Journal of Geography

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/rjog20>

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Published online: 09 May 2008.

To cite this article: N. M. Fenneman (1909) Some Anthro-Geo-graphic Effects of Glacial Erosion in the Alps, *Journal of Geography*, 7:8, 169-172, DOI: [10.1080/00221340908985394](https://doi.org/10.1080/00221340908985394)

To link to this article: <http://dx.doi.org/10.1080/00221340908985394>

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THE JOURNAL OF GEOGRAPHY

VOL. VII.

APRIL, 1909

No. 8

SOME ANTHROPO-GEOGRAPHIC EFFECTS OF GLACIAL EROSION IN THE ALPS

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THE theory that alpine glaciers are eroding agents has within recent years made rapid progress. Its acceptance, while not universal, is at least general. The extent of the effects which may be ascribed to this agency varies from a mere alteration of valley forms, mainly by lateral erosion, to the deepening of valleys by thousands of feet. The first-named effect, often called *over-steepening*, is the minimum acknowledged by all who may be called glacial erosionists. The second effect, called *over-deepening*, is accepted by most of them in varying degree. Either process changes the typical stream gorge, commonly called V-shaped, into a more open, smoother-bottomed and steeper-sided valley commonly described as U-shaped.

It is generally agreed that glaciers make their own cirques, cut down their floors, give them their often nearly vertical walls and cause the recession of these walls and widening of the cirques by a process appropriately called plucking. A necessary corollary to this is the narrowing of the ridges which separate neighboring cirques. Plucking may continue until little is left of these ridges but a narrow rampart whose crest is a series of crags or pinnacles. A continuance of the process may remove even these and cause the merging of adjacent cirques.

The purpose of this note is not to discuss glacial erosion or to show its importance in the Alps, both of which we may be allowed to assume, but to point out some of its effects on habitation.

The first of these effects is that of the characteristic scenery. It is true that scenery itself belongs primarily to physical and not to anthropo-

geography, but Switzerland and its immediate neighbors are among the places whose scenery is a leading asset in a commercial way, and for this, if for no more subtle reason, a most important element in anthropogeography. Whether glacial erosion be a fact or not, the features commonly ascribed to it are those which are most striking and characteristic in the Alps mountains. They are in fact those which make up a distinctly alpine style of topography as distinguished from that of other high mountains. Switzerland would probably be a beautiful place even without glacial erosion, but it would not be Switzerland. It might be visited by tourists and cultured people, but the flavor of the place, however delightful, would be something quite different from that now recognized. Take away the cirques and their over-steepened walls and there would be no Matterhorn. Remove the pinnacled partitions between neighboring cirques and there would be no Schreckhorn. The whole list of familiar "horns" would disappear with all their peculiarly alpine settings and in their places would be the still beautiful but more commonplace types of erosional topography.

The first effect of over-deepening by glaciers is seen in the many and beautiful lakes, for valleys were subject to very unequal deepening in different parts, thus making a succession of basins and cross-ridges. These lakes were formerly explained in other ways. Their influence on habitation may be illustrated by comparing the shores of Lake Geneva with the valley of the Rhone farther east, or those of Lake Como or Maggiore with other parts of the valleys which they occupy.

Even where there are no lakes there are sometimes beautiful alluvial basins, filled with sediment instead of water, and separated from one another by rock ridges where the glacier cut less deep. Through these rocky ridges the stream may rush in narrow gorges while loitering and broadly meandering through the intervening basins. Adjacent basins of this kind may support strongly individualized communities.

Next to the lakes the most striking features due to over-deepening are probably found in its effects on tributary valleys. Instead of decreasing in grade from source to mouth, as streams normally do, these join the master stream with a final plunge, not always vertical but often by a series of cascades, generally through a height of hundreds of feet; sometimes for several thousand feet. These are called hanging valleys. Among tributaries this condition is the rule and not the exception. In a single large valley may often be found thousands of vertical falls and rushing cascades, any one of which would make an American city famous. Some-

times the valley is so deepened and widened below that its sides overhang and the stream falls through the air for many hundreds of feet as at Lauterbrunnen. It will scarcely be questioned that the beauty of one Lauterbrunnen is at least as important in anthro-po-geography as the power of a dozen such falls devoted to manufacturing.

But there are many hanging valleys which are not known among visitors for their beauty, but are well known among residents for the sudden wildness and destructiveness of their floods. The local name given to these is *wildbach* (literally "wild brook"), which has no English equivalent except the feeble expression "mountain torrent." The destructiveness of the *wildbach* comes largely from its final plunge into the over-deepened valley of the master stream. Its injurious work is effected partly by the power of its rushing waters and partly by the burial of the lower valley with gravel and coarse rubble. We know something in the Southern Appalachians of this double effect of mountain floods, but to make the case parallel we must conceive the Southern Appalachians as lifted from 5,000 to 10,000 feet, their gorges greatly deepened by stream erosion, then further deepened and broadened below by ice, and the tributaries made vastly steeper in their lower courses. Then the forest should in large part be removed to allow prompt run-off.

The inhabitants of many localities live in perennial fear of the *wildbach*, so that fine alluvial fans in the master valleys may remain unoccupied by dwellings and uncultivated. In other cases they have been occupied only in more recent years, owing to increase of population and advance in engineering science by which the torrents are in part controlled.

It is only a step from this constant dread to the myths of folklore which assign the dreaded power to personal, half-human agencies. The sudden and half unaccountable advent of torrents of water doubtless lies at the base of such myths as are described in the classical legend of Undine. The essence of this is the exercise of a half malignant power by a race of water-sprites, human in all superficial respects, but without souls.

Perhaps nothing else is quite so characteristic of life in the Alps as the use of high pasture lands. So characteristic are these of the Alps that they have given their name to the mountain range, for the word "alp" was originally a common noun used to designate such pastures. The origin of these is a part of the glacial history of the region. Some of the highest are believed to be remnants of a pre-glacial mountain surface. This old surface was one of rounded or subdued mountain forms,

perhaps resembling the Schwartzwald or Southern Appalachians and produced by water erosion when the surface was much nearer to the sea level than at present. As the result of uplift the revived streams destroyed much if not most of this surface. Then glaciers widened the valley bottoms and expanded their heads as cirques until little of the old rounded mountain surface remained. These last remnants are believed to be represented by some of the highest rounded pastures of the present time.

The greater part of the high pastures hang, terrace-like, on the mountain sides. Such terraces are neither flat nor continuous, but are rather interruptions of the general valley slopes whose steepness between terraces is often precipitous. These terraces are believed to be remnants of former valley bottoms. If so, these older valleys must have been wider than those now existing and their bottoms higher, sometimes by several thousand feet. They were, then, quite as unlike valleys made by mountain streams as are those of to-day. They seem to have been the U-shaped valleys of former glacial epochs, whose floors were but partly destroyed by subsequent stream erosion and by the glacial erosion of later epochs. Often two or three such terraces may be seen rising successively above the present valley floor. Many have been tentatively correlated and assigned to particular glacial epochs.

The manner of life induced by these high pastures and their step-like arrangement is almost unique. The pastures at different altitudes become ready for use at different times, the lower first, and successively higher ones as the season advances. The life of the shepherd is therefore migratory but according to a definite plan. The direction of his migrations is vertical. The number and location of his halts are fixed by a process of adjustment which has extended through generations. Each halt becomes his home for some weeks or months. Buildings are always in waiting. In this way whole villages of substantial stone houses are left unoccupied during the greater part of the year, but become centers of life when their surrounding pastures are ready for grazing and the meadows for cutting.

The importance of the third dimension in alpine lands is not limited to pastures. The elevation of vineyards often differs from that of grain fields on the same slope and these again differ in elevation from pasture lands; all differing in their seasons of activity as they do in altitude. In some valleys a single family may have as many as four homes, each occupied for some part of the year by a part or all of the family.