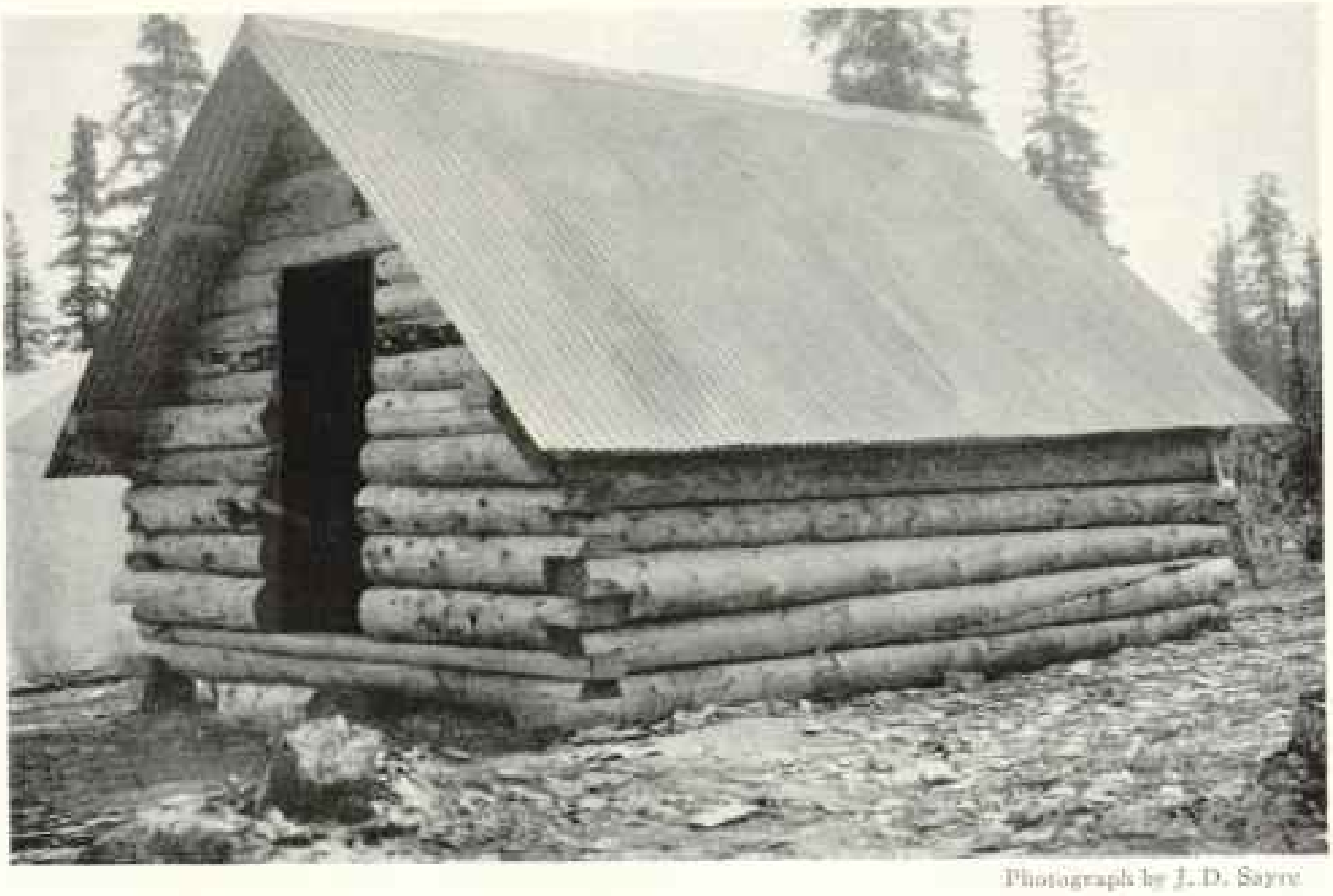
CORN PONE À LA FUMAROLE

The situation of the "cook-stove," which made such varied temperatures readily available in a short compass, was characteristic of many areas in the valley. It was located on the roof of one of the great bridged-over fissures which encircle the margin of the valley. In several places this fissure stood gaping open ten feet wide—a great cleft, narrowing be-

Photograph by R. F. Griggs

UNLOADING SUPPLIES AT THE HEAD OF NAKNEK LAKE

With power boats it was possible to bring all sorts of heavy freight up as far as the base camp (see text, page 243)



Photograph by J. D. Sayre

THE FIRST PERMANENT BUILDING WITHIN THE BOUNDARIES OF KATMAI NATIONAL MONUMENT

This pioneer structure was built to house the surplus equipment of the National Geographic Society's sixth expedition to the Katmai volcanic region.

Photograph by E. C. Kolb

THE LAST LEAP IN THE DESCENT INTO KATMAI CANYON

The canyon is 4,000 feet deep. The descent is not so difficult or hazardous as might be supposed from this picture. Before taking off, I took good care to see that there was a way back.

low, but reaching down farther than we could see into the depths.

From such openings issued enormous volumes of superheated steam, forming some of the greatest smokes of the valley. For the most part, however, this fissure was not open, but closed by an arched bridge of ash which in some way had been stretched across it, forming a span quite strong enough to support the weight of a large party, although when soaked up by a violent rain it caved in in places, forming new and impressive fumaroles as the hot steam rushed forth from the new outlets thus formed.

The cavern immediately beneath the bridge was, of course, full of highly heated gases pressing up to issue in one of the fumaroles. Under these circumstances every little crevice in the arching bridge was the path for a small seepage of steam, the temperature of which as it emerged depended on the volume.

The slow cookers were dug in places with little seepage; the hot spots had close connection with the steam below. It was not always possible to tell by looking at a hole how effective it would prove as a cooker, for there was little visible emanation from any of those we used.

BACON FRIED IN STEAM

In the hottest of our "stove-holes" the temperature was high enough to fry bacon or bake bread with ease. For some reason, the tastes of the party centered on johnny-cake rather than on white bread or biscuits, although the latter were occasionally made with equal success. The procedure was to put the batter inside one of the covered aluminum cooking pots, which was then simply set on the ground in the proper place and allowed to bake.

Baking over the fumarole requires somewhat the same sort of skill as it does anywhere. It would not do to go off and forget the corn bread, as we did the oatmeal; for if it was left longer than the allotted hour, it was burned up, just as it would have been in any other oven; but when taken off at just the right time, it came out with beautiful, crispy brown crust, as fine corn bread as was ever seen anywhere (see page 273).

For frying bacon we found it most convenient to repair to "Fumarole No. 5," at a little distance from the camp. Here a column of very hot steam came

EAGLETS IN THEIR NEST AT THE ENTRANCE TO GEOGRAPHIC HARBOR

This nest was built in the top of the tree shown at the right on page 282.

Photographs by E. C. Kalb

BIRDS COLLECTED BY THE EXPEDITION

The birds of the lake country (see illustrations, pages 284, 286, and 288) are quite different from those of the Pacific Slope. Among them were some familiar friends, such as robins like those of the Eastern States.

Photograph by J. D. Sayre

A WILD SWAN CAPTURED ALIVE BY MILLER

Being at the height of its molt, it was unable to fly, and so was easily overtaken and captured by the power dory. It made such a disturbance with its great white wings that the captor was glad to let it go.

out, under considerable pressure, from a round hole about a foot and a half in diameter, in such a way that it could be readily approached.

The emerging gas from this place was so hot and came out with such a rush that when we tried to pour a cup of water into the hole it never reached the ground, but was caught up by the outrushing steam and carried away before our eyes, vaporizing within a few inches. When we threw our hats into it they would go sailing away thirty feet into the air before coming down again.

The fry-pan had to be held *down* against the steam. Even the weight of the long stick we employed as a handle was not sufficient to balance the pressure of the fumarole, for it would keep wobbling around, up and down, in and out of the rushing steam unless firmly held. Needless to say, the bacon began to sizzle promptly and was soon as well crisped as when cooked over the best of camp-fires.

While experimenting to find the best place to hold the pan, we tried pushing it down into the cavern below the orifice; but no sooner had the fry-pan passed below the surface than—piff—the bacon was whisked out of the pan and went flying in every direction through the air, to be eagerly caught and devoured by the waiting spectators, who howled with delight at this sudden turn of events, which, after being discovered accidentally, was repeated again and again, until we tired of chasing the flying slices (see p. 236).

With such facilities at our command and a full stock of dehydrated fruits and vegetables, there was little in the way of "grub" that could not be supplied at Baked Mountain whenever occasion demanded.

The staples were oatmeal, rice, beans, corn-bread, dehydrated potatoes, with abundant butter, cheese, and pilot-bread. These were varied with an occasional mess of corn-beef hash, or of trout when some one brought them up from the lake. For green vegetables there were string-beans, spinach, and "boiled dinner vegetables," the latter soon becoming a joke because of the superabundance of carrot, of which every one quickly tired.

Our fruits included apples, raisins, peaches, pears, apricots, loganberries, cranberries, and cherries, the last being such a universal favorite that they were soon used up. One hot day we even indulged in iced tea, but for the most part we preferred hot dishes.

A DOUBLE-ENDED FUNNEL FOR STORMS

All went well at Baked Mountain camp as long as the weather remained good, but when the storms struck we encountered a fury that no tents could withstand. Katmai Pass, which stands at the head of the valley, has always had the unsavory reputation of being one of the windiest places in the whole world. The conformation of the mountains is such that the pass is a double-ended funnel, through

which the wind sucks with terrific violence, whichever way it blows.

Curiously enough, it is not on the windward, but on the lee side of the pass where the heavy "williwaws," or "woolies," as the boys called them, are experienced. Thus, while the northwest winds are unendurable on the Pacific side of the pass, it is the northeasters that are dreaded on the valley side.

We were blown out four times before we finally learned our lesson and moved camp to a safer, if less convenient, location. Fortunately, these storms came in a series of increasing violence, so that each time we were better shored up against trouble than before; otherwise they would have been even more disastrous than they were.

ATTEMPTS TO OBSERVE THE CRATER OF MT. MARTIN

One of the plans, which stood first among the intended projects of the expedition, was the exploration of Mt. Martin. This volcano, the existence of which was first made known by the expedition of 1915, being much the most active vent in the whole district, challenged our interest from the first. But it had always stood as a sort of hoodoo which had resisted our efforts (see pages 248-249).

As it is located in the most inaccessible part of the range, to get within striking distance was somewhat of a problem in itself. Moreover, it is so placed that it is the last peak to clear up and the first to cloud over in bad weather. Worse yet, the very strong updraft created by the ascent of its tremendous column of steam sucks up from the lowlands a body of warm air whose moisture promptly condenses into dense clouds when it reaches the heights.

Thus, while it is frequently clear for a little while morning and evening, it is often swathed in clouds during the middle of the day. One very often starts out in the morning with the best of prospects, only to find his labor wasted when he scales the heights.

Knowing something of these difficulties in advance, we planned to make the ascent early in June, when the weather is the most favorable. But here again we were balked, for we found that the snow persists longer around the head of Martin Creek than anywhere else in the district, so concealing those features whose study was our object that a climb at that season would have been fruitless.

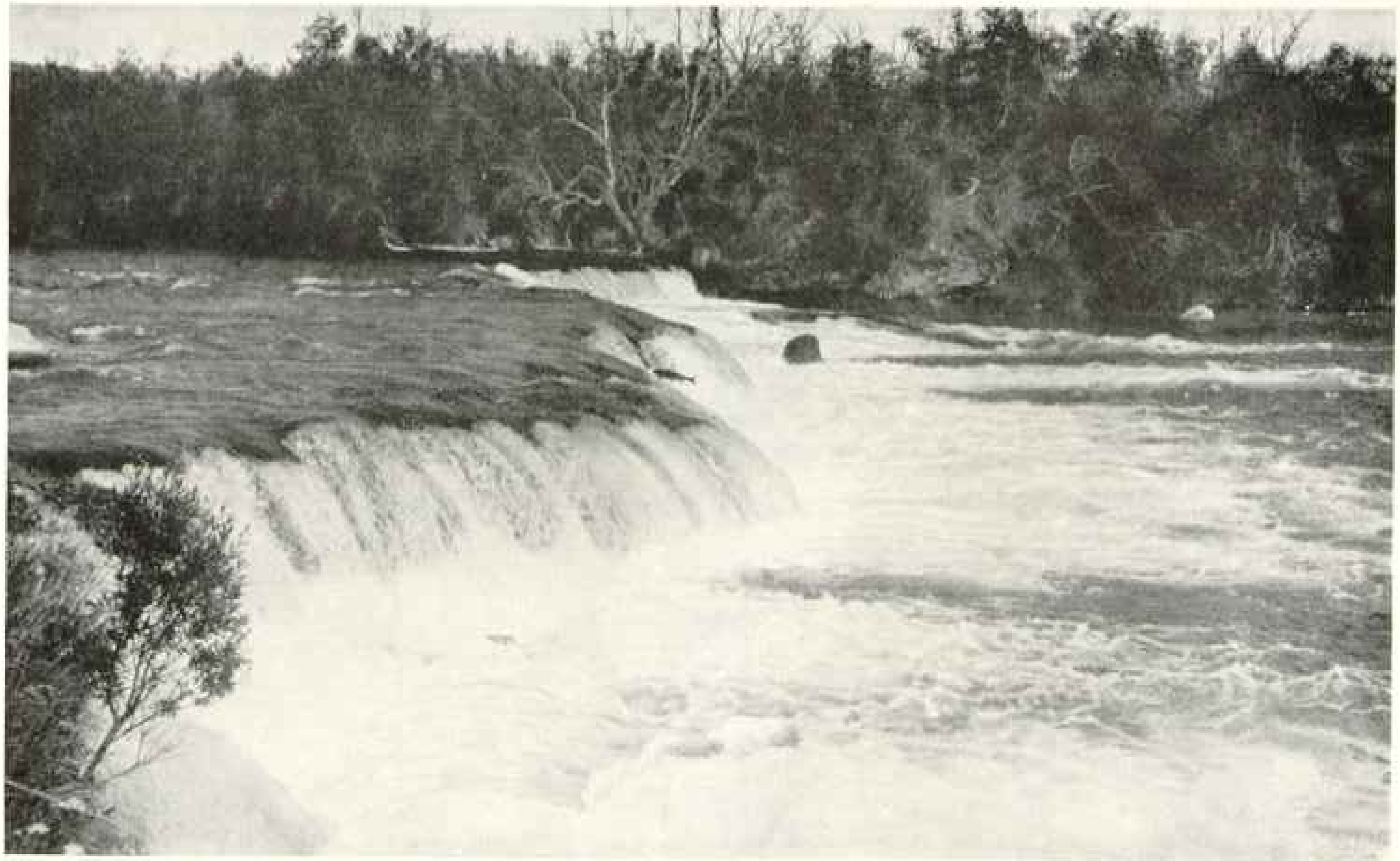
Photograph by W. L. Henning

GIANT RAINBOW TROUT FROM NAKNEK RIVER

The fishing is such as would make Izaak Walton turn green with envy. We never had to cast more than once or twice before we had a strike that kept us busy. The trout average about 24 inches long, but some are much larger. Our largest catch measured a full 32 inches (see page 290).

WITHIN A FEW MINUTES OF SUCCESS

Accordingly, it was not until August that we camped at its foot, waiting for a chance. The crater was clear early in the morning of the first day after my ar-



Photograph by E. C. Kolb

LEAPING SALMON ASCENDING THE FALLS TO SPAWN IN LAKE BROOKS

It was hard to catch them in still pictures. The motion-picture films sometimes show six in the air at once. After careful count, we estimated that these salmon were ascending at the rate of 1,200 an hour (see page 287).

rival, and so up I started, without waiting for Hagelbarger and Henning, who were to meet me; but before I had gone far it commenced to rain so hard that, though I could still see the volcano, it was of no use to try to take pictures. Nevertheless, the day was not wasted, for I was enabled to pick out the best route to the summit and to study the general situation of the mountain.

On the second attempt to climb, clouds settled down on us at the 3,500-foot level; but, thanks to bearings secured the first time, we were able to continue on across the glacier, through the obscurity, for another hour, in hope of a break that would permit us to scale the summit.

Finally, having gone as far as we dared beyond the previous observations and reached the main divide of the range, we sat down and ate our lunch, hoping in vain for a rift in the clouds that would permit us to get new bearings.

Later we found we were directly under the last steep pitch of the cone, and if we had only known the way could have climbed on to the rim in a few minutes more. But it would have been an empty stunt to have reached the top under such conditions, for we could have seen nothing when we got there.

It was a mournful "bunch" that descended the mountain that evening, for the demands of other work were imperative and camp had to be broken next day, with the crater yet unseen after two weeks of waiting for a chance to climb.

CLIMBING MARTIN FROM THE WRONG SIDE

Five days later, as I lay awake at Baked Mountain camp, I crawled out into the night to look at the valley and the volcanoes in the spectral light of a wonderful full moon. There was Martin puffing away, beautifully clear, its unconquered steam column rising majestically over all. Why not do it tomorrow? (see p. 220).

We were now on the wrong side of the range and so far from a favorable starting point that it was uncertain whether we could make it; but it was the only chance, for there were unmistakable signs that the good weather that had favored us for two days was about to change.

It meant covering a mile in altitude and 30 miles in distance; but I was not to be turned back if there was any possible way of getting there, and I knew Charlie Yori was as anxious as I to try it. Indeed, I should never have dared attempt to cross the glaciers that guard it on the valley side without his guidance.

So I waited until a decent time to rouse the camp, and then interceded with Dr. Allen, for Charlie was his man, for his release that day. This was readily obtained, for the chemists needed to pause in their field-work and rig up some new apparatus anyway. So Fenner and I got ready in a hurry and started off with Yori double quick, in our eagerness to get to the top before anything should happen.

The whole of the course after the first slope lay across glaciers and snow-fields. For the most part, going was not difficult, except that we had to waste much time winding in and out around the irregularities of the ash-covered glaciers—here following a drainage gully, there cutting across the ridges.

But before we reached the high snow-fields that surround the summit, we had to cross an area all cut up by close-set crevasses. As we entered this, Yori remarked, "This is a real glacier, all right enough."

With his customary hardihood, he professed to scorn a rope and took a sort of fiendish glee in trying me out in the most "ticklish" places he could find.

I will not deny that I was somewhat skittish, for my hob-nailed boots were worn out and I had been compelled to come in rubber-soled shoe-packs which could get no grip on the slippery surface—a fact that bothered me greatly, though the ice-axe which I carried probably counterbalanced the disadvantage.

Our way lay, as Fenner expressed it, "along the ridge-pole," following narrow crests, themselves sloping both ways, between bottomless crevasses on each side. Any slip would have meant certain death, and that glaring blue ice was deucedly slippery; but we crept along, using all the care we could, and finally reached the névé above without mishap.

AT THE EDGE OF THE CRATER RIM

Without stopping for the pictures we so much desired, we pressed forward feverishly in our anxiety to reach the

Photograph by E. C. Kolb

ESKIMO WOMAN DRESSING SALMON: NAKNEK

This woman was away from the village at the time the "flu" struck; otherwise she probably would have died, for the epidemic carried off practically every adult native in the whole Bristol Bay country.

Photograph by W. L. Henning

A YOUNG BEAR SHOT IN GEOGRAPHIC HARBOR

While he was swimming from island to island, he was overtaken by our gas boat, appropriately named the *Nimrod*, which gave chase and easily captured him.

summit while it was yet clear. A breeze had sprung up out of the northeast and we knew it was only a question of time before our mountain would be hidden in the clouds. Indeed, they had begun to gather already.

We made rapid progress now, over the smooth snow-field, circling the base of the cone, for the low point in the crater rim lay on the side opposite to our approach. We were in the clouds now, but had a glimpse out across the range to the Pacific.

When we came around under the low notch in the rim, we sat down and waited for a break in the clouds to get our bearings before taking the last steep slope, eating our lunch as we waited.

Hardly more than a hundred yards away was the hillock where we had stopped on our attempt from the opposite side. This time, however, we never doubted but that we should soon have our chance, for the clouds were only beginning to gather. Indeed, we had hardly begun to eat when they blew off a little.

There was the crater rim, seemingly only a few steps directly above us. Great masses of steam came rolling up close against it, but as we were on the windward side they were quickly carried off in the opposite direction.

From a distance the smoke of Martin always appears snow white, but from our position it took on a weird lemon-yellow color, which Dr. Fenner suggested must be due to reflection from a large body of sulphur within the crater.

The rim seemed so close that, dropping my cracker, I started for it, but before I could go a dozen steps the clouds closed in again. But we had our bearings now. As soon as we had finished our lunch we started up, so as to be on the rim when the next break came.

That last pitch, 250 feet it proved when we climbed it, was the steepest slope I have ever attempted. If it had been rock climbing, it would have been easy; but it was boulder clay left there by a glacier which had capped the mountain during its dormant period.

The slope was 60° by the clinometer (as compared with about 30° in a steep railroad embankment). The round boulders on which we depended for foot- and hand-holds were loosely held in the uncemented clay, so that it was extremely difficult to hang on.

Finally we reached the rim at 5,300 feet, but were unable to see anything in the cloud and steam that beset us. Inside the first sharp edge we found a slight depression, and then a second similar sharp inner rim. The original rim had evidently broken loose and slumped into the hole a little.

In the depression between the two rims was a little pool, over which we bent to secure a drink, for we had only snow with our lunch; but—ugh! it was strong acid. The fumes at the rim were disagreeable, and I was glad to retreat into a little hollow, where I could take notes in comparative comfort.

DESCENDING INTO THE CRATER OF MT. MARTIN

After a little, Fenner came back out of the cloud and reported that if we used our handkerchiefs for respirators we could go down inside the crater. So we all held our handkerchiefs to our noses and plunged over the edge.

On the rim we could see readily 50 feet through the cloud, but once inside it thickened rapidly until, only a few feet below the rim, we could hardly see each other, though standing close together.

Whenever a gust of wind swept the smoke back a few feet, we leaped on farther down until the obscurity closed over us again, and we were compelled to halt for fear of stepping off the edge of the precipice into the vent that we knew must be at the bottom of the funnel.

There we stood huddled together, like ninnies, panting through our handkerchiefs and pulling down our hats in futile efforts to protect our smarting eyes. If we loosened our handkerchiefs a little to get a freer breath, we got a suffocating draft that at once compelled us to clamp the protection back again.

Silent as ghosts we stood until one of us, caught by the ridiculous attitudes of his companions, burst out laughing, setting us all a-snickering behind our handkerchiefs like school-boys who fear the teacher's wrath, for we durst not lift our handkerchiefs to let in the fumes.

Thus we stood for nearly half an hour, but there came no further opportunity to proceed. As we could see nothing around us, we were compelled to give it up, and after picking up a few of the rocks immediately around us, which were ordinary andesite, scrambled back to the rim.

Here again we sat down and waited for an hour, but as there was not the slightest sign of a let-up we had to give up and start back. The momentary break that came while we were eating was the only near-by view of the crater we were to have.

Climbing up a slope of boulder clay at an angle of 60° is as nothing compared to wriggling down again. There was imminent danger of dislodging loose boulders on our companions below, and there were places where we simply had to let go and fall off, trusting to luck not to hit anything hard before we could stop.

When we reached the snow-fields again, we soon saw that the cloud cap was much thicker than when we had ascended, for we had to descend many hundred feet before we came out into clear day again.

We had not turned back a minute too soon. We needed no second hint. We all knew that to have been caught in a fog on that crevassed glacier, where we could neither follow the route by which we had come nor choose a new path that would take us across in safety, might mean disaster.

A PERILOUS TRIP ACROSS ROTTEN SNOW-BRIDGES

As we wormed our way in and out around the crevasses, we got into an area of snow-bridges at which Charlie, with his long experience with glaciers, hesitated. He kept protesting that he "didn't like that ice," and we went forward with great caution; but no better way was to be found and the certain menace of the thickening clouds compelled us to take the lesser risks of rotten snow-bridges and go ahead regardless of danger.

All's well that ends well, however. At length we passed the last crevasse and finally reached the solid floor of the valley again without accident.

It was a long drag across to camp, but we made it before half past eight, tired and disappointed, yet with the knowledge that we had succeeded in a difficult venture, even if we had been denied the fruits of our labors. And this, the 16th of August, had been the best opportunity to climb Mt. Martin since the 25th of July!

THE DESTRUCTION OF BAKED MOUNTAIN CAMP

As we came across the valley on our way back, the northeast wind freshened in a way which I knew meant that the "woolies" were to visit us that night. We were too tired from our climb to care much, however, for we knew we could sleep through anything, and the tents had been so shored up, as a result of previous experience, that, like the skipper of the *Hesperus*, we believed they "could weather the stiffest gale that ever wind did blow."

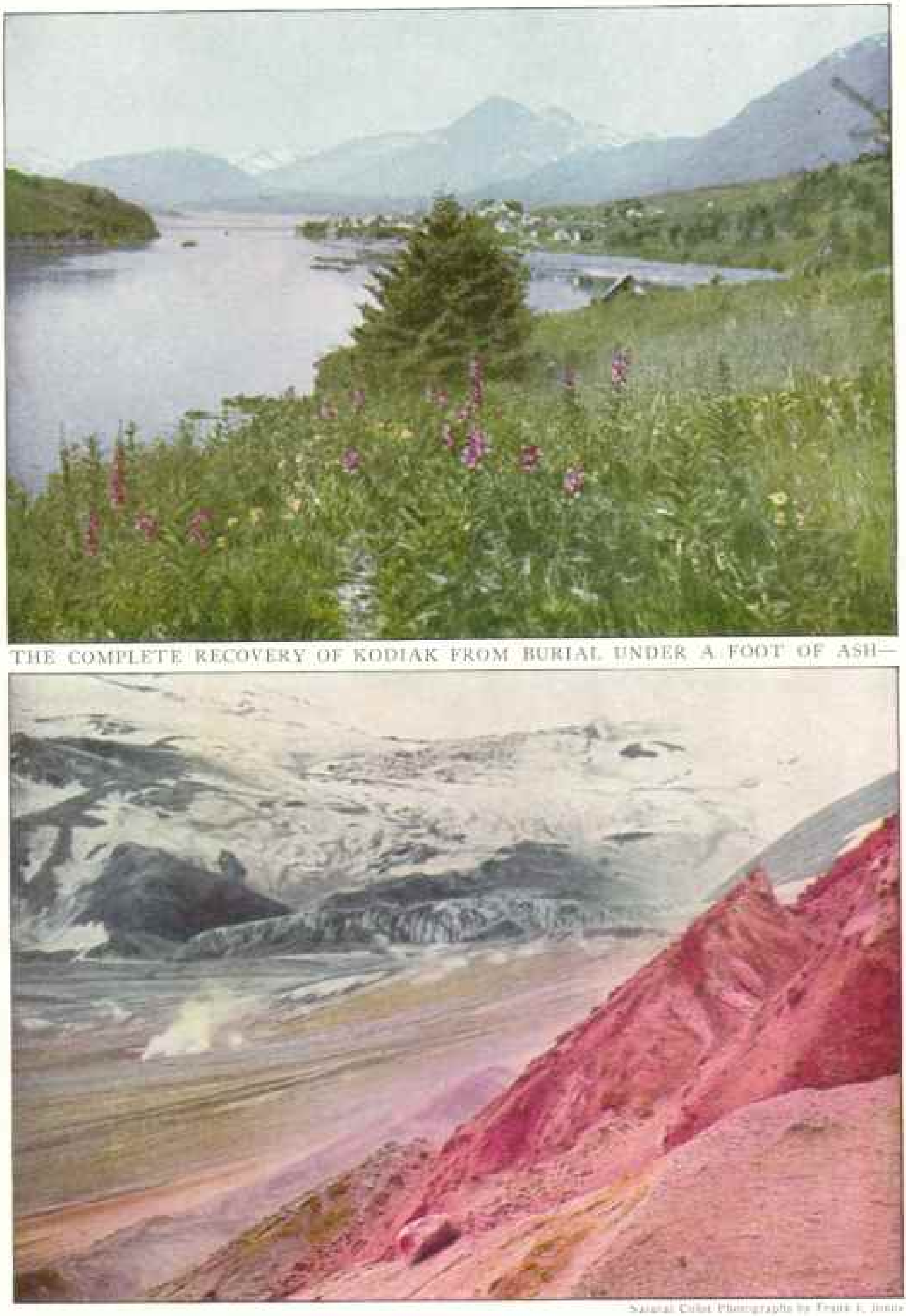
The frame of the grub tent had been strengthened by a multiplicity of poles and braces sunk deep in the ground until it formed a veritable cage, inside which parts of four tents had been patched together. Fully a thousand feet of rope and cord had been used in lashing the structure together. All the guys were anchored to boulders as big as a man could roll, deeply buried in the ground. On every side except the front there were at least two thicknesses of cloth to protect us from flying pumice.

A heavy canvas tarpaulin had been thrown over the second tent and buried in the ground on the windward side to reduce the resistance to the wind and prevent it from getting in under the eaves.

After the first few warning blasts I called to Yori, questioning whether we had not best take measures to protect the camp; but he let out a whoop of defiance—"Oh, let it blow; we can stand it."

I was too tired to get up and go out looking for trouble, so I lay down again to get the rest I so much wanted after the hard climb of the day. If I had gone out then, I could have saved the apparatus tent, which was afterwards sorely needed. But weariness is a great foe to will power, and so I missed my chance.

By the time it was fairly dark the storm had increased to considerable proportions. It came in great intermittent gusts, with intervals of quiet between



Natural Color Photographs by Frank E. Jones

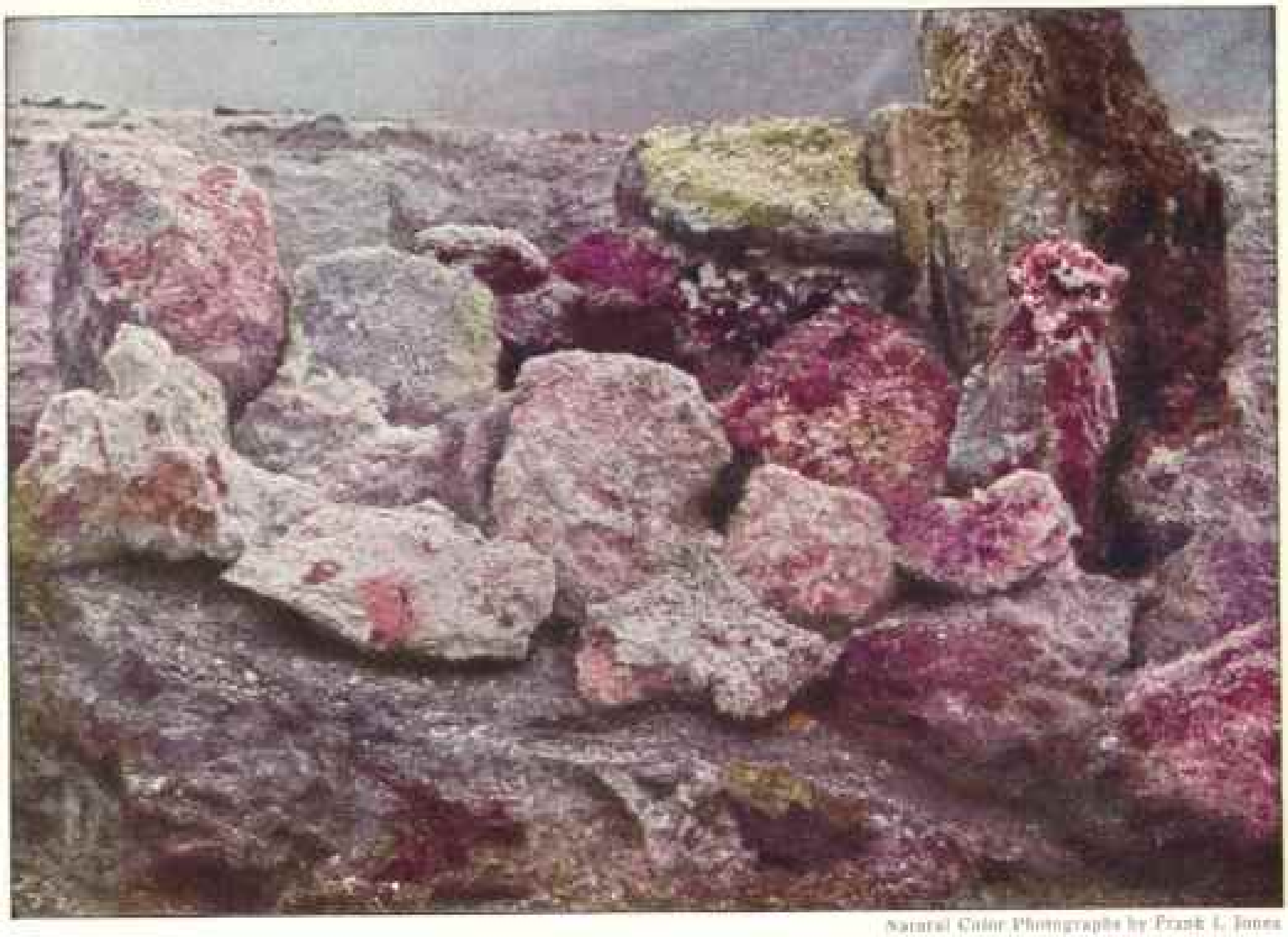
THE COMPLETE RECOVERY OF KODIAK FROM BURIAL UNDER A FOOT OF ASH—
—CONTRASTED WITH THE ONCE GREEN VALLEY OF SMOKES WHERE
EVERYTHING WAS CONSUMED BY FIRE

MOUNT CERBERUS KEEPS GUARD AT THE HEAD OF THE VALLEY

Natural Color Photographs by Frank L. Jones

FUMAROLES AT THE FOOT OF FALLING MOUNTAIN

THE OVEN WHERE CORN BREAD WAS BAKED BY NATURE'S FIRES



Natural Color Photographs by Frank I. Jones

MULTICOLORED INCRUSTATIONS GATHERED AROUND THE FUMAROLES

PEACEFUL FOREST AND PELLUCID LAKES WITHIN A DOZEN MILES OF THE SMOKES

Natural Color Photographs by Frank L. Jones

THE VARIHUED DEPOSITS RESEMBLE BRILLIANT MOSAICS

TAKING THE TEMPERATURE OF MOTHER EARTH

Natural Color Photographs by Frank J. Jones

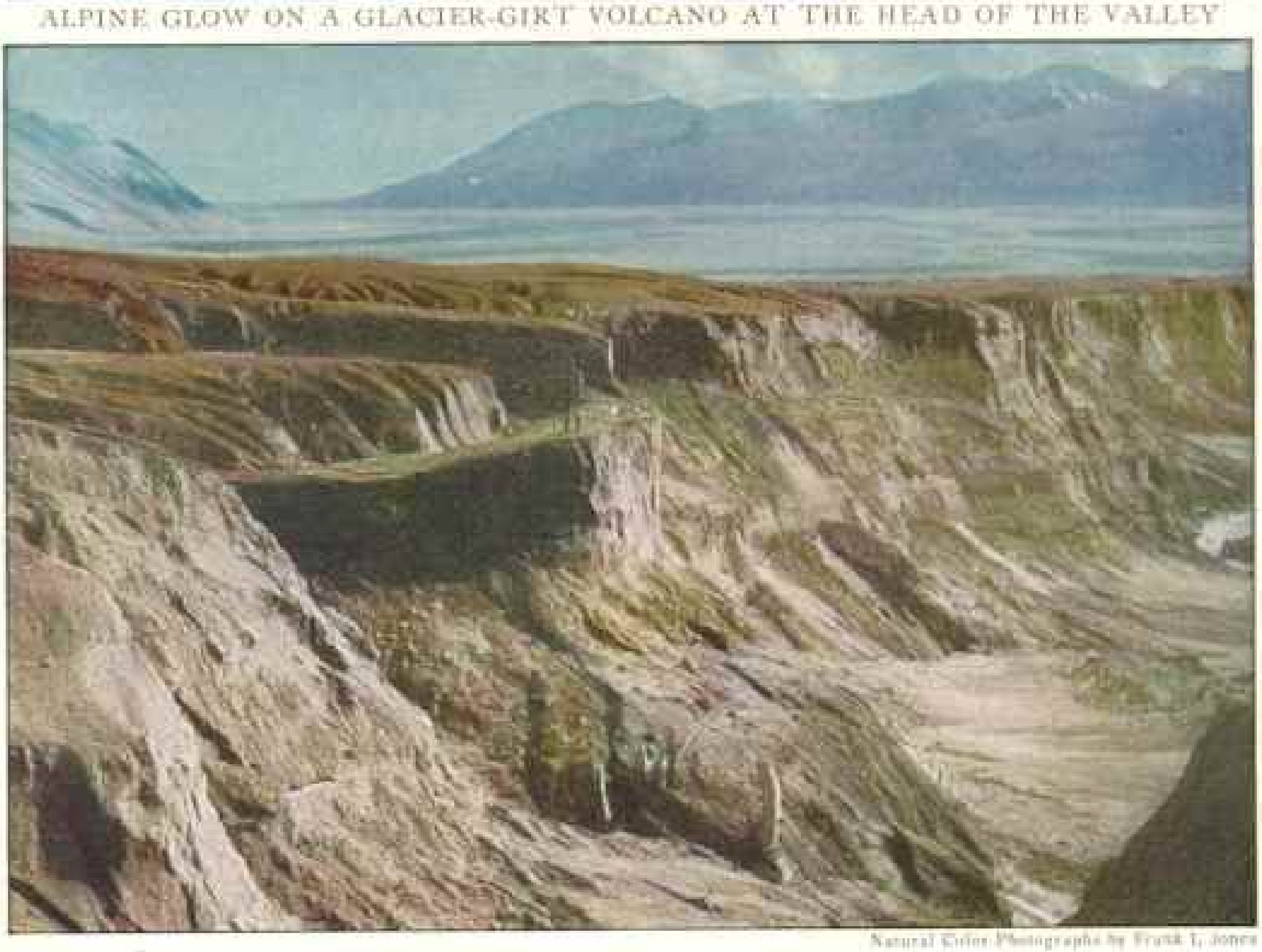
THE GAUDY MUDS OF THE VALLEY MAKE GOOD PIGMENTS FOR A PAINTER

THE CAVERNOUS BIRTHPLACE OF ONE OF THE SMOKES

Natural Color Photographs by Frank J. Inhes.

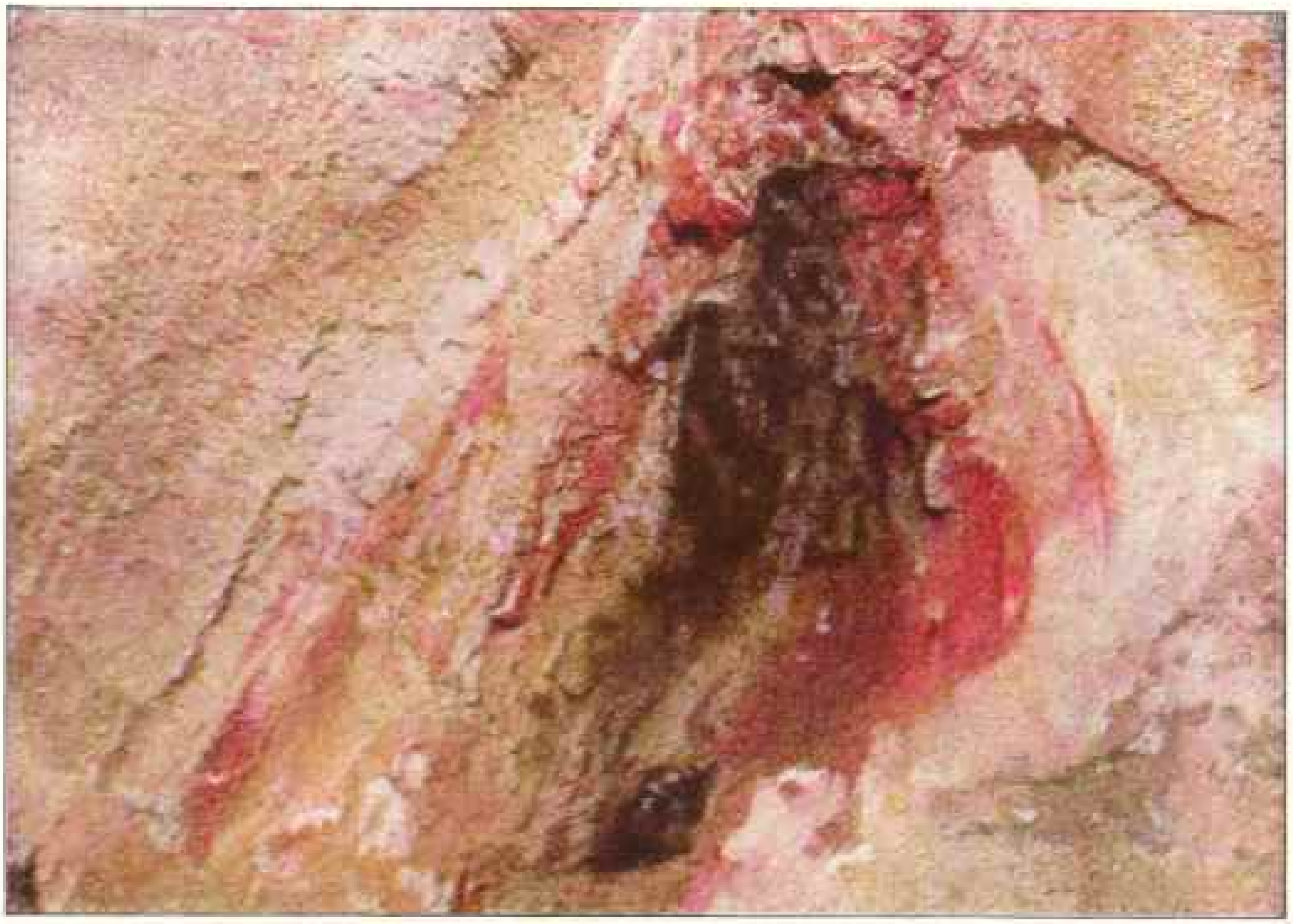
HARD-BAKED CRUST AROUND A SMALL FUMAROLE

ALPINE GLOW ON A GLACIER-GIRT VOLCANO AT THE HEAD OF THE VALLEY



Natural Color Photographs by Frank L. Jones

A CANYON IN THE MUDFLOW AT THE HEAD OF KATMAI VALLEY



THE INTERIOR OF A FUMAROLE LAID BARE

Natural Color Photographs by Frank J. Jones

RICE AND BEANS COOKING IN A GORGEOUS VOLCANIC STOVE

them. We could hear them coming over the mountains long before they reached us. Their frightful roar, as they tore their way down through the pass, was for a while more terrifying than the blow when it struck us, as we lay huddled together beneath the tent, wondering what would go next.

The apparatus tent went first, torn to shreds, exposing all the chemists' instruments as well as cameras and other valuable equipment to the soaking rain and driving pumice, which flew before the wind in sheets. By 10 o'clock the poles of our tent snapped, the broken ends tearing great rents in the fabric as they went down. Fortunately, the poles went one by one, so as to give us time to move our beds and duffle into the grub tent, which now alone remained standing.

When the last blanket was removed we managed to lay the wreck down and weight it with rocks, to prevent it from being all torn to pieces. It was all we could do to accomplish this, for by this time the fury of the wind was such that one could hardly manage even so small a thing as a prostrate tent, and the hail of flying pumice was impossible to face, even with goggles for protection. We were well repaid for our efforts, however, for the saving of that torn tent was all that made a resumption of the work possible after the storm.

Crawling into the remaining tent, I stretched out in my sleeping-bag to get a little rest, if I could, against the labors of the morrow. But it was not for long that such relaxation was permitted. It soon became a question whether even so strong a tent frame as ours could withstand the pressure.

Before long the spare tent, with which the lee side had been reinforced, gave way and, still holding to the frame by the corners, went flopping around in the wind to increase the general confusion. Two days later, when we returned, we found it, a new tent, torn clear in two!

No sort of rest was longer possible, so I got up and packed my bed with a little clothing inside my pack-sack to keep it dry, and put on all my extra sweaters and coats to keep out the cold of the driving rain. Some of the others, who continued to use their bedding as robes, were less fortunate, for it was extremely difficult to gather things together and keep them dry in the final break-up.

About 1 o'clock the extra tarpaulin lashed to the windward side tore away, leaving only one thin sheet between us and the gale. It did not seem possible that any light cotton fabric could endure the strain that came on that tent. It pulled so that it broke all our boasted guying and was held only by the frame. The pumice came beating against it with the noise of a hailstorm on a tin roof, but the stones were sharp at every corner, not round and smooth like hail.

The impact was so heavy that our flesh would not tolerate the pain if, trying to keep the tent in place, we pressed our bare hands or arms against the wall. Why the flying pumice did not instantly cut the tent to shreds was more than we could understand. But it held for half an hour more, and then gave way all at once with the crack of a gigantic whip, as a great rent opened from roof to floor.

A TERRIBLE HAIL OF SHARP PUMICE

The hail of pumice that greeted us as we crawled out to see if anything could be done cannot be imagined. It could not be endured on our flesh for an instant. It hurt clear through our clothing. It drove in around our "dust-proof" goggles, a constant menace to our eyes. Many of the pieces were as large as hickory-nuts and all armed with sharp corners that made them terrible missiles.

Once the tent had ripped, the wet pumice began to collect all over us—in our hair, down our necks, in our pockets, in our ears, in our noses, in our mouths—everything was permeated with it. Soon it was four inches deep on the floor, though more blew on out through the other side of the tent than lodged within.

The five of us—Allen, Zies, Fenner, Yori, and I—huddled against the windward corner, that gave the last little shelter remaining. It was suggested that we crawl into a gully, but I reminded the others that such places were but collecting grounds for the pumice, which would hail down on us in greater quantities than ever; so we agreed to stick it out as long as possible, praying fervently for the dawn.

Photograph by R. F. Griggs

SPEARING OUR SUPPER AT THE FOOT OF THE SALMON FALLS

The salmon here were all the choicest reds, or "sockeyes," which command the highest price on the market.

Photograph by R. E. Holt

TAKING MOTION PICTURES OF THE SALMON FALLS

Thinking to get pictures of the fish landing at the top of the falls, Mr. Kolb waded out to a favorable position, but as soon as he entered the water the jumping stopped and did not begin till he had waded ashore. As the fish could not see him, nor hear him, they must have detected his presence by the sense of taste: yet he wore rubber boots.

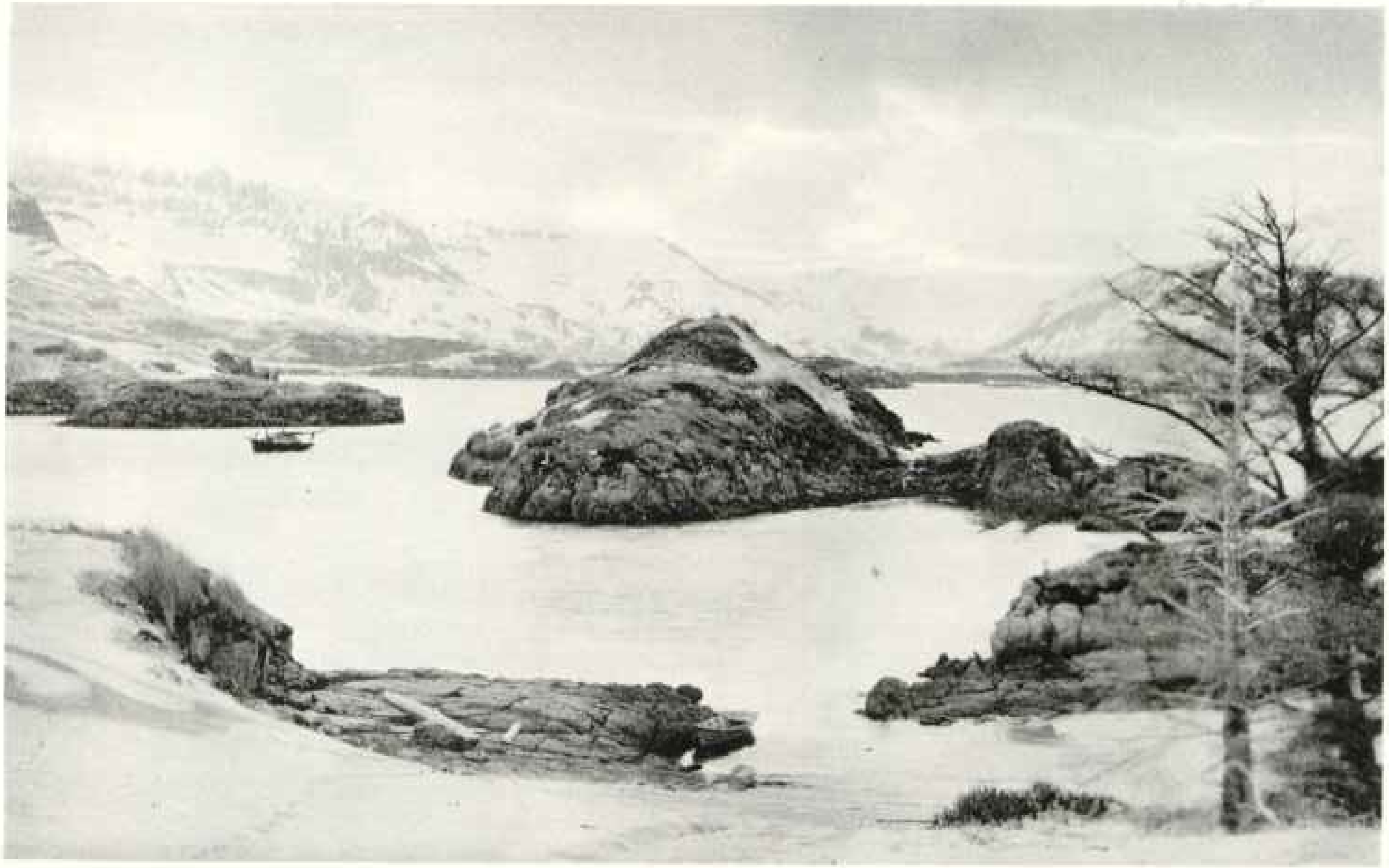
SALMON JUMPING THE FALLS AT THE OUTLET OF LAKE BROOKS

These falls, only five miles outside the boundaries of the park, are ascended annually by many thousands of fish, pressing upstream to their spawning grounds in the lake at its source.

Photograph by E. C. Kolb

NATIVES DRYING SALMON AT THE MOUTH OF THE NAKNEK RIVER

The catch from this single district, Bristol Bay, was worth in 1918 more than three times the entire price paid by the United States for Alaska. Unfortunately, it must be added that overfishing has so greatly reduced the runs that the canning industry will soon become a thing of the past, unless the government takes measures to check the present reckless exploitation.



Photograph by E. C. Kolb

ISLANDS IN AMALIK BAY AT THE ENTRANCE TO GEOGRAPHIC HARBOR

Dotted with picturesque islands and girt round about by sublime mountains, it is one of the most beautiful bays on the whole Alaska coast.

Photograph by P. R. Hagelbarger

GEOGRAPHIC HARBOR FROM THE HILL AT ITS HEAD

The outer island, which is 500 feet high, is seven miles away. It is thoroughly secure from all manner of tempests. The waters are, moreover, abundantly deep for the largest ships. We found no bottom anywhere in the channel with a 54-foot line (see page 292).

LAKE GROSVENOR

This picturesque mountain lake is 28 miles long, large enough to be shown on the general map of North America. That so large a body of water could have remained entirely unknown is eloquent testimony of the unexplored condition of the Alaskan peninsula. It is a great pleasure to commemorate the constant interest of the President of the National Geographic Society in the Katmai problems by giving his name to this beautiful lake (see page 287).

The nearest refuge was at Ukak, about ten miles down the valley. The wind was so fierce that at best we had little control over our bodily movements, and we dared not attempt to flee down through that maze of fumaroles in the darkness of the night.

How we watched the diminishing shreds of our tent and counted time against the wasting fabric! Could it shelter us until it was light enough to flee?

Time and again the wind would pick us up, as we braced our backs unitedly against the wall, and roll us into a pile in the middle of the floor. I sat on a flat valise weighing fifty pounds, on which I had set for protection a big rock weighing as much more; yet the wind repeatedly picked up the whole bundle — man, box, rock, and all—and rolled us into the middle of the tent.

Yori with characteristic self-sacrifice, chose the most exposed end of the line. He drew a canvas tarpaulin over his head and shoulders in a vain effort to mitigate the blast. Soon it was the only protection he had, and for some time he sat practically outside, while the wet pumice was driven down his neck. He must have been bitterly cold, but never a complaint escaped him.

Finally, at 4 o'clock, the gray shapes of the fumaroles began to be distinguishable in the general blackness. I went outside and decided it was little worse than within, for there one could at least move around. So, though all were fearful of being blown bodily into one of the fumaroles, it was agreed

that the time had come when we must try it down the valley.

Zies had a little flash-light, which made it possible to gather together the things we needed most; but before they were collected Allen came out and was almost literally carried away before the wind. Feeling that it was of the utmost importance for safety's sake that we keep together, I made frantic efforts to detain him, but he was gone like a ghost in the night, beyond recall, out of earshot almost at once. I turned my efforts to hurrying the others.

PICKED UP BODILY BY THE WIND

To face the gale was impossible; so I started backing toward the tent, bracing myself against the wind. Suddenly I found myself flying through the air, scared to death. I shall never forget the feeling of gratitude I experienced when my face landed in the mud, two gullies away. My feet kept on and nearly turned me another somersault, but I was safe on the ground again. The feeling that I was being carried bodily down the valley by the wind was one of the most terrible experiences in my life.

After that I decided it was useless to try to go back, so I started on to try to catch Allen and slow him down. Down the hill I sped, carried by the wind, with little chance of choosing my course. In the distance I spied the gray smoke of one of the big fumaroles dead ahead. I knew that I must avoid the yawning chasm by which it issued if I were to live.

By desperate scratching I managed to deflect my course a little, but slid by so close that had another gust, such as had picked me up, come just then I could not have avoided it.

It was some time before I could find Fenner and Zies, who were waiting for Charlie and me in a deep gulley. They had seen Allen go by down below, and we soon caught him and proceeded down the valley in somewhat more orderly, if none the less precipitate fashion.

The wind came obliquely over Baked Mountain, so that it was extremely difficult to avoid being drifted out into the middle of the valley, whereas safety required us to keep to the east side in order to make the ford of Knife Creek above the point where it plunges into an impassable canyon. If we missed the ford, our flight would have ended in a cul-de-sac among the canyons, from which there would have been no escape.

When we reached the shelter of Ukak, which trip we made in record time, despite the accumulated weariness of the day before and the strain of the night, we found, as we had hoped, that the camp was full. Every one jumped up to let us crawl into the warm sleeping-bags and we were soon sound asleep.

The gale continued all that day, but in the night it calmed down enough to permit us to visit the ruins the following day. The site of our former happy camp presented such a scene of desolation as can hardly be imagined. Everything was covered with pumice, blown onto the fallen heaps until no more could stick on.

Pumice had drifted a foot deep against the big stone we had rolled over the sleeping tent. It was so heavy on the tent that it took the united strength of Yori and me to roll back the fallen roof so as to expose the things that lay on the floor.

The single cot, which had served primarily as a bench for keeping the photographic materials off the ground, was removed from the fallen tent by "Cæsarian section," and the scattered effects gathered together and stowed on it in a secure cache until it was finally decided to move the camp over in front of Mt. Cerberus, which experience had meanwhile proven to be sheltered from the severest winds (see pages 251 and 252).

BEAUTIFUL DIVERSIFIED LAKE AND FOREST CLOSE TO THE SMOKES

It will have become clear to the reader before this that life in the valley, even under the most favorable circumstances, has certain limitations which render the presence of a base camp in a less-devastated region a necessity; but it is doubtful if many realize how near the Valley of Ten Thousand Smokes lies to country possessed of the greatest charms of natural beauty. Within five miles of the fumaroles one enters heavily timbered country, which was little injured by the eruption and supports an abundance of wild life.

The whole of the Katmai National

Photograph by J. D. Sayre

LAKE COVILLE

Named in honor of Frederick V. Coville, chairman of the Research Committee of the National Geographic Society, who was among the first to realize the importance of a scientific study of the Katmai district.

Photograph by P. H. Hagelbarger

GEOGRAPHIC HARBOR

Its superb scenery makes it a fitting entrance to such a wonderland as the Katmai National Monument.

Monument is by no means a devastated wilderness, without interest save for its volcanic wonders. The upper end of Naknek Lake, which lies within the boundary of the park, is as beautiful a body of water as can be found anywhere. Its deep-blue basin lies between the wooded slopes of two mountains whose precipitous summits seem almost to overhang the water.

On the one side Mount La Gorce towers 3,000 feet aloft. On the other, Mt. Katolinat rises 5,800 feet in a series of castellated pinnacles formed by the breaking up of a remarkable, massive conglomerate which weathers out in great sharp battlements (see map, page 222).

Ivan Petrof, one of the first agents of the American Government to travel these parts, was so impressed with the beauties of Naknek Lake that he inserted in his report a colored picture showing the east arm, or Iliuk Arm, with Mt. Katolinat, the only plate devoted to scenery in an account of travels that reached almost every corner of Alaska.

On scaling the pinnacled ridge of Katolinat, a feat which appears well-nigh impossible from below, but yet is easily accomplished, one obtains an unsurpassable view over wide stretches of country. Down the lake one may look on a clear day out across the flat, tundra-covered coastal plain to the waters of Bering Sea, nearly a hundred miles away. Behind him, to the south, stands forth the whole range of snow-capped volcanoes, plainly visible for 120 miles, from Douglas to Peulik, as grand a collection of glacier-covered volcanoes as can be imagined.

To the east lies the broad, green valley of Savanoski River, giving easy passage behind the range to the shores of Kamishak Bay on Cook Inlet. To the north is a great expanse of lake and mountain country heavily covered with forest.

LAKES GROSVENOR, COVILLE, AND BROOKS

Lying roughly parallel with Naknek Lake, one descries three other large lakes which were quite unknown to the outside world until news of them was brought back by THE GEOGRAPHIC expeditions. Two of them, which lie together, joined by a short but swift river, we named for the two men by whose vision and support the expeditions were made possible—Gilbert Grosvenor and Frederick V. Coville. The third we honored by naming after the dean of Alaskan explorers, Alfred H. Brooks, who likewise has had a large share in helping forward the work of the expeditions (see map, page 222).

Lake Grosvenor, which is 28 miles long, is even more beautiful than Naknek Lake. Sayre and Miller, who surveyed it, describe it as "the most beautiful spot in Alaska," which is high praise when it is remembered that it comes from men familiar with all the beauties of the celebrated "Inside Passage."

On all sides this lake is shut in by high, forest-clad mountains, which give it a charm that will certainly make it a favorite place of retreat when the park becomes a popular resort (see pp. 284, 288). It may be reached by an easy portage of a mile and a half from near the northeast corner of Naknek Lake, or by ascending its outlet from the Sabanoski River; for, although Lake Coville extends out of the mountains into the coastal plain, the system drains back into the head of Iliuk arm.

Lake Brooks (see page 288) lies on the other side of Naknek Lake, to the west, also separated from it by a high mountain. It is smaller than the others, only about 15 miles long, but it is quite large enough to show up on the general maps of Alaska. Like the others, its drainage is reversed; it empties from its "upper" end by a short river running into a bay on Naknek Lake.

WONDERFUL LEAPING SALMON

In the outlet stream from Lake Brooks is a waterfall about six feet high, which is an extremely interesting place to visit when the fish are running. These lakes are among the greatest spawning grounds in the world for the sockeye (red) salmon, which is considered the choicest species by the connoisseur of tinned foods. Of late years the runs have been much reduced by the operations of the canneries, but they still run into the lakes in unbelievable numbers.

The falls in the outlet of Lake Brooks afford an unsurpassed opportunity to observe the continuous procession of sal-

MORNING MISTS ON LAKE GROSVENOR

For the exploration of the lakes the expedition made use of native skin kayaks, now almost a thing of the past. Our surveyors describe Lake Grosvenor as "the most beautiful place in Alaska," which is high praise from men familiar with the beauties of the celebrated "Inside Passage" of southeastern Alaska.

Photograph by J. D. Sayre

THE OUTLET OF LAKE BROOKS

This beautiful body of water, fifteen miles long, is one of the discoveries of the expedition. The lake is named after Alfred H. Brooks, Alaskan explorer and for many years chief of the Alaskan Division of the U. S. Geological Survey. It was to this lake that the leaping salmon were running (see illustrations, pages 266, 280, and 281).

Photograph by L. G. Fulsom

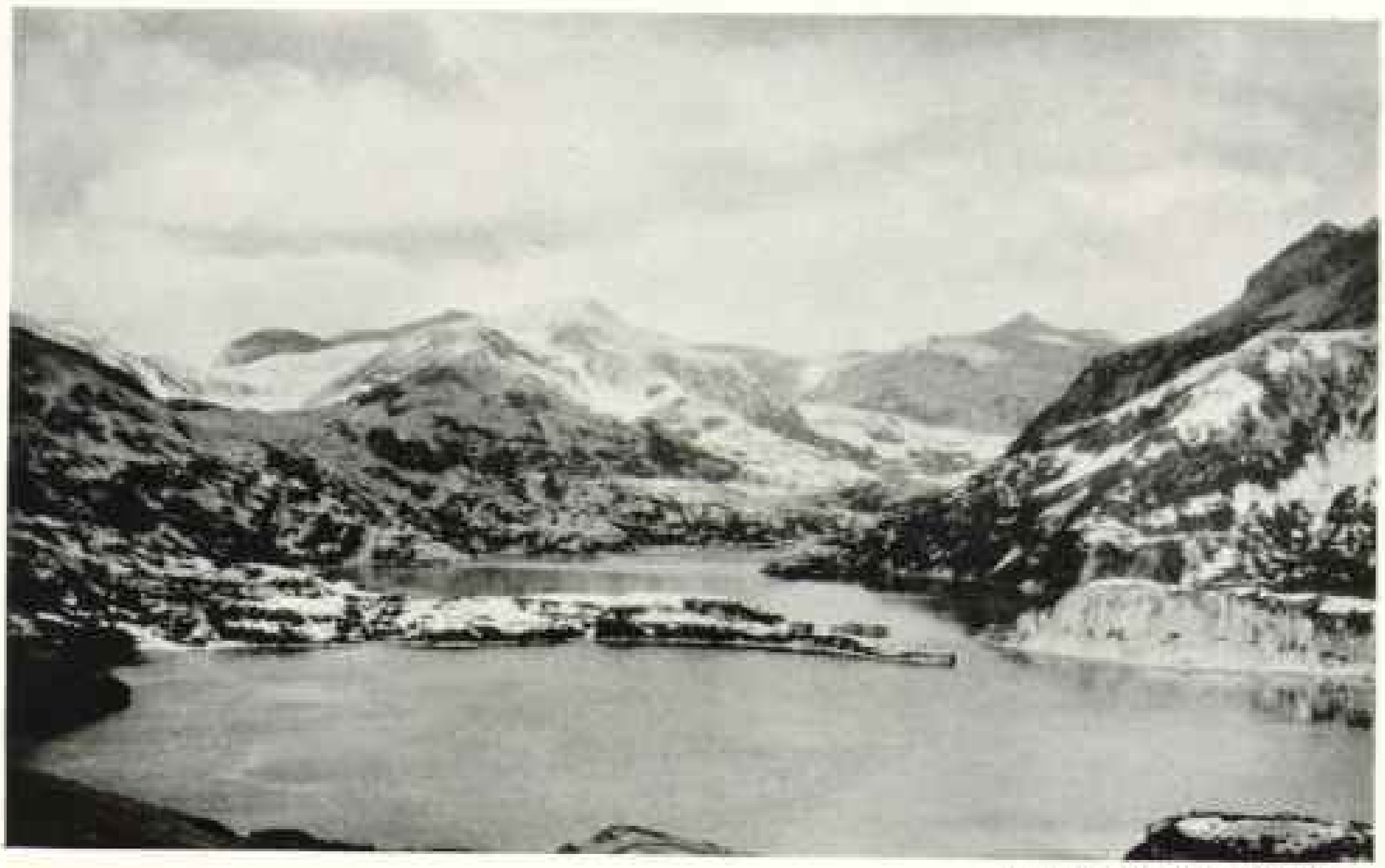
THE KATMAI EXPEDITION'S BOAT, THE "NIMROD," EXPLORING THE COAST IN SEARCH OF A HARBOR

Geographic Harbor, which was discovered by the expeditions, affords ready means of access to the whole region. Only 50 or 60 miles of automobile road is needed to open up all the wonders of the area to the public. When that is constructed, the traveler may tour the Katmai National Monument as easily as he now visits the Yellowstone.

Photograph by R. F. Griggs

MOUNTAIN WALL OF GEOGRAPHIC HARBOR

On entering this haven, one has an unusual opportunity to study volcanic action; for, contrasting with the ash of the recent eruption, there is an enormous lava flow that poured down the bay in Tertiary times, forming beautiful columnar joints, as seen in the nearer cliff.



Photograph by W. L. Henning

GEOGRAPHIC HARBOR (SEE TEXT, PAGE 291)

An easy pass, with an altitude of 1,200 feet, connects this harbor with Katmai Valley. About 60 miles of automobile road is all that is required to make the Valley of Ten Thousand Smokes and the whole Bristol Bay region readily accessible. The white spots on the ground are not snow, but ash from the recent eruption.

mon leaping upward under the urge of an irresistible instinct to reach the lake above, there to spawn and die.

Here we stood for hours, held by the fascination of the sight, as fish after fish leaped clear of the water and up over six feet of fall into the current above. Never was there a second when some fish did not make the try. Sometimes there were six of them in the air at once.

After careful count, we estimated that, although many fell back into the pool below, they were going over at the rate of 1,200 an hour. A little computation will show that in the course of a few days an enormous number of fish must pass up into the upper lake. What a sight they must have been in the old days, before overfishing by the canneries had depleted the runs!

It is too bad that the boundaries of the park do not include the falls, for there is no better place in the whole world to watch this wonderful sight.

Like the bear which made off at our approach, we took our toll of the "silver horde" lying in the pool below the falls, for they added a variety to our larder that was very grateful (see page 280).

TROUT 32 INCHES LONG

In addition to the salmon, the natives catch abundant "white fish" in gill-nets set in the lake; but we tried only the giant trout, with which the lakes and rivers are fairly teeming.

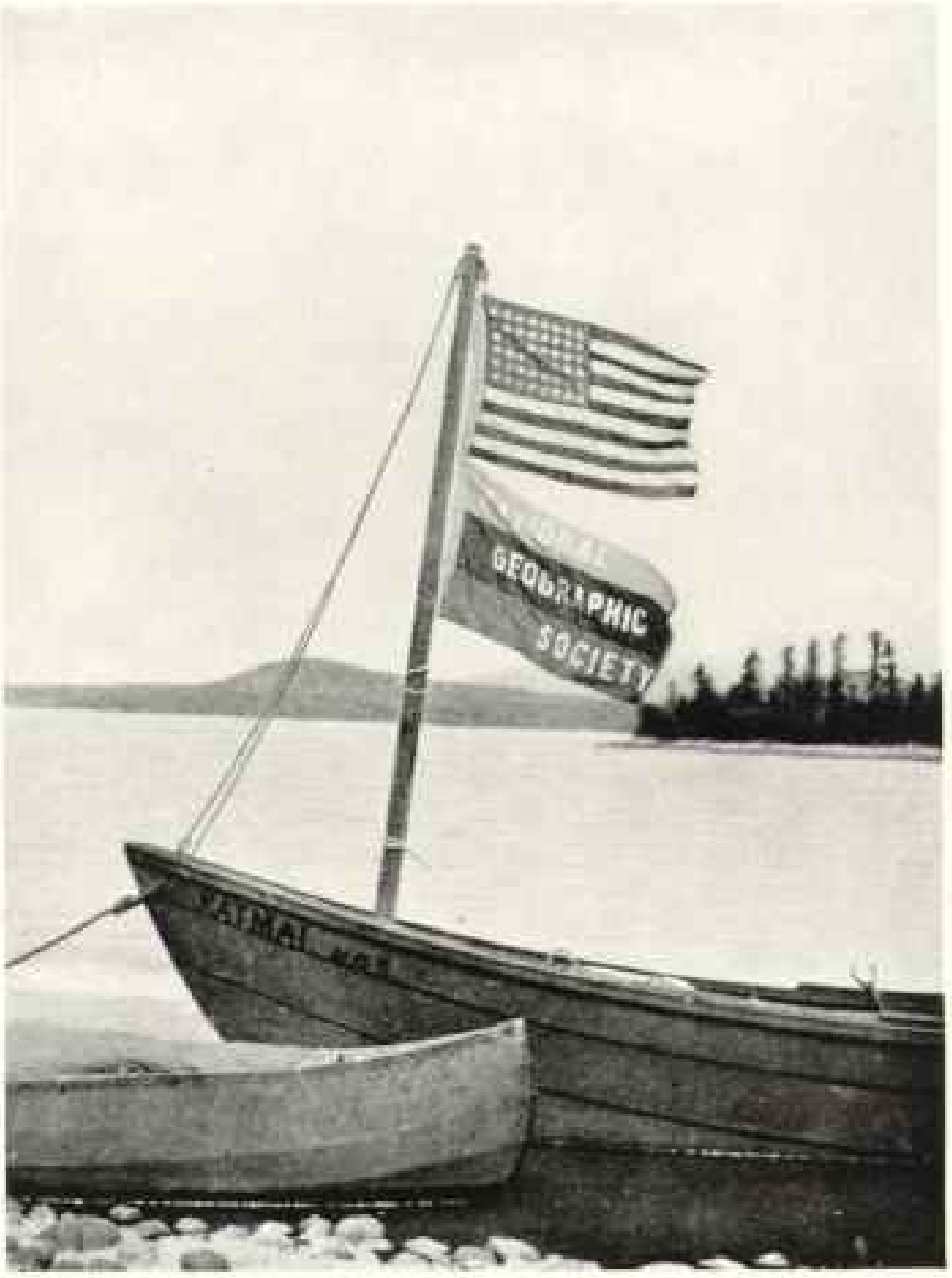
We had no need of any of the artificial flies which are supplied to anglers by the trade. These trout had such voracious appetites that our fishermen never had to cast more than once or twice before they had a strike that kept them busy.

Our bait, a scrap of bacon rind, was snapped up so quickly as to raise the suspicion that a piece of paper or anything else white would have served equally well. Our only trouble was that the fish were so big that they soon broke up all our tackle. Our catch averaged two feet in length; the largest, captured by Wallace, measured full 32 inches from nose to tail.

Bears are abundant in this country. Our work was too exacting to permit us

to take the time for a hunt, but we came upon them rather frequently as we tramped about the country, and one morning we killed one on the beach right in front of our tent. Their size is almost unbelievable. I have measured tracks 9 x 14 inches in hard ground, while in the soft places the same animal left a trail like an elephant, the individual tracks measuring 10½ x 16 inches, more than big enough to cover the two pages of this Magazine as it lies open.

A fox, ordinarily the shyest of animals, used regularly to bring her litter to feed at the garbage pile a few yards from our tents. Moose were common before the eruption and are beginning to come back. Caribou were formerly very abundant and may be expected to return in plenty within a few years. Elk were also found occasionally.



Photograph by P. R. Hagelburger

THE COLORS OF THE EXPEDITION ON NAKNEK LAKE

Our dory was the first power boat that ever sailed Naknek Lake.

There are grouse in the woods, and the numerous lakes and ponds are the breeding grounds of innumerable waterfowl of all sorts—swans, geese, and many kinds of ducks in immense numbers. We saw one flock of five hundred swans on Naknek River, while smaller flocks were frequently met.

Under the circumstances, the abundant geese and ducks attracted little notice, although the latter were far easier to bag than their larger cousins. We killed no geese, but shot a number of swans near our various camps. Their flesh is superior to any fowl I have ever tasted.

The Katmai National Monument is well located to serve as a sanctuary to conserve all this wild life, and will doubtless ultimately become one of the most important game preserves in the world.

DISCOVERY OF AN ENTRANCE TO THE KATMAI DISTRICT

Since the district has been set aside as a national monument by proclamation of the President of the United States (see THE GEOGRAPHIC for April, 1919), the first question in every one's mind has been, Can the place be made accessible? It is ideally located for a side trip from what will undoubtedly become the favorite Alaska tour when the new government railroad is completed—the trip through the "Inside Passage" and along the coast, under Mt. St. Elias, to the head

of Cook Inlet, thence into the interior past Mt. McKinley by rail and up the Yukon by steamer, returning via the White Pass.

To reach Katmai from the route of this tour would require the steamer to travel only a few hours out of her course. But it is self-evident that no great number of people can ever enjoy the Katmai National Monument if they are compelled to land in small boats through the surf, as we have had to do. Until our discovery, however, it was not known that a safe harbor existed in such a position as to furnish a feasible route from the sea to the Smokes.

A large place in the plans for 1919 was, therefore, given to the thorough exploration of the coast-line in hopes of finding a suitable harbor. One party, under the direction of P. R. Hagelbarger, spent almost the entire season in this work, and was able to report that they had found a harbor that was all that could be desired, and that there was a good route from it back into the reservation.

The new harbor, which we christened GEOGRAPHIC HARBOR in honor of the Society responsible for the discovery of the wonders of the district and for its reservation as the Katmai National Monument, lies in an arm of Amalik Bay, in an area hitherto shown as dry land on all charts (see map, page 222).

Boldly entering a narrow canal at the head of the charted portion of Amalik Bay, one steers a straight course for about a mile, when he finds himself in a broad inner bay, completely landlocked and secure from all manner of tempests. The inner bay is bisected by a chain of islands thrown across it, but there is a good passage around them, admitting one to the innermost harbor, which measures about two miles in diameter.

We had no apparatus for making complete soundings over the whole bay, but found the channel by which we had entered so deep that we got no bottom anywhere with nine fathoms (54 feet) of line. There is thus both plenty of water and room for the largest ships.

From the head of the bay an easy pass of 1,200 feet leads over the divide into Soluka Valley, which is entered close to a fine hot spring and sightly waterfall. This valley leads directly into Katmai Valley, to which it is tributary, thus affording a favorable route for the construction of a road through the whole of the district.

The length of road necessary to reach the Valley of Ten Thousand Smokes and to connect with navigation on Naknek Lake is not more than 50 or 60 miles. When this road is built it will be possible for a tourist to leave his steamer in the morning, traverse the Valley of Ten Thousand Smokes, and return to the boat before night.

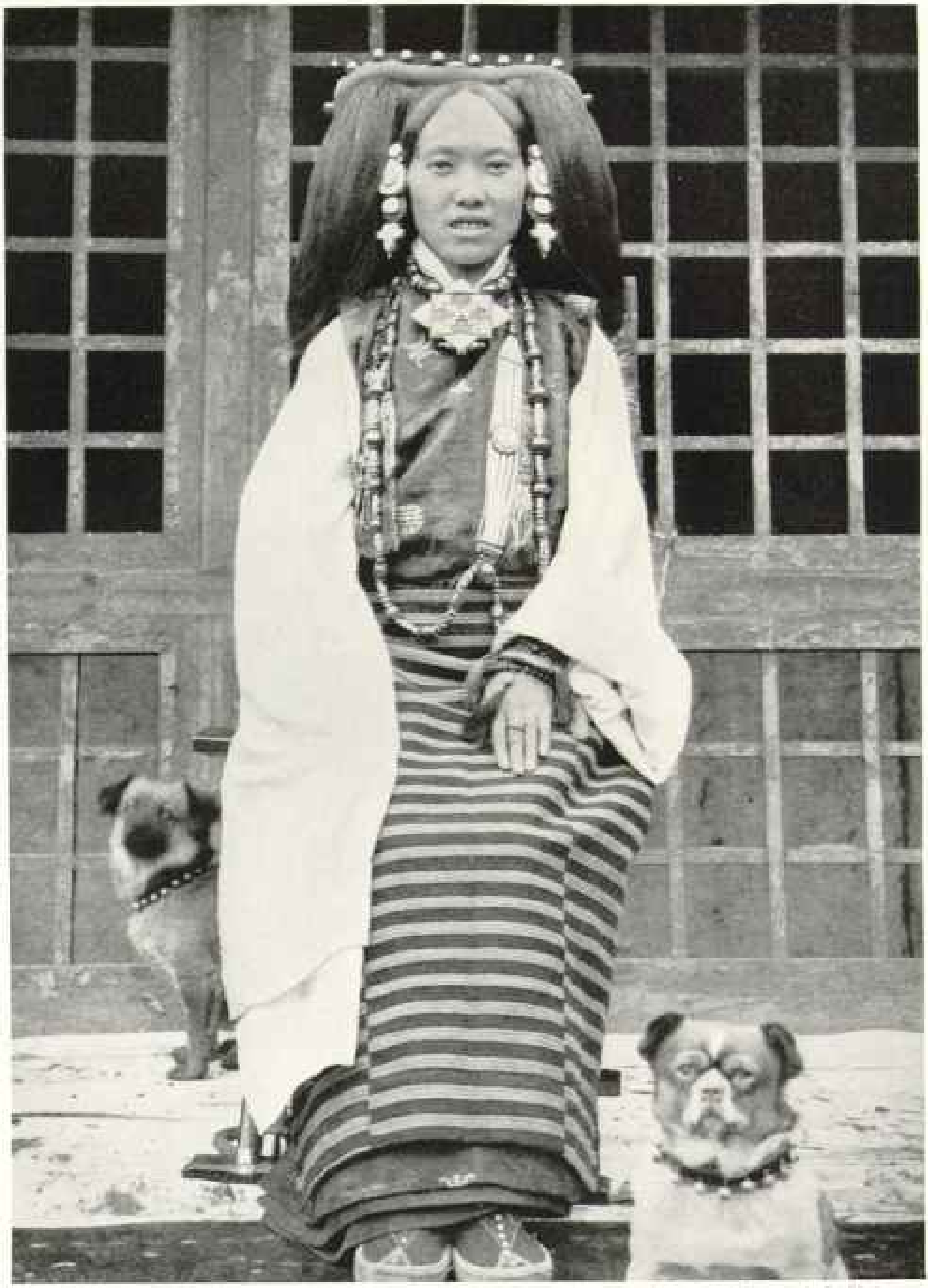
Few there are, to be sure, who would be content with a single glimpse of the wonders of the place; but, as far as covering the distance is concerned, a few hours would be all that was required for the actual travel.

GEOGRAPHIC HARBOR A FITTING ENTRANCE TO SUCH A WONDERLAND

Not only is this a safe and commodious harbor, but it is a fitting entrance to such a wonderland as the Katmai National Monument, for it is one of the most picturesque bays along the whole Alaskan coast. It is surrounded on all sides by the most rugged mountains, rising more than 3,000 feet out of the water.

With the exploration of a route into the Valley of Ten Thousand Smokes, the field program of the Katmai Expeditions has been completed. Although there remain many scientific problems yet to be solved, the general features of this region may be said to have been made known. It has been set aside as a part of our great national park system, for the perpetual use and enjoyment of the nation.

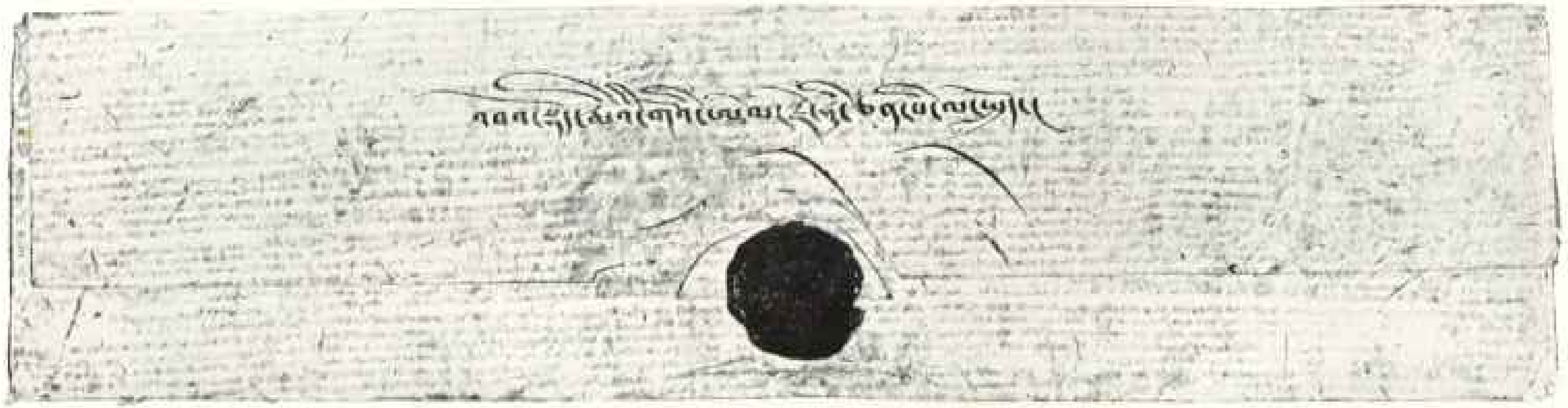
A route for a road by which the region can be made as accessible as any other of our national parks has been explored. It remains for the people to decide when such a road shall be constructed and the region opened to public travel.



Photograph by Dr. A. L. Shelton

WIFE OF THE GOVERNOR OF LOWER KHAM; TIBET

She is from southern Tibet and was very gracious in her hospitality to the American physician and his family while they were in Gartok. She is of small stature and is quite fond of her Tibetan dog. She is a woman of great ability and would sometimes dance at an evening entertainment to the accompaniment of the Scottish bagpipes (see page 297).



Photograph from Dr. A. L. Shelton

PERMISSION FROM THE DALAI LAMA, WITH HIS OFFICIAL SEAL AS SPIRITUAL AND POLITICAL RULER OF TIBET, TO DR. A. L. SHELTON, AND THE ENVELOPE IN WHICH IT CAME

The author of this article enjoys the unique distinction of having been invited to visit the Dalai Lama in the mysterious city of Lhasa. The permission came as a result of the American physician's ministrations to stricken Tibetan warriors. The Dalai Lama wished to profit by the Westerner's healing powers. Unfortunately, the prospective guest was captured by Chinese bandits and held for ransom while on his way to Lhasa. After many dangers and privations he managed to escape, but not until he had sustained injuries which necessitated his immediate return to the United States for serious operations, which restored his health.

LIFE AMONG THE PEOPLE OF EASTERN TIBET

By Dr. A. L. Shelton

For Seventeen Years Medical Missionary at Batang, near the China-Tibetan Border

WHERE East meets West on the border line between China and Tibet, the broad rôles that have come to be understood by those brief terms are completely reversed. There it is the East, personified by China, that has represented the greater progress; and Tibet, which stretches far to the west, that has preferred to exist for centuries behind the world's greatest rampart of mountains, inhospitable to the knocking of ideas more modern than its own.

Of all the great forces that have molded the outside world, only Buddhism, it might be said, has left its impress behind Tibet's towering border, and even that force, having once gained access, has been almost swallowed up in the devil-worship which is the highest religion that the Tibetans themselves have evolved.

Until recent years, practically nothing was known of Tibet by Caucasians except the doubtful information contained in the writings of a few adventurous travelers who in the Middle Ages made brief excursions into the country. The few resolute modern explorers who won their way behind the barriers of mountains and deserts were invariably turned back after brief sojourns, usually in the sparsely settled regions of the north.

LHASA REVEALED TO THE WORLD IN 1904

The expedition of Sir Francis Younghusband to Lhasa, the capital of Tibet, in 1904 made that hitherto forbidden city known to the outside world. More recent visits of travelers have added still further to the general knowledge in regard to Lhasa and a few other important valley towns close to the Indian border.*

But just as a familiarity with New York or Paris leaves much to be learned about the United States or France, so the knowledge that has been gained about Lhasa and its neighboring communities fails to afford an adequate picture of Tibet and the Tibetans. In regard to the nomadic people of the uplands and life in the villages of the agriculturists, that dot the many smaller valleys of Tibet, much has remained unknown.

While the complete picture of Tibet and its inhabitants probably will not be filled in for many years, my long sojourn in the border country where western China meets eastern Tibet, and my close association with its people, who with a very few exceptions are the people of Tibet, enable me to sketch in a few lines regarding Tibetan conditions outside the larger cities.

SCENE OF STRIFE BETWEEN TIBETANS AND CHINESE

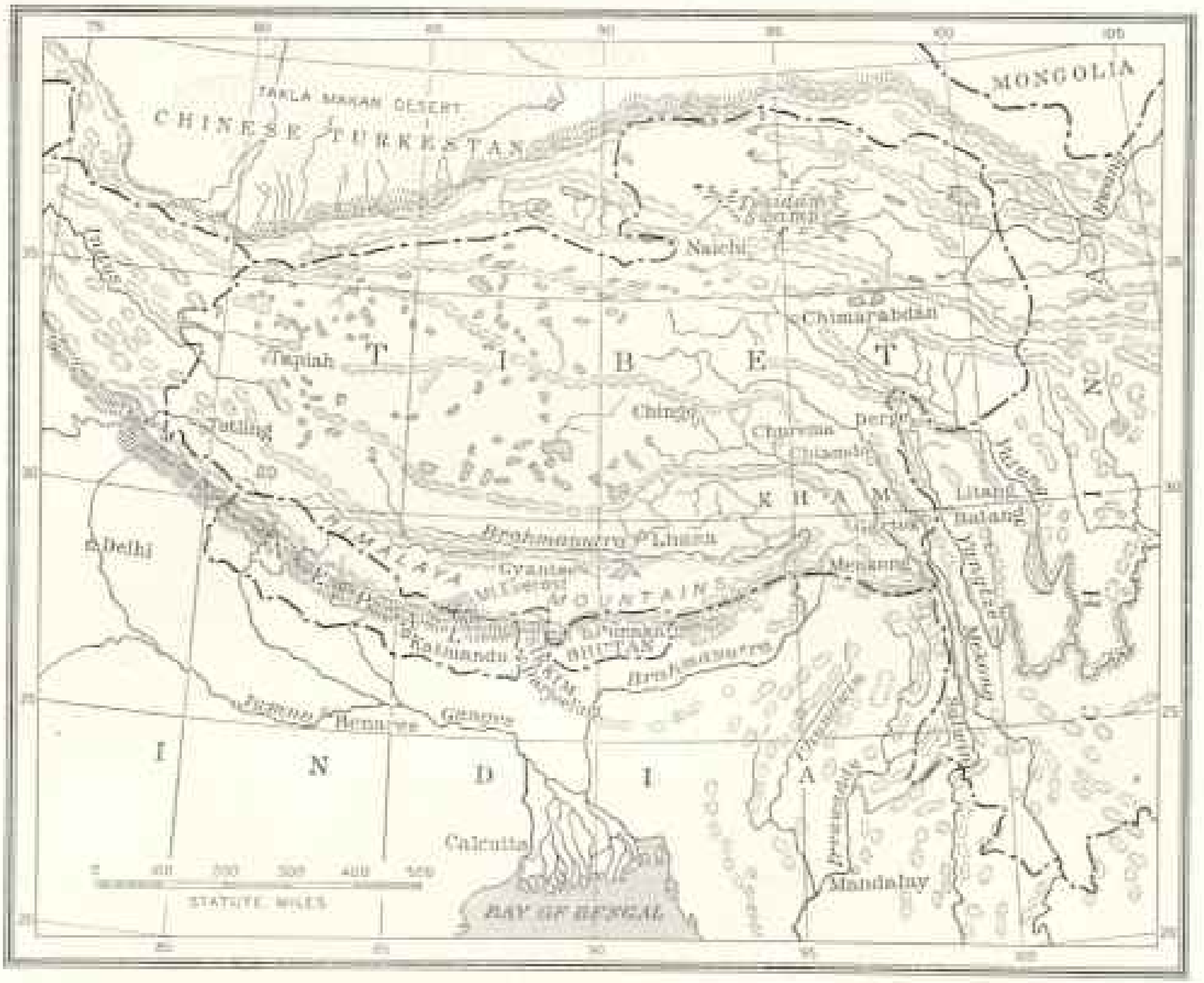
The southern portion of the border between China proper and Tibet is approximately the valley of the Yangtze, where that great river flows almost due south at the eastern end of the Himalayas before making a great swing to the northward through the most populous part of China. Where the Yangtze separates China and Tibet it is already a river of considerable size, its waters being between 700 and 1,000 miles along their way in their 3,400-mile journey to the sea.

Quite apart from the political divisions and nominal government, the region on both sides of the Yangtze where it flows south is in reality Tibetan. A territory approximately the area of Alabama, with Batang as its center, has been the scene in recent years of much strife between the Tibetans and the soldiers of China, whose officials were expelled from Tibet during the Chinese revolution in 1912.

Such authority as China maintains in this border region is most tenuous, and to the west of the Yangtze Valley it may be considered to vanish entirely.

This region contains both Protestant and Roman Catholic missions, and connected with the former is a medical mission. It marks the closest approach from the east of Christian influences and modern conceptions of sanitation, medicine, and surgery toward Lhasa, strong-

* See, in the National Geographic Magazine, "The World's Strangest Capital," by John Claude White (March, 1916), and "The Most Extraordinary City in the World," by Dr. Shaoching H. Chuan (October, 1912).



Drawn by James M. Darley

A MAP OF TIBET AND BORDER COUNTRIES

The meagerness of authentic information concerning the interior of Tibet is indicated by the fact that the population of its 463,000 square miles is variously estimated at from 1,500,000 to 6,000,000. The only census ever taken of the country was that conducted by the Chinese nearly two hundred years ago, showing 316,000 lamas (monks) and 635,000 laity. For a more detailed map of this region, see the National Geographic Society's "Map of Asia," published as a supplement with the May GEOGRAPHIC.

hold of Lamaism—the degenerate Buddhism of Tibet.

The border region is a country of mountains. Batang, the chief city, is one of the lowest points, and yet its altitude is 9,000 feet above sea-level, nearly twice that of Denver.

Most of the surrounding country is 12,000 to 15,000 feet high, the latter altitude being more than 500 feet higher than Mt. Whitney, California, highest peak in the United States proper. From this great upland rise numerous peaks 20,000 feet and more in height.

The view from the summits of some of the passes that must be traversed in traveling about this marvelously rugged country can hardly be surpassed anywhere in the world. The panorama for hundreds of miles on a clear day is one of countless high peaks inter-persed with greater snowy masses that exceed in height the topmost pinnacles of all other continents.

Below timber-line are some fine forests, and the Alpine-like flowers of the short summer are exceedingly beautiful. Here and there among the mountains are clear, sparkling lakes, their waters so cold that in most of them fish cannot live.

STRANGE MYTHS AS TO THE ORIGIN OF TIBETANS

Kham, the easternmost province of Tibet, gives its color to the entire border region, and its people are said to be the most robust of all Tibetans.

Little is known of the origin and an-

Photograph by Dr. A. L. Shelton

THE GOVERNOR OF LOWER KHAM, HIS WIFE AND PIPER

This piper was brought down from Chiamdo, a ten days' journey, for the entertainment of the American physician and his family. The Tibetans have adopted the Scottish bagpipes as their national military instrument. It was startling to hear the piper playing "The Cock of the North," "The Campbells are Coming," and "The Drunken Piper." He played with great skill, for the Tibetan instructors have learned their music in India (see page 293).

cestry of the Tibetans. This is probably due in large part to the rigid exclusion of men of science and other travelers. The Tibetans themselves dismiss the subject with hopeless fairy tales and legends. One of these has it that the progenitors of the race were "a she-devil of the Himalayas" and an ape from the plains of Hindustan.

To the lay observer there is no resemblance whatever between the Tibetans and the Chinese, nor are they similar to the Malayans. In features and characteristics they resemble the American Indians more nearly, perhaps, than any other distinct type, although in color and other characteristic features there is an indication that they may have sprung from the original Mongol people.

Many of the people of Kham are nomads, who tend their flocks of sheep and yak as they graze over the uplands, and

Photograph by Dr. A. L. Shelton

THE HIGH PRIEST OF BATANG WITH HIS ATTENDANTS

Both Chinese and Tibetan influences are seen in the features and dress of the attendants, while the rifle suggests the inroad of Western ideas.

live in black yak-hair tents. Others engage in a crude sort of farming in the valleys where the altitude is low enough for grain to mature.

The nomads live the year round in their tents, seldom even entering a house. When the lower slopes of the mountains become free from snow in the spring, they begin their upward pilgrimage with their herds, closely following the receding snow-line, until in summer they are living far up in the highlands and on the sides of the peaks.

When winter begins to set in they make the reverse journey, going down to the valleys only as fast as the descending snow-line drives them. In this way they are able to utilize the supply of grass to best advantage.

The herders remain close to the snow also because their yak thrive best in a cold temperature and cannot, in fact, stand any great degree of heat, especially if introduced into the warmer temperature suddenly.

So carefully must the yak's predilection for cold be indulged that traders bringing supplies in summer from the

Photograph by Dr. A. L. Shelton

THE KING OF DERGE, HIS TWO WIVES, AND OTHER MEMBERS OF HIS HOUSEHOLD

Derge for many years was an independent state, but is now under Tibetan rule. The Chinese and Tibetan influences are here plainly seen.

high country to Batang will not drive their animals into the town. They unload ten miles from their supposed destination, at a point about 12,000 feet in altitude, and the Batang consignees must provide transportation for the remainder of the distance to the 9,000-foot level.

The agricultural people of the lower valleys live in substantial houses of mud with flat roofs. In constructing the mud walls the Tibetans use forms of parallel boards not unlike the forms used in the United States for molding walls of concrete. The mud is beaten into the forms until it is puddled, and when dry it is very hard (see page 307).

The agriculturists have few animals. Yak are employed for plowing, however, being brought down from the higher country for the purpose at the proper time.

CRUDE PLOWS DRAWN BY YAK

The farm operations are carried on under conditions that a well-equipped American farmer would consider a heavy handicap. The plows used are made entirely of wood, with a single handle. They have been developed beyond the most primitive types of wooden plows, however, having removable digging parts, which are replaced when worn or broken.

The front end of the beam of the plow is attached to the middle of a wooden bar, each end of which is bound to the horns of a yak. One person usually leads the yak team, while another walks behind, holding the handle of the crude implement. The work of sowing and plowing is done mostly by the men, while the women do the greater part of the harvesting, a division of labor the reason for which is not apparent.

The harvested grain is carried to the tops of the houses, where it is threshed on the flat roofs by means of flails. Primitive mills are set up along the streams, where the grain is ground raw into flour and parched into "tsamba," the latter a particularly important article in the Tibetan diet. The mills are of a simple type common in many lands, consisting of a stationary lower stone and an upper stone revolved on the lower by

Photograph by Dr. A. L. Shelton

THE AUTOGRAPHED PHOTOGRAPH OF THE DALAI LAMA, A PRIZED POSSESSION OF THE CALON LAMA

The Calon Lama, or "receiver of commands," ranks immediately below the ruler of Tibet, who resides in Lhasa. The Calon Lama of Chiamdo was the commander-in-chief of the Tibetan army at the time when Dr. Shelton was asked to aid the wounded and sick warriors of the Tibetan forces (see text, page 319).

Photograph by Dr. A. L. Shelton

THE DAUGHTER OF THE KING OF JALA AND HER BRIDEGROOM

She is dressed in her bridal robes, with her husband (in the center) standing at her right. Jala, of which Tachienlu is the capital, is two provinces east of Batang.

means of a shaft extending upward through a central hole in the fixed stone. The shaft is attached to a water-wheel below.

"GOING TO BED" MEANS CURLING UP ON THE FLOOR

The living quarters in the homes of the valley folk usually consist of a single large room, in which all work, including the cooking, is done, and where the members of the family eat and sleep.

The comforts in such homes are meager indeed. In few establishments is there even the semblance of a bed. In the ordinary houses "going to bed" means merely loosening the girdle, opening the sheepskin garment, and curling up on the floor with the feet toward the stove, which is an essential feature of all habitations in this high, cold country.

The stoves are built of mud, with a fireplace below and a hole in the top into which pots may be set for cooking. The stove is usually built to one side of the living room, and the members of the family, on retiring for the night, range themselves in a fan-shaped group about it.

Families possessing domestic animals share their houses with them. In two-storied houses the lower floor is the stable, and through it the living quarters are reached. In some one-storied houses the front portion is given up to the animals, while the family lives in the rear.

BARLEY MEAL AND BUTTER TEA THE TIBETAN MENU

The food of the Tibetans is most monotonous to an American or European, accustomed to variety in his diet. They live almost the year round on two things, parched barley meal, called "tsamba," and "butter tea," neither of which seems at first view either appetizing or sustaining.

Tsamba is made by parching barley and then grinding it into a very fine flour. It becomes a sort of emergency ration, for, being parched, it requires no cooking. When Tibetans are on journeys or are wandering about with their flocks and herds, they carry tsamba in small leather bags inside their coats, thus always hav-

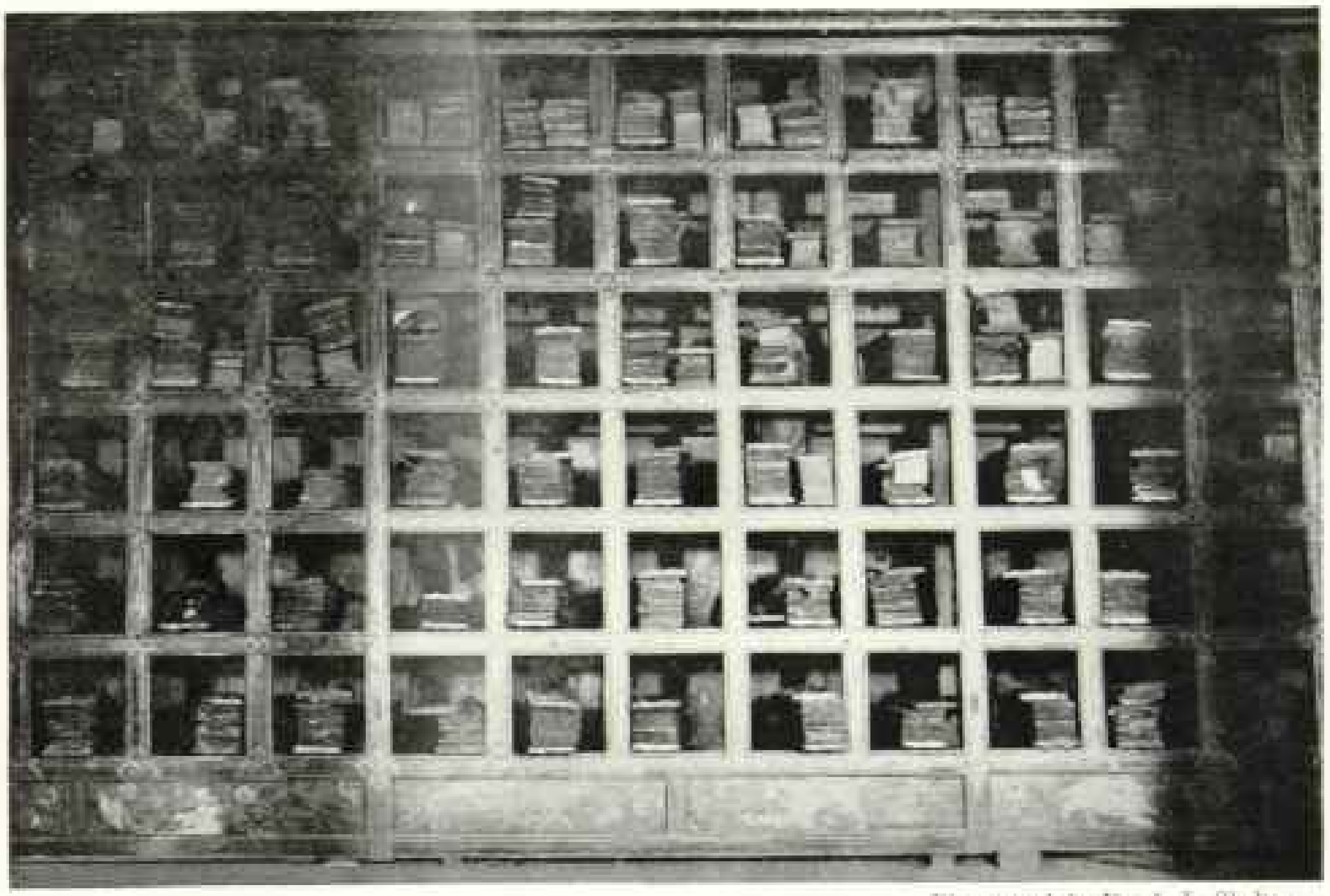
A THRILLING HORSEBACK RIDE ACROSS THE MEKONG RIVER

With his mount securely trussed to the rope bridge, the owner supplies his own motive power, hand over hand, as he pulls himself and beast across the chasm with the river far below.

Photographs by Dr. A. L. Shelton

CORACLES, OR SKIN BOATS, USED FOR CROSSING TIBETAN STREAMS

Such a craft has a framework of wattles over which is stretched green yak hides. The seams are sealed with pitch, which makes the boat practically watertight. Unless a person is careful, he is liable to stick his heel through the bottom, in which case it becomes necessary for him to keep it there until the boat has reached the other shore. A coracle is propelled by a native, who puts the broad paddle far out into the water and pulls it toward him.



Photograph by Dr. A. L. Shelton

PART OF THE LIBRARY IN THE LITANG LAMASERY

In Kham the sacred Buddhist writings are printed from blocks such as were first used in China, or are written by hand. The printing of religious books is one of the principal industries of the town of Litang. The Buddhist Bible is a work of 108 volumes and the companion commentary work is of equal bulk (see page 320).

ing at hand the materials for a hasty meal.

In preparing the other principal article of their diet the Tibetans first make a strong liquid by boiling the coarse Chinese tea which they prize most highly. The concoction is strained into a churn and to it are added a lump of butter, more or less stale, and a handful of salt. The queer mixture is then churned into an emulsion.

The typical meal among the valley folk of Tibet, and among many of the nomads as well, begins with the drinking of two or three cups of butter tea—a beverage which the Caucasian feels a constant inclination to speak of in quotation-marks, for to him it is neither tea, soup, nor gravy, but a combination of the three.

As the Tibetan drinks his hot butter tea, he continually blows back from the rim of his bowl the film of butter that rises to the top. After several bowls of the beverage have been drunk, there is a considerable accumulation of butter. The bowl is then half filled with the tea emulsion. Into the hot liquid, rich in butter fat, tsamba is now poured, to be kneaded by the fingers into lumps and eaten.

THE WOODEN BOWL IS LICKED CLEAN AFTER EACH MEAL

Knives, forks, and spoons are unknown in Tibet—all eating is done with fingers. The wooden bowl is carried in the sheepskin garment next to the skin, and each time after being used it is licked clean with the tongue and replaced in the garment.

To an observer from Europe or America it seems impossible that the Tibetans, leading a fairly active life in a country of rigorous climate, could be satisfied on tsamba and butter tea year in and year out. Their queer foods must constitute a fairly well-balanced ration, however, for they thrive on them.

When the occasion and their economic status permit, Tibetans also eat meat. Especially is this true of the nomads liv-

Photograph by Dr. A. L. Shelton

BANDIT BRAVE OR TIBETAN TROUBADOUR?

The horseman is making a circuit of the walls of a ruined lamasery at Batang. This monastery was once one of the most flourishing establishments in eastern Tibet, but was destroyed by the Chinese during one of their invasions. The Tibetans are not allowed to rebuild damaged lamaseries or to erect new ones, for the Chinese conceive these religious communities to be centers of rebellion.

ing far from the grain-producing valleys, to whom tsamba is a luxury. The meat is sometimes dried and preserved for future cooking, sometimes cooked while fresh.

FIRST USERS OF CONDENSED MILK

Most Tibetan meat eaters, however, are kindred spirits of Dr. Samuel Johnson, for, like him, they prefer their meat "high" and "gamy." But, after all, they go much further than the author of "Rasselas," for they eat the spoiled meat raw. Naturally, stomach trouble is rife among the Tibetan nomads.

The Tibetans of this region were probably the original users of condensed milk in the form of dry lumps, for they have prepared this article of food for many centuries. Fresh milk is poured into a churn which is never washed and the liquid therefore curdles almost the instant it comes into contact with the germ-incrusted walls of the container. It is then churned and the butter is extracted.

After the butter is extracted the milk is boiled in a large iron pot until it reaches the consistency of thick syrup. It is then poured out in a thin sheet and allowed to dry, after which it is broken into small pieces and stored. The lumps often become as hard as stone, and to eat them dry is out of the question. The nomads solve the problem by substituting the dry milk for tsamba, soaking it in their butter tea. It thus becomes softened to some extent and can be chewed.

The pastoral Tibetans produce a great deal of butter. Much they consume themselves, but there is a considerable surplus, which those in reach of the grain-producing valleys take to the lowlands and exchange for tsamba. There is such a quantity of yak hair in the butter that an observer would almost assume that it was a prized ingredient, but its presence does not lower the value of the product in the estimation of the native consumers.

Salt is so important to the Tibetans that in some parts of the country it is a medium of exchange. Its production constitutes an industry of considerable consequence in some of the valleys of the eastern border region, particularly at Yengin, where salt water may be obtained from shallow wells.

SALT WATER IS EVAPORATED ON MUD ROOFS

Flat roofs of mud, beaten on to a carpet of small poles supported by larger poles, are constructed. Along the edges raised rims are built. The beating or puddling makes the mud surfaces practically impervious to water. Women carry kegs of salt water on their backs to the roofs, climbing up notched poles that serve as ladders. The water is poured on the flat surfaces and evaporated by the wind.

After the water has disappeared the thin film of dry salt left on the roofs is collected, but not, it should be added, without considerable quantities of dirt and grit which are swept up with it.

Apparently the natives do not object to the dirt, for the salt, as it comes from the roofs, is carried as an article of commerce all over eastern Tibet. It is very cheap at the wells, but becomes progressively dear as the distance increases. In the remote districts the price of the salt becomes almost prohibitive and it is eagerly sought after. The salt produced near Batang is used by the staff of the American mission, but the precaution is taken to refine it by dissolving it, allowing the tiny stones and mud to settle, and boiling down the clear salt solution.

"ONE PERSON, ONE GARMENT"

The Tibetans are almost wholly independent of the outside world in the matter of clothing materials, and this is especially true of the nomads and village folk. The great majority of the nomads wear garments of raw sheepskin. Nor is their wardrobe more extensive than the variety of its materials. The usual rule is one person, one garment.

The sheepskin garments are made with the wool inside. A single garment will last for years, and naturally in the course of time comes to have other inhabitants than its owner. In warm weather the wearers of the sheepskins throw the top part of the garment off and go about naked to the waist, or, removing one arm, permit the skin gown to hang from the other.

The women among the nomads spin the wool from their flocks on a rude spin-

Photograph by Dr. A. L. Shelton

HE IS 78 YEARS OLD, BUT HE IS CARRYING 100 POUNDS OF TEA FROM YACHOW TO TACHIENLU, SZECHUAN

Sometimes as much as 280 catties (370 pounds) are carried across these mountain passes by a Chinese coolie. Often boys 12 to 13 years old are seen carrying as much as 75 pounds for days at a time.

Photograph by Dr. A. L. Shelton

TIBETAN HOUSES IN THE ROBBER-INFESTED BAD LANDS

These homes are built primarily for protection. With the exception of the main entrance, there is no opening until the third story is reached. This style of architecture greatly simplifies the problem of defense against marauders.

ning-wheel. This is little more than a small disk of wood fastened to an upright, the whole being twirled with thumb and finger.

The wool, which is fastened to the end of the upright, is thus twisted into thread; the thread is then woven on a crude loom into very heavy woolen cloth about six inches wide. From this cloth, purchased with tsamba and barley meal, the people of the lower valley, where the climate is not so cold, make their gown-like garments.

It is by no means easy to judge the financial status of a Tibetan by the kind of clothes he wears. One may see men dressed in rough sheepskin, with their hair hanging in tangles down their backs and their appearance indicating that they had never had a bath in their lives, bargain for something worth hundreds of dollars.

If such an individual decides to purchase the article, he will pull out of his dirty gown a leather bag of gold dust and unconcernedly weigh out a sufficient quantity of the shining powder to pay for it. Less uncouth purchasers will probably use in their transactions the rupees of Chinese mintage, which constitute the most generally employed medium of exchange in Tibet. Chinese brick tea, like salt, is also used in some sections in place of money.

MONOGAMY, POLYGAMY, AND POLYANDRY FLOURISH

The marriage customs of the people of Tibet present a peculiar combination of monogamy, polygamy, and polyandry—the last particularly characteristic of the country, though monogamy is actually the prevailing system. Under the polyandrous system, the eldest son of a family marries a woman and she becomes the common wife of himself and his brothers.

Polyandry is far more common, especially among the nomads, than one is likely to believe at first. Under this system a woman usually marries three or four brothers, but one case came under

Photograph by Dr. A. L. Shelton

A TIBETAN HOUSE IN THE COURSE OF CONSTRUCTION

Poles are used to hold together parallel boards, between which mud is puddled. Then the forms are raised and another layer of closely packed earth added. Similar methods are used from Shanghai to Russian Turkestan (see text, page 299).

my observation in which a woman had six brothers for husbands.

Under the ordinary arrangement, one husband will take care of the home in the valley, if there is one; another will be in charge of the yak or sheep in the uplands; a third will be the trader, taking care of the caravan, while others will be assigned special duties.

MULTIPLE HUSBANDS AND WIVES DWELL IN HARMONY

The oldest brother is considered the father and the other brothers the uncles of the family. In such families the children usually are not numerous, an average family of children being three to five.

If a family has no sons, but has daughters, one of them usually is kept in the home, and a husband is brought in for her and carries on the family succession. The remaining daughters are normally given to other families. In a few cases, however, where there are two daughters, one husband is brought in and a polygamous household is established.

It is surprising how well the families of multiple husbands and multiple wives get along together. One with Western ideas would imagine that there would be a great deal of ill feeling and fighting, but in both polyandrous and polygamous families the members seem to live together in peace and harmony.

The usual feeling in these households is exemplified by the following incident: While on a journey in the border country I was called one night, by some folk in a village where I had put up, to see a man who was ill. When I told them that the sick man was dying, both the other husband, who was a brother, and the common wife cried bitterly.

THE WOMAN IS HEAD OF THE HOME

As opposed to the usual harmony in polyandrous households, I knew of one case the moral to which seems to be that all the husbands should belong to the same race. In this case a Chinaman and Tibetan went into partnership with one wife. For a while all seemed to go well, but finally the Chinaman became dissatisfied and chased the Tibetan out.

Photograph by Dr. A. L. Shelton

A SCENE IN THE TIBETAN PLAY WHICH IS GIVEN EVERY FALL AT BATANG

The performance occupies four days. During the festivity people from all parts of the country lay aside their usual labors and come to enjoy the outing. Every one is free to attend, but those who are able to do so are expected to make presents, either of money, meat, flour, grain, butter, or any other useful article, to the group of players for that year. The plays are historical in character.

Woman, on the whole, occupies a better position in Tibet than in a great many of the Eastern countries. She is practically master in the home and usually all transactions of a business nature concerning the family must have her sanction. Nor is she confined and prevented from going out as she pleases.

Once while I was traveling in what we have christened the "Bad Lands," to the west of Batang, I observed a custom I had not met with in any other part of the border country, which illustrated the privileged character of the Tibetan wife. In that region, after a woman marries and goes into the home in which she is to live, no other woman is permitted to go inside the door. If she wishes to visit with any of the neighbors or they with her, the visiting must be done outside the houses.

ONE PERSON IN SEVEN IS A LAMA OR PRIEST

Any reference to the social institutions of the Tibetans would be incomplete without mention of the lamas. They are the monks or priests of Tibetan Buddhism and live in great monasteries called lamaseries. Nearly every family in the country has at least one son who is a lama. Fully one-seventh of the entire population of Tibet, it is estimated, live in the lamaseries, being supported, of

Photograph by Dr. A. L. Shelton

THE AUDIENCE AT AN HISTORICAL PLAY IN BATANG, TIBET

course, in the main, by the remainder of the population.

The lamas have acquired much money and land. They add to their incomes from contributions by lending money to the common people, renting them land, and in time of sickness and death giving medicines and saying prayers.

Some of the priests in the local monasteries are fairly well educated, according to the standards of the country, having spent some years in Lhasa at the great monasteries. After returning to their native homes they are looked upon as very holy men.

The towns of Tibet are in most cases small groups of dwelling-houses and a few shops in valleys at the foot of steps and winding paths leading to some monastery that towers above on the steep mountain side.

In the lamaseries is to be found whatever there is of art in Tibet, most valuable objects eventually finding their way into the hands of the priests, who on the death of a person may take much of his personal property in payment for prayers on his behalf.

The strong hold which lamaism, with its great privileges accorded to the priests, has upon the Tibetans is due to the fact that the inhabitants of this mountain-rimmed country are perhaps the most religious people on earth. Their faith is nominally Buddhism, but in reality it is more truly a veneer of Buddhism over the old Bon religion, a religion of devil-worship. They are exceedingly superstitious, believing in ghosts and in the daily interference of devils in their affairs.

One day the old man who taught me the Tibetan language came in limping. I asked the cause of his lameness.

"Why," said he, in a matter-of-fact way, "a devil just now hit me on the ankle out there and I sprained it."

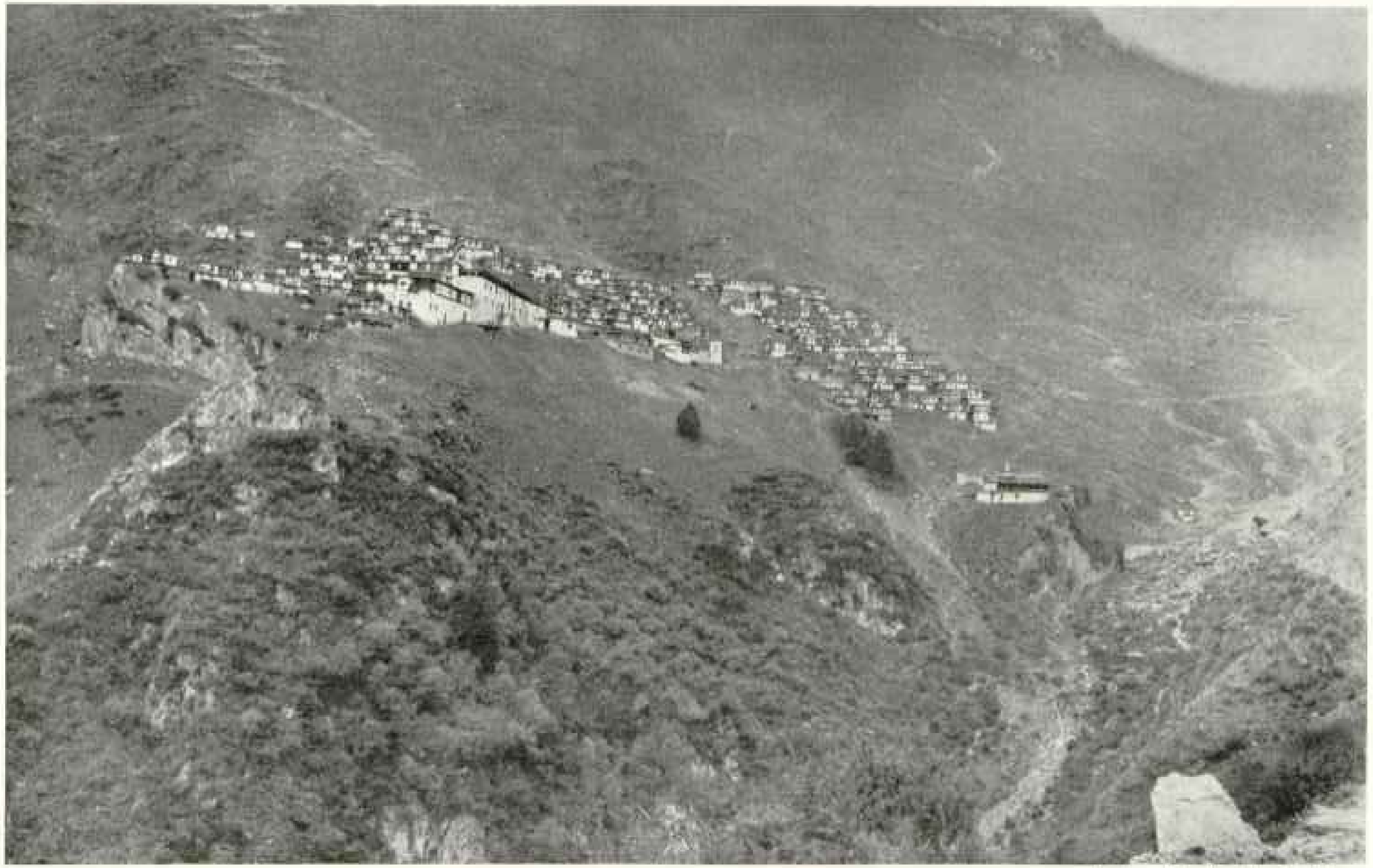
"Don't you think in reality you just stepped on a stone and turned your ankle," I said. "Wasn't that what hurt you?"

"Don't you think I know when a devil hits me?" he rejoined, with the tone of one defending the most obvious of common-sense statements.

In its form of government, Tibet is one of the few remaining theocracies in the world. The Dalai Lama of Lhasa combines in his person the functions of head of the lamaist church and supreme temporal ruler of Tibet. His chief governmental assistants are also priests.

The lamas, even the ordinary monks, occupy a privileged position, constituting in effect a class to themselves.

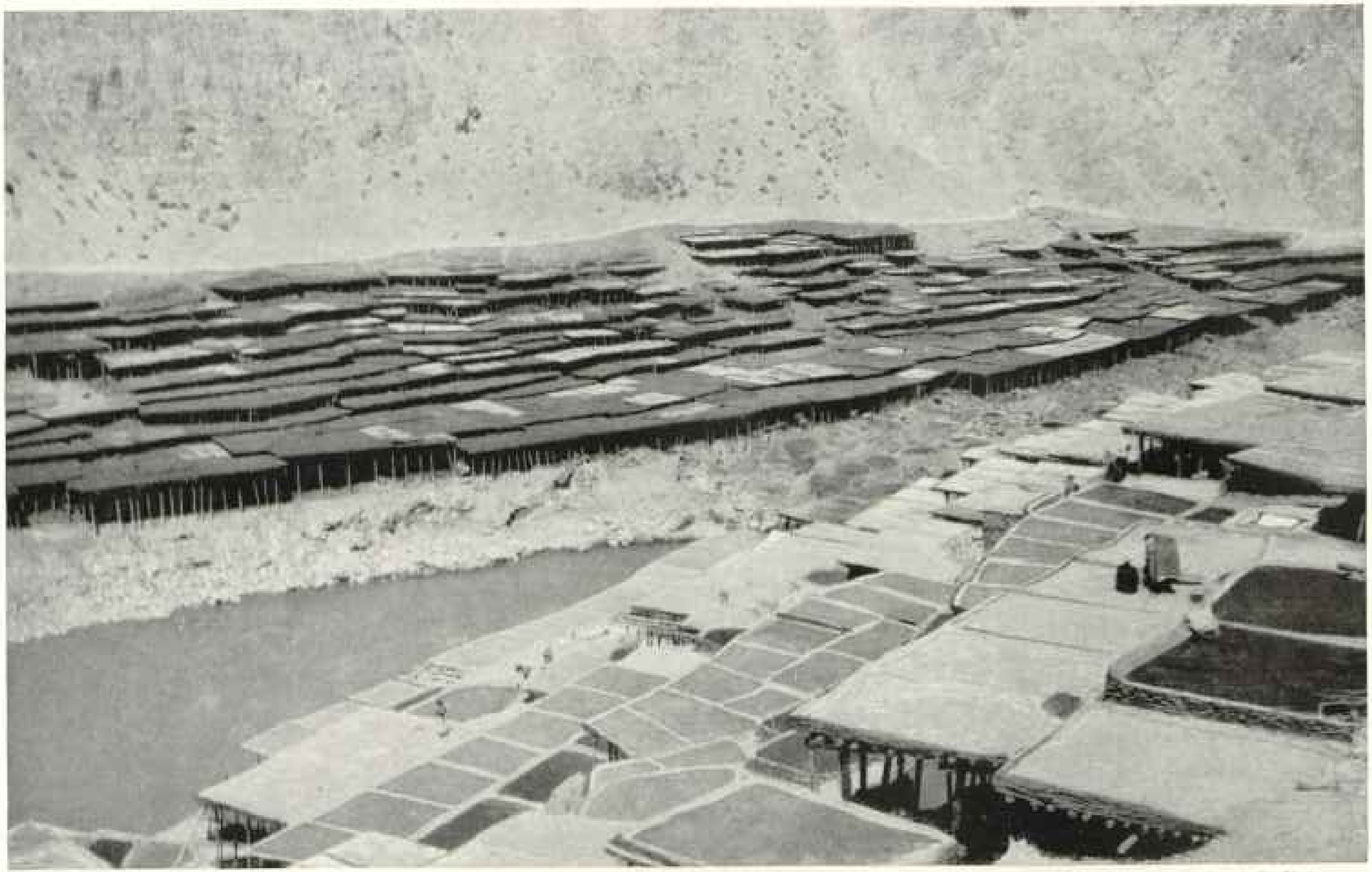
Next in rank to the ruling lamas are



Photograph by Dr. A. L. Shelton

GARTOK MONASTERY, WHERE THOUSANDS OF IMAGES ARE MADE AND GILDED FOR SALE

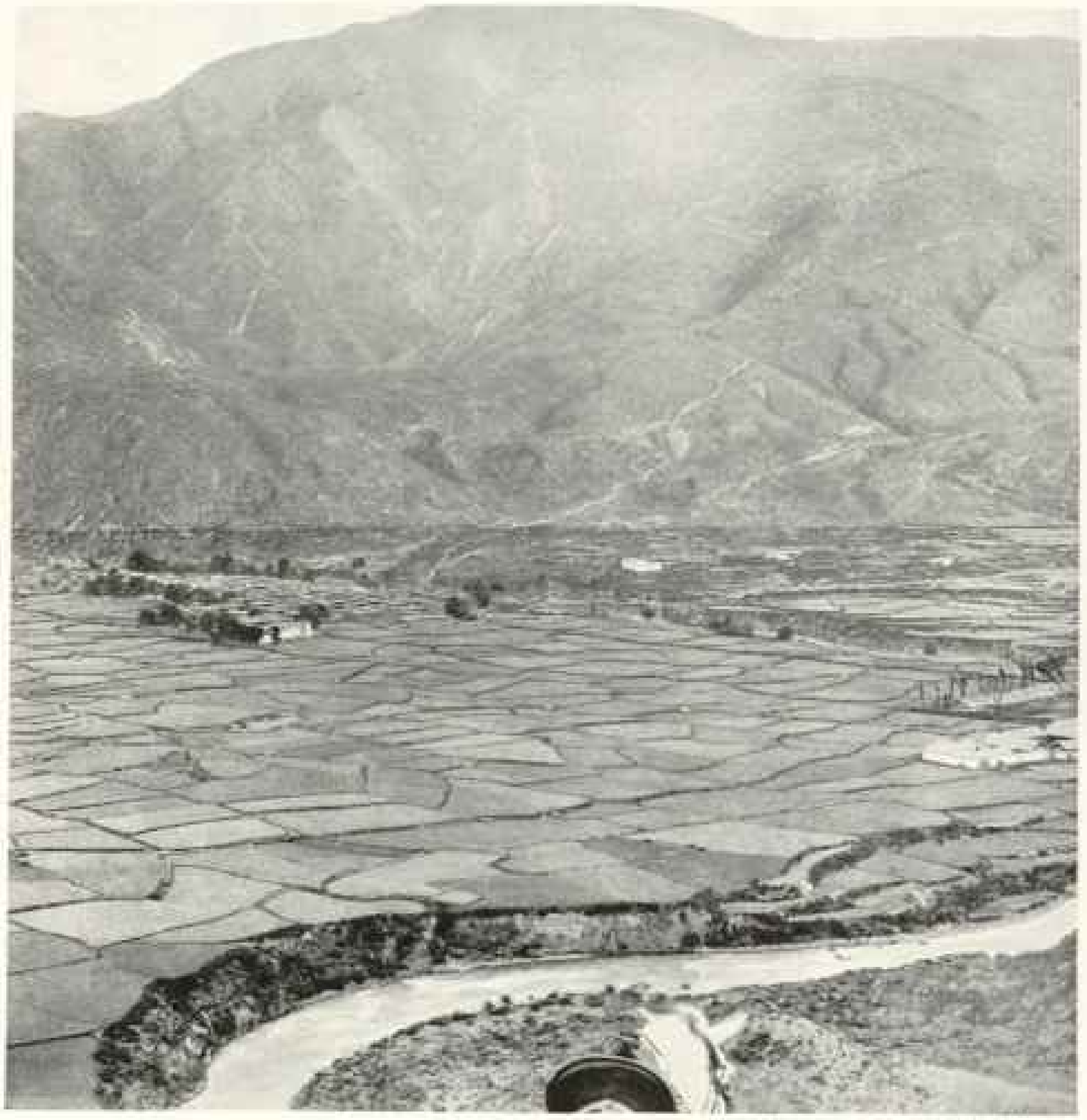
This home of idolatry is situated about nine days' journey from Batang. With their crude facilities the monks are unable to apply a cheap gilt to their idols, but are forced to use a rather heavy coat of pure gold (see page 399).



Photograph by Dr. A. L. Shelton

A VIEW OF YEN-GIN, FAMOUS FOR ITS SALT WELLS, WHICH HAVE BEEN PRODUCTIVE FOR HUNDREDS OF YEARS

Salt water from these wells is poured out upon raised platforms specially built to hold water. After the wind evaporates the water, the salt is swept up and sold with the dirt which is mixed with it. The white spots are platforms incrusted with dried salt (see text, page 305).



Photograph by Dr. A. L. Shelton

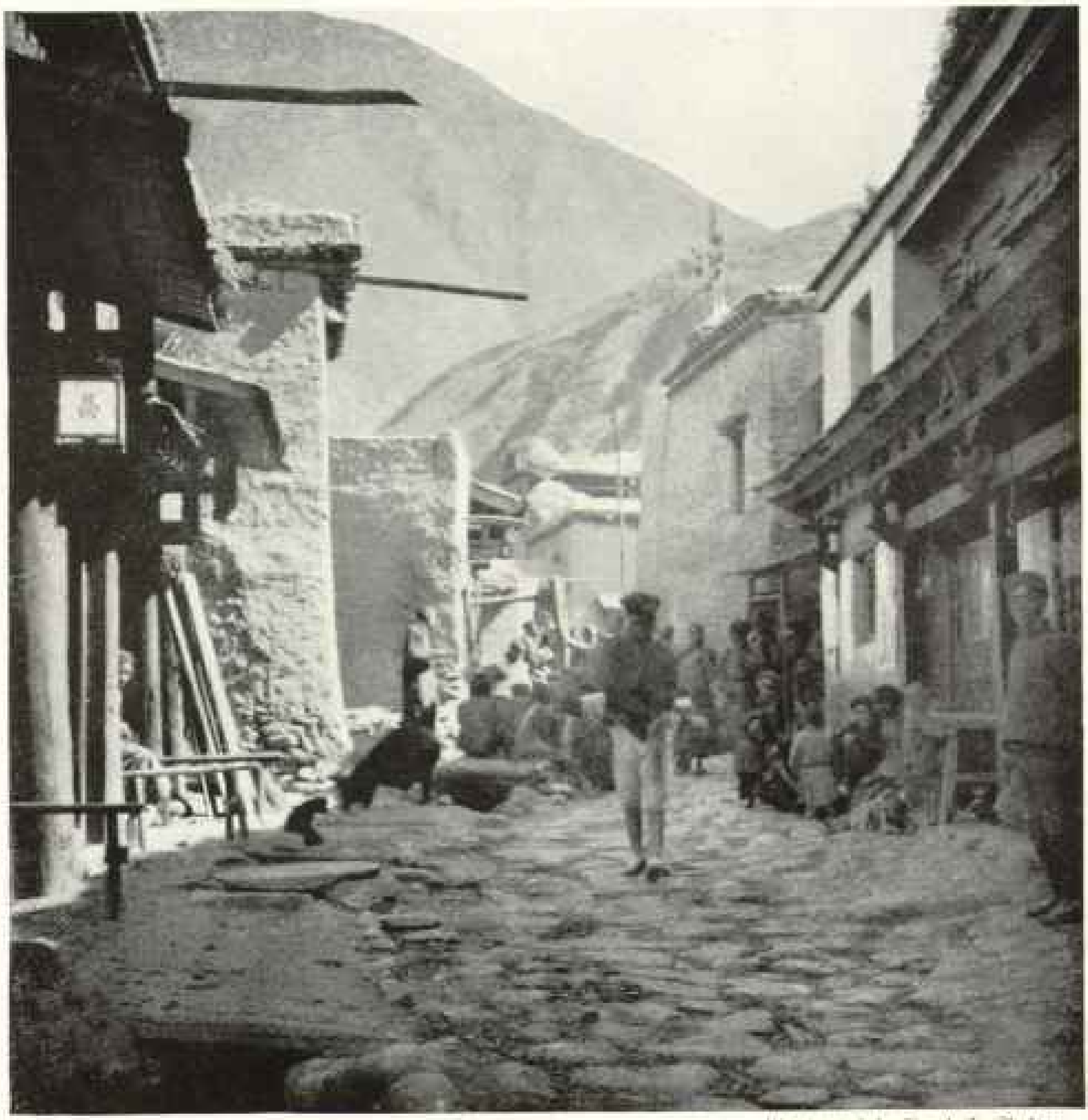
BIRD'S-EYE VIEW OF BATANG SURROUNDED BY TERRACED FIELDS

The white buildings on the hill are the hospital and residence of the American mission. Note the head of the horse in the foreground; the photograph was taken from the vantage point of its back.

the lay officials of the government. The next lower step in social gradation leads to the headmen of the villages, usually the wealthiest residents of the localities. Next in order are the wealthy villagers not headmen, and below these come the ordinary folk. At the bottom of the social ladder are the servants and slaves of the well-to-do.

PRAYER-WHEELS OPERATED BY WATER

In education the Tibetans are very backward, there being nothing in the country in the nature of public instruction. A few of the more wealthy families hire a priest to come into their homes to teach their sons. The "education" which these favored ones obtain, however, is usually of very little value to them, for a great many of the priests are not able to read or write, but have simply learned to say from memory long strings of prayers or the inevitable "Om-mani-padme-hum," the repetition of which is supposed to insure the laying up of great merit.



Photograph by Dr. A. L. Shelton

A STREET SCENE IN BATANG

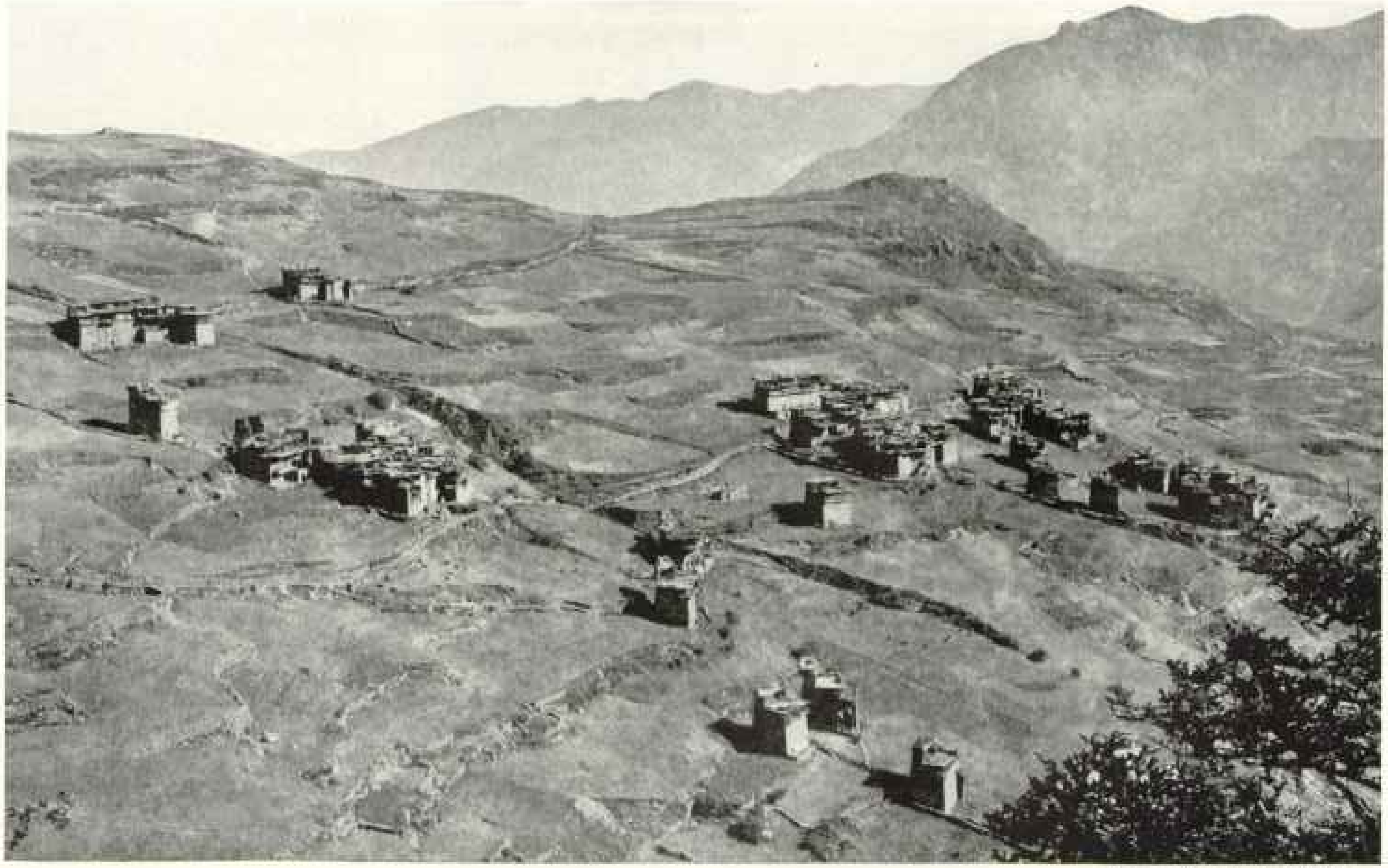
Batang, or Paanhsien, derives most of its importance from the Tibetan trade route, which passes through it on its way from Yachow to Chiaundo, connecting the Yangtze Valley with the highlands of Tibet (see map, page 296).

This sacred combination of sounds—a sort of religious abracadabra—is a thing on which the Tibetans and other votaries of lamaism rely for comfort in this life and for assurance of happiness after death, or to prevent their being reborn in a lower scale of life. It is said thousands of times a day by the faithful, as they go about their work. Often it is counted off on strings of beads.

The Tibetan Buddhists believe also that there is merit in "repeating" this magical formula mechanically. Accordingly it is written on yards and yards of paper which are placed in prayer-wheels. In most cases these wheels are twirled by the hands of the worshipers, but so confident are they of the efficacy of mechanical prayer that they construct what might be termed power prayer-wheels operated by water.

The very winds are harnessed to pray for the Tibetans, for the mystic phrase is written upon thousands of flags, which are strung upon poles and ropes. Windmills connected to prayer-wheels carry the mechanical prayer still farther.

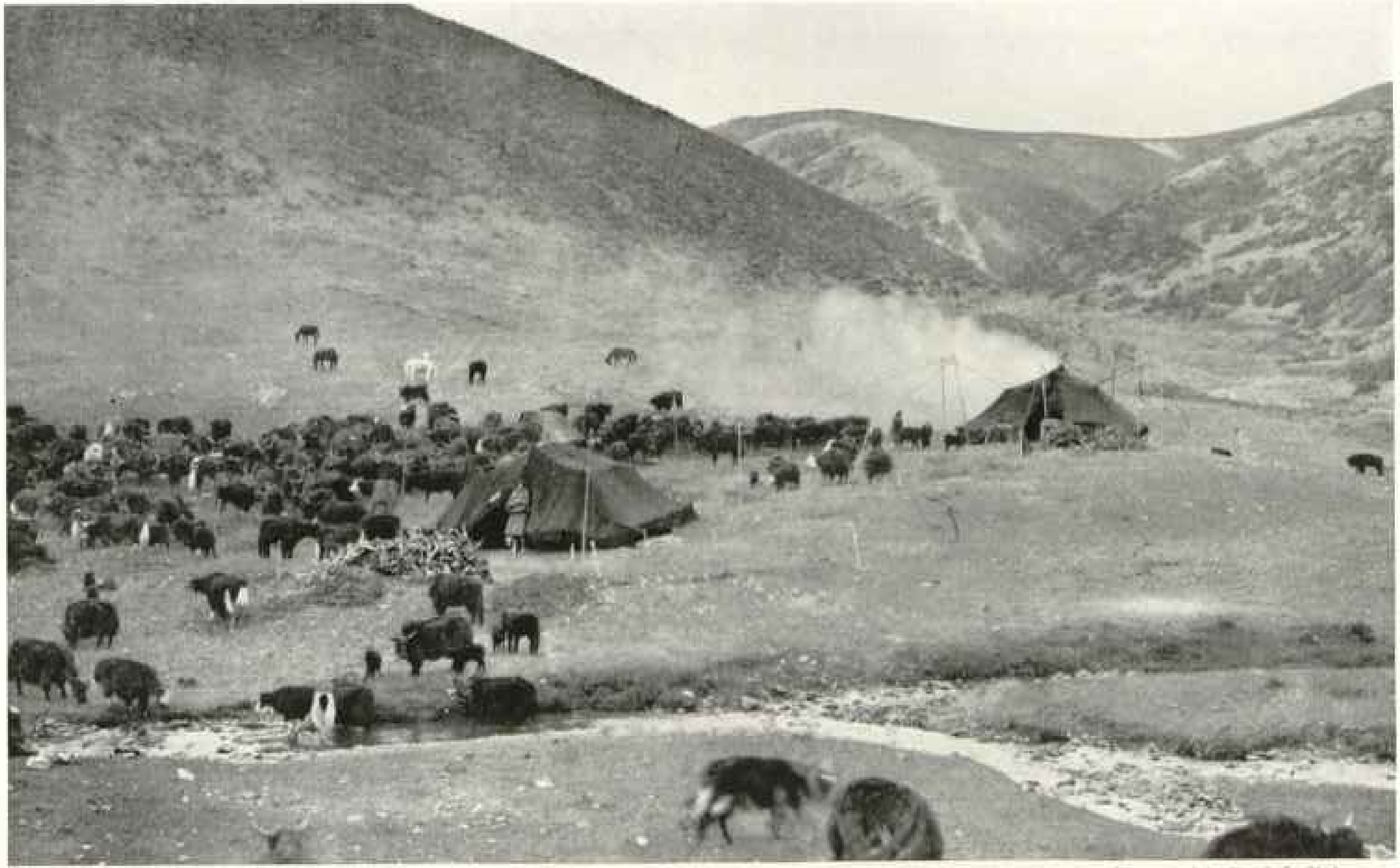
The sacred words are even carved on



Photograph by Dr. A. L. Shelton

A TYPICAL TIBETAN VILLAGE, SHOWING THE PECULIAR DISTRIBUTION OF THE HOUSES IN GROUPS UPON THE HILLSIDE

For a description of the Tibetan dwellings, see illustrations on pages 306 and 307 and text, page 299.



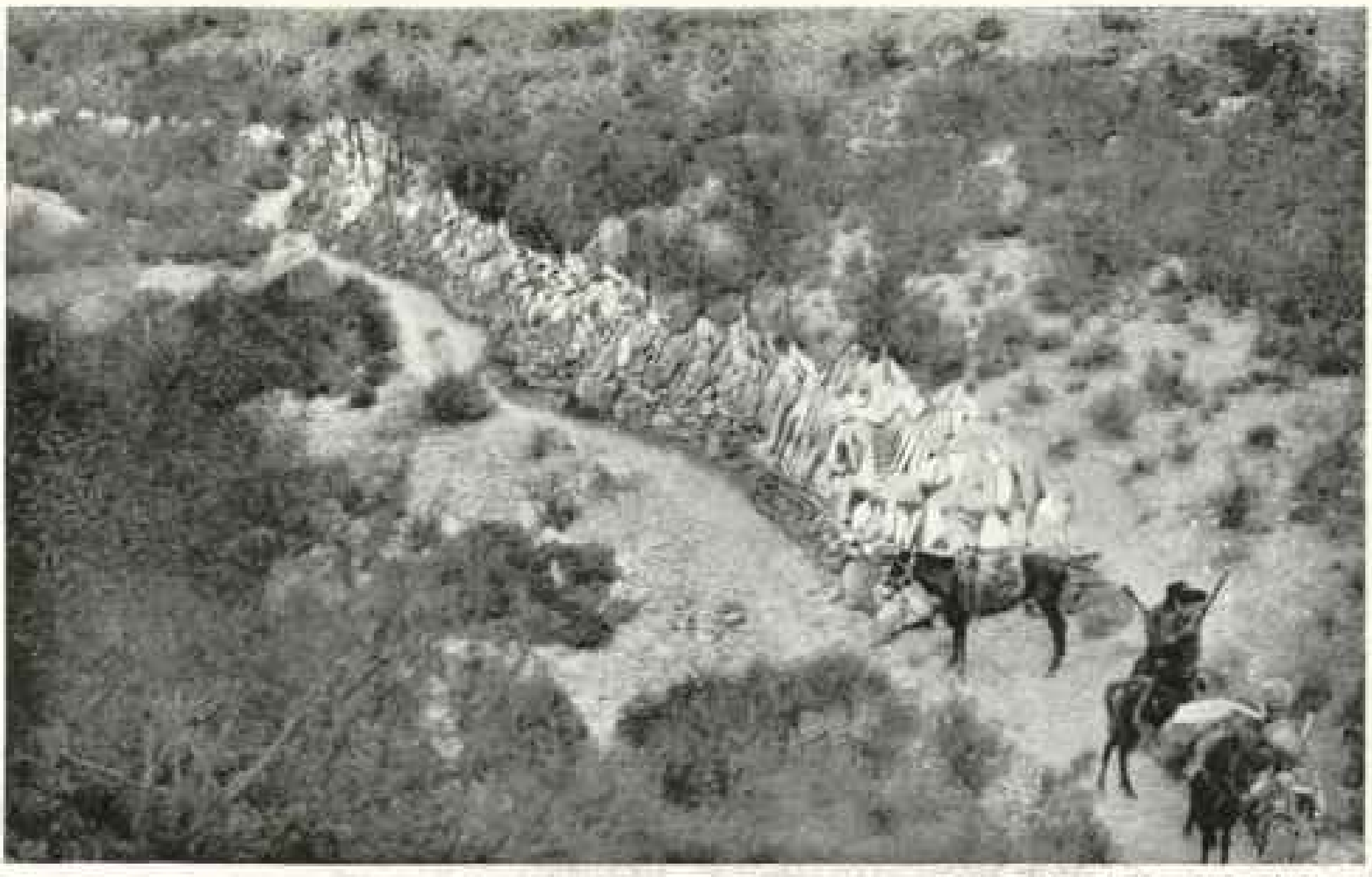
Photograph by Dr. A. L. Shelton

A CAMP OF NOMADS IN THE TIBETAN HIGHLANDS

These nomads change their camps from the valleys to the mountain heights according to the season of the year. In the spring they follow the new grass as it appears below the ever-receding snow-line. In the fall, as the snow-line descends again, they keep just below it with their herds of yak, until in midwinter they are in the lowest valleys (see page 298).

PRAYER-FLAGS SET UP NEAR THE GRAVE OF A PROMINENT TIBETAN

As the tinkling temple bells of Mandalay direct one's thoughts to unseen forces, so the Tibetan prayer-flags flutter in the wind, which bloweth where it listeth and is seldom still (see page 309).



Photographs by Dr. A. L. Shelton

WHERE PRAYERS ENCOMPASS THE EARTH

In Tibet, the land of mechanical prayer, the winds and waters are utilized in seeking the favor of gods and devils. Huge piles of stones, each inscribed with a prayer, parallel the trails and dot the landscape (see text, pages 309 and 312).

stones, which are placed in great piles along the roads. Some of these piles are many feet high and represent years of labor spent by priests in carving and placing them. In no place in Tibet can the eye or ear escape the omnipresent "Om-mani-padme-hum."

HUNTING THE MUSK DEER IS A DYING INDUSTRY

The country folk of Tibet, as the villagers and nomads may be called in distinction from the thousands of residents of the lamaseries and the few traders of the larger towns, engage in a number of minor industries in addition to tilling the soil and tending their herds and flocks.

In the past a considerable number of Tibetans have hunted musk deer, collecting the musk for export. Owing to the rapid decrease in the number of animals, however, the exports have fallen off markedly and the industry may be said to be a dying one.

Photograph by Dr. A. L. Shelton

SACRED MANI FILES OF CARVED STONES: TIBET

On these stones are carved the magic formula, "Om-mani-padme-hum." The Tibetans are unable to explain the meaning of this phrase, but the most generally accepted translation is "Oh, Jewel in the Lotus!" which has been analyzed as indicating an expression of reverence for the Dalai Lama. The lotus flower is symbolic of heaven, of heavenly birth (see text, page 309).

The methods employed have been largely responsible for the dwindling importance of the industry. The deer have been hunted ordinarily not with guns, but by means of snares set in the paths which they frequent. They are caught by the feet and swung completely off the ground. Although the musk is obtained only from the males, the snares, of course, catch both males and females.

Wonderful and awe-inspiring concoctions of Chinese medicine contribute much to the industries of the Tibetans. The collection of deer horns "in the velvet" is a case in point. Large numbers of deer are killed each June and July, primarily for the horns, which are then in the proper stage of growth. The horns are sold to the Chinese, by whom they are prized as one of the best tonic ingredients in all their pharmacopoeia.

In the spring and summer months the Tibetans also dig plants and collect fungi and other articles of supposed medicinal value for export to the Chinese market.

One of these ingredients very highly prized by the Chinese is the grass worm. When dug it looks like a small plant a part of which is a worm. In reality it is

Photograph by Dr. A. L. Shelton

ONE OF THE LARGE MANI PILES NEAR BATANG CONTAINING COUNTLESS STONES ON EACH OF WHICH IS CARVED A MAGICAL PRAYER FORMULA

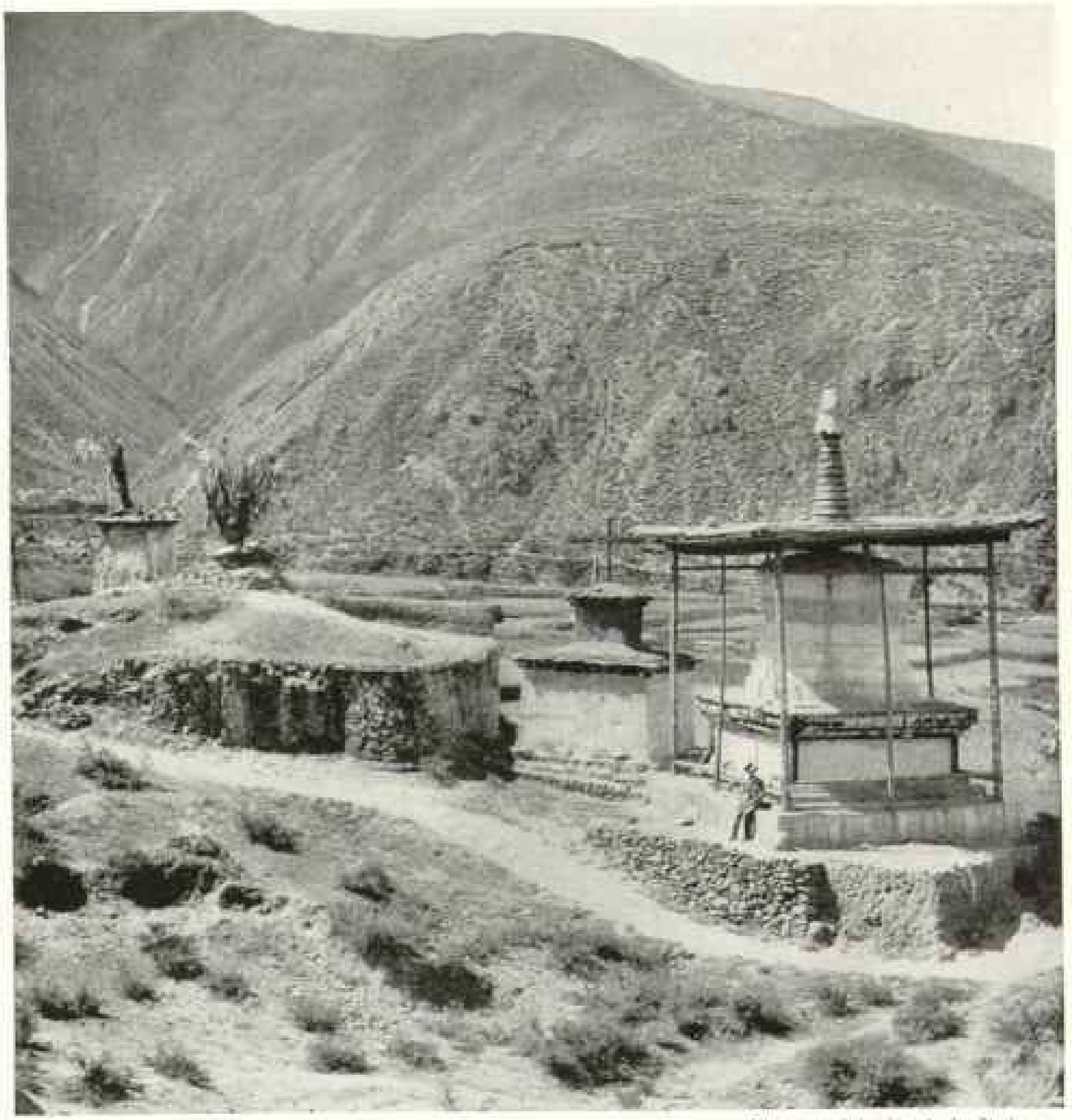
the remains of a grub which has been attacked by a fungus. The grub is killed by the fungus, the root of the latter, which is in the grub, absorbing its body. Only the outer husk is left in the semblance of the original grub. This seeming combination of animal and vegetable life is not only used as a medicine, but is also eaten as a delicacy.

METAL WORK AMONG THE TIBETANS

Some mining is carried on by the Tibetans of the eastern border region, but the industry is of small proportions. The products mined include lead, gold, and iron. Iron is used for swords, some of the most elaborately ornamented commanding a high price.

The Tibetans love to embellish their scabbards with silver, coral, and turquoise, and some of them are fine examples of workmanship. Iron is also used in the manufacture of crude guns, or was until within the last few years, when it became possible to obtain firearms of Western manufacture.

In Chiamdo, principal town of Kham, Tibetan workers in iron make of that



Photograph by Dr. A. L. Shelton

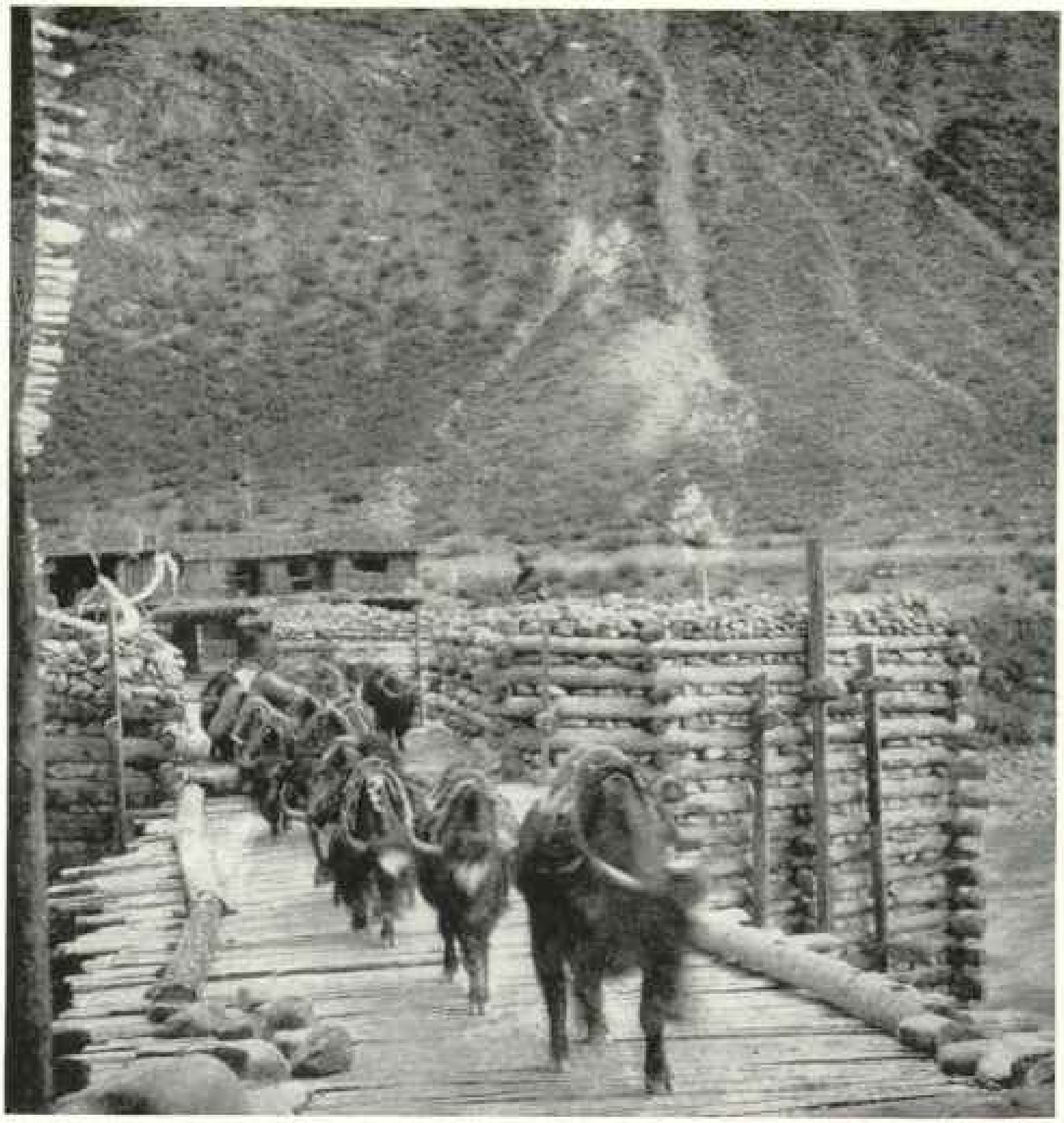
AN ELABORATE CHORTEN (SHRINE) NEAR BATANG

Chortens are a common sight in Tibet and the surrounding lands. In Peking there are large Lama towers similar to these shrines, which are built solid, though they may contain valued relics.

metal large wine flasks, which are much sought after throughout Tibet. I spent some time in Chiamdo in 1918 caring for the wounded, after the fighting in the border country between Chinese and Tibetans, and became well acquainted with the Galon Lama, stationed there. He is one of three Galons, literally "receivers of commands," who rank immediately below the Dalai Lama. This Galon was commander-in-chief of the Tibetan army, and while serving in that capacity had given up his ecclesiastical functions.

When I left the city he presented me with two of the famous hammered-iron objects of Tibetan handicraft, into which had been pounded figures in gold and silver. They are crude but very beautiful.

In some of the lamaseries of Tibet the monks make and gild idols for sale all over the country. The Gartok lamasery near Batang turns out thousands of the images. With their crude facilities, the monks are unable to gild the idols as it would be done by a modern Western



Photograph by Dr. A. L. Shelton

YAK CROSSING THE MEKONG RIVER ON THE BRIDGE AT CHIAMDO

Throughout the whole region of western China and eastern Tibet, bridges are few and primitive, the suspension type, ranging all the way from single ropes to heavy structures, being most popular (see illustration, page 302).

process, but must apply a rather heavy coat of pure gold. Because of this, the prices are high.

THE BUDDHIST BIBLE IS A 108-VOLUME WORK

At Litang, about a hundred miles to the east of Batang, where there is a large lamasery, and in the lamasery of Derge, about 200 miles above Batang, in the Yangtze Valley, the printing of religious books is an industry of importance.

The Kanjur, which is the Buddhist Bible, and the Tanjur, its commentary, each comprising 108 volumes, are printed at the two lamaseries from blocks on which characters are carved. The blocks occupy many large rooms and the printing of one set requires the work of many men for many days.

In Litang, until recently, there was a copy of the Tanjur which was written out by hand in gold and silver. The paper had first been lacquered with Chinese ink.

Photograph by Dr. A. L. Shelton

A YAK CARAVAN WAITING TO BE LOADED

The Tibetan yak is not only a reliable beast of burden and a provider of good beef, milk, and butter, but also furnishes a fine, silky hair which is woven into fabrics. The yak tail is used as a ceremonial fly-switch and is often represented in Indian sculptures.

The gold and silver fluids in which the characters were written were made by rubbing the precious metals on a rough stone and mixing the powder with glue water. It was one of the most perfect pieces of work I have ever seen. It was destroyed a few years ago by Chinese soldiers who understood nothing of its value.

As in most of the world's border lands at times, brigandage is rife in Kham, especially among the nomads. Bandits prey both upon other Tibetans and upon the caravans that pass between China and Tibet, and all travelers go armed.

WHERE FEUDS RAGE

Until a few years ago, the most formidable weapons employed in this part of the world were the old firelocks of local manufacture. More recently, however, many modern firearms have been introduced, with the result that the depredations of the outlaws are now much more serious.

Rough and but partly civilized as these people of eastern Tibet are, it is natural that their conceptions of personal and family honor should lead to the blood feuds that rage among folk of similar development throughout the world. A few years ago I had a particularly dramatic introduction to their custom of "hulen," as they call their feuds.

I was on a mountain road about five days journey to the south of Batang and, with my traveling companions, was approaching a village early one morning. Before we came in sight of the dwellings we saw a large column of smoke rising. Hastening down the mountain side and through some woods, we found that the house of the headman was in ruins and was a mass of flames.

Soon we came upon a dead man lying in the road. Farther on was the body of a child, which had been run through with a bayonet. We came upon body after body of men and women—twelve in all.

The story of the devastation, which the excited survivors of the village finally told us, was this: Six or eight years before, the murdered headman had been a

Photograph by Dr. A. L. Shelton

UNTIL RECENTLY, BOWS AND ARROWS WERE IN USE AS WEAPONS IN TIBET, BUT THEY HAVE BEEN SUPPLANTED BY FIREARMS

The Tibetans of the Province of Kham spend most of their time out of doors and are a sturdy people. Games are uncommon, but there are many tests of strength, skill, and marksmanship.

leader in a party which, by command of some Chinese official, had exterminated another family. Twelve people had been killed. However, the party had not done its work with complete thoroughness, for one boy of about fifteen years of age had escaped.

This boy had fled to inner Tibet, had spent the intervening years nursing his grudge, and the night before, in company with some twenty or thirty friends, he had come to the village and had succeeded in killing twelve members of the headman's family.

By a strange coincidence, one boy of about fourteen years, belonging to the headman's family, had escaped by hiding in the ruined house. I afterward became well acquainted with this young man and found that he was living for just one thing—revenge.

IMPLACABLE ENEMIES, FAITHFUL FRIENDS

In Batang I know little boys who will undoubtedly be future victims of halen. They are playing together as they grow up, but in the course of time, unless they are willing to be disgraced in the eyes of their friends, they must become sworn enemies and attempt to destroy each other because of events in the past history of their families.

Although these people are implacable in their hatreds, they are no less faithful to their friends. Two years ago, during the time when I was acting as mediator between the Chinese and the Tibetans and attempting to arrange an armistice while the fighting was going on, I spent some two months in Gartok, Tibet, as the guest of the Tibetan governor; also there at the same time was Lozong, the head of a band of brigands, who had come to ask the governor to permit him and his followers to take Batang for him.

During our stay, Lozong and I became quite good friends, often visiting each other. One day he proposed to me that we should be brothers. According to this custom among the people of Kham,

when two persons like each other very much they draw up an agreement declaring that they are brothers and that they will help and stand by each other through all things.

BECOMING A "BROTHER" OF A TIBETAN

When Lozong made the proposal I told him that I could not accept it.

"Why not?" said he, "we are friends."

"Yes," I replied, "I know we are good friends, but you occasionally kill people, and you rob, and you drink whiskey, and I cannot do these things."

He did not like that at all. He went away, but two or three days later he came back again.

"Well," he said, "if your religion will not allow you to become brother with me, since you say you came here to help people and not to kill them, what will your religion allow you to do?"

I told him something of our purpose and of our faith and he went away again. Two or three days later he came back, all smiles.

"I've got things all fixed up now," he said. "We can be brothers all right. I went up to the high priest this morning and took an oath that I will not kill anybody, that I will not rob, and that I will not drink whiskey."

I assured him that I was greatly pleased.

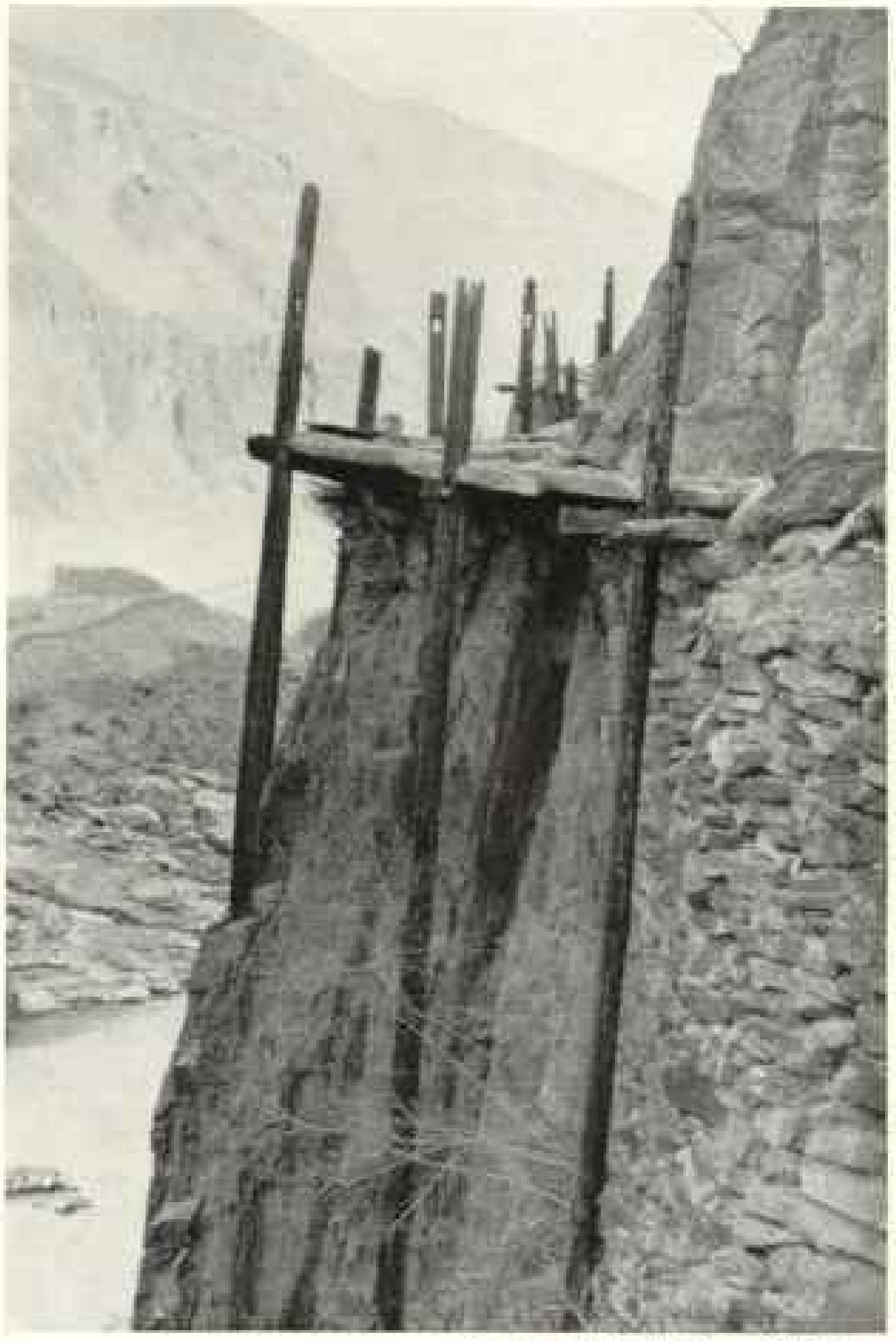
"Then," he said, as he reached inside his gown and pulled out a paper, "how is this?"

He had it all written out and proceeded to read the paper to me. It ran somewhat in this fashion:

"In view of the fact that General Lozong (he called himself General) and Doctor Shelton have both taken an oath that they will not kill anybody, they will not rob any one, they will not drink whiskey, they have decided to be brothers."

He enumerated several other conditions, and in closing said: "And, furthermore, this is to give notice to any one that if you ever molest Doctor Shelton in any way I will bring a thousand men and wipe you off the face of the earth."

This paper is a pretty good passport in some parts of the country. And there



Photograph by Dr. A. L. Shelton

WHERE A FALSE STEP MEANS DEATH: ALONG THE MEKONG RIVER

Safety apparently is not an important factor in the calculations of the Tibetan highway engineer, but he is not lacking in daring, a trait which he assumes the traveler as well as the road-builder to possess. These roads are never repaired until they break down completely.

Photographs by Dr. A. L. Shelton

MEN AND WOMEN THRESHING WITH FLAILS ON THE ROOF OF A BATANG HOME

Threshing methods are primitive throughout the East; but, with primitive transportation methods and small fields, a modern threshing-machine would be useless (see text, page 329).

is a sequel to this experience. A year and a half later, just before I left Batang, I received a letter from Lozong from about two hundred miles to the south, in which, after asking about my health and that of my family, he said:

"This is to inform you that I have rigidly kept my oath of a year and a half ago."

That some conception of Western ideals is not beyond the people of Tibet was indicated on another occasion by one of their leaders, the Galon Lama of Chiamdo. During my stay in Chiamdo I had many talks with the lamaist prelate about religion, politics, and many other topics of interest. Mostly, though, we discussed religion.

We found that there was not a great deal of difference in some of the commands of our two religions, but naturally there were many things that we could not agree upon. On parting from him, however, I made him a proposition which I was delighted to have him accept.

"There are some things on which we cannot agree," I said, "but I want to propose this to you and see if we cannot agree to it: That from this day forth you and I will work together for the good of our brother men."

"I can accept that," he replied, "with my whole heart."

CAPTURED BY BANDITS

As a demonstration of his interest in philanthropy, the Markham Tigi, Governor of Lower Kham, assisted me in forwarding to the Dalai Lama at Lhasa a letter asking for permission to establish in the Forbidden City a hospital in which young Tibetans could be trained for medical work.

The Tibetan ruler sent a favorable reply, stating that, so far as he was concerned, he would be very glad to have the work undertaken in Lhasa, provided there were no foreign treaties to prevent.

It was my intention to establish the hospital without delay, but during a preliminary journey to the coast of China I was captured by Chinese bandits and received injuries which necessitated a trip to America. The establishment of a hos-

A CAULDRON WHICH HAS BEEN USED BY THE CHINESE FOR COOKING TIBETANS

Lovers of peace, haters of war and militarism, the Chinese are capable of extraordinary barbarities, which seem as natural to them as holding a chisel with their toes.

Photographs by Dr. A. L. Shelton

VARYING PENALTIES FOR LARCENY IN TIBET

One hand and one foot of the culprit at the right have been cut off, while the lesser offender, at the left, has been deprived of a hand only. Sometimes both hands are amputated.

Photograph by Dr. A. L. Shelton

A TIBETAN CEREMONIAL ALTAR ON WHICH DEAD BODIES ARE LAID PREPARATORY TO BEING DISMEMBERED AND FED TO VULTURES

The two men shown in the illustration are only posing to show how the bodies of natives are ordinarily placed.

pital in Lhasa has been delayed, but it is my intention to carry the project through eventually.

The Tibetans have been making great strides in the last few years, especially since the Younghusband Expedition in 1904 and 1905. Far from making them antagonistic to Westerners, this contact with the outer world has done more to break down prejudice and to give them a thirst for knowledge than all previous events in their circumscribed kingdom.

The treatment accorded the prisoners and populace by that expedition have become renowned all over Tibet. I met one of the captains who was wounded at Gyantse. He said to me in apparent astonishment:

"Do you know that after I had been wounded I expected that they would kill me, but when they got me they didn't kill me at all. They took me and put me to bed and put medicine on my wound. They fed me and took care of me, and at last, when I got well, they not only let me go, but gave me a little money to get home with."

This man swears by the English.

During my stay in Chiamdo I met one man who had been in several of the capitals of Europe. The captain who was deputized to attend me had a son in London studying. Several officials had sons or relatives in India in the schools.

The fact that thirst for a knowledge of the world is making itself felt in Tibet argues well for the future of its virile, though socially undeveloped, people.

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AT AN expense of over $90,000 The Society sent a notable series of expeditions into Peru to investigate the traces of the Inca race. Their discoveries form a large share of our knowledge of a civilization which was waning when Pizarro first set foot in Peru.

THE Society also had the honor of subscribing a substantial sum to the historic expedition of Admiral Peary, who discovered the North Pole.

NOT long ago The Society granted $25,000, and in addition $75,000 was given by individual members through The Society to the Federal Government when the congressional appropriation for the purchase was insufficient, and the finest of the giant sequoia trees of California were thereby saved for the American people and incorporated into a National Park.

THE Society is conducting extensive explorations and excavations in Northwestern New Mexico, which was one of the most densely populated areas in North America before Columbus came, a region where prehistoric peoples lived in vast communal dwellings whose ruins are ranked second to none of ancient times in point of architecture, and whose customs, ceremonies, and name have been engulfed in an oblivion more complete than any other people who left traces comparable to theirs.

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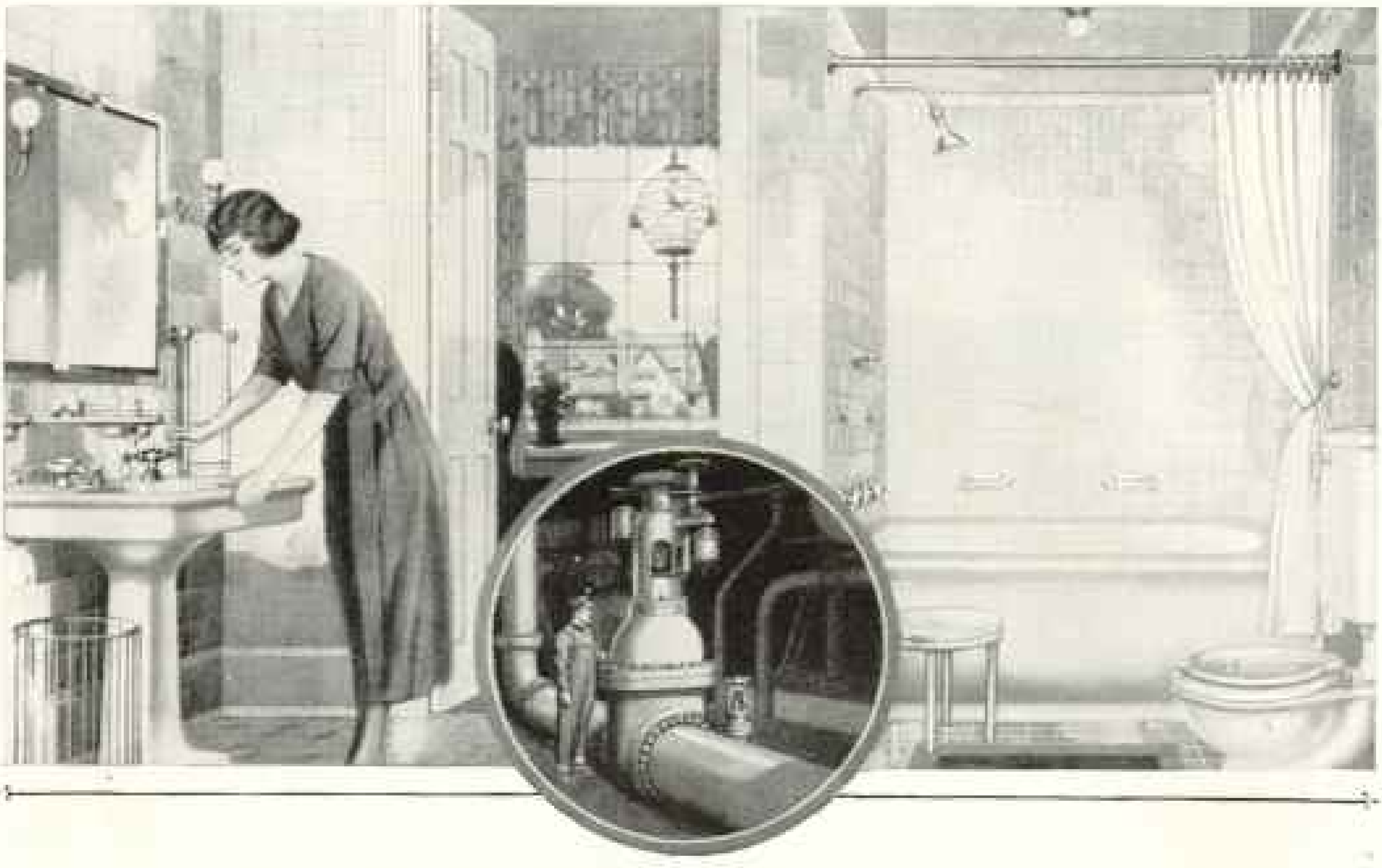

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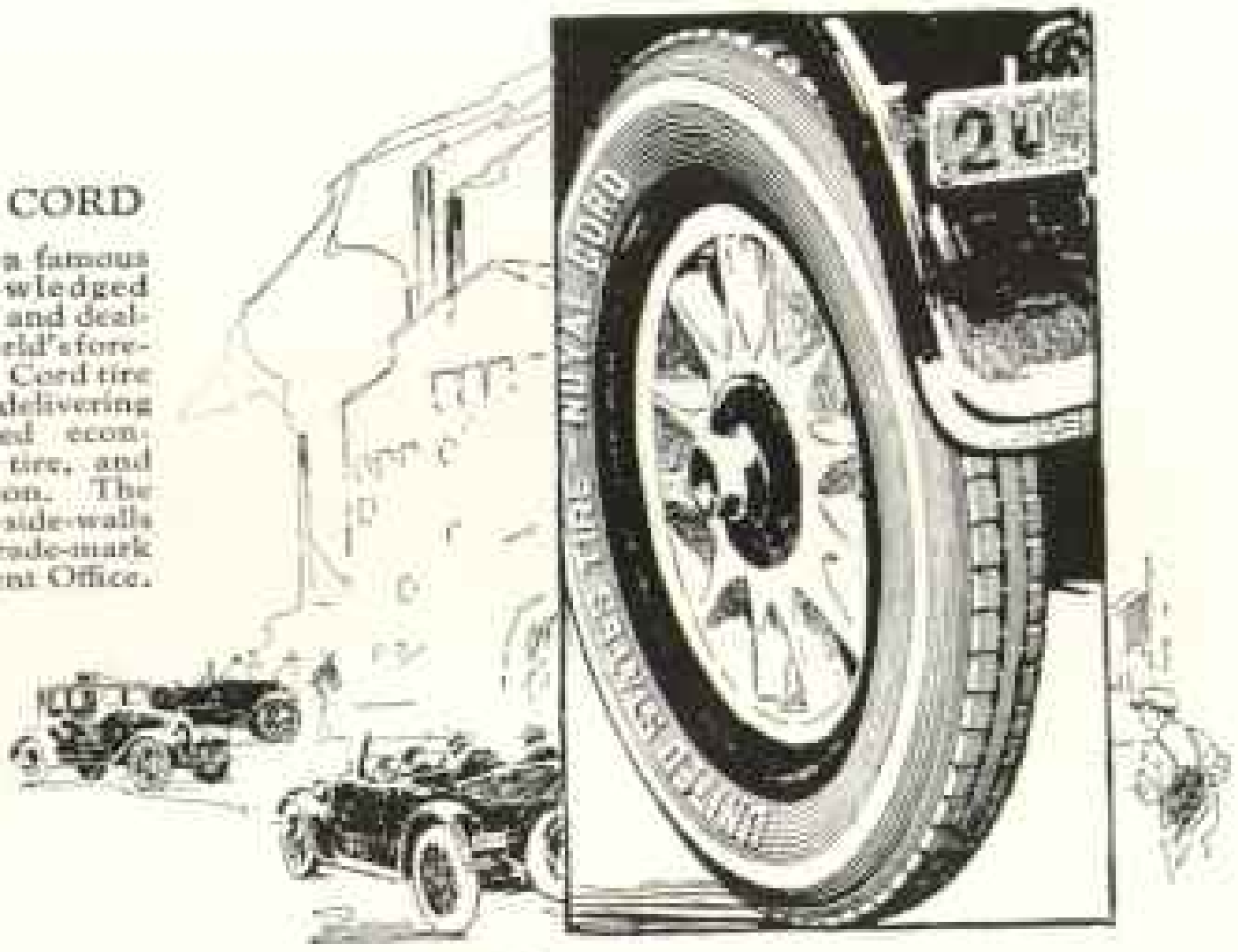

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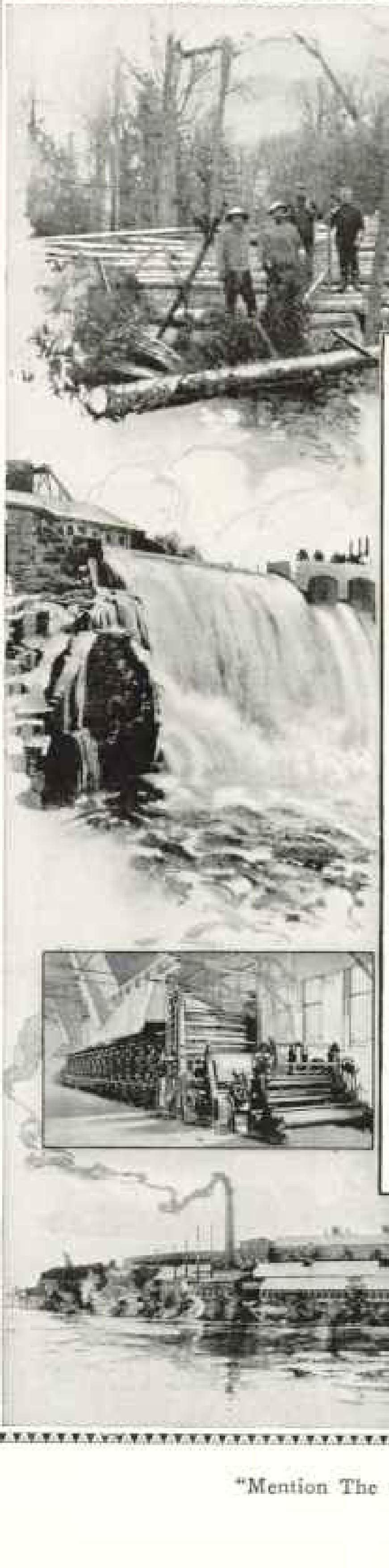

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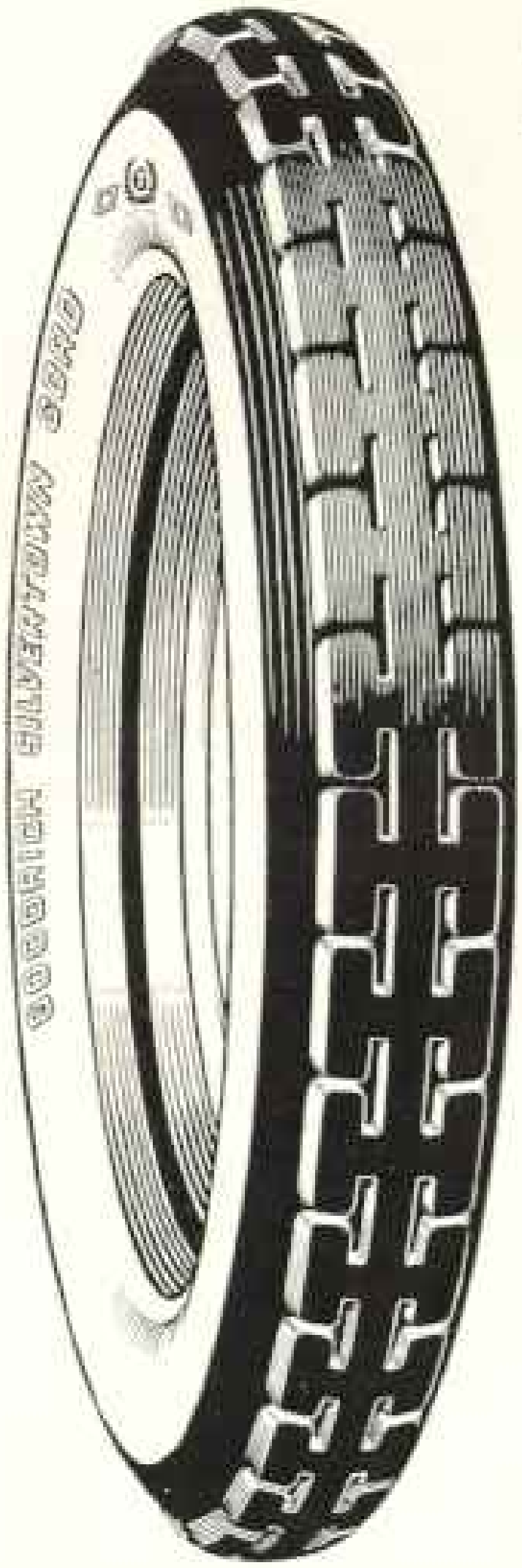

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The name of Goodrich on a tire means just one thing—quality. And that quality is always the highest that can be produced.

Each tire is specially designed for the service it must deliver. Goodrich Fabrics, in the popular sizes, have established themselves as unusual values from the standpoint of real economy. Silvertown Cords in their class have always held first place in the esteem of motorists, not only because of their symmetrical perfection of finish, but furthermore, by reason of their long life, complete dependability and satisfactory performance.

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SIZE	Anti-Skid Safety Tread	TUBES
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32x3½	32.90	2.90
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33x5	58.90	5.55
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FABRIC TIRES

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The Goodrich price reduction which took effect May 2nd was without reservation. It included Silvertowns together with Goodrich Fabric tires and Goodrich Red and Gray inner tubes.

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That Campbell's is better and quicker
Than any the cook will provide.

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Campbell's Tomato Soup

has a delicious flavor, tempting and appetizing. Choice red-ripe tomatoes, grown from selected seed, are prepared with pure granulated sugar, creamery butter and other tasty foods. Put this delightful soup first on your market list.

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Campbells' Soups

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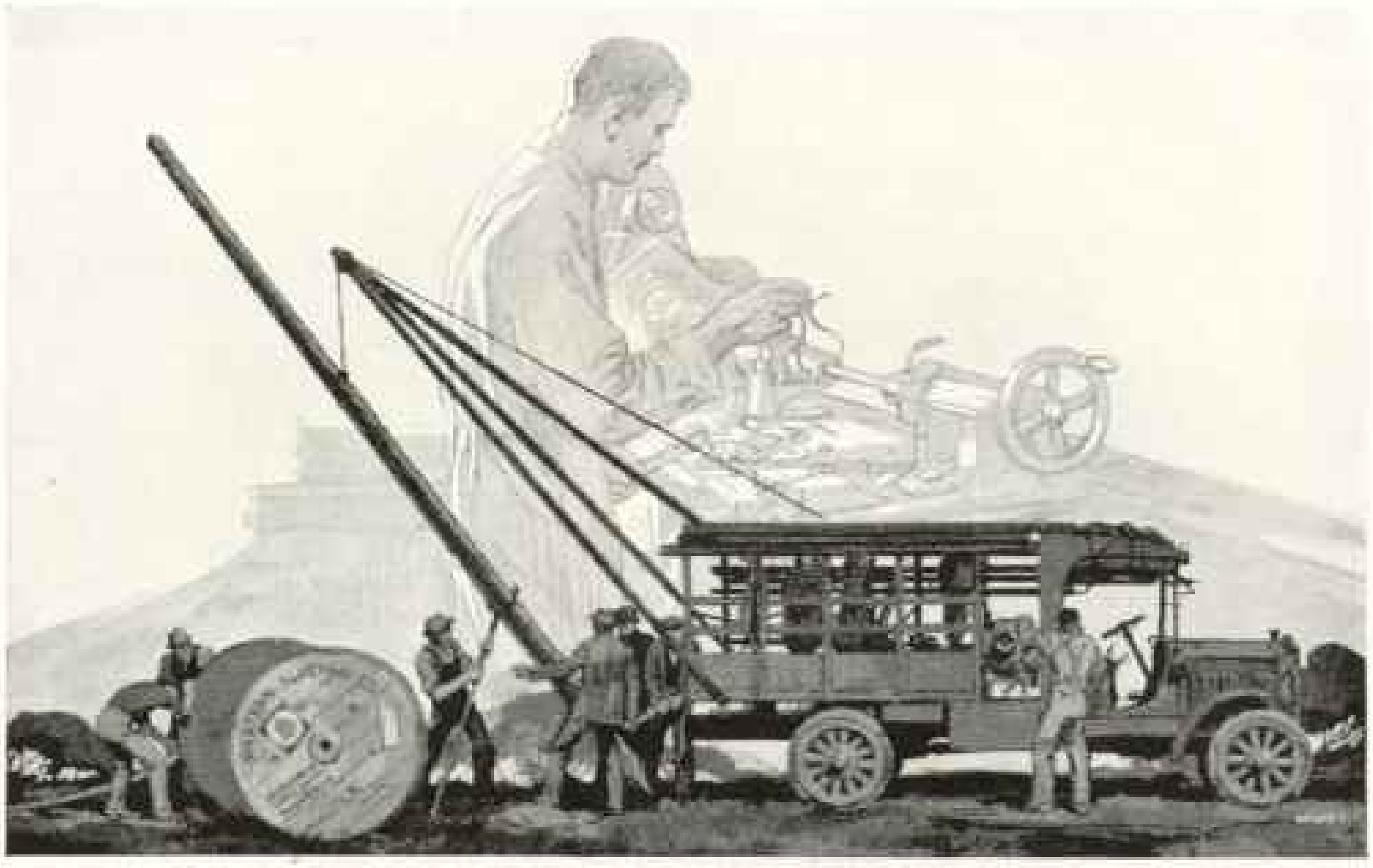

Tools of Industry

In industry, art, science, in fact in all kinds of work, good results require good implements kept in good condition.

If the right sort of implement is important to an individual workman, efficient tools for industry and commerce are a vital necessity to the nation.

Telephone service is one of the tools of American industry and commerce in most common use and upon which much depends. The American public cannot afford to let this tool get dull.

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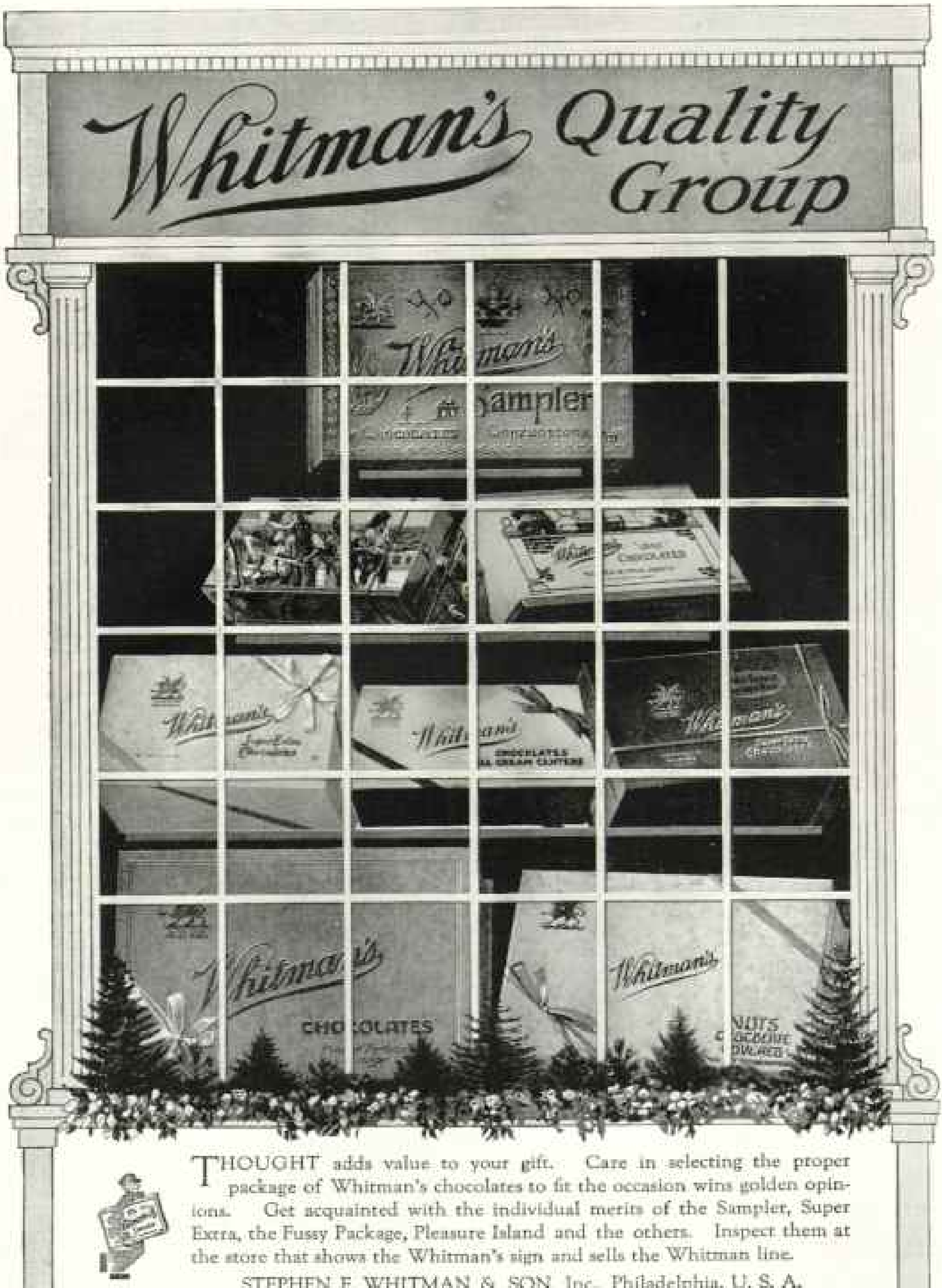
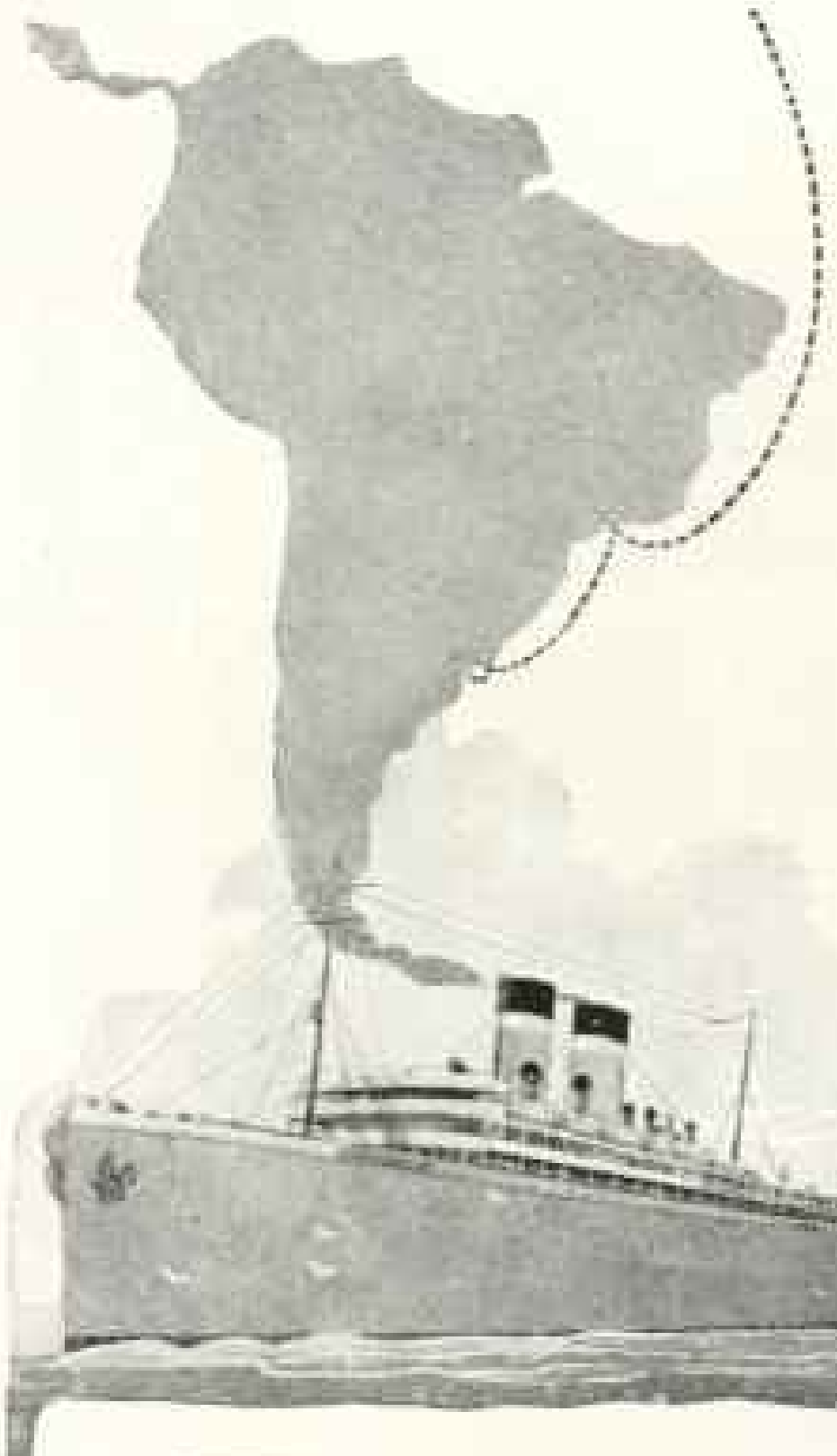


THOUGHT adds value to your gift. Care in selecting the proper package of Whitman's chocolates to fit the occasion wins golden opinions. Get acquainted with the individual merits of the Sampler, Super Extra, the Fussy Package, Pleasure Island and the others. Inspect them at the store that shows the Whitman's sign and sells the Whitman line.

STEPHEN F. WHITMAN & SON, Inc., Philadelphia, U. S. A.



SOUTH America, little known, strangely beautiful and interesting, tempts tourist and commercial man as never before.

Other countries have their attractions, but South America is a new field for pleasure and business. It affords the fresh variety travelers always seek. Added to the reputation of the Munson Line are new and splendid facilities. "American Legion" and "Southern Cross," new oil-burning steamers of the U. S. Shipping Board, have now entered the service of the Munson Fleet.

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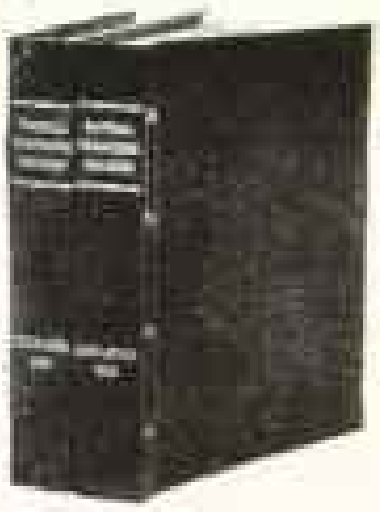

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A superior camera equipped with a superior lens.

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We make the Kodak Anastigmats in our own lens factory from our own formulae. The men who design the camera and the men who design the lens work hand in hand. Obviously, then, the lens expert does not have the generality "camera" in mind but rather a specific model, of known capabilities, in a specific size and with a specific shutter. The camera maker and the lens maker are aiming—not at a common target—but at a common bull's-eye.

The Kodak Anastigmats are at least the equal of the best anastigmats made anywhere in the whole world. They lack nothing in speed, the negatives they produce have that crisp, clean sharpness to the very corners that is characteristic of the true anastigmat.

The particular lens used on the 2C Autographic Kodak Junior is made specifically for that camera. It has a little more speed than the best of Rectilinear lenses; in the other anastigmat characteristics—sharpness and covering power—it has no superior.

The No. 2C Kodak is for pictures 2⅞ x 4⅞ inches, nearly post card size. It has the Kodak Ball Bearing shutter and, like all Kodaks, it has the autographic feature for dating and titling the film at the time of exposure.

An efficient camera of quality.

At all Kodak dealers'.

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Add This Beauty

to your features—whiter teeth

Millions of people have learned a way to whiter, cleaner, safer teeth. A ten-day test will prove it, and that test is free.

This is to urge that you try the method. Watch how your teeth improve. See what beauty whiter teeth can add.

A dingy film

Teeth become coated with a dingy film. At first it is viscous—you can feel it with your tongue. It clings to teeth, enters crevices and stays.

That film is what discolors, not the teeth. It dims the natural luster. But it also is the cause of most tooth troubles.

Film is the basis of tartar. It holds food substance which ferments and forms acid. It holds the acid in contact with the teeth to cause decay.

Millions of germs breed in it. They, with tartar, are the chief cause of pyorrhea.

Must combat it

The ordinary tooth paste does not effectively combat film. So the tooth brush has left much of it intact. As a result, the best-brushed teeth will often discolor and decay. Very few people have escaped the troubles caused by film.

Dental science has now found effective film combatants. Authorities have amply proved them. Now leading dentists everywhere advise their daily use.

The methods are embodied in a dentifrice called Pepsodent. And other factors, now considered essential, are included with them.

The five effects

Pepsodent attacks the film in two effective ways. It keeps the teeth so highly polished that film less easily adheres.

It stimulates the salivary flow—Nature's great tooth-protecting agent. It multiplies the starch digestant in the saliva, to digest starch deposits that cling. It multiplies the alkalinity of the saliva to neutralize the acids which cause tooth decay.

So every use brings five effects which authorities desire.

Watch it act

Send the coupon for a 10-Day Tube. Note how clean the teeth feel after using. Mark the absence of the viscous film. See how teeth whiten as the film-coats disappear. Watch the other good effects.

Ten days will show you how much this method means to you and yours. The facts are most important. Cut out the coupon now.

Pepsodent
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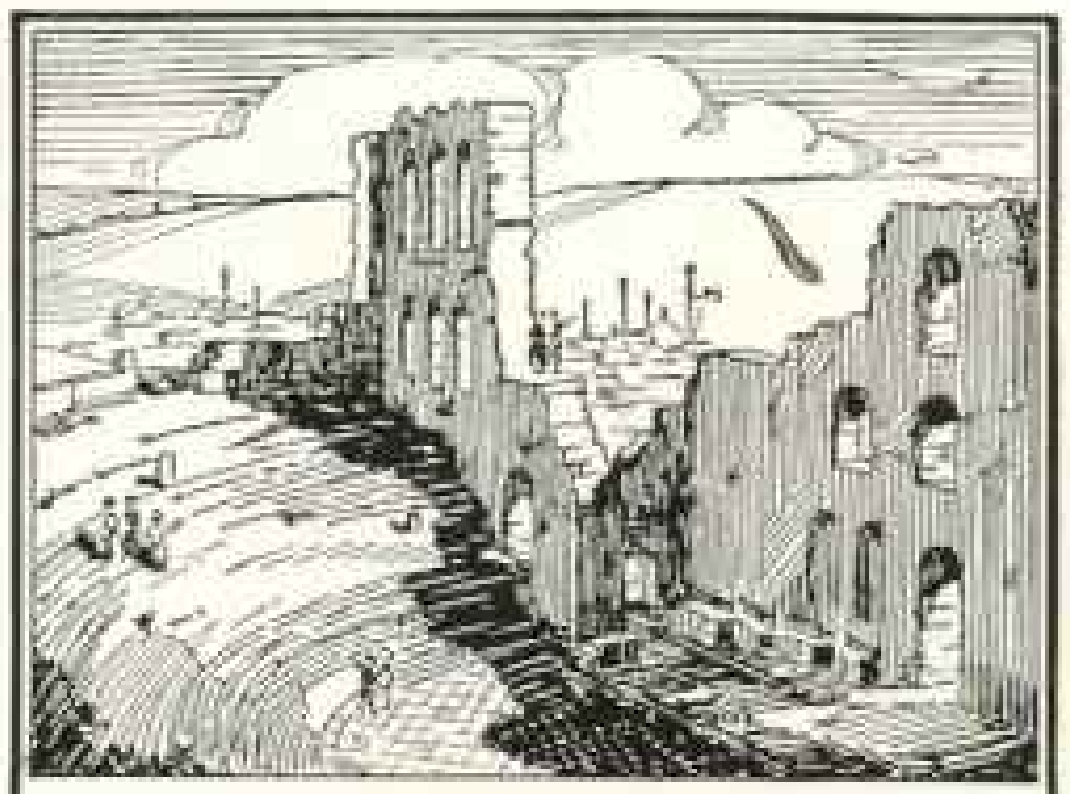
The New-Day Dentifrice

A scientific film combatant, whose every application brings five desired effects. Approved by highest authorities, and now advised by leading dentists everywhere. All druggists supply the large tubes.

10-Day Tube Free

THE PEPSODENT COMPANY,
Dept. 977, 1104 S. Wabash Ave., Chicago, Ill.:
Mail 10-Day Tube of Pepsodent to

Only one tube to a family



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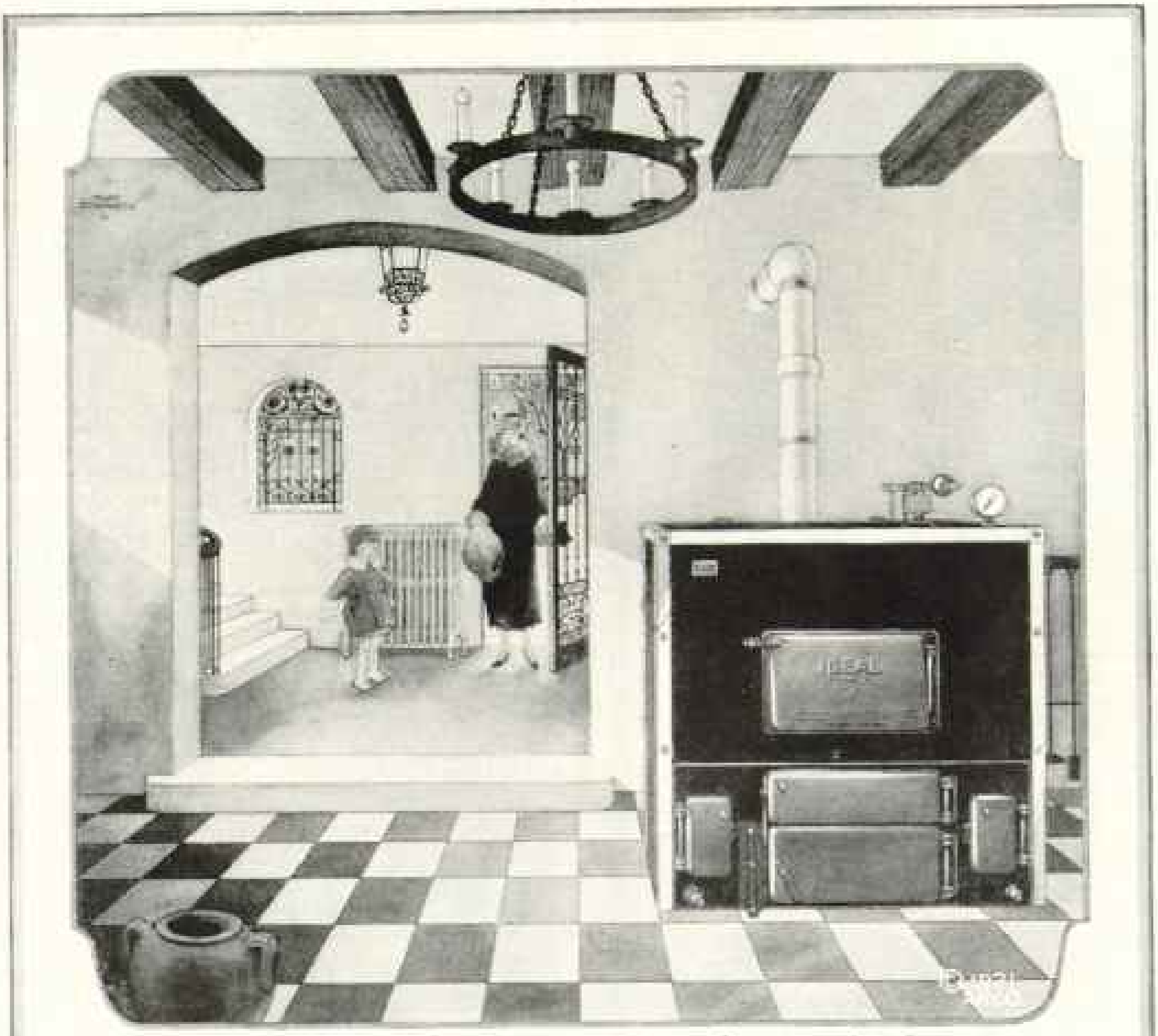
Sani-Flush

Cleans Closet Bowls Without Scouring



THERE is the same difference in appearance between the old-fashioned boiler and the IDEAL TYPE A HEAT MACHINE as between a furnaceman and a well-groomed butler. But you pay your butler; the IDEAL TYPE A pays for itself.

Too rich to care— but he *did* care just the same

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PLANT NAMED VARIETIES IN YOUR GARDEN THIS FALL

The purpose of offering **10 named varieties of Giant Darwin Tulips** to the readers of National Geographic Magazine is to acquaint them with the possibilities of planning their spring display according to a color scheme.

The following ten varieties, if planted in the order named, will give a good color scheme.

Clara Butt. Beautiful clear salmon-pink. No other variety offered by us has the same distinctive and pleasing color. Borne on stems 22 inches long.
10 bulbs, 45c.; 100 bulbs, $3.50

La Tulipe Noire (The Black Tulip). The nearest in color to the so-called "Black Tulip" of romancers' fame. Deep maroon-black, which has a velvety sheen in the sunlight. Borne on stems 25 inches long.
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Ronald Gunn. Bright shade of violet, edged pale lavender, with a conspicuous white base. A flower of splendid shape. Borne on stems 26 inches long.
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Massachusetts. A long and beautiful flower, clear carmine-rose at midrib, toning off to soft pink at edges. Borne on stems 26 inches long.
10 bulbs, 70c.; 100 bulbs, $6.00

Pride of Haarlem. Magnificently formed flower of immense size, of a brilliant deep rose, shaded scarlet, with light blue base. Sometimes attaining height of 3 feet.
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Purple Perfection. Bright glossy purple, large in size and of wonderful substance. Grows to a height of 2½ inches.
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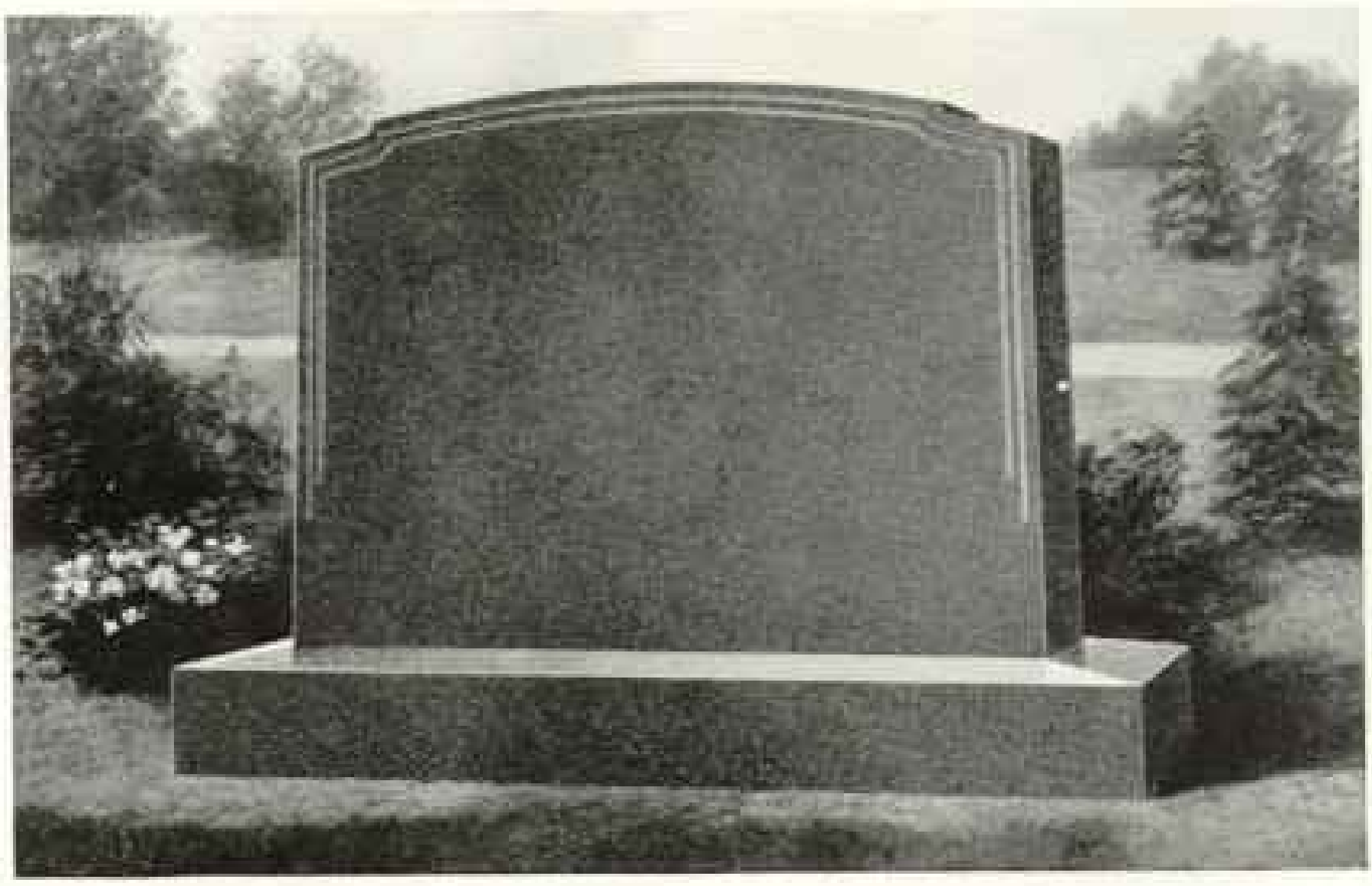

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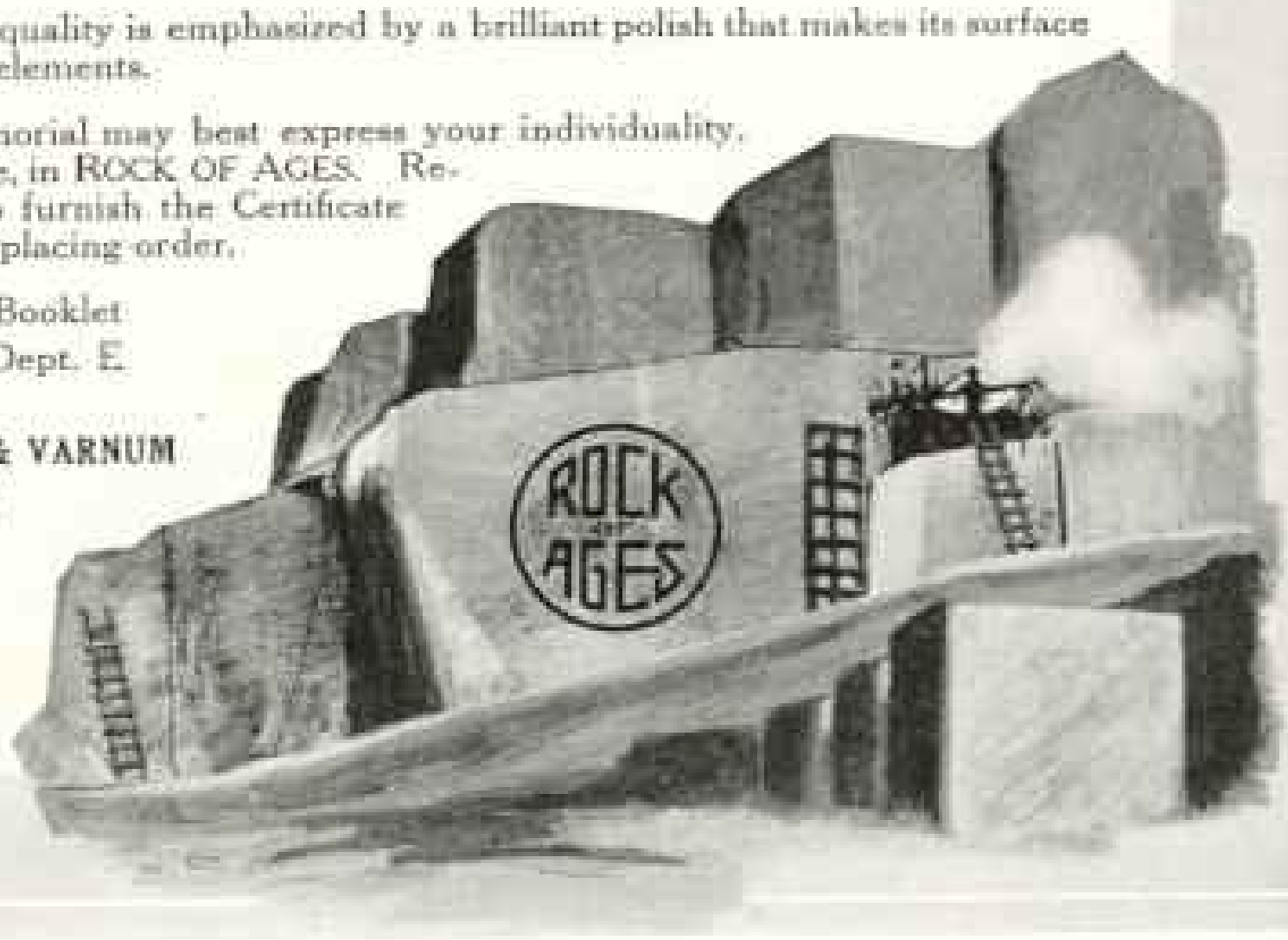

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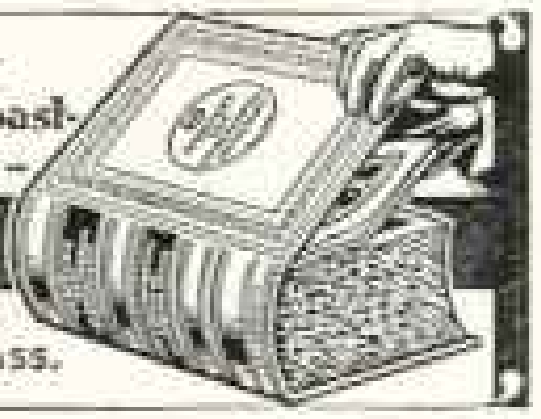

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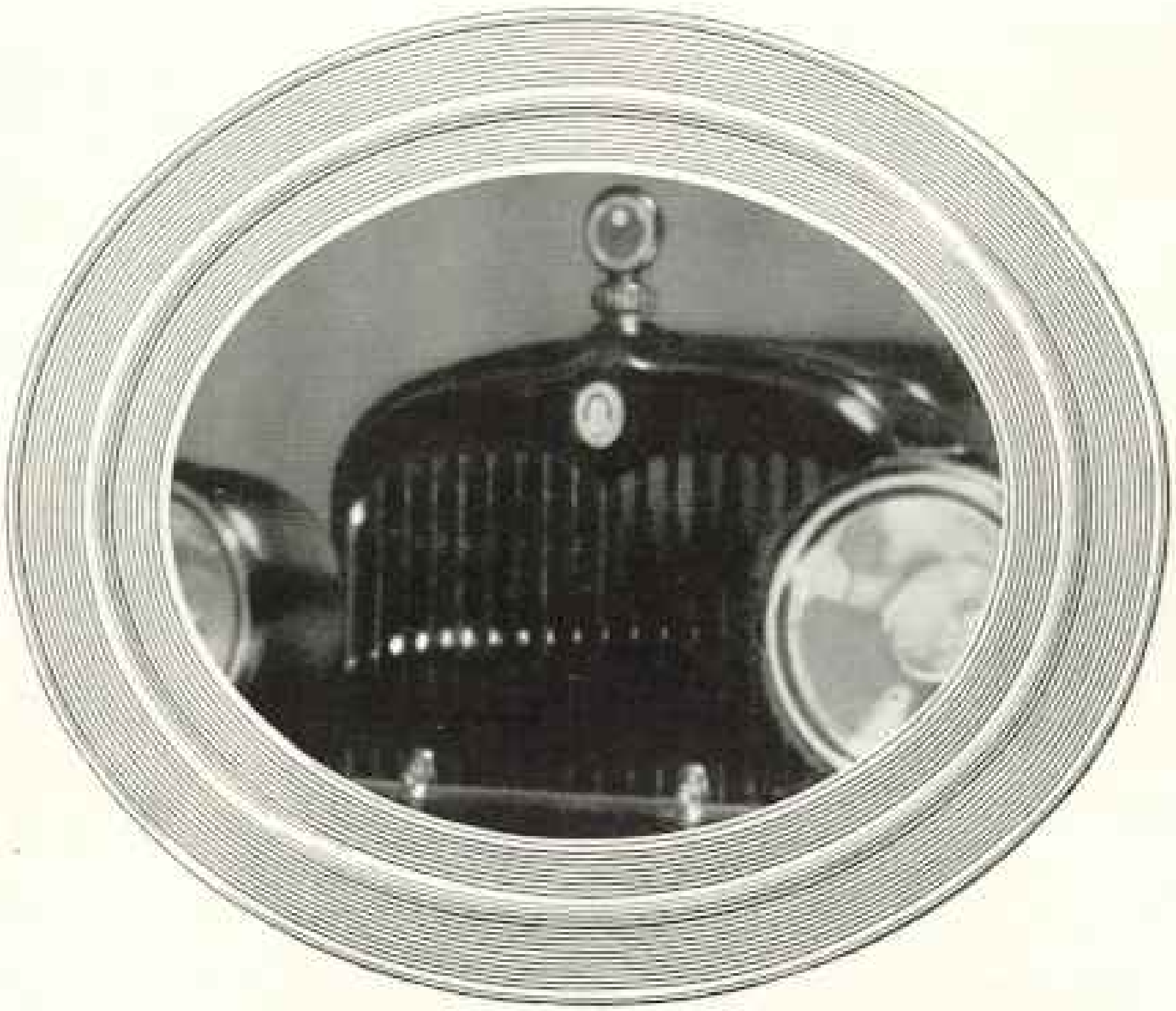

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That this belief has been fostered by owners there can be no doubt.

In every city in the land LaFayette owners are those who buy that which pleases them, regardless of the purchase price.

Their selection of our car indicates their preference for it over all others.

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