

SURFICIAL BANDING AND SHARK'S-TOOTH PROJECTIONS IN THE CRACKS OF BASALTIC LAVA.

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ABSTRACT.

The walls of many of the vertical cracks in the top of the McCartys flow, New Mexico, are veneered with bands of glassy lava alternating with bands of duller less glassy lava. The veneer is not more than an eighth of an inch thick. The bands are parallel to the surface of the flow and are due to refusions of the walls by the hot gases emitted from below during the progressive deepening of the cracks.

Associated with these bands are triangular or shark's-tooth projections on the walls of the cracks. These ridges and points are formed by the scraping of the walls of the cracks against one another at a time when the lava is still stiffly viscous.

Cracks whose walls show these features were formed before cracks in which these features are absent but which commonly show good columnar jointing.

INTRODUCTION.

In a detailed study of the vertical cracks in the upper part of the McCartys basalt flow¹, in Valencia County, New Mexico, banded lava and shark's-tooth projections on lava were found. This banded lava has not heretofore been described. Both of these features have significance with regard to the age of the cracks in which they are found, and moreover, the state of consolidation of the crust and of the underlying lava at the time of formation of the cracks is implied in the origin of these minor features. These criteria thus deserve description and analysis.

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DESCRIPTION OF BANDED LAVA.

Many of the medial cracks of the pressure ridges, and other large vertical cracks in the crust of the McCartys flow, and presumably in other basalt flows, have a surficial layer or veneer on their walls. The veneer consists of bands of dark and less dark material that extend in from the faces of the cracks not more than an eighth of an inch and which are more or less parallel to the surface of the flow. The bands are one inch to four inches wide and scores of feet in length. This banding is shown in Plate I, Figs. 1 and 2. The bands consist of glassy

¹ Nichols, R. L.: "Quarternary Geology of the San José Valley, New Mexico," Geol. Soc. Amer. Proc., p. 453 (abst.), 1933.



Fig. 1

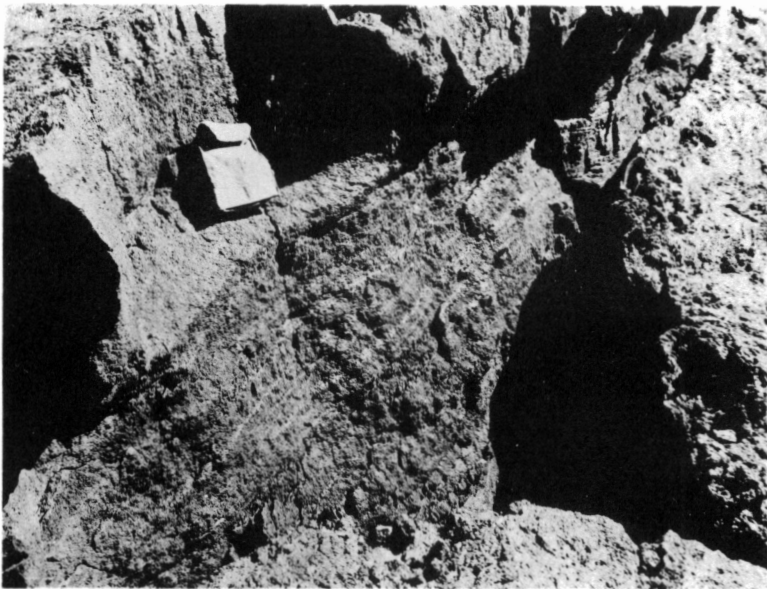


Fig. 2

Fig. 1. Banded lava in the medial crack of a pressure ridge on the McCarty's flow. The bands can best be seen above and to the right of the rod. The bands should not be confused with the ropes to the right and left of the rod.

Fig. 2. Alternate bands of glassy and less glassy lava on the walls of a large crack in the McCarty's flow.

lava alternating with bands of duller, less glassy lava, the whole forming a veneer on the crystalline basalt that normally forms the walls of the cracks. Usually the glass is black but may also be red, purple, bluish black, and green.

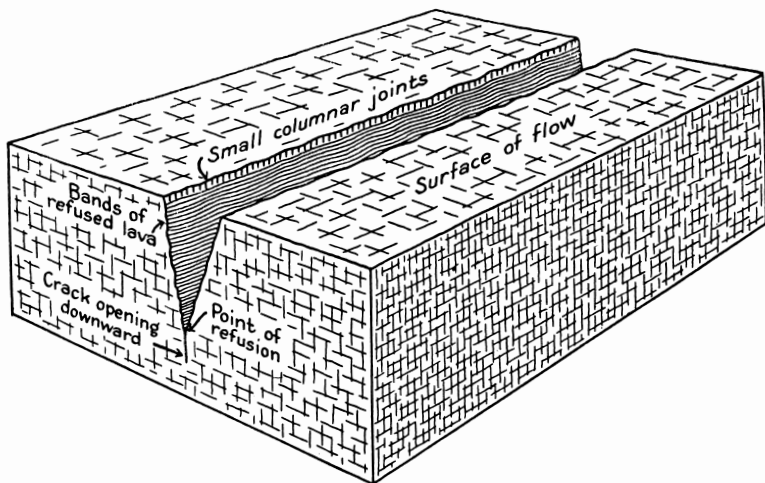


Fig. 1. Diagrammatic sketch showing banded lava.

ORIGIN OF BANDED LAVA.

If a crack, in the crust of a slowly cooling flow, extends down to liquid lava, it is possible under certain conditions for the wall rock at the bottom of the crack to be sprayed with liquid lava thrown upward from below. If the coating is thin, it will cool rapidly, forming a band of glass veneering the crystalline basalt. Progressive thickening of the crust together with a deepening of the crack followed by further spraying will result in the formation of another band. In this way a series of glassy bands might be formed. However, the thinness of the veneer, the absence of drip features, and the regularity of the bands strongly suggest that this is not the explanation for this type of banded lava.

One of the most characteristic processes in the cooling of a flow is the emission of gas, which is often produced in great quantities. The emission of this gas, in the case of large flows, is often continued for months after the extrusion of the lava. Day and Shepherd² have convincingly demonstrated in their

² Day, Arthur L. and Shepherd, E. S.: "Water and Volcanic Activity," Bull. Geol. Soc. Am., Vol. 24, pp. 573-606, 1913. See also Jaggar, T. A.: "Thermal Gradient of Kilauea Lava Lake," Jour. Wash. Acad. Sci., Vol. 7, pp. 397-405, 1917.

studies at Kilauea that some of these initially very hot gases can be oxidized, can react with one another, and may therefore have temperatures in excess of that of the lava from which they are emitted.

The walls of a crack formed in the upper crust of a slowly cooling flow will be composed in the main of crystalline basalt. If these hot gases are emitted from below into such a crack, it seems reasonable to suppose that they might melt a thin film of the crystalline basalt. This film, because of rapid cooling, would form a veneer of glass coating the crystalline basalt of the wall. The melting would in all probability be localized near the bottom of the crack where the volcanic gases first came in contact with the atmosphere. In this way a band of glassy lava would be formed near the base of the crack. The alternation of bands of less glassy and more glassy lava described in the present paper would be due, under this hypothesis, either to an unequal rate of emission of gases or to an unequal downward propagation of the crack. Probably both the rate of downward propagation of the cracks and the rate of emission of gas varied.

This banding would also be formed if the flow were composed of layers of vesicular lava alternating with layers of less vesicular lava. The vesicular lava would melt more easily than the non-vesicular and bands of glassy lava alternating with bands of less glassy lava would be formed. However, no evidence has been found for the existence of such a variation in the vesicularity of the basalt of the McCartys flow.

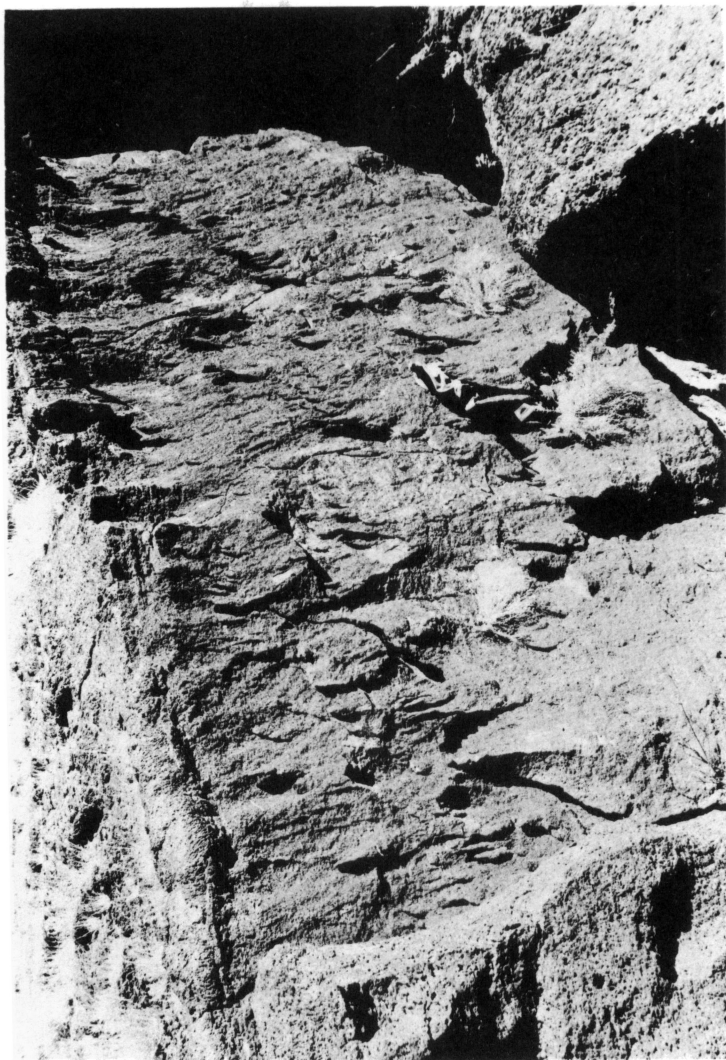
Diller³ has described the refusion of fragments of basaltic lava found in pockets of scoria near the surface of a lava flow. He writes: "It is believed that the hot gases escaping from the lava-flow into the pockets met the gases of the air and reacted so as to become hot enough to melt the adjacent lava." Stearns⁴ has suggested that certain stalactites and stalagmites found in lava tubes of the Hawaiian Islands are probably formed by a secondary reheating process due to the oxidation of combustible gases emitted from the flow.

As incipient fusion of crystalline basalt begins at approximately 1050°C.,⁵ it is evident that gases at this and greater

³ Diller, J. S.: "Surface Fusion of Lava," *Bull. Geol. Soc. Am.*, Vol. 33, pp. 142-144, 1922.

⁴ Stearns, H. T., and Clark, W. O.: "Geology and Water Resources of the Kau District, Hawaii," *U. S. Geol. Surv. Water-Supply Paper* 616, pp. 113-114, 1930. See also Jaggar, T. A., *Bull. Haw. Vol. Obs.*, Vol. 9, p. 139, 1921.

⁵ Daly, R. A.: "Igneous Rocks and the Depths of the Earth," McGraw-Hill Book Company, Inc., p. 66, 1933.



Shark's-tooth projections on the wall of a large crack in the McCarty's flow.

temperatures, if in sufficient quantities, might re-fuse the lava and form these bands. However, Professor Larsen of Harvard University thinks it likely that under favorable conditions gases with temperatures as low as that at which any part of the lava was liquid might also have formed these bands. Jaggar⁶ found that the liquid lava in the lava pool of Halemaumau may be as low as 850°C. As the McCartys basalt is similar petrographically to the Hawaiian basalts, it appears that the temperature of the gases responsible for these bands may be as low as 850°C.

SHARK'S-TOOTH PROJECTIONS.

The walls of many of the cracks that show banded lava are also covered with triangular ridges and points that project out

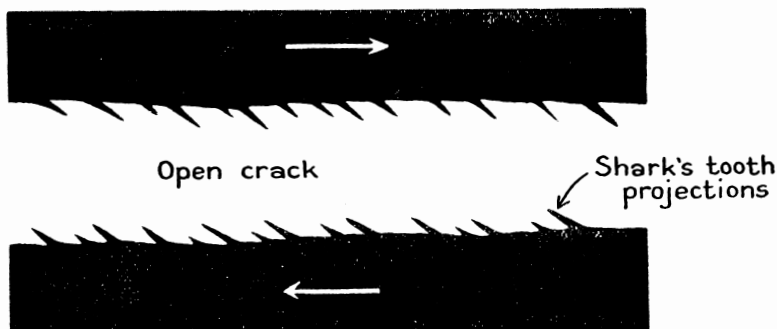


Fig. 2. A diagrammatic sketch showing the shark's-tooth projections on the walls of a crack. The arrows indicate relative motion of the walls.

into the cracks. Stearns⁷ has called them "shark teeth" slickensides and Daly⁸ calls them shark's-tooth projections. These ridges and points make, in many cases, high angles with the wall rock. They may be as much as a foot in length, and are well shown in Plate II. The projections on one wall of the crack always point in the opposite direction from those on the other wall, as is illustrated in figure 2. The projections along one part of a wall will always point in the same direction; farther on they may all point in the opposite direction; however, when they change direction on one wall they always change

⁶ Jaggar, T. A.: "Thermal Gradient of Kilauea Lava Lake," Jour. Wash. Acad. Sci., Vol. 7, p. 398, 1917.

⁷ Stearns, H. T.: "The Keaiwa or 1823 Flow from Kilauea Volcano, Hawaii," Jour. Geol., Vol. 34, p. 343, 1926.

⁸ Daly, R. A.: "The Geology of Ascension Island," Proc. Amer. Acad. Arts Sci., Vol. 60, No. 1, p. 21, 1925.

direction on the other. All the projections seen in Plate II are pointing in the same direction.

Usually those cracks whose walls are banded and covered with shark's-tooth projections do not show any columnar jointing. However, some do show small columnar joints that extend down into the flow for a distance as great as three feet. Below this columnar crust is the zone in which the walls of the cracks are banded and covered with shark's-tooth projections. This columnar jointing indicates that a crust of measurable thickness, sufficiently consolidated to be capable of shrinking, was developed. Thereafter the movements were initiated that were responsible for the formation of the cracks and also for the shark's-tooth projections.

Shark's-tooth projections are formed by the scraping of the walls of the cracks against one another when the lava is more or less viscous. However, as none of these projections has any features that indicate flowage after formation, the lava must have been so stiff that after the shark's tooth projections were formed no further flowage could occur. The orientation of the shark's-teeth in the McCartys flow indicates that they were formed by motion which in the main was lateral. That the projections on one part of a wall may be pointing in a given direction, whereas farther along on the same wall they may all point in the opposite direction may be explained as follows. If the walls of a crack scrape past one another after it is formed, shark's-tooth projections will form if the lava in the walls is of the right degree of viscosity. If this crack is then differentially widened and the walls are scraped past one another, in the opposite direction from the first movement, the earlier formed projections may be preserved where the crack is wide and destroyed where it is narrow. Another system of projections oriented in the opposite direction will take the place of those destroyed. As the internal movements in a lava flow may be long continued and in various directions, and as the crust may be broken by cracks that are crooked as well as straight, other mechanisms for the production of the two systems of projections may be imagined. The motions of the stiffened crust that are responsible for these projections are undoubtedly related to the movements of the still liquid lava at depth.

DIFFERENTIATION OF EARLIER FORMED CRACKS FROM THOSE FORMED LATER.

The presence or absence of banded lava and shark's-tooth projections can be used to date the formation of the cracks in the flow. In a limited area of the McCartys flow the cracks

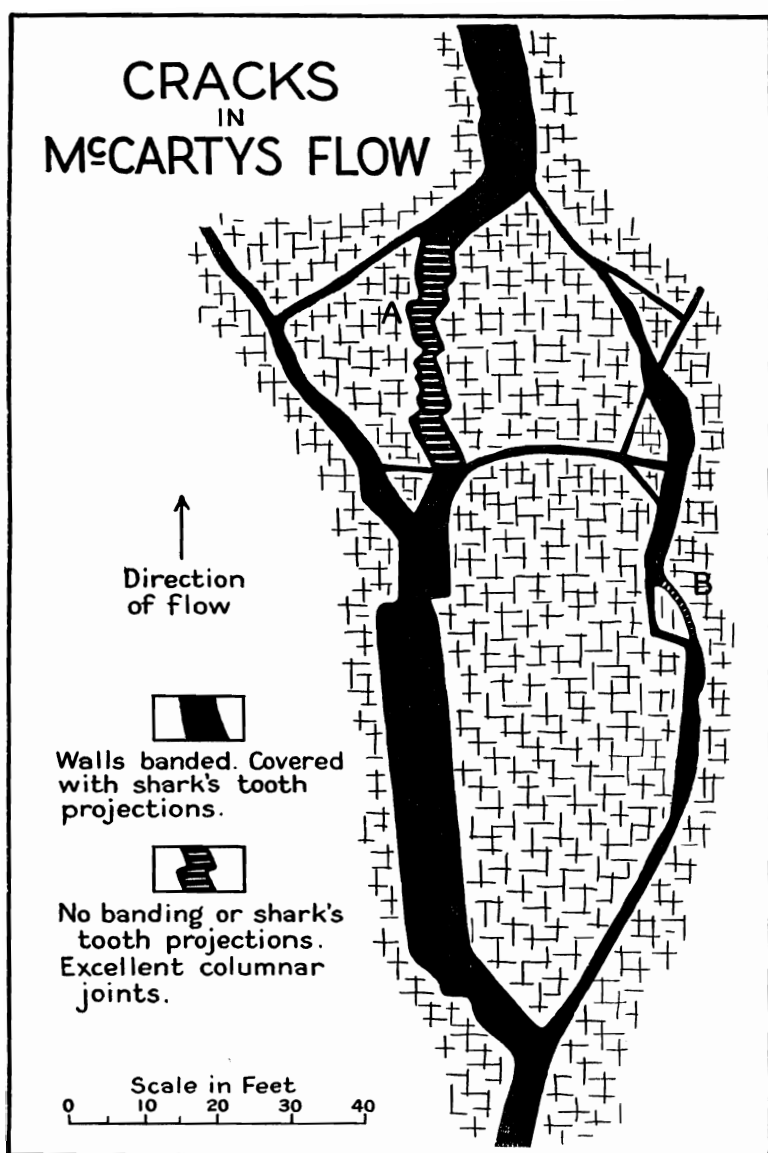


Fig. 3. A map showing the cracks and joints on a limited area of the McCartys flow.

were mapped. Those cracks which are not outlined by horizontal lines on figure 3 contain banded lava and shark's-tooth projections, and the lava is commonly red. As is indicated above, these cracks were formed when hot gases were still issuing from the interior of the flow, while the lava was still viscous, and when the crust was being differentially moved because of the movement of the liquid lava. They were formed, therefore, relatively early in the thermal history of the flow. However, the walls of the other cracks shown in figure 3 do not contain banded lava and shark's-tooth projections, nor, as a rule, are their walls red. However, they invariably show good columnar jointing. It seems likely that these cracks were formed at a time subsequent to the formation of those whose walls are banded. They are the result, not of differential movement caused by the underlying liquid lava, but rather of contraction due to the cooling. The younger cracks are located at points A and B on figure 3, for here, because of the alignment of the earlier formed cracks, a natural weakness existed.

SIGNIFICANCE OF BANDED LAVA AND
SHARK'S-TOOTH PROJECTIONS.

The presence of this type of banded lava in a flow may be taken as proof that hot gases were emitted during the cooling process. The presence of shark's-tooth projections on the walls of a crack indicate differential movement within the flow, which resulted in the scraping of one wall against another at a time when the lava was still stiffly viscous. Cracks whose walls are banded and covered with shark's-tooth projections are formed earlier than cracks that do not contain these features.

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