1924

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REPRINTED FROM
THE GEOGRAPHICAL REVIEW
Vol. XIV, No. 3, JULY, 1924
Pp. 388–393

AMERICAN GEOGRAPHICAL SOCIETY
BROADWAY AT 156TH STREET
NEW YORK

[Reprinted from *The Geographical Review*, Vol. XIV, No. 3, July 1924

ROCK CREEP ON MT. KTAADN, MAINE

By Edward S. C. Smith and Philip W. K. Sweet

Mt. Ktaadn is situated nearly at the geographic center of the State of Maine in Piscataquis County in a practically uninhabited region. As it is thirty miles from the railroad and difficult of approach, to make a protracted stay at the mountain one must be prepared to rough it with the camping equipment that may be packed in on horseback. Recently, however, lumbering operations have reduced the distance over which pack methods must be employed.

No good topographic map of Ktaadn has yet been made, but the broader features are shown on the hachure map (Fig. 1) which accompanies this paper. As seen from the south (Fig. 2) the mountain rises abruptly from a general level not exceeding a few hundred to 5273 feet above the sea. On the northeast, north, and northwest appear other mountain groups such as Turner Mountain, Wissataquoik Mountain, Mt. O J I, and others, though none of these compare in height or extent with Ktaadn. At only short distances either side of the mountain flow the east and west branches of the Penobscot River, both of which were used as avenues of approach to it in the early days and still are favorite routes.

Early Ascents

Numerous excursions took place in those earlier days, and there is much of historical interest attaching to Ktaadn in this connection. In fact, a volume might be written concerning those pioneer ascents, and it may be well to review some of the outstanding ones. The earliest recorded ascent of the mountain was made in 1804 by Charles Turner, Jr., and party. Turner was engaged in his duties as a land surveyor. It appears that the Indians of the vicinity, Penobscots and Abnakis, believed the mountain the lair of an evil spirit whom they called Pamola; and never would an Indian ascend higher than the tree limit for fear of this monster. Nevertheless, the Indian guides of Turner's party went to the top, apparently willingly, after they found the white men determined to go. The name Pamola is at present applied to one of the lesser peaks of Ktaadn.

During the northeastern boundary controversy we find that the mountain was ascended in 1819 by Colin Campbell, one of the surveyors employed by the British Government. In 1836 Professor J. W. Bailey of West Point and Professors Keely and Barnes of Waterville (now Colby) College visited the mountain. The following year Dr. Charles T. Jackson with a party climbed Ktaadn in a snowstorm while performing his duties as first State Geologist of Maine. In 1847 an ascent was made by the Rev. Marcus

R. Keep, Home Missionary in Aroostook. A born naturalist with a great love for the out of doors, he neglected no opportunity to further his knowledge of the wilderness in which he found himself placed, and his name will always be linked with Ktaadn. It was he who accompanied Charles H. Hitchcock about Ktaadn in 1861 at the time of the second geological sur-

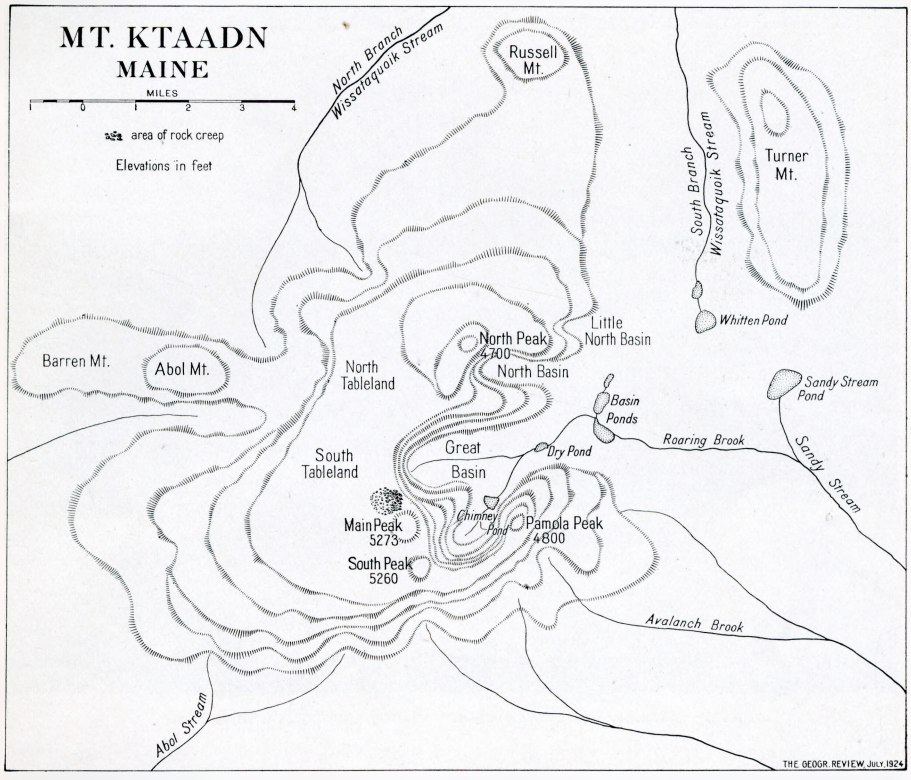

FIG. 1—Map of Mt. Ktaadn showing position of the area of rock creep and other general features.

vey of the state. In the summers of 1873 and 1874 Merritt C. Fernald, at one time President of the University of Maine, made expeditions to Ktaadn which resulted in the first reliable determination of its height, previously believed to be much over one mile. Fernald's determinations gave about 5215 feet as the altitude. Subsequent measurements show the true elevation as 5273 feet.

TOPOGRAPHY OF THE MOUNTAIN

It was the privilege of the writers to visit this region in August, 1923, and carry out a study of the bed rock geology already contemplated for several years. At the same time observations were made upon the rock creep which is taking place over a large area on the upper portions of the mountain. As this phenomenon is not one which may be said to be of com-

mon occurrence, this opportunity is taken to present the facts in brief form.

As both C. E. Hamlin[1] and R. S. Tarr[2] have given excellent descriptions of the topography of the mountain, it will be sufficient to say here that Mt. Ktaadn may be considered as a part of a great granite batholith which has been only slightly dissected into the several mountain groups mentioned above; Ktaadn itself remains as the largest mass. The mountain has suffered erosion by ancient valley glaciers as well as from the last con-

FIG. 2—Mt. Ktaadn from the south. (Photograph by Call, Dexter, Me.)

tinental ice sheet. At the present time streams are in a limited way assisting in dissection, and the atmospheric agencies are very active. Both mechanical and chemical weathering are proceeding rapidly.

Glaciers and streams have carved a number of spurs running out from the main portion of the mountain, the so-called table-land whose elevation is about 4300 feet. From this table-land the upper slopes to the various peaks are relatively gentle, probably about 1500 feet to the mile as an estimate in absence of instrumental determinations.

ROCK CREEP AND ITS CAUSE

It is upon the slope on the northern side of the main peak that an example of rock creep such as is peculiar to semiarctic regions is to be seen.

[1] C. E. Hamlin: Observations Upon the Physical Geography and Geology of Mount Ktaadn, and the Adjacent District, *Bull. Museum of Comp. Zoöl. at Harvard College*, Vol. 7 (Geol. Series, Vol. 1), 1880–84, pp. 189–224.

[2] R. S. Tarr: Glaciation of Mount Ktaadn, Maine, *Bull. Geol. Soc. of America*, Vol. 11, 1900, pp. 433–448.

FIG. 3

FIG. 4

FIG. 3—"The Knife Edge," the upper walls of the Chimney Pond cirque. (Photograph by Call, Dexter, Me.)

FIG. 4—General view of the slope on which the principal creep is taking place. (Photograph copyrighted by W. F. Dawson, Lynn, Mass.)

Here an area some acres in extent is covered with a mantle of rock of this nature. Essentially all the material has resulted from the disruption of the Ktaadn granite along its joint planes and is well sorted; the larger and more massive fragments are found nearer the summit and source of the rock, the smaller farther down the slope. Passing downward, the rock fragments are seen to become distinctly subangular and in rare cases actually rounded. The condition of subangularity is less apparent towards their source. Certain parts of the mass tend to radiate tongue-like and resemble a rock flow. One of these tongues is especially prominent and extends for thirty or forty feet. Occasionally it is possible to see the rock fragments a foot or so deep far down the slope; and, thinning radially, they thus approach the true rock flow. Such observations make it quite evident that there has been a movement down grade under the influence of gravity which has resulted in reciprocal abrasion and rude sorting.

It is well known that in mountainous regions where a considerable degree of cold prevails for the greater part of the year rock creep or flowage may go on at such a rapid rate that vegetation of any kind is prevented from gaining a foothold. Such conditions obtain in certain parts of the Ktaadn rock flow. The creep, or flow, is due primarily to the action of the frost which forms underneath boulders or pebbles. The expansive force of the freezing water lifts the rock a small but definite distance from the ground. As this lift is in a direction at right angles to the inclination of the surface on which the fragment rests, and the eventual melting of the ice crystals allows gravity to act in the true vertical, the boulder or pebble is thus advanced forward and down the given slope. This action repeated many times will serve to transport fragments of even considerable size long distances provided the angle of depression remains sufficiently sharp.

The rock flow examined occurs, as we have said, on the north-facing side of the main peak, exposed to cold winds and frost for the greater part of the year. In addition, a wide daily range of temperature obtains in all seasons and aids very materially in the disintegration of the granite. Actual observations of temperature differences on the main summit between sun and shade at noon in September have shown fifty Fahrenheit degrees.

The granite of the upper sections of the mountain shows three well developed sets of joints nearly at right angles to one another, which results in the formation of rectangular, sometimes cubical, joint blocks and offers an excellent opportunity for frost work. It is probable that during the late fall and early spring, when alternations of freezing and thawing go on apace, the larger prisms are detached from the parent ledge. Such an effect is to be observed on a grand scale at the upper walls of the cirque at Chimney Pond and has been referred to by Tarr in another connection. No doubt the blocks are often temporarily held in a position of instability awaiting only the melting of the ice to allow gravity free play. It is not difficult to imagine that, in the course of freezing and thawing, a not inconsiderable movement of such blocks will take place and, having once

started, will tend to keep in motion. The larger and more angular pieces will be moved only slowly at first: however, exfoliate weathering occurs to some extent, and, as their contours become more rounded, transportation takes place without much difficulty. Further, the slight mutual concussions tend towards the same end, thus making for a greater ease of movement. The rate at which fresh material is being added to the Ktaadn rock flow is now much slower than it must have been formerly, and the chief interest at the present time is centered not in the derivation of this material so much as in its downward sweep across the slope.

In a region which has had a fair share of valley as well as continental glaciers, it is only pertinent to consider whether or not such a deposit as above described might be explained on the basis of glacial action. That we are not dealing with the phenomena of valley glaciers is quite obvious because of the location of the materials, and it is also difficult to understand how an otherwise impartial continental ice sheet should have failed to make other similar deposits elsewhere about the table-land where the granite was equally available for attack. Further, it is generally conceded that the transporting power of the continental glacier was considerably reduced as it rode over the tops of mountains as high as Ktaadn. The material acks the characteristics of any sort of moraine. Finally one may ask why, under glacial conditions, the rock fragments would be noticeably larger in the direction away from that in which the ice moved. Actual proof of flowage is found beside a few of the larger boulders where streams, if we may use the term, of rock have swept around them or in rare instances have been pushed up on them. Several cases of larger fragments being buried by the smaller ones were noted.

In conclusion, it is believed that the rock mantle described has resulted from the disintegration and subsequent creep down grade of joint blocks and their autoclastic derivatives, that it is post-Pleistocene in age, and that the chief activity now is the creep or flow of the more or less rounded boulders, pebbles, and coarse gravel.

It is believed also that the condition described is rare, perhaps unique for New England; no others are known to have been described from the higher mountains of that region.