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ART. XXXVII.—*An Instance of the Action of the Ice-sheet upon Slender Projecting Rock Masses*;* by WILLIAM HERBERT HOBBS. (With Plate IX.)

THE present paper will discuss what seems clearly to be a case of degradational action by the ice mantle exerting its pressure in a lateral direction against steep and slender masses of projecting rock. The conditions are in some respects peculiar to the locality, which lies in an island-like area of Newark traps and arkoses within protecting walls of the crystalline schists—the Pomperaug Valley area of Connecticut. The preservation here of the Newark rocks from erosion, which has elsewhere so generally removed them, is a direct result of their deformation by jointing and their depression in the form of a composite crustal block along the marginal joint planes as fault walls.† This depression has been irregular in so far as the blocks of the smaller orders of magnitude within the larger composite block have been depressed by different amounts so as to produce a mosaic of small prismatic blocks. The present positions of basalt and arkose within the area are also dependent upon the high position of the main basalt flow in the local Newark series, and upon the low easterly dip (±20°) of the beds and flows previous to their dislocation. Their positions are further affected by the fact that the displacement by faulting was distributive largely within a marginal zone. As a result of all these conditions the dense resistant basalt now occupies the central portion of the depressed area and is bordered by the softer shales and arkoses.

Could the area have been visited subsequent to its deformation by faulting but previous to its degradation through the

* Read before the Wisconsin Academy of Sciences, Arts, and Letters, at Milwaukee, December, 1901.

† The Newark System of the Pomperaug Valley. 21st Ann. Rept. U. S. Geol. Survey, Pt. III, pp. 1-160.

agencies of subærial and of ice erosion, we may believe that it would have presented an irregular surface not unlike that of a mosaic from which a local area of the back had become displaced and the overlying blocks allowed to slide down by small amounts while still restrained by their friction upon their neighbors. The effect of subærial erosion has been to etch out the marginal areas of soft sandstone and leave the basalt prisms of the central area in strong relief like the image of a cameo. The basalt itself discloses no marks of the subærial erosion, for the reasons: first, that it is intensely resistant; and, second, that its area is so small (six miles in length by two miles in greatest breadth) that no streams of any power have been developed upon it. It is not, however, to be assumed that no considerable degradational action has occurred within the area of the basalt masses of the valley, for the three upper members of the Newark series found in the Connecticut Valley area, which begins less than a score of miles to the east, are missing from the Pomperaug Valley series, and were doubtless removed by subærial erosion, while large thicknesses of the surrounding schists were being carried away.

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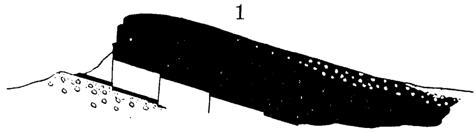

FIG. 1. Schematic profile of basalt ridges of the Pomperaug Valley. Black, basalt; black spotted with white, amygdaloidal basalt; white, shale; white with black circles, conglomerate (where stippled, baked zone of contact); stippled area, drift and alluvium.

The work of the ice within the valley is revealed in the profiles of the basalt ridges. These ridges have generally fault scarps on their western and northern sides (which face in the direction from which the ice moved) and gentle slopes to the eastward and southward, conforming to the dip of the beds and flows of which they are composed. In these general outlines the action of the ice is not disclosed, but the caps of all the ridges seem to have been removed by an appreciable fraction of their height. This is brought out in the schematic figure 1 and in the author's report above cited.* That this degradational action by the ice is localized largely at the crests of ridges is also shown by the texture of the rock found at the crests when compared with that upon the flanks of the southern ridges. Dense and massive at the crest in correspondence with the lower beds of the flow, it is amygdaloidal and vesicular upon the southeastern flanks, where it doubtless represents upper layers of the flow.

* Loc. cit., pl. V, A.

Some clue to the manner of decapitation of the basalt ridges may be found in two trains of basalt blocks, one of which is represented in Plate IX. This train, which is the one of the greater interest, proceeds from the ridge known as Sherman Hill,* the extreme southwestern elevation of the

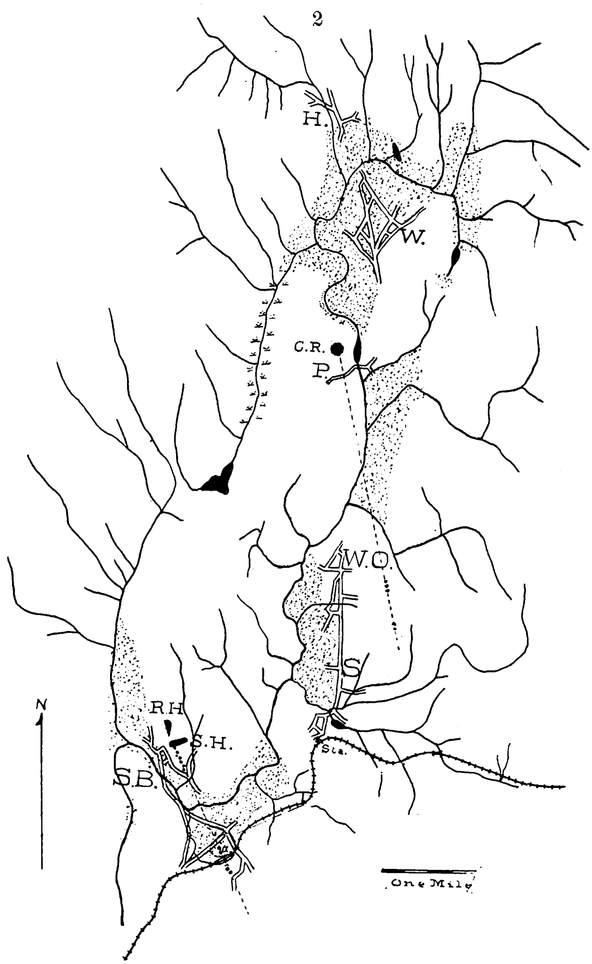

FIG. 2. Sketch map of the Pomperaug Valley showing the distribution of the terrace deposits and of basalt trains. W., Woodbury; S., Southbury; H., Hotchkissville; P., Pomperaug; S. B., South Britain; W. O., White Oaks; S. H., Sherman Hill; R. H., Rattlesnake Hill; C. R., Castle Rock. The stippled area represents roughly the distribution of the terrace deposits, and the lines of larger spots the trains of basalt blocks; A., area of terrace excavated for railroad fill.

* Sometimes considered a part of Rattlesnake Hill.

basalt within the valley. The position and direction of this train is brought out in fig. 2, which is a sketch map of the Pomperaug Valley. Upon the south-southeastern flank of Sherman Hill the train begins as a collection of irregular blocks of basalt, occupying a belt about one hundred feet in width and extending from the present low tower-like crest of the hill to the corner of the highway, where is the edge of the terrace floor of the valley and where the train appears to end abruptly. Within this portion of the train are a dozen or more blocks six to eight feet in diameter, and very many smaller ones. Fig. 1, Pl. IX is a view looking up the train from a point near the road corner toward the summit of Sherman Hill.

Lost in the terrace deposits of the valley the train is again picked up upon the south side of the valley so soon as the slope begins to rise above the level of the terrace. This locality is near and west of the road from South Britain over Georges Hill (see fig. 2) and just above the great fill upon the railroad. The sand and gravel for this fill was obtained from the area immediately north where indicated upon the map (A of fig. 2). Mr. Henry M. Campbell of South Britain pointed out to the writer a place where three large blocks of the basalt, one of them six feet or more in diameter, were unearthed and removed by blasting during the excavation of this section of terrace. The location would fall within the line of the train from Sherman Hill.

The blocks now in evidence south of the railroad fill are of special interest because of their location in the line of the train and because of their unusual size. Fig. 2, Pl. IX, which looks northwestward along the train, includes two of the largest. The hill from which they were separated is visible in the distance (more than a mile and a half away) between their tops. There are several blocks of this size (15 to 25 ft. in largest dimensions), some partially buried in earth along with many smaller blocks, but all located within a belt less than a hundred feet in width. The train does not appear to extend southward beyond this point, but no attempt has been made to follow it farther. The direction from Sherman Hill of these great blocks of basalt, which form a landmark in the valley, is S. 28° to 29° E., a value near that of the average movement of the ice over the higher points in the vicinity.

The conditions seem here to be best explained by assuming that from the pre-glacial surface produced by subærial erosion the faulted prisms of basalt projected in pinnacles above the softer sandstones, in part opposing to the ice stout walls and in part comparatively slender walls and towers. Sherman Hill, as indicated by the geological map in the report here cited, unlike practically all of the other ridges of the valley, opposed its long face and, therefore, its weakest direction to the ice mass, which was directed against its thin vertical walls. Owing in part to dip and in part to the manner of faulting, its western end (the present peak) projected above its general wall-like mass. This part also was unprotected by the higher mass of Rattlesnake Hill. In this way, it is believed, the great blocks which are now found over a mile and a half away and connected by the train with this elevation were separated from their parent mass.

Castle Rock, a prismatic block of nearly equal basal dimensions and now having a sheer cliff upon its northern face nearly one hundred feet in height, is located in the north-eastern part of the area.* Like the west end of Sherman Hill its position left it unprotected by other masses from the north-west, where a considerable valley allowed the ice to sag well below the crests of the elevations surrounding the valley. The row of basalt blocks located southeast of White Oaks is believed to have been derived from this elevation much as the other train has been from Sherman Hill. The slender nature of the prism of Castle Rock, its considerable elevation above the general level, and its exposure upon the northwestern edge of the area all favor such an hypothesis. The direction of this train (S. 13° E.) would indicate that the long valley east of the basalt masses has modified the direction of movement of the lower portions of the ice mantle.

That the ice found a depression in the Pomperaug Valley, into which its substance sagged, is indicated by the present altitudes of the higher basalt ridges which have been decapitated, in comparison with those of the gneiss hills of the vicinity (the basalt ridges are some 200 to 300 feet the lower). It must be assumed that erosion in post-glacial time has been more effective upon the gneiss than upon the basalt, though this would doubtless be modified by the soft arkose members above the main basalt.

To ascribe these trains to the separation of blocks from the lee side of ledges due to the frictional action of overriding, is to leave unexplained their large size and the distance to which some have been carried, more especially, however, the restriction of the trains to ledges which the geological study shows to have been slender in form and with deep valleys northwest of them into which the ice could sink and act in a horizontal direction against their walls.

Professor Chamberlin has informed me that he has observed in Greenland an undoubted instance of such degradational action of the ice from lateral pressure upon rock walls.

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* Loc. cit., fig. 41, p. 111.

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FIG. 1.—BOWLDER TRAIN UPON THE SLOPE OF SHERMAN HILL
The view looks north-northwest along the train toward the crown of the hill.

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FIG. 2.—SOUTHERN END OF THE TRAIN OF BASALT BLOCKS FROM SHERMAN HILL.
The view looks north-northwest along the train, Sherman Hill itself, distant a mile and a half, appearing between the two largest blocks.