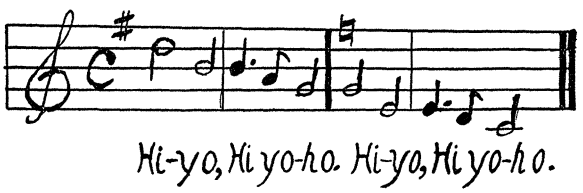
suppressing mere noises. Chiefly it seems to be the direction in which the walls run which acts on the mixed sounds as a prism does on the mixed waves of light; the roughness of the cliffs which acts acoustically as a Rowland grating does optically; and the super-position of several mirror echoes which gives a result analogous to that of a Michelson interferometer.

So far as I am aware, no one has reported these spectral or analyzed echoes as occurring on Mt. Desert, and it is certainly not generally known that the precipitous granite hills carved out by the glaciers in this region are peculiarly rich in these beautiful acoustic properties. They are much more numerous there and easier to elicit than in any other region with which I am acquainted. On the western side of the island I have found only a few spots with spectral echoes, although echoes of the ordinary or mirror type are perfect in at least two places on that side. On the cliff in Somes Sound a very sharply defined mirror echo is well known, but very little prismatic effect is obtainable. At Echo Lake there is also a well-known mirror echo; and there it is only necessary to go a few rods southward from the focus of the mirror echo, in order to obtain a fine spectral effect.

On the eastern half of the island there are no such sharp mirror echoes as those on the western side, for there are fewer smooth, vertical and isolated walls. There are, however, several splendid spectral echoes. The first to be found is on the trail up Jordan Mountain from Asticou, about two thirds of the way up. It comes across a gorge between two ridges. Even finer spectral echoes are obtainable at several places along the upper part of the cliff trail on the eastern face of Jordan Mountain, reflected from Pemetic and the Bubbles. But perhaps the best of all are those on the "goat trail" down the side of Pemetic Mountain to Jordan Pond. Sounds from there are reflected from the broken eastern face of Jordan Mountain and from the Bubbles. These spectral echoes are multiple, a succession of two or three distinct and separate returns.

In calling musical echoes it is best, in my opinion, to sing or rather shout a few successive notes, either a scale or arpeggio. Best of all is a bar of five notes which are associated with the "fire motif" in Wagner's opera of "Die Walküre."

Of course a considerable volume of sound helps; but it is not necessary to strain an ordinary voice; for distinct and repeated returns may be obtained even by a woman's voice. If a man's voice has in it any musical quality at all, the acoustic prism or grating picks out the harmonious elements and suppresses all mere noise. Thus a rather harshly shouted succession of notes comes back rich, sweet and full, again and again, and finally faint and far, but still clear, as if it were the voice of some elf of the mountains way up among the crags.




I can not resist repeating some of the lines of Emerson from the passage which Professor Forbes quotes at greater length. No scientific description could be truer, for the sounds even of a voice of little natural musical quality, as he says:

> Softened are above their will,
> Take tones from groves they wandered through
> Or flutes which passing angels blew.
> All grating discords melt,
> No dissonant note is dealt,
> And though thy voice be shrill
> Like rasping file on steel,
> Such is the temper of the air,
> Echo waits with art and care,
> And will the faults of song repair.
>
> * * * *
>
> The artful air will separate
> Note by note all sounds that grate,
> Smothering in her ample breast
> All but godlike words,
> Reporting to the happy ear
> Only purified accords.

I recommend the search for spectral echoes as a delightful motive for scrambles among these and other hills.

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## RECENT CHANGES IN THE PLATEAU REGION

THE Plateau region, as used in this paper, refers to the plateau south and east of the Colorado River, extending eastward to the Rio Grande country of New Mexico and southward over the highlands of both New Mexico and Arizona to the Mexican line.

A close observation shows that a deep cutting began in this region some time in the early Pleistocene and continued uninterrupted till probably in the late Quaternary (Recent), when the incising process was arrested. Then there set in a refilling of the valleys which continued till our own time. And the valleys are now incising themselves again at a rapid rate.

Concerning the filling of the valleys, Dutton, who examined the region with Powell, 1878–1880, says:[1]

[1] Dutton, C. F., "Tertiary history of the Grand Canyon districts," U. S. Geol. Sur. Mon. 2, pp. 228, 229; 1882.

> Most of those lateral canyons . . . are slowly filling up with alluvium at the present time, but very plainly they were much deeper at no remote epoch in the past. The lower talus in some of them is completely buried, and the alluvium mounts on the breasts of perpendicular scarps. In some cases a smooth floor of alluvium extends from side to side of what was originally a canyon valley.

As an instance, when the first white people came to the Marsh Pass-Laguna Creek country and the Segi Canyon region in the Navajo country, 174 miles northeast of Flagstaff, Arizona, there was no Laguna Creek. The valley and canyon floors were a vast plain, dotted with lakes and swamps. A U. S. topographic map made of the region in 1881 shows no stream leading out of it. Hunting parties frequented the region to kill ducks in the swamps and marshes; and the government road led through the pass over the marshy flats, hence the name "Marsh Pass." Then Laguna Creek began to cut back from Chinle Creek thirty miles to the eastward. Year by year it extended its possessions till to-day it ramifies every part of the inner valley and the Segi canyons, has drained all the ancient pools, swamps and lakes, and has the whole country cut up with a maze of lateral, straight-walled chasms fifty feet or more in depth. And the Tokas Jay, the stream leading northward up the valley along the road to Marsh Pass from Moenkopi wash, and Pueblo Colorado wash at Ganado, 45 miles west of Fort Defiance, Arizona, will cut up those valleys and destroy their lakes and pools, as Laguna Creek has done in the Kayenta region, unless man brings about some means to stop their devastating process.

Many people, including the geologist, Herbert E. Gregory,[2] believe that the aggrading of the valley floors of this region was due solely to climatic changes —little rainfall and the action of the wind. They also believe that the cutting of the present valley fillings is due in the main to the overgrazing of the region and the making of paths and roads.

The factors above mentioned no doubt aided in building up or degrading the fluviatile valley floors; but it would seem to the writer that possibly the main agent in causing the aggrading of the valley floors was man.

The Hopis (and occasionally the Navajos) of to-day build dams and ditches to direct the flood waters of the respective washes and also to prevent canyon cutting; also a series of check dams are often built along moderate slopes and along small washes to retard the run-off and to impound water for stock and house use. Occasionally the valley sides are terraced to prevent arroyo cutting. The dams, which are about five feet in height, are of earth and consequently have to be made annually. Though requiring a great amount of work, through this impounding of water and diverting of washes, water is furnished for much of their stock, and over 20,000 acres of land is irrigated.

In the long ago, when this region was densely populated, as has been shown by Messrs. Kidder and Guernsey,[3] and by the writer,[4] each little wash and flat had its village, and the water was carefully husbanded in the irrigation of the necessary fields and was impounded by reservoirs and check dams for village use. At the present time more than 90 per cent. of the flood waters escape down the washes. The escape of the flood water then was nil, and probably this condition existed for thousands of years. As evidence that such damming and diverting of water was practiced by the ancients, fragments of check dams of loosely piled stone arranged on sloping rock benches and on the terraced floors of the washes may be seen near many of the ruins of the ancient cliff houses and villages of this region (and these villages and cliff houses were numerous).

The triangular Laguna Creek area between Marsh Pass and Church Rock, eighteen miles in length and seven miles across its base at Church Rock, contains 202 ruins of villages, and the Cornfields region from Ganado southward down Pueblo Colorado wash valley to Sunrise Springs, a distance of seventeen miles, contains 173 ruins. This reduced the run-off to the minimum. As a result the *débris* brought down from the mesas by washes was left on the fields and deposited as fans over the valley flats. As no water ran down the main channels, they gradually filled up. Wind action no doubt played a part in filling up the valleys. However, there is no evidence that sand dunes were the main factors in closing any part of the streams of the region. On the contrary, their banks are clays, pond deposits (including layers filled with snail shells) and wash material. In time the drainage became wholly blocked, not because of a lack of rain sufficient to carry off the *débris,* but *because man used the accumulating waters for his own use.* Outrushing washes, descending from the higher areas, also now and then pushed their dry fans farther and farther across the region till the valleys were wholly dammed and the excess water impounded in shallow lakes. Then by this same process the valley flats were gradually aggraded. That this valley filling occurred since the coming of the villagers is evidenced by the presence of pottery, corn cobs, kitchen refuse and occa-

[2] "Water resources of the Navajo country," U. S. Geol. Sur., Water Supply Paper 380, 1916, p. 100.

[3] Kidder, Alfred Vincent, and Guernsey, Samuel J., "Archeological explorations in northeastern Arizona," Bulletin 65, Bureau of American Ethnology, Washington, 1919.

[4] Reagan, Albert B., "Archeology of the Tuba-Kayenta region in Arizona," Trans. Kan. Acad. Sci., Vol. 30.

sional walls of rooms, buried beneath the filling of the terraces, now exposed in the banks of the present streams. The villagers and cliff people then left the region. The region then remained in a state of equilibrium as they left it for hundreds of years, except that the ponded areas probably increased in depth and the fluvial, dry ridges increased in height, for, as is well known, an established condition will remain till some excessive influence (change) overwhelms it. Thus the valley aggrading continued. Then the Navajo came with his stock and the white man with his roads and trails. The grass and herbage was short-cropped, and trails led down the valleys and from the mesas and mountains. Moreover, but little or no water was used for irrigation. As a consequence of these changes the rainfall rushed down the almost bare slopes, collected in the trails and rushed on toward a central point in the respective valley. Along these paths (and roads) canyons were cut and permanent channels formed. By these the waters collected in the central area in sufficient volume to commence cutting a channel to a master stream; and this cutting will continue till man again arrests its progress.

In summary, the intensive farming and use of water for irrigation and the reservoiring of every side mountain canyon for village use and for irrigation in the days when the villagers swarmed the land caused the master streams to be filled up and the valleys to be aggraded, a process which continued even to our own time. Professor Gregory says, as we have seen, that a lack of rainfall to a certain limit would cause the valleys to be aggraded. *If, on the other hand, man used the water to that same limit, the aggrading result would be the same.* And the evidence that the cliff-village dwellers did so is unquestionable. Every side wash, canyon and flat had its village or villages, its dams, ditches and reservoirs, as is readily seen by examining the region. The aggrading of the valley floors and the often laking of same was evidently directly due to man's work. This is attested by the fact (1) that the flora and fauna are now the same as when the cliff dwellers lived there, with the exception of what the white man has destroyed since his coming; and (2) that in the sections that have little rainfall now but few villages in the open or in the canyons are found, and these are often small, whether open or cliff ruins, indicating that they were merely hunting-season or summer-outing villages. The evidence adduced is that the climate is the same now as when the villagers lived here. (Of the known 73 species of the living fauna of the region, including birds, 51 of the species have been found in the village-cliff ruins, and probably 40 per cent. of the characteristic living flora of to-day has likewise been found in the *débris* left by those ancient peoples.) Moreover, then and up to thirty years ago all the precipitation was kept in the region, and the rainfall of to-day would sustain a large population if it was all used for crop production, as it was then, provided the people had as few wants as those villagers had and also made use of all the herbs of the fields and mountain slopes as even the Hopis do, it being said that they now use 146 plants. Moreover, the evidence on the whole must lead to the conclusion that the intensive use of the water by the natives was a cause of the aggrading of the valleys. The evidence also further shows that when the conditions of the region were most favorable for the habitation of the villagers, they left it.

The writer also wishes to add this factor to the cause of the aggrading mentioned above. When the villagers dominated the region, which was for hundreds of years, they had no domesticated animals. Moreover, the wild animals of the country were killed off for food and clothing by them. This left nothing to prevent a rather rank vegetation to dominate any part of the region not under cultivation. Grass, weeds, shrubbery and timber was evidently more abundant. As is recognized and advocated by all advocates of keeping up reserving our forests, this prevented a rapid run-off of the water of the summer rains and winter snows, and this, too, aided materially in the valley building which we have been considering. Then the overgrazing in our own time is bringing about a degrading of the same region.

This brings out the fact that a change of elevation in high and moderately elevated regions is not necessary for the streams to begin to incise their channels; but this incising of the streams may be brought about by an overgrazing (deforesting) of the region —by domestic stock of civilized man or by the increasing and incoming of herds of wild beasts. This probably accounts for certain cutting of streams in the past. Then when the beasts had destroyed the vegetation by grazing and had either left the region or starved to death in it, the vegetation sprang up again and the streams began again to aggrade their valley floors. This overgrazing of regions may also account for the extermination of many species in the past. When the edible plants became so destroyed that the beasts could not be properly nourished, they would become diseased and finally exterminated, provided they did not migrate to some other more favorable region, which was not always possible. The aggrading and degrading of valleys and the coming and going (dying) of hordes of herbivorous beasts seem to have a direct relation to each other, but in reverse order. The streams aggraded their valleys when herbivorous animals are few in number, and degrade their valleys when hordes of them are consuming the vegetation.

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