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ANIAKCHAK CRATER, ALASKA PENINSULA

BY

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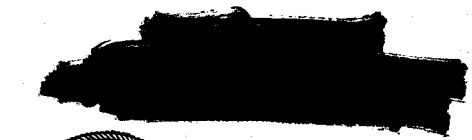
Shorter contributions to general geology, 1923-1924

(Pages 139-145)



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ILLUSTRATIONS.

ANIAKCHAK CRATER, ALASKA PENINSULA.

By WALTER R. SMITH.

The discovery of a gigantic crater northwest of Aniakchak Bay (see fig. 11) closes what had been thought to be a wide gap in the extensive series of volcanoes occurring at irregular intervals for nearly 600 miles along the axial line of the Alaska Peninsula and the Aleutian Islands. In this belt there are more active and recently active volcanoes than in all the rest of North America. Exclusive of those on the west side of Cook Inlet, which, however, belong to the same group, this belt contains at least 42 active or well-preserved volcanoes and about half as many mountains suspected or reported to be volcanoes. The locations of some of these mountains and the hot springs on the Alaska Peninsula and the Aleutian Islands are shown on a map prepared by G. A. Waring.[1] Attention has been called to these volcanoes for nearly two centuries, but a record of their activity since the discovery of Alaska is far from being complete, and an adequate description of them as a group has never been written. Owing to their recent activity or unusual scenic beauty, some of the best known of the group are Mounts Katmai, Bogoslof, and Shishaldin, but there are many other beautiful and interesting cones and craters.

Aniakchak Crater (Pls. XLI, XLII) was discovered in August, 1922,[2] by a United States Geological Survey party, in charge of R. H. Sargent, topographic engineer, in the course of a reconnaissance topographic and geologic survey of the country west of the Aleutian Mountains between Wide and Aniakchak bays. The first evidence of an ancient volcanic eruption in the district was observed 30 miles northeast of the crater, in the form of thin deposits of fine ash concentrated in small depressions on the hillsides. As the work progressed southwestward the deposits of volcanic ash became more numerous and the material coarser. Along Ray Creek, 18½ miles from the crater, pieces of scoria and fine ash had consolidated and subsequently been cut by the stream until vertical walls stand 6 to 12 feet high on both banks. (See Pl. XLIII, *A*, *B*.) The floor of the broad valley of Cinder River was found to be entirely covered by volcanic ejecta, but the source of the material was not discovered until the summit of Elephant Mountain was occupied by Mr. Sargent and the writer. Prior to the view of the crater, however, locations on the topographic map of a group of peaks in the distance had assumed the form of a circle, but the reason of the arrangement was not suspected.

Aniakchak Crater is 24 miles northwest of Aniakchak Bay, approximately in the central part of the Alaska Peninsula, on the divide between the Pacific Ocean and Bering Sea. Although there are no trails, the district is easily accessible from either side of the peninsula. Aniakchak River, the largest stream on the peninsula flowing into the Pacific Ocean, rises within the crater and breaks through the east side of the rim in a narrow and picturesquely castled canyon which has been named "The Gates" (Pl. XLIII, *C*), from two long, nearly symmetrical mountain spurs that diverge from the canyon, one on each side of the river, and inclose the upper valley. The crater is nearly circular in outline and has a maximum diameter of 6¾ miles and a minimum diameter of a little over 5¾ miles. The lowest part of the crater floor is 1,100 feet above sea level and contains Surprise Lake, a body of water with an area of 2 square miles. The walls are well preserved and rise almost vertically in places to altitudes of 1,200 to 3,000 feet above the bottom of the crater. A large truncated cinder cone, the summit of which is 2,200 feet above Surprise Lake, occupies the south-central part of the area inclosed within the crater rim.

[1] Waring, G. A., Mineral springs of Alaska: U. S. Geol. Survey Water-Supply Paper 418, pl. 1, 1917.

[2] It has recently been reported that W. W. French, an engineer, and party visited the crater in July, 1921, but no report of the discovery was made at that time.

The crater was first mentioned without a name by R. F. Griggs[3] in a book that was printed shortly after the return of Mr. Sargent's party. Under the name "Old Crater" its position is indicated on the map of Alaska published by the Survey in 1923. A very brief description of the crater was included in a report[4] on the geology of the district. In a chronologic account of observed volcanic activity in Alaska, Grewingk[5] gives the geographic position of Veniaminof volcano as

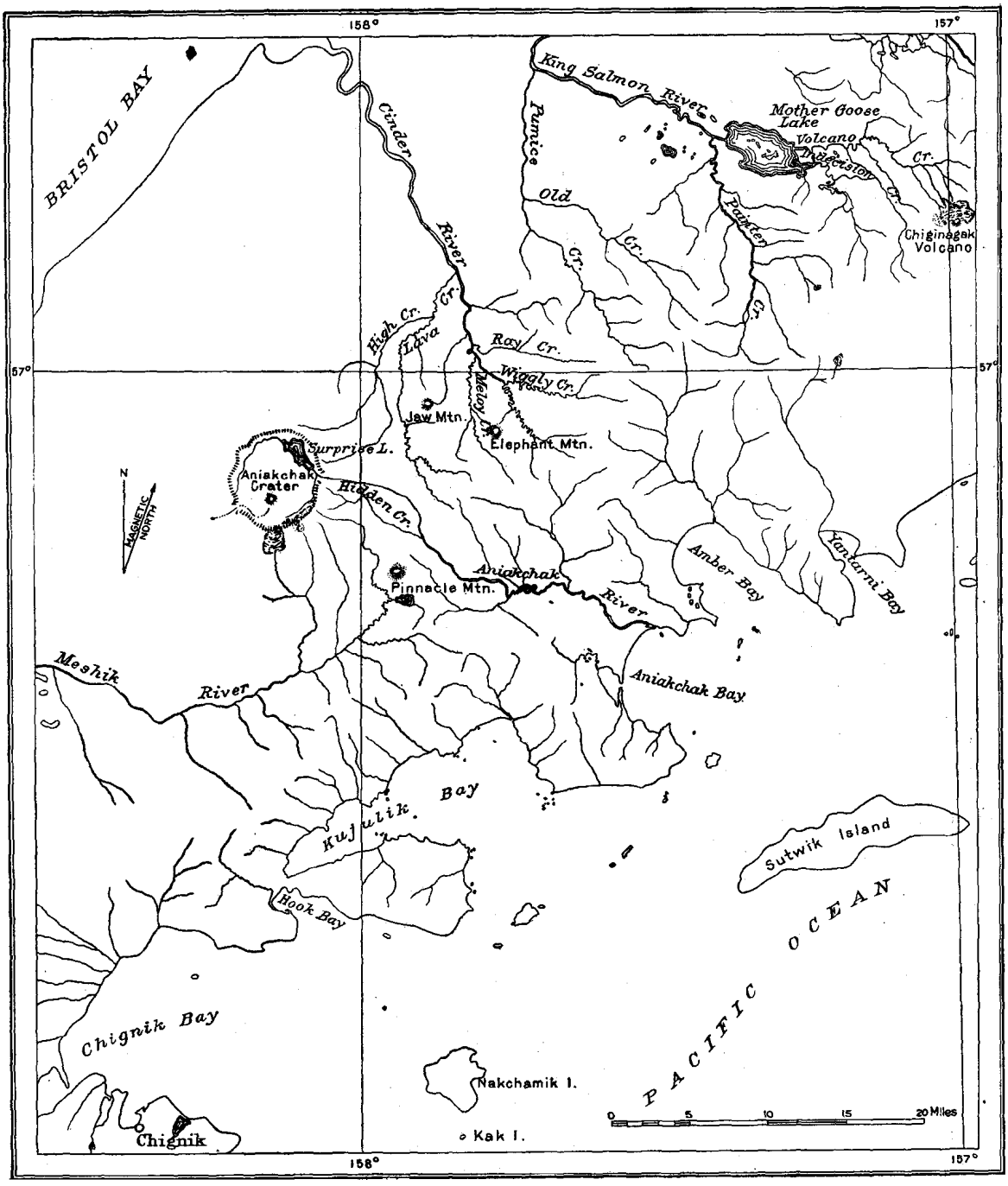


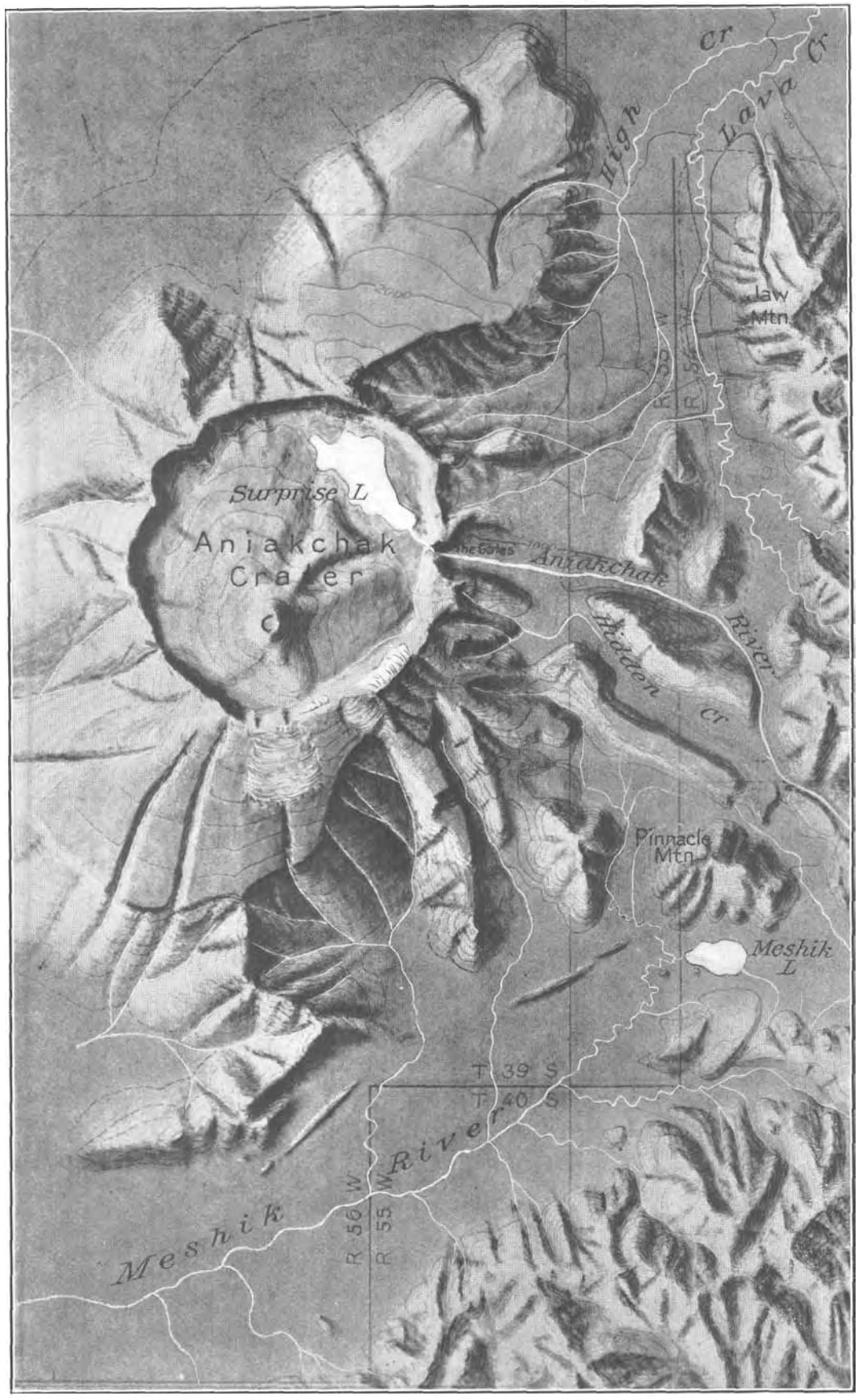
FIGURE 11.—Sketch map showing location of Aniakchak Crater, Alaska Peninsula.

[3] The Valley of Ten Thousand Smokes, p. 65, footnote, 1922.

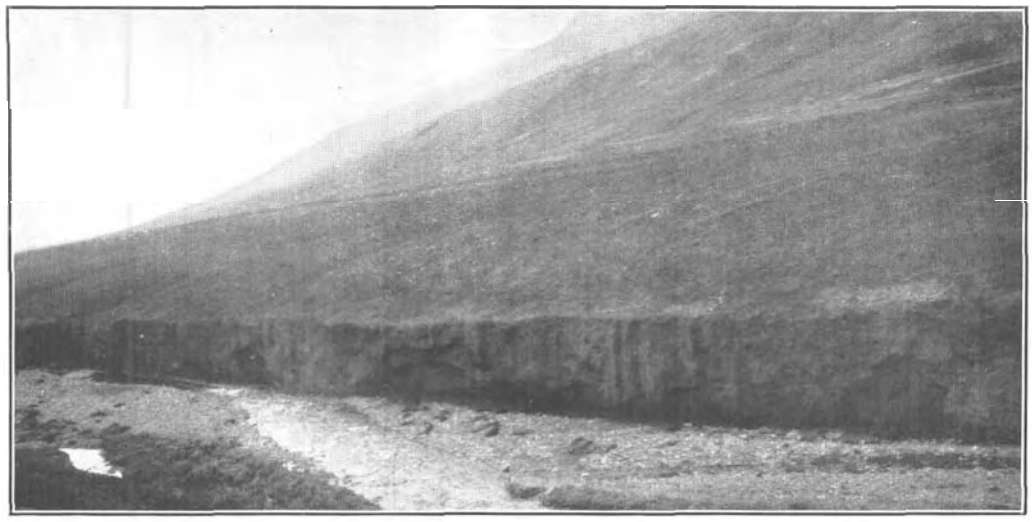
[4] Smith, W. R., and Baker, A. A., The Cold Bay-Chignik district: U. S. Geol. Survey Bull. 755, p. 157, 1924.

[5] Grewingk, Constantin, Beiträge zur Kentniss der orographischen und geognostischen Beschaffenheit der Nord-west Kuste Amerikas, mit den anliegenden Inseln (with geologic and other maps), St. Petersburg, 1850.

ANIAKCHAK CRATER, ALASKA PENINSULA



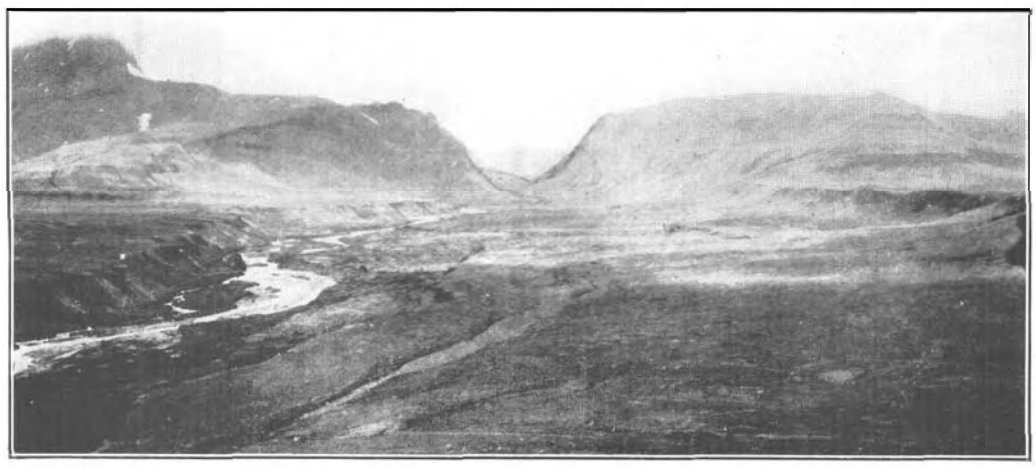
RELIEF MAP OF ANIAKCHAK CRATER AND VICINITY, ALASKA PENINSULA



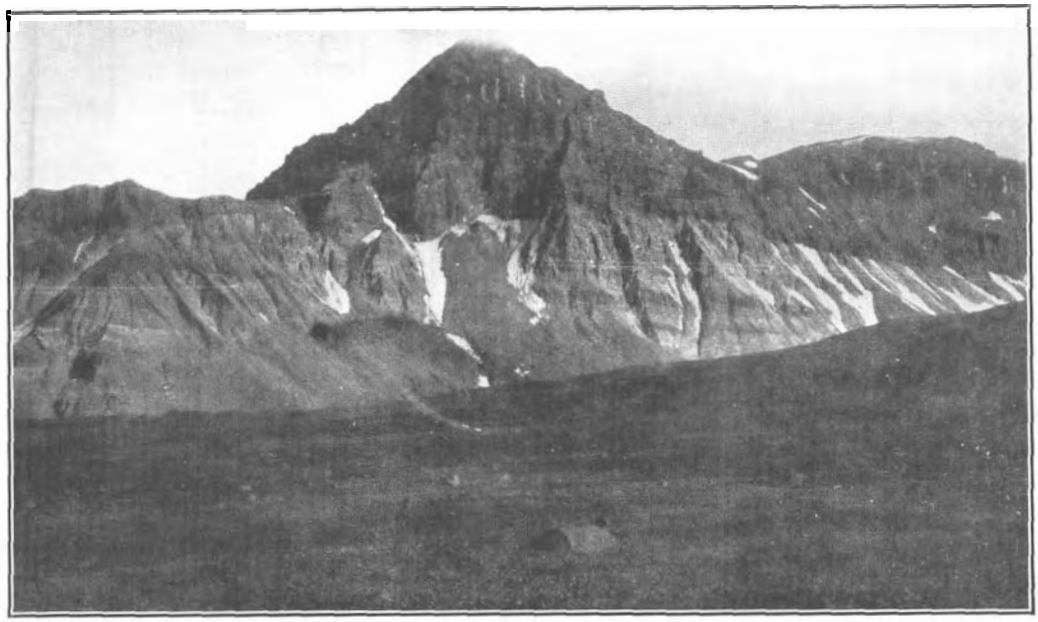
A

B

A, B. EXPOSURES OF VOLCANIC ASH ON RAY CREEK, ALASKA PENINSULA



C. "THE GATES" OF ANIAKCHAK CRATER, ALASKA PENINSULA



A. BLACK NOSE, ALASKA PENINSULA

B. MOUNT CHIGINAGAK, ALASKA PENINSULA

latitude 56° and longitude 158° to 159°. This position is rather close to that of Aniakchak Crater, which is latitude 56° 45' and longitude 158° 9′, but from the short account given it is quite evident that Grewingk meant the volcano known at present as Veniaminof, latitude 56" 17' and longitude 159° 15′, and not Aniakchak Crater. Although the Russian scientists and travelers recorded many interesting and valuable observations regarding the volcanoes of Alaska Peninsula, they made no mention, so far as known to the writer, of the immense crater discovered in 1922. It is quite probable that some of the Russian fur hunters, or perhaps a prospector or trapper of more recent days, came across the crater but either failed to recognize it as such or failed to report it. Inquiries were made of the inhabitant? of Chignik, the nearest settlement, and of local trappers, all of whom knew nothing about the crater. The present paper is based on observations made by the writer during a few hours. Time was not available to determine the age of the crater or the exact manner in which it was formed.

The observer at a distance would not suspect the existence of a huge crater within the cluster of rather gentle peaks which are separated from the other mountains of the district by broad level areas. The valleys of Meshik and Aniakchak rivers west of the crater are in general less than 200 feet above sea level. The boldest portion of the outer rim of the crater is along the east side of the mountains, where cliffs rise abruptly from the tributary valleys of Aniakchak and Meshik rivers. Over these precipitous cliffs many streams cascade from the glaciers near the summit of the rim. One of these streams has a vertical fall of at least 1,000 feet. The west and north sides of the rim slope more gently away from the crater and are covered to a great depth by ash and cinders. Gullies 30 feet deep on these slopes do not expose the solid rock beneath but show rudely stratified layers of ash and large lava and scoria boulders 4 feet and less in diameter.

The panorama of the crater (Pl. XLI) conveys a rather poor conception of its magnitude, owing to the large size of the area inclosed within the proportionally low rim and to the absence of an object of known dimensions. However, the greatest length of Surprise Lake visible in the photograph is 2½ miles, and the small cones near the upper end of the lake rise about 200 feet above the floor of the crater. The summit of the large cinder cone is 4½ miles from the point at which the picture was taken; the mountains beyond the cone are 6 miles from the observer. The inner wall is abrupt—at places nearly vertical—and so far as known it can not be easily descended except just north of The Gates. A view of Black Nose (Pl. XLIV, A), the peak immediately south of The Gates, taken from a cinder ridge within the crater, gives an idea of the steepness of parts of the inner wall. The south side of the crater rim affords a gathering ground for the snow, and here vigorous alpine glaciers have been formed on the steep slopes. Evidence of slumping along the inner wall was not noted except for several talus slopes in the canyon of Aniakchak River and near the base of Black Nose. The circumference of the crater is nearly 19 miles. The rim is broken in two places—the sharp notch through which Aniakchak River flows and a depression on the west side which was not seen in 1922 but has been reported by M. W. Taylor, of Seattle, who visited the crater in 1923. On the south side the highest point on the rim is 4,200 feet above sea level and 3,000 feet above Surprise Lake. This peak and several others close by were obscured by clouds at the time the photograph reproduced in Plate XLIV was taken. The greater part of the crest of the rim is not jagged, although Black Nose and several other sharp peaks rise above the average altitude, which is approximately 3,000 feet.

Along the north and northeast sides the inner wall is partly covered by detritus, but in the few exposures seen the rocks appeared to be layers of pink and black lava, probably obsidian, several hundred feet thick, overlying a light-colored quartz diorite. Most of these exposures are inaccessible and were not closely examined, but a specimen of the quartz diorite was taken on the outer wall northeast of the crater. Exposures in the cliffs along the canyon and near the bottom of Black Nose consist of nearly horizontal sedimentary rocks, chiefly very massive gray sandstone. In the lower 500 feet the rocks exposed in the canyon are abundantly fossiliferous; the greater part of the fossils belong to several species of *Aucella* that are characteristic of the Naknek formation, of Upper Jurassic age. From a distance the summit of Black Nose apparently consists of

lava, but the upper portion may be in part sedimentary rock, presumably of Tertiary age. The unconformity and the contrast in lithology between the rocks of the two kinds can be seen in Plate XLIV, *A*. Although the high mountains forming the south side of the rim were not closely examined, they probably consist entirely of sedimentary rocks, the greater part of which are Upper Jurassic. A rugged spur north of the north wing of The Gates is composed of very coarse agglomerate or tuff' similar to that overlying large areas in the vicinity of Aniakchak and Kejulik bays. Most of the large and small boulders that make up the agglomerate are angular, but some are rounded. Individual blocks attain 16 feet in diameter and display the darker shades of red, green, and gray. Many of the boulders are black, and all of them show a scoriaceous texture.

The area of the bottom of the crater is approximately 30 square miles. The entire floor is covered to an unknown depth by black and gray scoria ranging in coarseness from very fine material to pieces several feet in diameter. About one-third of the floor is level; around the base of the large cone ridges of cinders, 200 to 800 feet high, radiate toward the crater wall. The formation of the cones and the position of the material within the rim are undoubtedly the results of activity subsequent to the major eruptions that produced the great crater. The later activity probably decreased the original depth of the crater by partly filling it with cinders', The upper 800 feet of the large cone is remarkably circular and well preserved. It is thought to be formed entirely of cinders, as no lava was observed on the ridges around the base. The summit is truncated and may be slightly depressed. An attempt was made to reach the top, but traveling over the loose material is wearisome, and the attempt was given up late in the evening with the realization that a trip of 10 miles to camp was yet to be made. The small cones near the head of the lake were not examined. Toward the west side of the crater, 5 miles from the writer's nearest point of observation, another small cone, which was not caught by the camera, could be seen by aid of a field glass. Near this cone a curious bowl-shaped deposit of white material, probably formed by hot mineral waters, stands out in contrast to the surrounding black scoria, which appeared to be very coarse at that locality. Only a rough estimate of the dimensions of the bowl can be given, but it is at least 200 feet in diameter.

. Surprise Lake, in the northeastern part of the crater, is irregular in outline and has a maximum length of 2½ miles and average width of three-fourths of a mile. It covers an area of nearly 2 square miles, but the bluish-green color of the water indicates that the depth is not great. The lake may have formerly covered a much larger area, before the river had deepened its channel through the canyon, but terraces or high-water marks could not be detected on the wall at the few places examined. An ill-defined bench occurs well up on the sides of the cinder cone, however, but the bench is not continuous nor sufficiently well preserved to consider it an ancient lake shore. A small circular lake or pool several hundred feet higher than Surprise Lake is situated at the base of Black Nose. Although a stream of considerable size flows from the lake and unites with Aniakchak River just inside The Gates, the lake has no affluents and must derive its supply of water from the snow fields and glaciers by seepage through the cinders.

The narrow notch in the crater's rim through which Aniakchak River flows has undoubtedly been deepened by the erosive power of the stream, which is very turbulent as it emerges through The Gates. The break in the wall, however, is thought to be caused by a rift, which may extend across the crater and account for the depression on the west side. No evidence of relative vertical displacement of the opposite sides of the canyon was noted. The photograph of The Gates (Pl. XLIII, C), taken through the haze from a point 5½ miles down the valley, does not do justice to their profoundly impressive beauty. Several terraces formed by the river in the ash and pumice can be seen in the foreground. The crater can be entered through The Gates without difficulty on the soyth side of the river. The stream was too swift to be waded within the canyon when it was visited in August, and an attempt to pass through on the north side of the river terminated by climbing .a precipitous cliff 1,600 feet high.

Only the east side of the crater was visited, but the country to the north could be seen from Jaw Mountain and the southeast outer

wall from Pinnacle Mountain. All the valleys of the surrounding country for many miles are covered by thick deposits of ejecta from the crater. The material consists of fine ash, fragments of black and pink lava, and gray, black, and red pumice, The greatest observed thickness is exposed in the steep banks of Lava Creek. The stream has developed many beautiful terraces and its present bed, west of Jaw Mountain, is cut, perhaps 50 feet, into a deposit of black volcanic glass, as reported by Mr. Sargent. The glass or obsidian is 10 miles from the nearest point on the crater's rim, and whatever its source it was extruded before the great eruptions of the volcano, as it is overlain by at least 150 feet of loose material, the greater part of which is black pumice. This is the only lava seen in place except on the inner wall of the crater, but many fragments of black obsidian, containing a few glassy lath-shaped crystals of feldspar, were found on the mountains many miles from the crater. Indications of extinct fumaroles were sought in the ash-covered area east of the crater, but much of the volcanic material has been worked over by streams, and no evidence of fumarolic activity was found. The upper valley of Meshik River and also the valley of Aniakchak River in the vicinity of Albert Johnson Creek have been filled with volcanic débris to such an extent that the present valley floors are very broad and nearly level. A few low isolated hills near the margins of the level area appear to have been partly buried, with only their summits left exposed, but this is probably an illusion. Several high mountains southeast of the crater are sharp-peaked, especially Pinnacle Mountain, and are composed of hornblende andesite. A stream of considerable size, Hidden Creek, a tributary of Aniakchak River, flows through a subterranean channel beneath the ash and cinders for a distance of 5 or 6 miles and emerges on the west bank of the river. The Aniakchak is about 100 feet wide and 4 feet deep below the North Fork. The current is swift enough to transport small pieces of pumice along the bottom. At 4 miles from its mouth the river has eroded a picturesque gorge through a thick deposit of volcanic agglomerate. The southwest side of the gorge is formed by a rugged spur that projects across the valley from the hills to the southwest and is locally known as Cape Horn. (See fig. 11.) The river is navigable by small boats as far as the meanders below the mouth of Mystery Creek.

A broad marshy lowland lies between the shore line of Aniakchak Bay and the hills toward the northwest. In this area a remarkable series of nine crescent-shaped ancient beaches can be seen from the mountains north of the river in the form of low ridges conforming in direction to the present shore line. A large part of the material in these ridges consists of volcanic ash and pumice washed ashore by the waves after having been transported into the bay by the river. The bay is uncharted and is not a protected harbor, although deep water is reported by masters of fishing schooners who have entered the bay. Hook Bay, 25 miles directly south of the crater, affords an excellent harbor for boats of moderate size. An old trail leads from this bay over the mountains toward Meshik River valley and is probably the best route from the Pacific coast to the crater, although in fair weather a landing can be made at the mouth of the river at Aniachak Bay. From this point the distance to the crater is not so great as from Hook Bay, and the route is over level country. Chignik is the nearest settlement and is 40 miles southwest in a direct line from the crater but at least 60 miles by trail. A trapper's cabin has been built near the lagoon at Aniakchak Bay and one on the south side of the valley below Albert Johnson Creek. The trappers occupying the cabins during the winter had traveled over the cinders as far west as Meshik Lake for many years, but they did not know of the existence of Aniakchak Crater.

Vegetation has gained a footing in places throughout the area covered by ash, and even within the crater several tufts of grass and low flowering plants were seen. Large areas, however, within a radius of 20 miles of the crater, are entirely barren of plant life and have the appearance of arid plains. Alder bushes have grown to a height of 6 feet in the valleys of High and Lava creeks and furnish sufficient fuel for camp purposes, but they are not straight enough to be used for tent poles. Foxes and Kodiak bears inhabit the region. Small herds of caribou were seen near the valley of Pumice Creek.

The wide general use of the term "crater" includes several varieties or types, which have

been differentiated as impact craters, subsidence craters, upbuilt craters, and explosion craters. An impact crater may be formed by the fall of a body, such as a large meteorite or a projectile from a cannon. Such a bowl-shaped hollow or pit may have nothing in common with volcanic activity. A subsidence crater is a depression below the general level of the country or a concave area on a mountain, made by the collapse of the roof of a cavity. In limestone countries such depressions are common, but the use of the term is restricted by many geographers to pits occurring in volcanic regions. These pits are usually caused by the collapse of cavities formed in volcanoes by the eruption of lava and other material. Craters formed in this manner are also known as caldrons. The largest and some of the best-known craters on the earth are of this variety, to which belong Kilauea, in the Hawaiian Islands (2.93 miles in diameter); the pit of Crater Lake, Oregon (5½ miles in diameter): Ngorongoro, East Africa (12 miles in diameter); and Aso-san, in Japan (dimensions, 9 by 14 miles). An upbuilt crater has the form of a more or less circular mound surrounding an aperture, relatively small in diameter but usually deep, which serves as a vent for the lava, ash, and fumes thrown out by a volcano. This is the normal and most common type of craters and occurs on the summits of Lassen, Etna, Cotopaxi, Fuji, and scores of other volcanoes. Stromboli, in the Mediterranean Sea, is taken as the type of the explosion craters. Better examples, however, are known, such as the crater formed by the ancient explosion of Vesuvius, A. D. 79, of which Mount Somma is a remnant, and the ruins of Krakatoa in 1883 and of Katmai in 1912. Excavations made by erosive agents have been referred to and classified as craters, but they have nothing to do with volcanic action.

All the evidence now available points to the origin of Aniakchak Crater by explosive activity and not by subsidence. Besides the vast quantities of rather fine material thrown from the crater and concentrated in the valleys of the surrounding country, huge projectiles were hurled many miles. On the north slope of Elephant Mountain, 1,000 feet above the valley of Meloy Creek and 23½ miles from the center of the crater, a block of black obsidian was found which measured at least 2 cubic feet in volume. About 14 miles southeast of the crater an angular mass of sandstone, 5 feet in diameter and containing fossils similar to those found near Black Nose, occurs near the summit of a small hill composed of agglomerate. The large boulder is not waterworn, and there is slight probability that it was carried to its present position by a glacier. The ash contains smaller fragments of sandstone that have the same lithologic character as that exposed in the southeast wall of the crater and were not derived from rock in the immediate vicinity in which they were found. That tremendous explosive forces were active at the time the present crater was formed is quite evident. All the known craters of the world as large as Aniakchak Crater or larger are thought to have been formed by subsidence. Katmai Crater, 3 miles in diameter, 151 miles to the northeast, was formerly considered the largest crater of the explosive type known, but it is greatly surpassed by Aniakchak Crater, 6¾ miles in diameter. In diameter and general outline the caldron of Crater Lake, Oreg., and Aniakchak Crater are remarkably similar, although the two are of entirely different types.

The form of the mountain mass that occupied the present site of the crater prior to the eruptions that resulted in the formation of the depression can of course only be conjectured. Before the existence of the volcano the area now within the crater was probably occupied by one or more mountains of moderate altitude—that is, by analogy with other mountains in the district, between 3,000 and 4,000 feet—which were composed of very slightly folded sedimentary rocks, intruded on the north by a large mass of quartz diorite. Why volcanic vents should be formed near the summits of high mountains composed of nearly horizontal strata is difficult to explain, but on the Alaska Peninsula many of the active and extinct volcanoes originated in mountains of this type. This is especially true of the volcanoes toward the northwest, of which Mounts Katmai, Magiek, Peulik, and Chiginagak are examples. These volcanoes and many others on the Alaska Peninsula have formed cones and increased their altitudes to heights ranging from 5,000 to nearly 10,000 feet by successive lava flows over the sedimentary rocks. Mount Chiginagak (Pl. XLIV, *B*), an active volcano 43 miles northwest of Aniakchak Crater, is an impressive and typical example of an upbuilt cone. That a similar cone once towered above the site of Aniakchak Crater is suggested by beheaded lava flows,

remnants of which are exposed on the east wall of the crater, on the summit of Black Nose, and possibly in the bed of Lava Creek. An imaginary cone reconstructed a mile in height above the present floor of the crater would be slightly over 6,000 feet above sea level, an altitude which is very low in proportion to the diameter of the base and also relatively low if compared with the altitudes of other volcanic cones. But even if a low cone is postulated the amount of material to be accounted for is enormous and the force necessary to remove it in one or several explosions is beyond imagination. The capacity of the crater alone. if 1,600 feet is taken as the average height of' the' rim, is about 9 cubic miles. Subtracting 1 cubic mile for the large cinder cone still leaves space for 8 cubic miles within the crater. To this must be added at least 7 cubic miles if the low cone. suggested above, ever existed. Between 300 and 400 square miles of adjacent country on the east and south is known to be covered to various depths by volcanic ash and cinders, and if an equally large area north and west of the crater is also overlain by ejecta, certainly an appreciable part of the supposed total of 15 cubic miles is still to be seen.

Ordinarily the Bering Sea coastal plain on the northwest side of the peninsula is dotted with thousands of small lakes, but in the area north of the crater no lakes could be seen from Jaw Mountain. That all depressions in this part of the plain were filled by material from the crater is a fair deduction. The volume of material ejected from Katmai is estimated at 4.75 cubic miles, but Katmai Crater has a capacity of only 2 cubic miles. The ejection of vast quantities of material from a single source and perhaps during a single period of eruption is not unheard of in volcanism. Capps[6] has estimated a volume of 10 cubic miles of volcanic ash thrown from a vent in the upper White River basin, and other large estimates have been made. Most of these computations, however, were made from measurements of the material ejected and not from the capacity of the crater.

Few date, are now available for estimating the age of Aniakchak Crater. However, it is believed to be one of the oldest of the series of volcanoes along the Aleutian Range. That the eruption antedates historic record is suggested by the amount of stream erosion, especially in Lava Creek, and the vegetation of the area, including alders. If the absence of evidence of glaciation since the eruption is taken as a criterion it would appear that the eruption is of post-Pleistocene age. Although the ash is more or less concentrated in' the valleys it is not in the form of glacial moraines, and unless an ice sheet in which there was little or no movement covered the entire area, moraines of the loose pyroclastic material would be expected had this material been deposited before glaciation. A few of the valleys, such as that of Ray Creek, in which thick deposits of ash occur, are rather narrow and probably have been formed almost entirely by stream erosion. Most of the valleys are broad and suggest extensive glaciation before they were partly filled by ash. A detailed study is necessary for a more definite age determination.

An examination of the relief map (Pl. XLII) will perhaps convey a better idea of the giant crater than a description. Nearly all distances were scaled from Mr. Sargent's skillfully drawn topographic map, on which the relief map by Mr. Renshawe is based. The topographic map is published separately as the Cold Bay-Chignik map.

The writer wishes to acknowledge his indebtedness to Mr. Sargent for cooperation during the field work and for valuable assistance and criticism in the preparation of this paper. Thanks are also expressed to Mr. Sidney Old, who accompanied the writer into the crater and led the way across Aniakchak River.

The scenery of the Aniakchak district, with its broad prairie-like valleys, margined by majestic, sharp-peaked mountains, is impressive and in many respects unique. The once active scene of terrific earth convulsions is now almost oppressively silent. The coloration of the country is somber and together with the fretFully driven clouds tends to create a rather pleasing weirdness. Aniakchak Crater is one of the great natural curiosities of North America and is certainly worthy of further investigation. Although small in comparison, it is probably the nearest counterpart on earth to the craters of the moon in regard to the manner of its formation. Were it not so remote From the usual paths of travel the setting apart of this crater as a national monument would be justified.

[6] Capps, S. R., An ancient volcanic eruption in the upper Yukon basin: U. 6. Geol. Survey Prof. Paper 95, p. 62, 1915.

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