

GROOVED LAVA IN THE CROSS-SECTION OF BIG CRATERS, IDAHO.

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ABSTRACT. The surfaces of many thin flows interbedded with the pyroclastic material of Big Craters, Craters of the Moon National Monument, Idaho, are grooved, striated, pock-marked, and covered with shark's-tooth projections.

These features in most cases resulted from the falling or rolling of blocks, bombs, and lapilli onto the surfaces of molten flows. They indicate that there were periods during the growth of the cone, when there was simultaneous extrusion of lava and pyroclastic material.

However, one outcrop of grooved lava was found in which the grooves probably resulted from the sliding of solid material onto the soft surface of a flow.

INTRODUCTION.

At several places grooved and pock-marked lava was found in the cross-section exposed on the inner wall of Big Craters, Craters of the Moon National Monument, Idaho. Some of these grooves have been formed by the bombardment of molten flows by blocks, bombs, and lapilli. This mechanism for the formation of grooved lava has not been previously described, and, as grooved lava has never been described from the cross-section, it is thought that these features merit description. The field study was made in the summer of 1938 during a brief visit to the Craters of the Moon National Monument. The writers gratefully acknowledge the cooperation of the officials of the Monument and the field assistance of Mr. Charles E. Baker of Tufts College. Thanks are also due to Prof. Kirk Bryan of Harvard University for help in the preparation of the manuscript.

DESCRIPTION OF BIG CRATERS.

Big Craters¹ is a group of three craters located in the Craters of the Moon National Monument, Idaho (Fig. 1).

The cone is 300 feet high and the largest and deepest crater is about 100 feet deep. As it is barren, it is obviously of very recent date (Plate I, Fig. 1). It is composed chiefly of uncon-

¹Stearns, H. T. "Craters of the Moon National Monument Idaho," The Caxton Printers, Ltd., Caldwell, Idaho, p. 13, 1936. See also Stearns, H. T., Crandall, Lynn, and Steward, W. G.: "Geology and Ground-Water Resources of the Snake River Plain in Southeastern Idaho," U.S.G.S. Water-Supply Paper 774, pp. 94-100, 1938.

solidated, loosely packed cinders with occasional interbedded basaltic flows ranging from a few inches to several feet in thickness. The flows have been exposed in cross-section on the inner

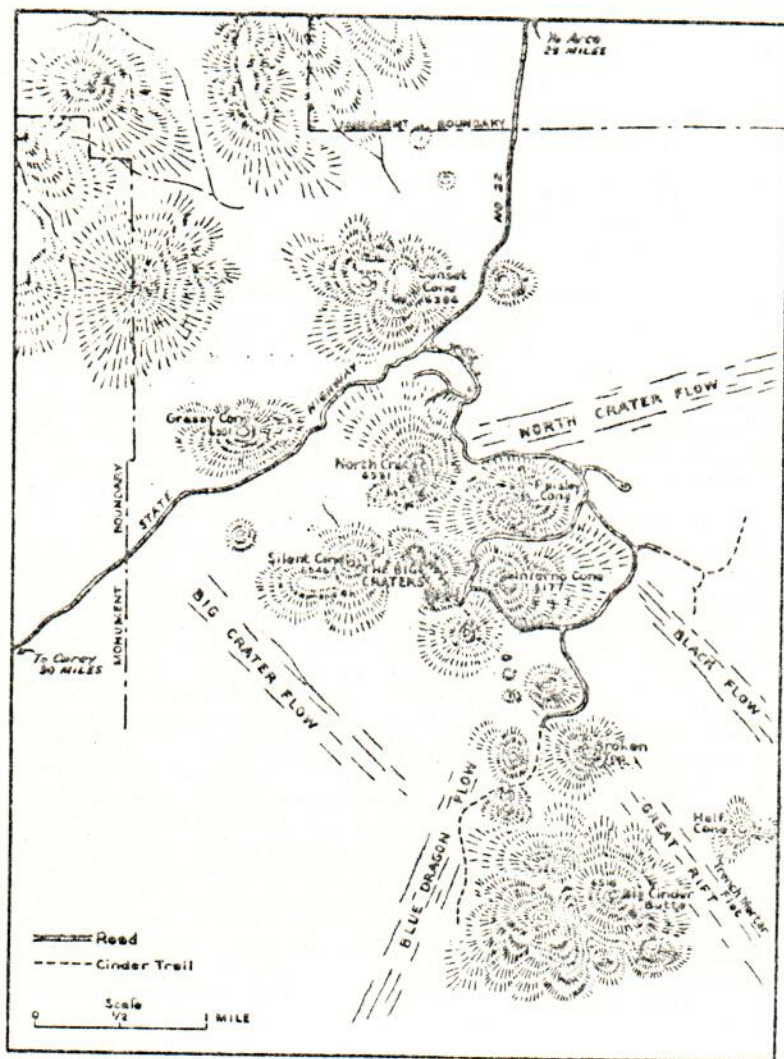


Fig. 1. Road map of the northwest portion of Craters of the Moon National Monument, showing the position of Big Craters with respect to some of the other features of the Monument.

wall of the crater by crater enlargement; they have been exposed in plan by natural and artificial removal of the loose cinders which covered them.

MOLTEN LAVA GROOVED BY THE IMPACT OF PYROCLASTICS.

Description.

Grooves were found in several places on the surfaces of flows exposed in cliffs on the west side of the southern part of the inner crater wall. These thin, narrow, vesicular flows which ran down the slope of the cone dip outward from the crater at angles up to 25° (Fig. 2).

The grooved lava stands out in sharp contrast to the non-grooved surfaces. The grooves vary from the finest scratches to furrows three and four inches deep. They are subparallel and run very nearly up and down the original slope of the flows. Many die out, with others taking their place. A bench about four feet deep and eight feet wide, which is covered with grooves, is shown in Plate I, Fig. 2, and Plate II, Fig. 1. The bench was exposed by removal of the more or less loosely packed cinders and bombs that covered it. The grooves were traced for about four feet across the bench and were observed to pass under the cinders. In many places individual grooves and furrows stop suddenly at fragments imbedded in the flow. In each case it was found that there is a perfect correspondence between the shape and details of the furrows and those of the fragment against which they terminate. The furrows are always on the up-slope side of the fragments. On the down-slope side the flow is usually elevated into a bulge peripheral to the fragment as if it had been plowed or pushed up by the fragment (Fig. 2).

The grooved surfaces are in places covered with pockmarks a few inches in diameter and an inch or two in depth. In some of these pockmarks cinders were found which fitted them perfectly (Plate II, Fig. 1). These pockmarks are obviously the result of cinders falling on a flow that was still liquid.

The grooved surfaces are also covered in places with shark's-tooth projections.² These projections point up the dip slope and may stand as much as one inch above the grooved surface.

Origin.

These grooves and shark's-tooth projections could not have been made in solid and brittle lava. They were formed when

² Nichols, R. L.: "Surficial Banding and Shark's-Tooth Projections in the Cracks of Basaltic Lava," *This Journal*, Vol. 237, pp. 191-192, 1939. See also Stearns, H. T.: "The Keaiwa or 1823 Flow from Kilauea Volcano, Hawaii," *Jour. Geol.*, Vol. 34, p. 842, 1926.

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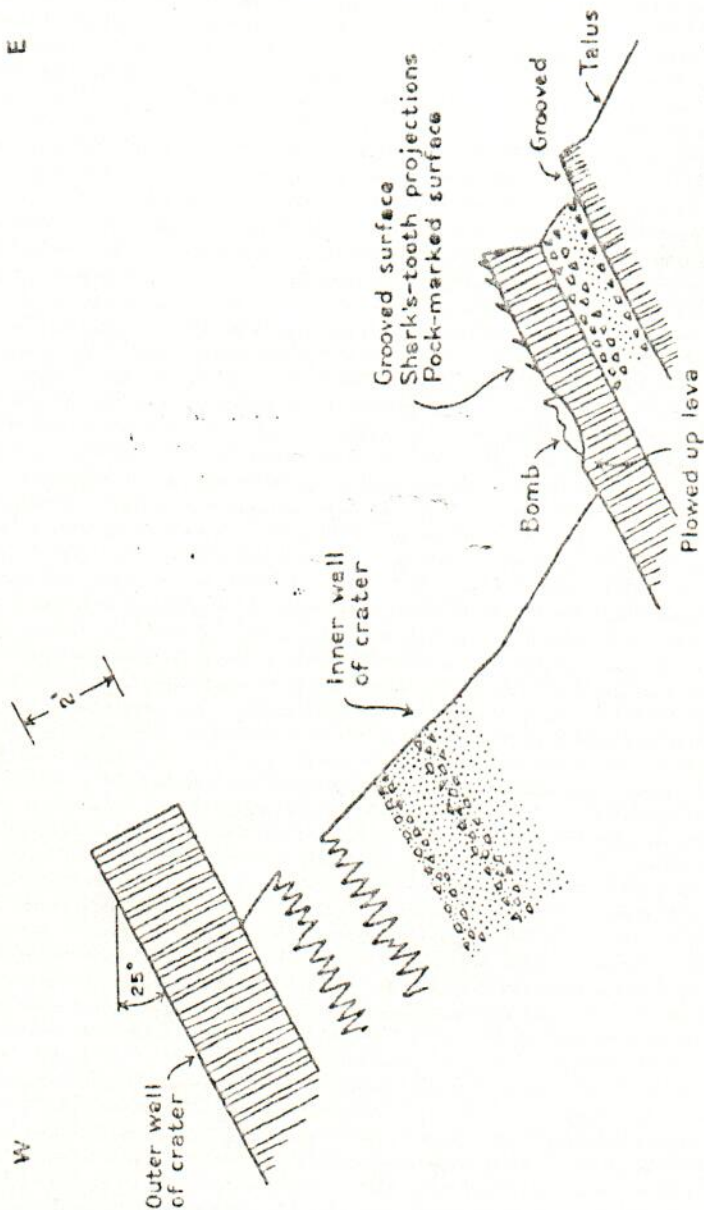


Fig. 2. A diagrammatic cross-section of the area shown in Plate I, Fig. 2, and Plate II, Fig. 1. This section shows two flows, the surfaces of which are grooved, pock-marked, and covered with shark's-tooth projections.

solid material scraped and plowed across the surfaces of still liquid flows. That they were formed by many small fragments rather than by a single fragment is proved by the following facts: (1) The area of the grooved surface, shown in Plate I, Fig. 2, and Plate II, Fig. 1, is so great that the impact of several fragments would be necessary to form these grooves. (2) The grooves are subparallel and often converge. This would be difficult to explain in terms of one fragment. (3) Individual furrows often terminate against individual fragments, the impacts of which were obviously responsible for the furrows. (4) The existence of several widely separated grooved surfaces obviously demands at least one fragment for the formation of each grooved surface.

The fragments that formed the grooves and shark's-tooth projections were pyroclastics ejected from the vent of Big Craters as is indicated by the following facts: (1) The grooved surfaces are buried by pyroclastics. (2) As the pockmarks resulted from the impact of pyroclastic fragments on the soft flows, it seems reasonable to conclude that the grooves were formed by the same mechanism. (3) There is a perfect correspondence between the size and shape of the furrows and the size and shape of the pyroclastic fragments against which some of them terminate. When the angle of incidence of the fragments onto the lava was high, pockmarks were formed; when, however, the angle was low, grooves were formed. As these fragments are now found in basins on the flows, they apparently depressed the flows isostatically after coming to rest (Fig. 2). These pyroclastics were either ejected directly from the vent onto the soft flows, or fell on the outer slope of the cone and then rolled, bounced, and ricocheted down onto them.

If the pyroclastics were projected from the vent directly onto the flows, the grooves would be subparallel, as the fragments coming from different parts of the vent would have slightly different paths. The angle between grooves is a function of the length of the vent at the time of their formation, the distance of the grooved surface from the vent, and the angle between the long axis of the vent and the paths of the pyroclastics. The smaller the vent, the greater the distance of the grooved surface from the vent, and the more nearly parallel the long axis of the vent to the paths of the fragments, the smaller the angle between the grooves. The rotation and shape of the fragments would also be factors controlling the angle between

grooves. If, on the other hand, the fragments rolled down onto the flows from above, it is obvious that the grooves would also be subparallel.

The fragments that formed the grooves shown in Plate I, Fig. 2, and Plate II, Fig. 1, moved from left to right, that is, down the slope of the flow, because (1) The shark's-tooth projections point from right to left, indicating that the fragments moved from left to right.⁸ (2) The grooves are to the left of the fragments against which they terminate. (3) The lava pushed up in front of the pyroclastics is always on the right-hand side. (4) The length of individual grooves is too great to have been formed by fragments moving up the 25° slope of the flow. This would have been the case if the fragments had moved from right to left. (5) At the present time, the crater is to the left of the grooved surface and the structure of the cone indicates that this was the case when the grooves were formed. As the fragments which formed the grooves were ejected from the crater, it is obvious that they must have moved from left to right.

As the flow was extruded from a vent to the left of the grooved surface (indicated by the attitude of the flow) and as the pyroclastics that formed the grooves also came from the left, obviously they were both extruded from the same vent.

This type of grooved lava indicates that pyroclastics and lava flows were extruded, practically simultaneously, from the same vent during many stages in the growth of this cone. The simultaneous extrusion of pyroclastics and lava flows from the same vent has, of course, been observed many times in the eruptions of active volcanoes.

SEQUENCE OF EVENTS.

The sequence of events for this part of the cone is (Fig. 2):

1. Extrusion of a flow.
2. Flow grooved by the impact of pyroclastic fragments.
(Time interval involved in stages 1 and 2 is small.)
3. Deposition of additional pyroclastic material.
4. Extrusion of a flow.
5. Flow grooved, pock-marked, and covered with shark's-tooth projections by the impact of pyroclastic fragments. (Time interval involved in stages 4 and 5 is small.)

⁸Op. cit., pp. 191-192.

BIG CRATERS, CRATERS OF MOON NAT. MON., IDAHO
face of Inner Wall of Crater

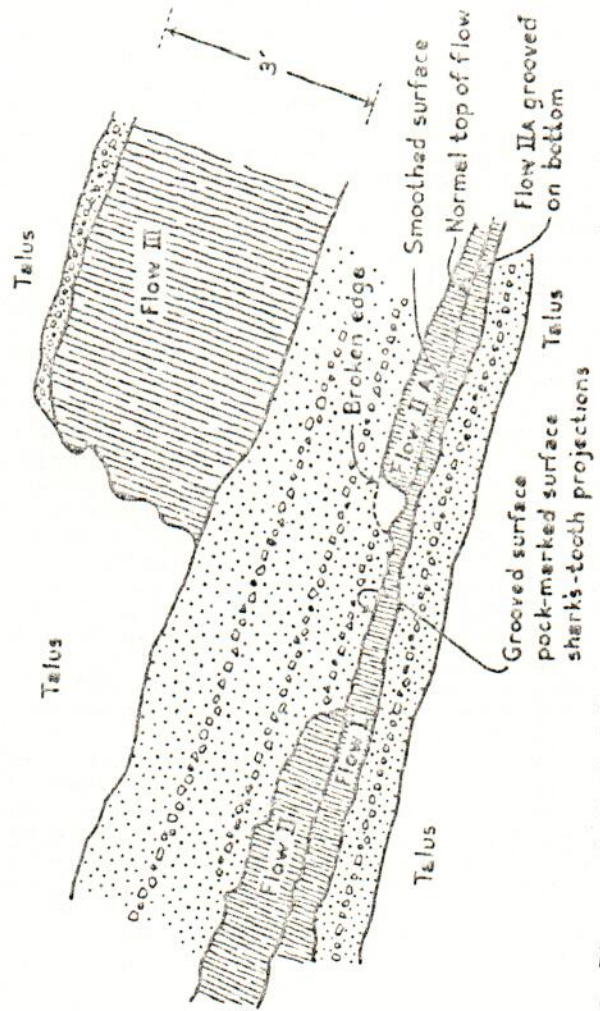


Fig. 8. Diagrammatic sketch of the inner wall of the crater where the grooved lava was found.

6. Deposition of additional pyroclastics.
7. Extrusion of a flow.
8. Enlargement of crater exposing the present cross-section.

LAVA GROOVED BY SLIDING FRAGMENTS.

Description.

Grooves were found, on the east side of the southern end of the inner crater wall, which had not been formed by the impact of pyroclastics. They were found on the bench shown in Plate II, Fig. 2. The bench is about ten feet long, at most three feet wide, and is formed by a flow about six inches thick. There are three kinds of surfaces on the bench: a grooved surface, a smoothed surface, and a vesicular surface such as is common on fresh basaltic flows (Plate III, Fig. 1). These grooves are finer in detail and shallower than those formed by the impact of pyroclastics. They are parallel and extend across the full width of the bench. Superimposed upon these grooves, and in part destroying them, are a few shorter, rougher grooves, shark's-tooth projections, and pockmarks, which were formed by falling pyroclastic fragments. The best grooves were found on a separate block (Plate III, Fig. 2) that had broken from the bench. The grooves dip into the crater wall at an angle of about 7° , although the surface of the flow itself has a dip of about 25° . The grooved flow is buried by thin flows and pyroclastic material (Fig. 3).

Origin.

The marked parallelism of these grooves suggests that they were formed by one fragment. The area of the grooved surface seems to be too great to have been formed by any fragment hurled from the vent. The shallow depth of the grooves suggests that they were not formed by a fragment that fell or rolled onto the flow. Furthermore they resemble grooves that Nichols⁴ has shown were formed by the scraping of fragments across soft, viscous lava. In view of this it seems likely that these grooves can best be explained as formed by a single large fragment that slid across the flow while the flow was still soft. In general one would expect grooves formed in this way to be parallel with the slope of the flow. That this is not the case

⁴ Nichols, R. L.: "Grooved Lava," Jour. Geol., Vol. 43, pp. 603-614, 1935.

at the present time may be due either to an oblique motion of the sliding fragment with respect to the slope of the flow or to a later change in the attitude of the flow. The vesicular surface is a portion of the flow untouched by the sliding fragment, and the smoothed surface an area where the sliding fragment passed over the soft lava but did not groove it. That the flow was smoothed rather than grooved may have been due to the physical characteristics of the flow or to the nature of the undersurface of the fragment.

BIG CRATERS, CRATERS OF MOON NAT. MON., IDAHO

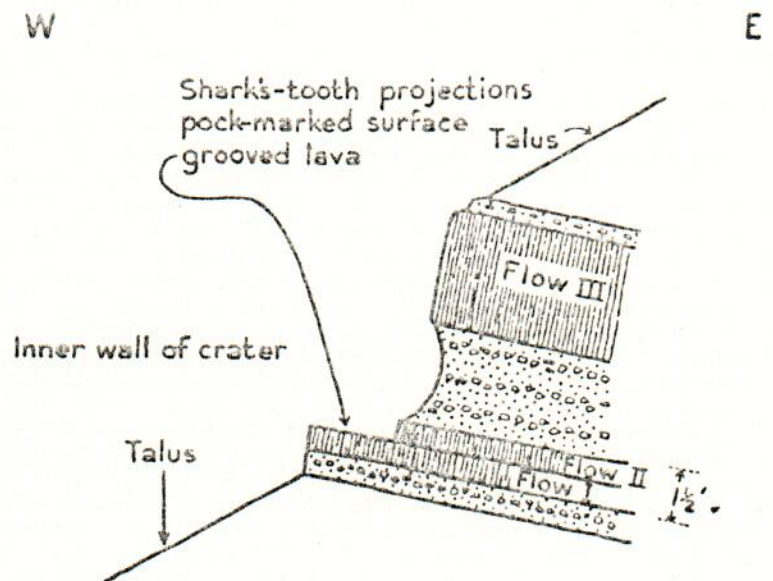


Fig. 4. Diagrammatic cross-section of the inner crater wall where the grooved lava formed by a sliding fragment was found.

GROOVES ON THE BOTTOM OF FLOW II A.

Flow I and Flow II A (Fig. 3) are similar in size, thickness, and physical characteristics. They are in close contact in most places, although here and there small cavities are found between them. The bottom of Flow II A is also in part marked by grooves. These grooves occur on that part of the undersurface of Flow II A which forms the roof of a small cavity imme-

diately down slope from a rough protuberance on the surface of Flow I. They were formed apparently when Flow II A failed to close in around the down slope side of the rough protuberance after having passed over it.

These grooves dip away from the crater at about 7°. Since grooves formed by this mechanism would normally be more or less parallel to the dip slope of a flow, the present 25° dip of the flow is probably the result of movement that followed the formation of these grooves.

SEQUENCE OF EVENTS.

The sequence of events for this part of the cone is (Figs. 3 and 4):

1. Deposition of pyroclastics.
2. Extrusion of Flow I.
3. While Flow I was still liquid it was grooved and smoothed by a large block that slid across its surface.
4. Formation of pockmarks and small grooves by the impact of pyroclastic fragments. (The time interval involved in stages 2, 3 and 4 must have been small as the flow is thin and therefore cooled rapidly.)
5. Extrusion of Flow II and II A.
6. Deposition of pyroclastics.
7. Extrusion of Flow III.
8. Deposition of pyroclastics which built up the cone to about its present height.
9. Enlargement of crater, exposing the present cross-section.

Flow II A was probably displaced some time following its extrusion. This movement may have been responsible for the enlargement of the crater. That the sequences of events for the west and east sides of the southern part of the crater are different is of course what would be expected.