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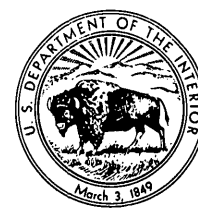
Erosion and Related Phenomena At Parícutin in 1957

By KENNETH SEGERSTROM

GEOLOGIC INVESTIGATIONS IN MEXICO

GEOLOGICAL SURVEY BULLETIN 1104-A

A report on the changes in erosion, deposition, and drainage of the Parícutin area from 1946 to 1957—Prepared in cooperation with the Universidad Nacional Autónoma de México, Instituto de Geología, under the auspices of the International Cooperation Administration, Department of State



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ILLUSTRATIONS

GEOLOGIC INVESTIGATIONS IN MEXICO

EROSION AND RELATED PHENOMENA AT PARÍCUTIN IN 1957

By KENNETH SEGERSTROM

ABSTRACT

No appreciable compaction of the ash mantle of Parícutin volcano occurred during the period 1947–57. In 1957 the floor of the crater was subsiding and there were nearly continuous rockslides from the oversteepened inner walls of the cone. Most of the area blocked to exterior drainage during 1943–44 was still blocked in 1957, although flood channels had developed around the edge of the lava field. The rate of stripping of the ash mantle was markedly reduced by revegetation during the decade. A general increase in ground-water flow that was noted in 1946 was even more apparent 11 years later. By 1957 plantlife had appeared at many places on the ash and lava flows from Parícutin, and even on the summit of the volcano. In the devasted area 5 years after cessation of Parícutin's erupted activity, three villages previously abandoned by townspeople and farmers had been resettled.

INTRODUCTION

The writer made observations of erosion of the ash at Parícutin volcano, Michoacán, Mexico, in 1946, just 3 years after the volcano first erupted, and again in 1947 (Segerstrom, 1950). On February 25, 1952, the eruptive activity of the volcano ceased (Fries and Gutiérrez, 1954), but erosive process initiated or accelerated by the eruption continued. Consequently, the writer, after an absence of 10 years, decided to return to the Parícutin area to observe again the results of erosion and related phenomena.

The scope of this investigation included determining the extent of compaction, redeposition, and stripping of the ash mantle; the amount of new plant growth on ash and lava flows; the changes in drainage and flow of ground water; and the number of people repopulating the devastated area. The geographic setting is presented in plate 1.

Special thanks for aid in making the present brief study are due Celedonio Gutiérrez, who accompanied the writer in the field, and Eduardo Chávez, Minister of Hydraulic Resources of Mexico, who gave use of his house at Pantzingo. Others who helped include W. A.

Eggler, who identified plants collected on the volcano, Carlos Escalante Foglia, chief of the Tepalcatepec River Commission, Ray E. Wilcox, who reviewed the manuscript, and Carl Fries, Jr., who accompanied the author and Gutiérrez on the ascent of the Parícutin cone.

COMPACTION OF ASH

Some compaction of the ash mantle during the 10 years (1947–56) was expected, for fine-grained particles should tend to settle into interstices between underlying coarser grains, aided by rain impact and earthquake shocks. Rainfall was very heavy during the summer months, and earthquakes were frequent throughout the eruptive period. Moreover, ash erupted after 1946 undoubtedly had a higher percentage of fine-grained material than earlier ash falls, so that the compacting effects should have been magnified in later years. Even after emission of ash and lava ceased, earth tremors continued and were so strong in March and April 1952 that it was believed they might indicate a renewal of eruptive activity (Fries and Gutiérrez, 1954).

Not withstanding the factors favoring compaction, the ash mantle in 1957 was still loose and apparently uncompacted when dry. Vehicles sank into the dry ash, as at the time of the previous investigation, in areas where 30 cm or more of ash had fallen, and the only roads passable to automobiles and trucks were those which had been plowed out as if from drifting snow. Automobiles sank as much as 7 cm in dry ash in 1957; pedestrians sank at least one-third as much. In 1946 a person of average weight sank from 2 to 4 centimeters in the ash while walking (Segerstrom, 1950).

Pits were dug for ash measurement in 1957 to the east and north of the Parícutin cone on interfluves where it is unlikely that either erosion or redeposition of the ash could have taken place. On the highest summit of Curitzerán, 7.5 km north of the cone where it had been 28 cm thick in 1946, the mantle was 34 cm thick in 1957, an increment of about 20 percent. On an unnamed hill 6.3 km east of the cone the thickness of the ash mantle increased during the same period from about 36 cm to 45 cm, or 25 percent.

During most of the first half of the period 1946–57 the volcano continued to erupt, though at a much slower rate than during the first 3 or 4 years of its ife. At Cuezeño, 5 km north of the cone, the pre-1947 ashfall totaled 48 cm; the post-1947 increment, measured by totaling daily falls, was about 8 cm (Fries and Gutiérrez, 1954), of 17 percent of the pre-1947 fall. This increment of total ashfall is comparable to the increase in thickness of the ash mantle at Curitzerán, which is 2.7 km northwest of Cuezeño. It was concluded from these

measurements that compaction of the ash mantle in 10 years must have been very small, for had there been an appreciable amount of compaction of the ash from 1946 to 1957, the increase at Curitzerán should have been less than 17 percent.

If there was no appreciable compaction, and if the ashfall increments in all directions from the cone are directly proportional to that measured at Cuezeño (Fries, 1953, p. 604), the increase in thickness east of the cone between 1946 and 1947 should also have been about 17 percent. The 25-percent increment east of the volcano was measured at a place where pine needles are present in the upper part of the mantle; therefore it is not surprising that this increment was actually somewhat greater than the probable ashfall for that period.

EROSION AND REDEPOSITION OF ASH

In contrast to the very minor degree of compaction, the pyroclastic products of Parícutin have been eroded and redeposited on a grand scale. In 1957 the Parícutin area was still very active geologically, even though eruptive activity had ceased, for enormous volumes of material were being transported from higher to lower places at a rapid rate. Changes that have taken place in the ash mantle and in the local hydrological regimen are discussed below.

MASS MOVEMENT

Mass movements and flows of ash, lapilli, and scoria have affected the appearance of the cone to a marked degree. Long narrow flows of loose lapilli extend like fingers down the sides of the cone (fig. 1). The crater is ringed with roughly concentric fissures and faults, some of which reach the rim of the crater and some the outer slope of the cone (fig. 2).

On February 24, 1957, the rim of the cone had prominent eastern and western summits; the western summit was 5–10 m higher than the eastern one. The crater contained two partly filled depressions, trending northeastward. These depressions were about 50 m below the southwest, or lower, saddle between the two high points of the rim. Almost continuous rock slides on the inner side of the steep western summit were observed on the day of a visit to the crater. The western rim was very narrow compared with the eastern rim, and a reduction in the height of the west peak to less than that of the east peak seemed imminent. By way of comparison, on April 29, 1952, 2 months after eruptive activity of the volcano had ceased, the east and west peaks were approximately equal in height, and the bottom of the crater was some 30 or 40 m below the 2 saddles (Fries and Gutiérrez, 1954). The slides and resulting fluctuation in relative

FIGURE 1.—Long narrow flows of loose lapilli (light color) extending like fingers down the northwest side of Parícutin cone.

heights of the summits were plainly caused by subsidence of the crater.

Landslides of ash and underlying soil, ash, and rocks have left deep scars on the steep slopes in the region. After 1947, three gashes were opened on the east and south slopes of Cerro del Cebo, southwest of Parícutin volcano. The enormous cuts, which are about 100 m wide and 50 m deep (fig. 3), are in brownish-red and yellowish-brown old ash mantled thinly with gray ash from Parícutin. The preexisting ash has well-defined bedding that dips in the same direction and at the same inclination as the hill slope. The ash beds were aerially deposited at their angle of repose and mass movement resulted when the sloping surface was oversteepened by headward retreat of newly deepened gullies.

DRAINAGE CHANGES

Before the new volcano Parícutin erupted, two intermittent streams, headwaters of the Río Itzícuaro, drained all the area that was later covered by lava and ash. The Arroyo Principal drained the area to the east and north and passed westward along the south edge of the town of San Juan Parangaricutiro. Arroyo de Parícutin drained the area to the south and passed northward along the east edge of the town of Parícutin, joining the Arroyo Principal in Huirambosta. La Laganita, a large area of interior drainage was between the two

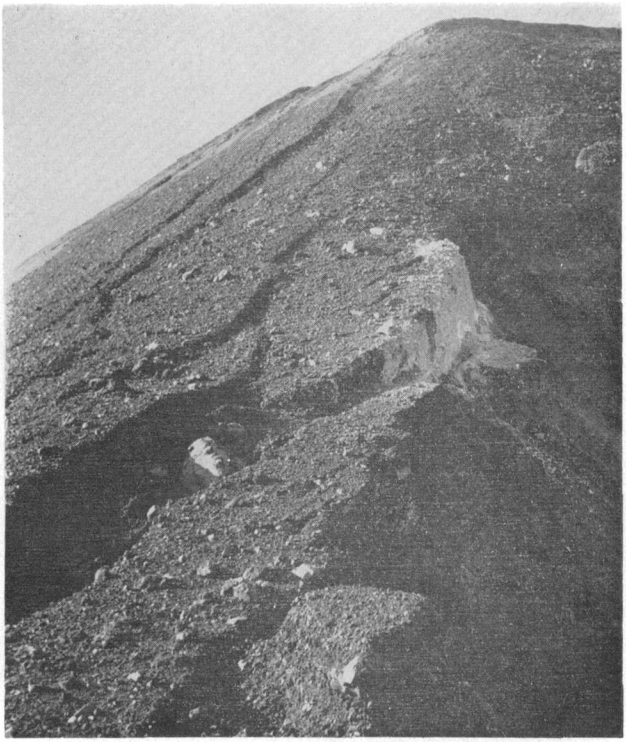

FIGURE 2.—East rim of Parícutin cone, showing fissures and faults.

arroyos northeast of where Parícutin volcano later erupted. (See pl. 1.)

In the years 1943–45, flows of lava from Parícutin blocked and covered major parts of the preexisting drainage systems, but ash-laden floods soon sought new exit routes around the edges of the lava field. In 1946, although several previously undrained areas were drained, about 50 percent of the terrain that had been mantled by ash more than 50 cm deep was still blocked by lava (Segerstrom, 1950, p. 33 and pl. 1). By February 1957, in spite of the extrusion of new lava flows between 1946 and 1952, large areas north and west of the volcano that were closed basins in 1946 now drained into the west-flowing Río Itzícuaro during flash floods. Most of the remaining area of blocked drainage south and east of the volcano, distributed between the Arroyo Principal, La Lagunita, and Arroyo de Parícutin watersheds before the eruption and into several separate undrained basins in 1946, formed a single connected system in 1957. This system drained

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FIGURE 3.—Cut in old ash deposit on east slope of Cerro del Cebo.

into an ephemeral lake at Tipacua, 5 km northeast of the cone, at the edge of the lava field.

The following description of the new "Arroyo Principal" encompasses the upper reaches of the stream northward around the east edge of the lava field to its undrained outlet northeast of Parícutin volcano. The main headwaters of the stream are on mountain slopes that descend eastward from the lofty peak Cerro de Tancítaro (altitude 3,842 m). The altitude of the alluvial-fill deposit at Tipacua is about 2,310 m above sea level.

At Llano de Yahuácuaro, near the south end of the area of plate 1, the small headwaters stream formerly disappeared in a sinkhole at the edge of a prehistoric but unweathered lava flow from Cerro Prieto, farther to the southeast. Apparently this underground outlet became choked by ash from Parícutin, so that the plain was periodically flooded. In 1954 Victor Soto, a local farmer, dug a drainage ditch 20 m long, 2 m wide, and as much as 1.3 m deep, at the north edge of the benchlike plain (loc. 1, pl. 1). A low brush diversion dam was built across the plain to protect corn fields from flooding and to conduct flood waters to the drainage ditch. The drainage operation was so successful that in 1957 a new cut about 20 m wide and 20 m deep had been eroded in steeply sloping terrain for a distance of 350 m northward from the ditch in old ash along the west edge of the lava from Cerro Prieto.

At the mouth of this enormous cut an alluvial fan has formed in a place of sharply decreased slope gradient, near the south end of Llano de La Cantera. This fan nearly overlaps another fan farther north at the mouth of an old bedrock gully that emerges from Cerro de Tisne to the west.

Llano de La Cantera, formerly a small undrained basin on a topographic bench, was cultivated for many years before the eruption of Parícutin, but in 1943 or 1944 an ash-laden flash flood from the steep slopes of Tisne littered the fields with logs and with boulders as much as 2 m in diameter (Segerstrom, 1950, fig. 54). No cultivation has been attempted since then.

The combined arroyos from the south and west are intrenched in fresh alluvium to a depth of several meters; at the north edge of the bench, where the gradient is greater, the stream plunges into a new cut 8–12 m deep and 12 m wide in old ash. (loc. 2, pl. 1; see also fig. 4)

Farther north the gradient is less, and the arroyo has formed another alluvial fan at the south edge of the broad Llano de Teruto. This deposit nearly overlaps another similar deposit farther north, at the mouth of a large barranca that drains the steep slopes near La Escondida, toward the southwest. The plain is littered with boulders

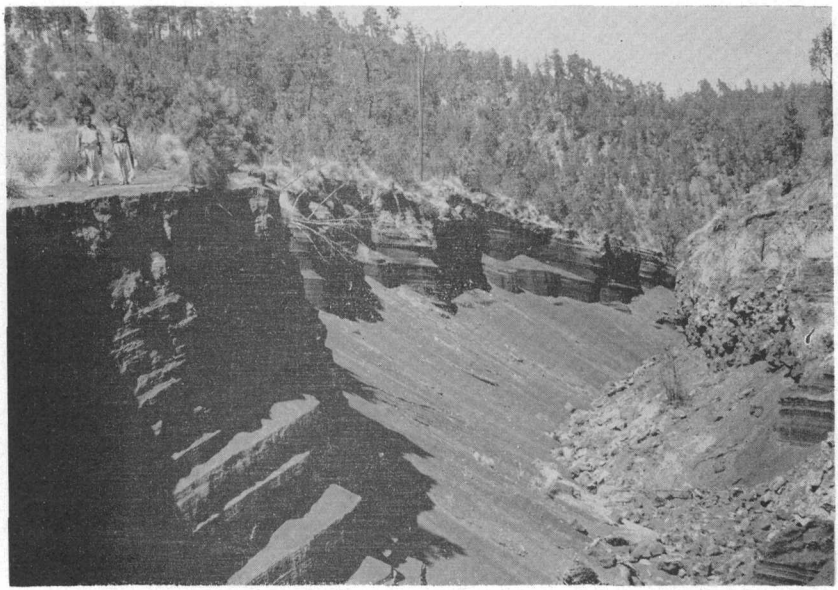

FIGURE 4.—New cut in preexisting ash (left) and lava (right) near Llano de La Cantera.

and logs. El Charco, in the eastern part of the flood plain, was an intermittent lake in 1946 (Segerstrom, 1950, p. 117). The lakebed was partly covered with water every rainy season from that time until 1955 or 1956, when the alluvial dam from La Escondida was bypassed and the floods from Llano de Yahuácuaro and Llano de La Cantera began to drain northward toward the lava field from Parícutin. Corn was planted and harvested in 1956 at El Charco for the first time in 10 years.

The main arroyo increases, as it passes northward across Llano de Teruto, from 7 m in width and 1.6 m in depth (loc. 3, pl. 1) to 25 m in width and 15 m in depth (loc. 4, pl. 1) in a distance of 1.1 km. About 1 km farther north, where the gradient is greatest, the arroyo attains a width of 50 m and a maximum depth of 35 m; most of the cut is in newly exposed ash and lava from prehistoric eruptions (fig. 5). The gradient lessens abruptly a short distance below locality 5, and the arroyo becomes shallow; then the drainage is diverted toward the northeast by the lava field from Parícutin.

At this place a tributary arroyo comes in from the west, along the south edge of the lava. The branch stream heads about 1 km away, in a low saddle at the northeast base of Cerro de Nuréndiro (loc. 6, pl. 1). In 1957 the saddle was only 2.5 m higher than the surface of a large alluvial deposit that lies at the lower end of an extensive undrained area farther west.

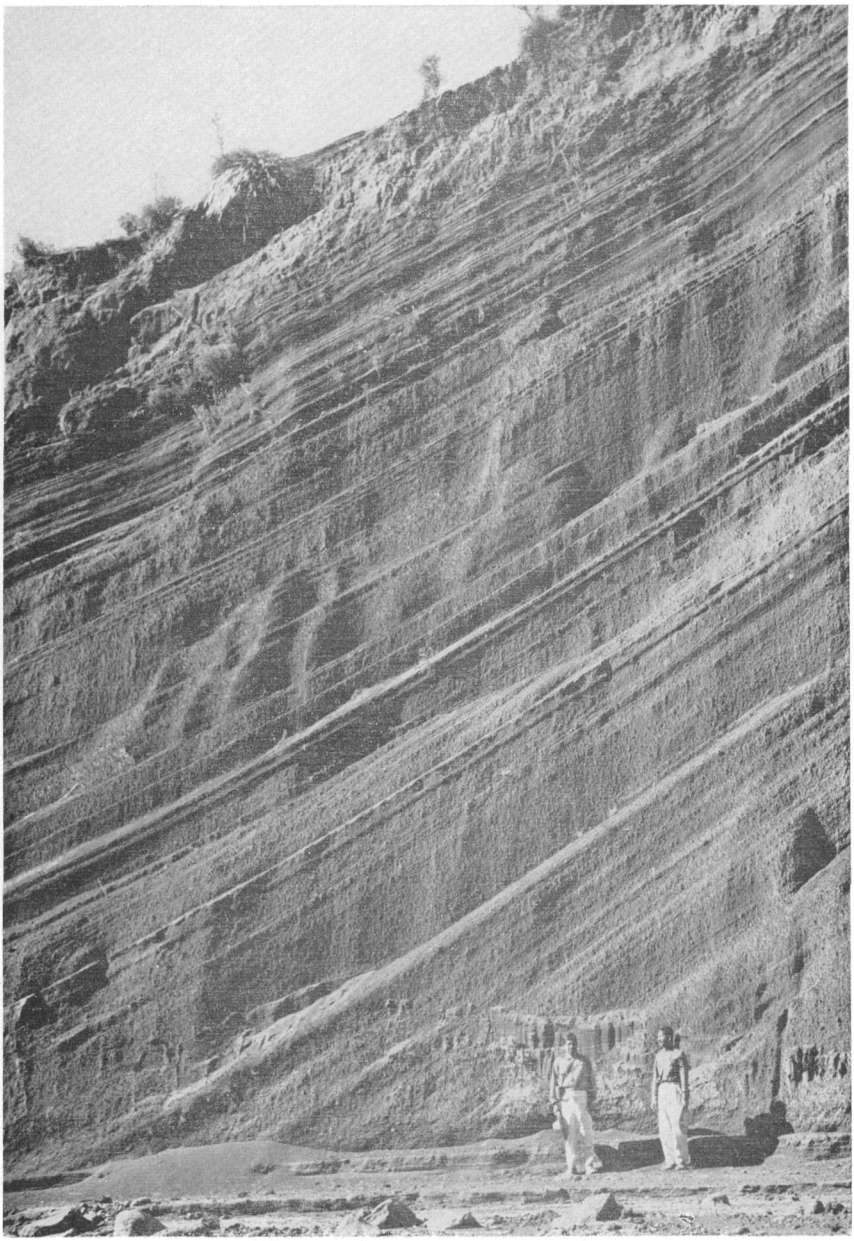

FIGURE 5.—Well-bedded preexisting ash in the wall of a new cut about 1 km northeast of Cerro de Camiro.

The combined arroyos from Teruto and Nuréndiro flow in a single channel along and near the southeast edge of the lava field for several kilometers, cutting shallowly across three former areas of deposition. Between the second and third of these areas, northeast of Curínguaro, the arroyo has cut a narrow gorge in bedrock, when storm waters pass through the gorge (loc. 7) the roar of the sediment-laden floods can be heard as far away as Pantzingo, 3 km distant. However, these floods are apparently of short duration, for their roar is heard for no more than 20 minutes at Pantzingo.

Near the south base of Cerro de Curupichu, the main channel swings toward the east across the third basin-fill deposit, opposite to the former drainage direction. At locality 8, where the former watershed divide was breached during a storm in 1950, the main arroyo has cut through the ash and 2.3 m of the preexisting soil. Several distributary channels from the south disappear before reaching the divide; hence, it is evident that only a few of the floods actually cross over to the north. Inhabitants of Pantzingo stated that the floods from the south flow beyond Curupichu only 4 or 5 times a year.

About 150 m downstream from locality 8 the arroyo channel has a box-in-box cross profile; its total width is 20 m, but only the central part, about 4 m wide, had cut into preexisting soil by 1957, to a depth of 3.3 m. Less than 100 m steeply downstream, the channel deepens to 7 m and the deep part becomes the full width of 20 m.

At the upper edge of a basin-fill deposit on the northeast side of the lava field, where the gradient is less and the stream is shallow, the northwest-trending channel of the arroyo is sharply diverted to the northeast and then to the northwest (locs. 9, 10) by a low brush-and-log dam 900 m long. This primitive engineering structure was built to protect a cultivated area below the dam (fig. 6).

At the northwest end of the basin-fill area (loc. 10), a ditch 50 m long, 1 m wide, and 1.5 m deep was dug along the edge of the lava field in 1953 to provide an outlet for the diverted flood waters. The artificial channel at that place has since been eroded to a width of 4 m and a maximum depth of 3 m. About 300 m farther downstream the gully attains a width of 7 or 8 m and a depth of 4 m.

The arroyo is diverted at locality 11 from its course at the edge of the lava by a rock dam 65 m long., 1.3 m wide, and 2 m in maximum height. The diverted floods pour northwestward into a low part of the adjacent lava field, where the fill deposit being laid down in 1957 over barren rock will provide fields for future cultivation.

Before it was diverted, the arroyo drained into the large basin-fill area of Tipacua and Chórotiro, to the north. The older fill deposit lies along the outer edge of the lava field and extends up the tributary

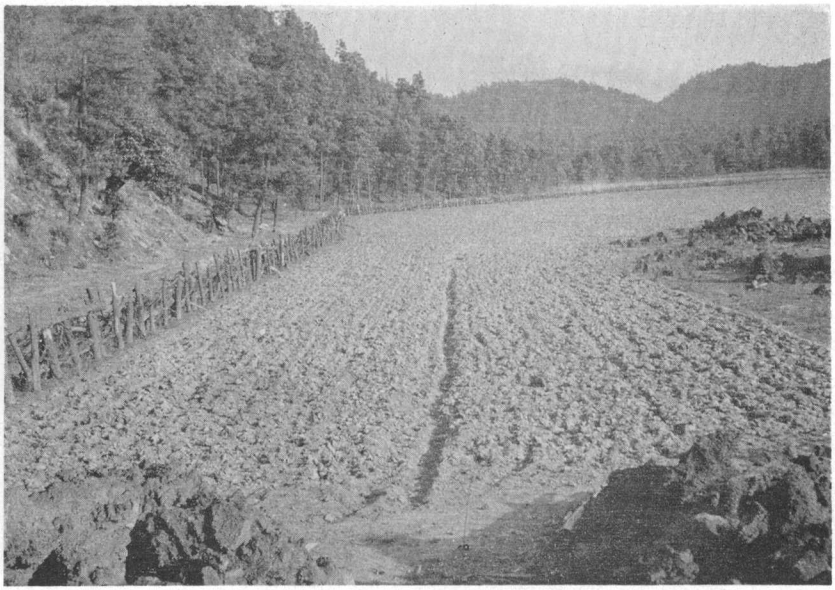

FIGURE 6.—Cultivated field in basin-fill deposit north of Curupichu. The fencelike construction at the left is a low brush-and-log diversion dam. The edge of the lava field from Parícutin is in the foreground and to the right.

valleys to the east and north from which most of the sedimentary fill material was derived.

Cultivation of this deposit was attempted at Chórotiro as early as 1946 but was unsuccessful because of flooding from Arroyo de Nureto, which comes in from the northeast (Segerstrom, 1950, fig. 3). Another low brush-and-log dam was built across the mouth of Arroyo de Nureto (loc. 12) to divert flood waters westward around the upper end of the basin-fill area at Chórotiro and hence southward into the topographic low of the adjacent lava field. Another dam (loc. 13) kept the floods from following the edge of the lava field to Terúpicua.

For about 1.5 km beyond Terúpicua no drainage channel existed along the edge of the lava in 1957. A very large basin-fill area at the edge of the lava near Cuezeño, to the northwest, was undrained in 1946 and was filling with sediment brought down from the northeast by Arroyo de Hurengo (Segerstrom, 1950, p. 111 and pl. 5). At some time during the decade 1947–57 the Cuezeño basin overflowed (loc. 14), and a new channel was cut along the north edge of the lava field from the place of overflow westward to Arroyo de Ticuiro, which before 1946 had also cut a channel (6 m deep in 1957) along the edge of the lava. The arroyo from Hurengo and Ticuiro joins the preeruption Arroyo Principal at locality 15.

The lava field west of Parícutin overlaps the east base of Cerro de Canicjuata. This large cinder cone stands squarely in the way of any possible arroyo whose development on the west side might be comparable to that of the arroyo on the east side of the lava field. A major drainage change occurred during the 1947 rainy season when flood waters broke over the watershed divide at the south base of Cerro de Canicjuata (Segerstrom, 1950, p. 33). Drainage which was formerly northeastward into Arroyo de Parícutin is now diverted westward into Arroyo de Corucjuata. A large new channel, 13.5 m deep in 1957, crosses the old topographic saddle where the overflow occurred (loc. 16).

STRIPPING OF THE ASH MANTLE

Areas of complete stripping of the ash from Parícutin to lay bare the underlying soil and rocks are shown on plate 1, but only at distances of 1 km or less from the edge of the lava field. At greater distances these areas are so large that their representation would obscure other details on the map. The areas shown do not include the stripped channels of arroyos. The degree of stripping increases rapidly outward from the lava field.

Not enough stripping of the ash mantle was accomplished during the decade 1947–57 to change the general aspect of the terrain near the lava field (fig. 7; compare with Segerstrom, 1950, fig. 41). This ob-

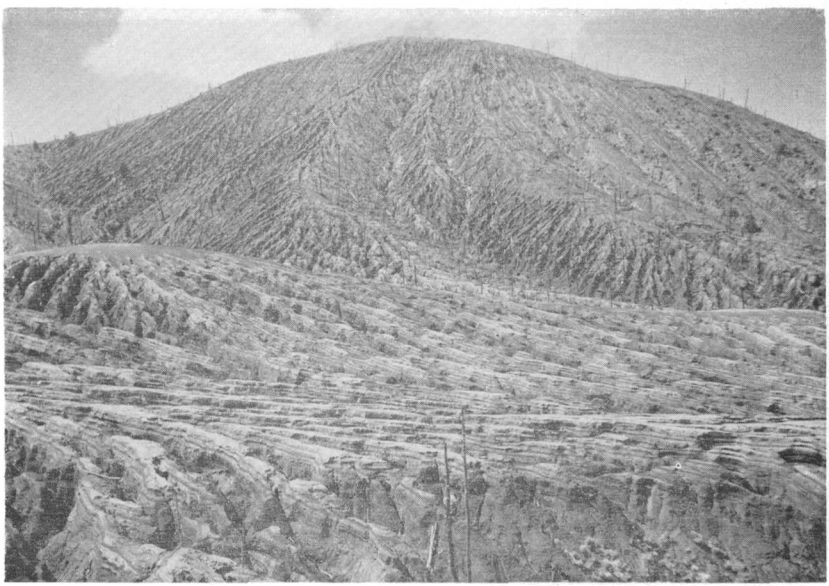

FIGURE 7.—Intense gullying of ash from Parícutin in a heavily mantled area west of the volcano, February 1957.

servation contrasts greatly with an early estimate that the ash from Parícutin would be completely removed from the region by 1950 (Arias-Portillo, 1945). Complete stripping of very small, steeply sloping areas where the mantle had been 6 m deep in 1944 was noted at Cocjarao, near the southwest edge of the lava field, as early as 1946. Complete stripping at Cocjarao was still confined in 1957 to small areas with average slopes of degrees. Large areas sloping 12 degrees or less, where the mantle had been about 60 cm thick, were still covered with ash at Capánguito, near the northeast edge of the lava field, as late as 1957. Baring of the preexisting surface in well-wooded rolling terrain southeast of the lava field, between Tzirapan and Pantzingo, was largely confined to stream channels.

By 1946, the ash from Parícutin was already completely stripped at the headwalls of old barrancas on the maturely dissected cone of Corucjuata, near the west edge of the lava field (Segerstrom, 1950, p. 127). This stripping was greatly aided by landsliding. Some of the stripped areas at Corcujuata had enlarged and coalesced by 1957. At that time, headwall stripping had laid bare small areas of preexisting soil and rocks on the old, maturely dissected cone of Canicjuata and larger areas on the nearby youthful cone of Loma Larga where there were no bared areas in 1946. A relatively large area on the maturely dissected Camiro cone and another on the less dissected Tzirapan cone, both near the southeast edge of the lava field, were bared during the decade 1947–57. Very steep slopes east of Equijuata and north of Capatzun, both within the large lava-free island in the north part of the lava field, were also stripped during the decade.

In general, the rate of stripping of the ash mantle seems to be decelerating. This rate was much faster from 1943 to 1946, during the first 3 years of Parícutin's activity, than during the next decade. As reclamation of the region by vegetation increases, the rate of ash stripping will further decrease, and the remaining mantle will become well enough stabilized, even on many sloping areas, for development of a new soil profile.

REDEPOSITION OF THE ASH BY WATER

Erosion and redeposition of the ash are so closely allied that it is impracticable to discuss them as completely separate subjects. Thus, the formation of alluvial fans and basin-fill deposits has already been discussed under drainage changes. More ample treatment of redeposition is in the earlier paper on erosion at Parícutin (Segerstrom, 1950).

The rate of deposition notably decelerated during the decade. A crater of the Curitzerán cinder cones, northwest of Angahuan and a short distance outside the area of plate 1, showed no raising of its floor

by redeposition of ash washed down from the inner slopes. In 1946 the crater lacked only 1.5 m of further ash redeposition on its floor for runoff to flow over the lowest part of the rim (Segerstrom, 1950, p. 131). In 1957 the situation was the same. Forest growth on the crater slopes had inhibited, if not stopped, erosion and redeposition at that place.

Rapid redeposition 400 m south of Cocjarao, on the southwest side of the lava field, was noted in 1946. The surface of a basin-fill deposit at that place rose 40 m in 18 months (Segerstrom, 1950, p. 114). The rise was due in part to invasion by several lava flows, each about 4 m thick. In 1957 the surface of this fill deposit had risen about 20 m more (as related to the nearby Casita de Cocjarao, whose altitude was determined in 1945). After 1946 the deposit increased enormously in area, (fig. 8) as well as 20 m in thickness, owing partly to further lava extrusion and subsequent burial of the lava by redeposited ash. Field inspection in 1957 of vertical aerial photographs taken in 1953 by the Compñía Mexicana Aerofoto showed that the boundaries of the basin-fill deposit did not appreciably change from 1953 to 1957; apparently little ash was redeposited over the area in the intervening 4 years. However, the area of the fill deposit was so great by 1953 (nearly twice as long as in 1946) that the introduction of a given volume of new material had a much smaller effect on the altitude than before.

FIGURE 8.—Paricutin and Cutzato cones from the southwest, in 1957. The lakelike area to the right is the basin-fill deposit at the edge of the lava field south of Cocjarao. From 1946 to 1953 the area quadrupled in size.

GROUND-WATER FLOW

At Terúpicua, on the north edge of the lava field, a drainage channel 2.5 m wide and 80 cm deep runs directly into a wall of lava from Parícutin (fig. 9). The lava is extremely permeable, and provides abundant underground storage space. Although percolation of water into the lava is slower at most other places, it occurs to a marked degree on all sides of the lava field. The springs of Sipicha (outside area of pl. 1) rise in a meadow near the preexisting Arroyo Principal several kilometers downstream from Huirambosta, which is at the lower end of the lava field from Parícutin. The combined flow from these springs increased from 8 m^3 per min in 1946 (Segerstrom, 1950, p. 27) to 12.6 m^3 in 1957, probably because the effectiveness of the lava field as a recharge area was greater than before. The continued ability of prehistoric lava flows from Cerro Prieto, southeast of Parícutin volcano, to absorb flood waters indicates that the lava field from Parícutin will not lose its effectiveness as an aquifer for many centuries.

A well, the Ojo de Pomacuarán, supplied San Juan Viejo, the partly repopulated and rebuilt town of San Juan Parangaricutiro, in

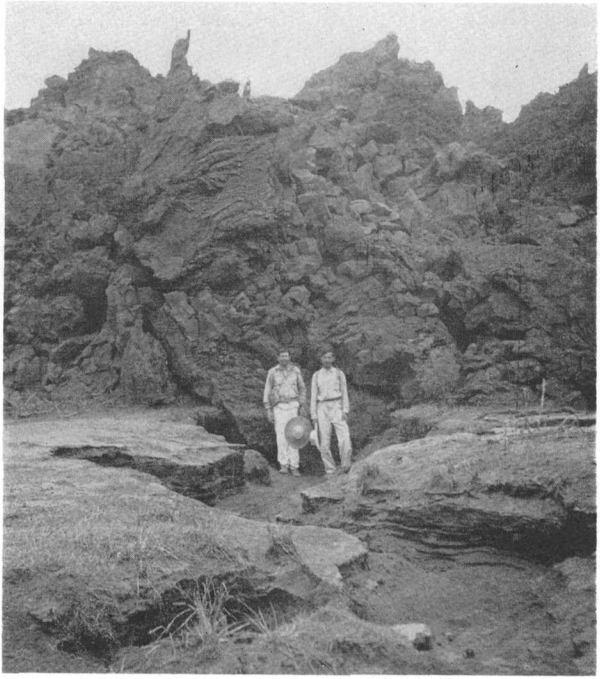

FIGURE 9.—Drainage channel at Terúpicua where storm waters enter the north edge of the lava field from Parícutin.

1957. It was said that the well of Pomacuarán, about 2 km north of the town, had three times as much water in 1957 as it had before it dried up in 1943. Reports of increased flow of other springs in the region were numerous in 1957.

On the other hand, an old spring near the north base of Cerro de Curupichu that had been buried by ash in 1943 and exposed by erosion after 1946 was dry in 1957. The Nuréndiro spring, near the south edge of the lava field, was flowing in 1952, but in 1957 it was buried under about 15 m of redeposited ash.

REVEGETATION ON ASH AND LAVA

About three-fourths of the area around the volcano, including the hilltops and the arroyo bottoms, was forested with pines and broad-leaved trees before the eruption. The remaining fourth of the area consisted of clearings and low-gradient bottom lands (Segerstrom, 1950, p. 14), which were subsequently covered in large part by lava. The forest was destroyed by heavy ash fall through an area of about 40 sq km to the south and west of the lava field, but it remained relatively intact to the north, east, and southeast.

In 1957, small pine seedlings were growing vigorously in the ash not only where the forest remained intact, but at many places where it had been destroyed. At the edge of Llano de Teruto, where about 0.5 m of ash was aerially deposited, 67 pine seedlings 3–4 cm high were counted in 1957 on a square surface measuring 75 by 75 cm. These plants had not taken root in barren ash, but rather in a layer 2–3 cm thick formed on top of the ash by matted and partly decomposed pine needles that had fallen from the parent trees.

Grass also was growing in the fallen pine needles and under broad-leaved trees in a similar matted layer that was 6 or 7 cm deep in places. Where the trees were scattered, as in some places north of the lava field, they provided sustenance to islands of grass surrounded by areas of barren ash (fig. 10).

Southwest and west of the volcano, where the trees had been killed by heavy ash fall, the stumps and fallen trunks have rotted enough to give root to new plants. The big basin-fill deposit south of Cocjarao was richly mixed in places with acorns, dead branches, and preexisting soil; it could support much plant life if it were not repeatedly flooded during the rainy season.

Lichens and two varieties of larger plants, a broad-leaved and a narrow-leaved one, were found on the crater rim of Parícutin volcano in February 1957. The plants were growing in coarse pyroclastic material moistened by warm acidic water vapor that was emerging from fissures. Specimens of the two larger plants were sent to W. A.

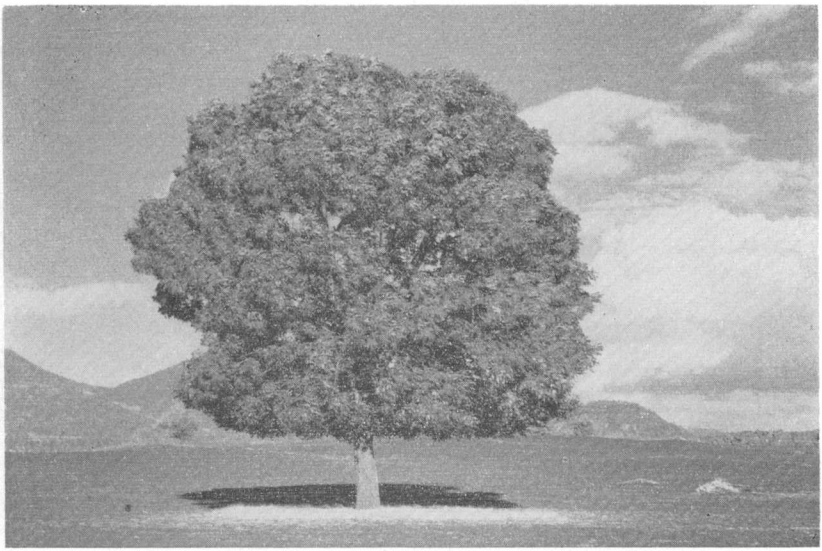

FIGURE 10.—Island of grass (light color under tree) surrounded by barren ash, 2.5 km west of San Juan Parangaricutiro (now San Juan Viego).

Eggler, at Tulane University, for identification; Mr. Eggler reported: "Neither kind of plant was in the reproductive stage and identification was difficult. One is almost certainly a species of *Gnaphalium* and the other is believed to be an *Eryngium*. It is interesting that these two seed plants would get started in this difficult situation before mosses and ferns" (Eggler, 1959, p. 273).

A brackenlike fern known locally as pescadillo was growing at many places on the Parícutin lava field in 1957.

Practically everywhere outside the area of plate 1, except immediately to the west, agriculture was conducted in 1957 much the same as before the eruption. Near the lava field, however, crops were raised only on basin-fill deposits, where strong admixtures of old soil and vegetal debris have made the ground arable. Corn was planted and harvested in 1957 on most of the areas of basin-fill deposits at the northeast and north edges of the lava field, which were protected by the drainage ditches and diversion dams. The yields were low at first, because of flooding, but in 1957 they were about average for the Mexican highland.

REPOPULATION

Three communities were active in 1957 in the area that had been devastated by the eruption and abandoned by the people of the region during 1943 and 1944. Pantzingo, 5.5 km east of the volcano, had a population of 60 persons in 1958, 10 of whom moved there during Octo-

ber 1956. The livelihood of people living at Pantzingo was chiefly from collecting pine sap for the manufacture of turpentine. San Juan Viejo, resettled in the ruins of San Juan Parangaricutiro, 4.5 km north of the volcano, had a population of 4 families totaling 19 persons in 1957. The people of San Juan Viejo cultivated the basin-fill deposit north of town. In 1951, 8 families moved back to La Escondida, an old settlement 5 km south of the volcano, where there had been a logging industry. In 1957 there was no logging at La Escondida, but the people were eking out a living by cultivating corn in nearby sloping fields that had been covered with about 35 cm of ash from Parícutin. There was talk at that time of moving the population of La Escondida to Capilla de San Isidro, a new townsite 3 or 4 km farther south, where there was less ash.

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