NEW EVIDENCE OF HIGH-LEVEL GLACIAL DRAINAGE IN THE WHITE MOUNTAINS, N.H.

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Abstract. A newly discovered pothole field in the White Mountains, N.H., is described, and is attributed to action of melt water from the last continental glacier. Discordance of pothole orientation with slope direction is explained by inferring the presence of a retaining wall of ice which controlled stream flow direction during the period of pothole formation. The potholes constitute the highest evidence of continental glacial drainage yet known in New England.

Zusammenfassung. Ein neu entdecktes Gebiet mit Gletschertöpfen in den White Mountains, N.H. wird beschrieben. Es wird auf die Wirkung von vom letzten kontinentalen Gletscher herrührenden Schmelzwasser zurückgeführt. Mangel an Übereinstimmung der Gletschertopf-Orientierung mit dem Richtungsverlauf des Abhanges wird dadurch erklärt, dass eine Stützmauer aus Eis vorhanden war, durch welche die Richtung des Stromverlaufs in der Zeit der Gletschertopfbildung bedingt war.

Introduction

Evidences of continental glaciation in the Presidential Range of the White Mountains in northern New Hampshire are both abundant and clear; however, features relating to high-level glacial drainage are not common. In his paper "Geology of the Presidential Range" R. P. Goldthwait [1] states "The only definite evidence of flowing melt water at high altitude is the occurrence of small cylindrical potholes drilled in the top of a partially detached ledge at a 'lookout' on Ridge of Caps Trail". These potholes lie at an elevation of 3760 ft. (1146 m.) and are located on the west side of the Presidential Range. That the potholes may not be in place is noted by J. W. Goldthwait *et al.*[2]. Other high-level potholes of New Hampshire and Vermont are mentioned by Doll [3] who includes a description of a fairly large example that lies at an elevation of 2820 ft. (860 m.) in the Green Mountains. Doll claims this to be "The highest known *in-situ* pothole occurring in New England".

Recently, the writer discovered a large pothole field on the northeast flank of Mt. Washington, highest peak in the Presidential Range. The potholes are scattered across the slope and range in elevation from approximately 4090 ft. (1247 m.) to 4285 ft. (1306 m.).* Practically all of the potholes are confined to the outcrop area of a large pegmatite dike which is clearly shown on a recent geologic map of the Mount Washington Quadrangle.[4] †

The potholes lie mostly east of the Mt. Washington Auto Toll Road (Fig. 1), on a spur known as Chandler Ridge, and are approximately four and one-half miles (7·25 km.) from the toll gate at the base. The topography flattens in this area, and on the gentler slopes the potholes are more numerous.

The pegmatite, which contains nearly all of the well-developed potholes, is rather fine grained and forms a NNE-SSW-trending outcrop that lies sub-parallel to the crest of Chandler Ridge. There are very few well-developed potholes in the adjacent sillimanite schist, although schist on either side of the dike shows moderately abundant evidence of potholing activity. North of the dike there are numerous small cylindrical holes less than two inches in diameter. South of the dike there are a few larger potholes. Elongated sillimanite crystals appear to have had a retarding effect on pothole development in the schist because many of the smaller holes lie between the crystals; fluting and grooving of the schist, parallel to and between sillimanite crystals, supports this conclusion.

* Elevations determined by altimeter.

† In the text accompanying the map the small potholes on Ridge of Caps Trail are the only evidence cited in support of high-level glacial drainage.

Description of Potholes

Although no precise count of potholes was attempted, the writer believes they number at least 400. Many are partly or wholly filled with soil or turf; others are obscured by scrub spruce and sub-alpine shrubs. Furthermore, the pegmatite exposures are scattered because much of the outcrop area is vegetated.

Most of the potholes are circular to subcircular in plan; many coalesce with others to form groups of two or more holes. Some potholes are greatly elongated because of developmental control by fractures; however, most holes of whatever shape, have no visible relationship to rock fractures.

One rather flat-topped ledge measuring 8 by 16 ft. (2·4 by 4·9 m.) has not less than twenty-six potholes that range in perfection from obscure to very well formed. In contrast, isolated pegmatite exposures containing only a single pothole are common.

Except for weathered pegmatite debris, soil, or turf, all the holes examined were empty, save one; in it there was a single broken but otherwise well-rounded quartzite pebble. Proximity of this particular pothole to the Toll Road negates categoric assumption that the pebble is a pothole "grinder".

In Table I are listed measurements of twenty potholes, selected to illustrate range in size and shape.* Those for which only depth and width are given are virtually circular in plan. From the table one can see that breadth exceeds depth in most of the potholes; these generally possess inclined walls. However, a few are deeper than they are wide and have vertical walls. Undercutting of the lower part of the walls is a common feature.

Table I

Pothole	*Depth* (cm.)	*Width* (cm.)	*Length* (cm.)	*Remarks*
	1·6	6·2	7·6	
2	3·8	3·8		
3	5·1	10·2		
4	6·0	8·9	15·2	
5	6·6	9·5	11·4	coalesced with 8
6	7·6	15·2		
7	8·5	14·0	20·3	coalesced with 10
8	9·5	19·1		coalesced with 5
9	9·5	17·8		
10	12·1	19·1		coalesced with 7
11	12·1	25·4		
12	14·0	28·0		
13	14·0	20·3	35·6	
14	14·0	33·0	43·2	
15	15·2	17·8	20·3	
16	15·9	36·8	48·3	
17	19·1	40·6		in schist
18	19·1	51·0		coalesced with 19
19	21·0	48·3	55·9	coalesced with 18
20	25·4	41·9	66·0	depth against highest wall only

The orientation of potholes, exclusive of those exhibiting fracture control, generally is not perpendicular to the slope. Compass bearings were taken of those potholes (1) that are elongated, (2) that are aligned in groups of two or more, or (3) whose outlets clearly relate to general flow direction. Potholes of the last two categories are commonly circular but orientations derived therefrom are in accordance with the orientation of elongated potholes.

* Depth was measured to deepest part of pothole from a straightedge laid across the hole from high to low wall; the outlets are commonly lower than the low wall, however.

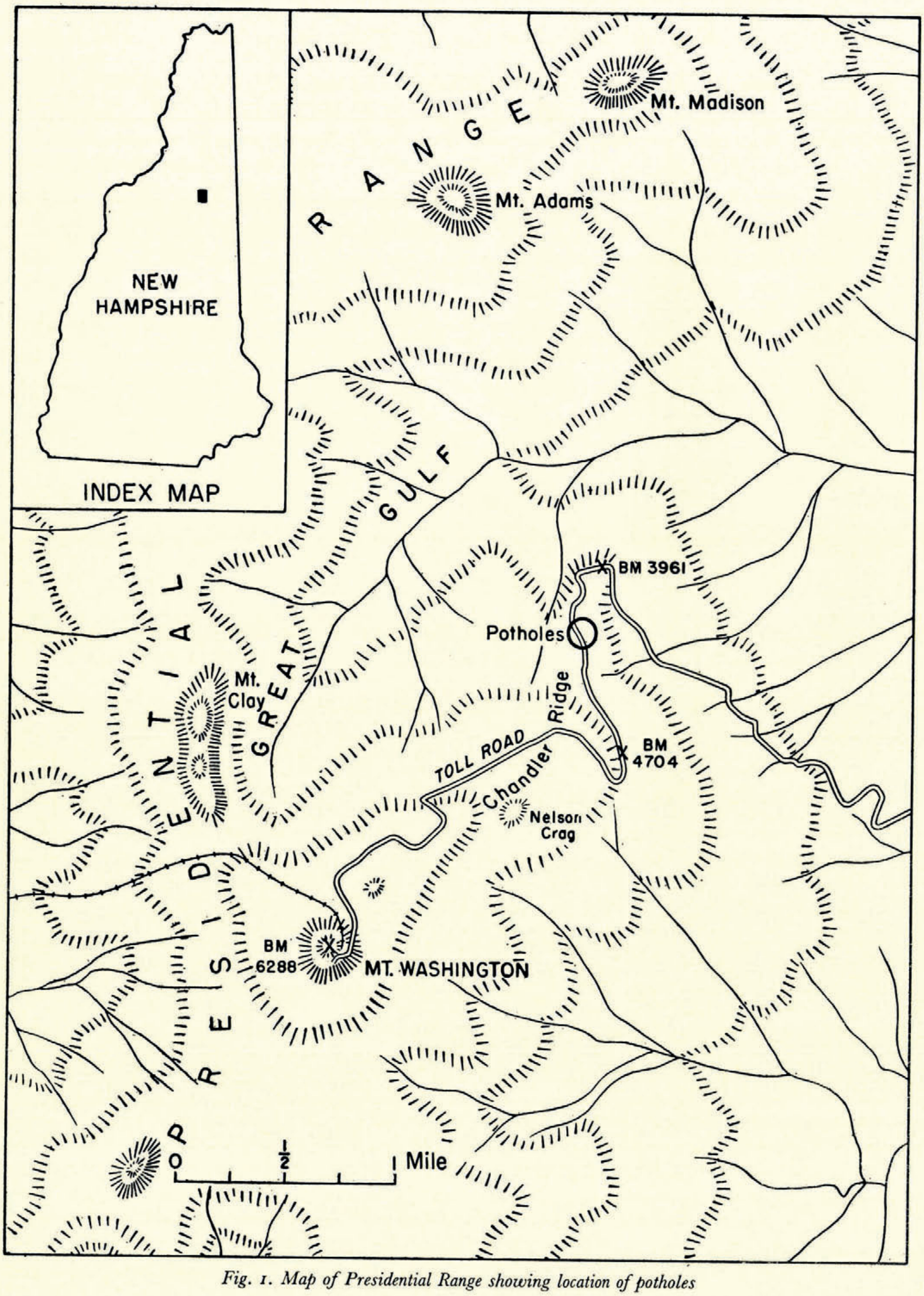

Fig. 1. Map of Presidential Range showing location of potholes

Compass bearings and related slope directions are plotted in Fig. 2, which is an orientation diagram illustrating general divergence of pothole orientation from slope direction. The small number of readings is due to lack of potholes well suited to this purpose. The average slope direction is about N. 56° E. and the average pothole orientation is N. 81° E. for the plotted potholes. Because several potholes serving as flow-direction indicators are not elongated, the general orientation observed is seemingly neither texturally nor structurally controlled. It appears, rather, that the stream which produced these erosional features flowed somewhat obliquely downslope.

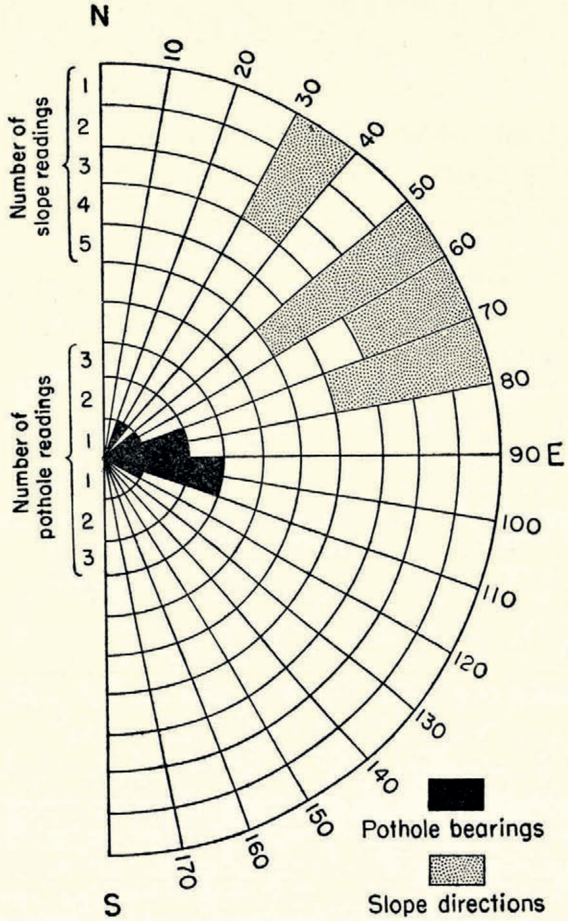

Fig. 2. Pothole orientation

Interpretation

Stream-corrasion origin of the potholes is favored by (1) their large number, (2) marked geographic localization, (3) their presence in rocks of dissimilar lithology, (4) the fact that some drained into and coalesced with others, and (5) smooth, undercut lower walls, which indicate swirling action of water. These are clearly the potholes of common usage or what Alexander[5] called eddy holes.

Historical Significance

Features attributed to both mountain (alpine) and continental types of glaciation are exhibited in the Presidential Range of the White Mountains. Evidence in support of the hypothesis that local glaciers were not re-established after melting of the last continental ice sheet was advanced by J. W. Goldthwait[6] and R. P. Goldthwait.[1] The writer doubts that the potholes under consideration were formed during the time of local mountain glaciation for the following reasons:

(1) Pothole location does not accord with probable mountain-glacier location as suggested by R. P. Goldthwait.

(2) Continental glaciation would have obliterated many, if not most, of earlier-formed potholes, especially those perched on projecting ledges.

(3) Local glaciation could not account for the discordance of pothole orientation with slope direction.

It is likely that the potholes on Chandler Ridge developed during melting of the last continental ice sheet. Ice-marginal, or partly subglacial, streams rushing along, or under, the edge of the stagnant ice mass, which mantled all but higher elevations, could have crossed the ridge at the place described. Deviation of stream direction from slope direction at the time of potholing can be explained by inferring the presence of a retaining wall of ice. That all the potholes were not formed simultaneously is quite possible; stream migration down-slope as the ice mass shrank would account for the wide range in pothole elevations. That such a stream probably did not long remain in one course is evinced by the smallness of the potholes.

The potholes described above are clear evidence of high-level continental glacial drainage. Similar features are not known elsewhere in New England at elevations in excess of 4000 ft. (1220 m.).

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