A STUDY OF EROSION SURFACES

IN

THE SOUTHERN PART OF THE EASTERN TOWNSHIPS OF QUEBEC

by

A.M.STALKER

A thesis submitted in partial fulfilment of
the requirements for the degree
of Master of Science.

Department of Geological Sciences
McGill University
April 1948

A STUDY OF EROSION SURFACES
IN THE SOUTHERN PART OF THE EASTERN TOWNSHIPS OF QUEBEC.

I N D E X.

(References to the bibliography in the text are made by means of numbers after the various authors names).

A P P E N D I X.

INTRODUCTORY

This survey was undertaken in the hope of extending our knowledge of the Appalachian Mountain System and its erosional history by study of the topography of part of the System in Canada.

The area studied lies chiefly in the Eastern Townships of Quebec, where the Appalachians cross with a northeasterly trend, south of the St. Lawrence River, and north of the United States border. This part of the Appalachians in Canada is, in the main, a continuation of the Green Mountains of Vermont and is known as the Notre Dame Mountains. The System also includes the Sutton and Megantic Mountains. The Topographic Survey of Canada has published contour maps of this region on a scale of one mile to one inch, with a contour interval of twenty-five feet.

This study is based on the Davis concept of erosion cycles. Davis conceived of erosion in an area as working towards a state of planation. This process does not ordinarily proceed smoothly to completion, but is interrupted by changes of conditions such as a shift in sea-level, warping of the crust or a change in climate. Thus new cycles are inaugurated and so it happens that topographies commonly show evidences of several incomplete cycles. Most observers are agreed that the Appalachians present a multicycle topography, but there is little agreement on the number of cycles, their geological age, or their duration. There is also some doubt as to the part played by marine erosion as compared with that played by sub-aerial erosion. The even skyline of much of the Appalachians in the United States was observed and studied by the early physiographers. This informity of summit elevation and evidence of repeated rejuvenation are clearly visible on topographic maps, but features like flat summits truncating rock structures and terraces along river valleys, seen at different places, have been correlated in different ways by different writers. Careful detailed study is needed to trace out these surfaces. Warping, faulting, the occurrence of resistant rock masses acting as temporary base levels and, in the northern part of the area, glaciation have complicated the problem tremendously. Thus, though the physiography of the Appalachians has been studied for sixty-odd years, and though many theories and conjectures have been advanced, there is still much doubt and variance of opinion about the erosional history of these mountains.

Some of the views held about the erosional history are shown in table number one. The earlier observers, including Davis (18), Hayes and Campbell (9), on the whole limited the number of erosional surfaces to not more than three. Some observers, including Barrell (7), and Knopf (33), increased the number of surfaces greatly, Barrell mentioning five or six, and eleven marine of Maine, New Hampshire, and Vermont, the amount decreasing as the Canadian border is neared. One reason for this is the fact that as yet no topographic maps have been published for large areas of northern Maine. In addition, the northern regions of these states are thinly populated and inaccessible. Further, the erosion surfaces are harder to recognize in these areas, partly due to the strong glaciation, and also due to the fact that much of the region rises as monadnocks above the levels of the probable erosion surfaces, Some work has been done in this area, however, largely in the White Mountains.

In his studies of this area Lobeck (35), concluded "An attempt to trace the New England (Schooley) Peneplane from the base of Mount Monadnock to the White Mountains has led to the unqualified conclusion that in the latter region the peneplane lies near the base of the mountains, and that the mountains represent monadnoks rising far above the badly dissected upland surface. In addition to the field evidence, a study of the topographic sheets east of the mountains, and Hitchcock's atlas of New Hampshire, by means of projected sections, decisively supports the conclusion". Goldthwaite (23) also has studied erosion surfaces in the Presidential Range of the White Mountains, and while not coming to any definite conclusions, thinks a certain flattening of the hill spurs at about 4,000 feet may be due to former residual mountains at about this height. Davis earlier had thought that the peneplane explanation might not apply to the

White Mountains, due to their ruggedness.

The most widely recognized peneplane in the northern Appalachians is the Schooley (New England). This surface is thought to reach the White Mountains and the northern parts of New England at an elevation of about 2,000 feet. Several persons have tentatively correlated this peneplane with the Kittatinny and Upland surfaces recognized in various regions. Many people assume a peneplane older than the Schooley, the so-called Fall-Zone peneplane. This surface is thought to have been covered by coastal plain sediments, in the east and south, and is now seen only where these sediments are removed, showing the surface of the old peneplane. Some authorities have recognized surfaces younger than the Schooley, developed largely on less resistant rocks. Among the more commonly used names are the Harrisburg for a surface younger than the Schooley, and the Somerville for a surface younger than the Harrisburg. Parker and Coosa are names often given to the strath known as the Somerville. Different observers may omit one or more of the erosion cycles, such as the Fall-Zone peneplane, or may add one or more surfaces. Also many different names are used for these erosion surfaces, over twenty having been used in Pennsylvania alone.

METHODS USED IN STUDIES OF THE APPALACHIAN EROSION SURFACES.

Topographic maps are used to a large extent in the study of erosion surfaces. Whereas in the field only a small area may be studied at a time, with the use of maps having good elevation contours wide areas may be studied and erosion surfaces may be traced from area to area, in many cases without spending a great deal of time and with much less trouble than it would take in the field. Geologic maps are necessary in assessing the effects of structure and varied rock resistances on erosion. When possible these map studies should be supplemented by direct observation in the field.

Several methods have been used in the systematic analysis of topographic maps for the purpose of detecting old peneplane or strath levels. One method is by the construction of profiles or cross-sections of the topography of a region. For best results these should be constructed parallel to one another and as nearly across the strike of the hills as possible. Usually the vertical scale is exaggerated, sometimes as much as fifty times. The distance between profiles varies, depending upon the district, topography and the shape of the hills. Once the profiles have been constructed they may be studied individually or they may be projected in groups onto a single vertical plane. Often summits alone or surfaces within a given elevation range may be projected to the base-line, in order to emphasize any accordance of levels.

Another method is to make partial models from the profiles. This is usually done by cutting the profiles out of cardboard and placing them in their correct relative positions to scale. The model may then be studied from different directions and angles, and any dip or warping of the erosion surface may be seen fairly easily. This method of studying the profiles has an advantage over the projected profiles in that most of the features of the topography may still be seen, whereas in the projected profiles only the traces of the higher surfaces are usually seen, the hills and terraces of the lower surfaces often being lost behind the profiles in the foreground. The study of the single profiles also shows up all the topographic features such as hilltops and terraces, but it may be more difficult to recognize the surfaces in the first place, and it may also be more difficult to follow the surfaces from one profile to the next. If the surfaces are much dissected and few traces of them remain, it may also be difficult to find and follow them on the model.

If the surfaces have been greatly dissected and few traces of them ramain, and if these traces include no flat topped hills and no or few terraces, but only a few eroded and much-rounded hills, methods other than profiles may be best. In such a region the profiles would have to be constructed at very close intervals in order to cross the majority of the remaining traces of the erosion surfaces and even in this case many of the profiles would cut across the sides of hills, and be practically useless. Several methods many be used in a case like this. For instance the tops of the hills may be projected to a base line taken across the strike of the range, and the elevations found into which the majority of the hilltops seem to fall. Different contour ranges on the maps may be coloured in different manners, and studied in order to determine the height of hills and the amount of surface which lie within certain contour ranges. Usually a different colour is used for each contour interval of about a hundred feet. Another method is to colour hilltops according to their elevation, once again using a different colour for each elevataion range of about one hundred feet. These last three methods are more or less based on the same principle, to show the number of hills that lie within certain elevation ranges.

Besides these methods using hilltops, there are others which may in certain cases be used, mainly to find the younger and less complete erosion surfaces and straths. Rivers and their valleys may be examined to find evidences of renewed downcutting and rejuvenation. This may be shown by knick-points, incised meanders, or by a river cutting deeply below a flood plain of its own formation. Usually these signs of rejuvenation are related to the last cycle of erosion only, and it is possible that they may merely show the removal of a temporary base-level. The terraces along a river valley may in some cases give some information about a cycle of erosion, and if the straths extend over a fairly large area they may be considered as an erosion surface, such a one-being usually seen in only the least resistant of the rocks. Attempts have been made to use other criteria, such as correspondence of wind gaps in various parts of a range.

The above mentioned methods are, on the whole, the main ones used for the study of erosion surfaces from topographic maps. Not every method is suitable for all districts, but usually several of them may be used with some success.

While studying an area for erosion surfaces it is wise to remember that apparent surfaces may be caused by other methods than peneplanation. If a peneplane is uplifted, the less resistant rocks should be eroded more quickly than the resistant ones. These resistant rocks may, in places, slow down gradation enough to cause local leveling. Rocks of different resistances forming the peneplane surface may, after uplift, be worn down at different rates, while yet retaining a semblance of flatness, thus forming several levels. These levels might be mistaken for the results of differing cycles of erosion. Faulting may also uplift one part of a surface more than another part, again giving a misleading evidence of more than one erosion surface. For these and other reasons the geology and structure of a region must also be taken into account in a study of this type.

REGIONS OF THE APPALACHIANS THAT HAVE BEEN EXAMINED BY THESE METHODS.

Much of the area of the Appalachians has been examined by one or other of the methods mentioned above. Goldthwaite (23), Johnson (26), Lobeck (35) and Lane (34) have investigated the White Mountains area. Davis (17) has written on a large area, often with special emphasis on the drainage. Amongst the districtshe has described are Pennsylvania, northern New Jersey and southern New England. Fridley (20) has studied the erosion surfaces of south central New York. Toppan (45) has written on the physiography of Maine, and Perkins (38) on the physiography of Vermont. Alcock (1), has described probable traces of an old peneplane surface in the Shickshock Mountains (a continuation in Gaspe of the Notre Dame Mountains of Quebec and the Green Mountains of Vermont). Cooke (15) and others have described the even skylines of the Canadian Shield area. Barrell (7) has studied wide areas of the northern Appalachians, especially the regions bordering the Atlantic Ocean, where he has recognized what he thinks are marine-carved terraces. Much work has also been done on regions farther south in the Appalachians. Lately Shaffer (40),has tried to correlate the surfaces found in the Southern Appalachians with those recognized in the northern Appalachians studying an intervening stretch in Tennessee and Kentucky. Thus widespread areas have been studied in the attempts to unravel the erosional history of the Appalachians.

AREA STUDIED IN THIS SURVEY.

The area studied in this paper is all included in the Province of Quebec, Canada, except for some study which was given to certain quadrangles of the United States Topographic Survey along the Canadian United States border in the States of Maine, New Hampshire and Vermont. These quadrangles were referred to at times to aid in clarifying problems that were hard to solve from the Canadian side only.

In the Province of Quebec the area studied was all south of the St.Lawrence River, and largely in that part to which the name Eastern Townships has been given, with part of the St.Lawrence Plain included.

It extends eastward from the point where the St.Lawrence River meets the United States border. The northern boundary of the area is formed by the St.Lawrence River and the 46 degree 45 minute parallel of latitude. The southern boundary of the area is that of the boundary of Quebec with the States of New York, Vermont, New Hampshire and Maine. The eastern boundary is formed by the state of Maine up to latitude 46 degrees 45 minutes.

GEOLOGY AND STRUCTURE OF THE AREA EXAMINED.

The Appalachians, sometimes called the Notre

Dame Mountains in this area, cross the region with a generally northeast trend. Limited parts have been mapped in detail, but what is known shows great complexity.

The rocks range from Pre-Cambrian to Devonian Bordering the St.Lawrence River is the fairly flat belt of moderate elevation known as the St. Lawrence Plain. This is composed of Paleozoic sandstone, limestone, dolomite and shale, usually horizontal or with low dips. Dividing the St. Lawrence Plain from the Appalachians there is the Logan fault line.

The Appalachians include a great diversity of rocks. They include folded sediments and volcanics of early Paleozoic age, somewhat metamorphosed and cut by basic and acidic intrusives. The row of eight or so Monteregion Hills running from Montreal to the United States border has been placed as late as Tertiary in age.

Little of the area has been closely studied geologically and few of the formations have been definitely delimited.

Over much of the area studied, the type of rock outcrop seems to affect the elevation of a region greatly. Often the rivers have worn their valleys on the weaker rocks, such as shales and limestones, and cut across the more massive or chemically inert types such as granite and quartzite in narrower channels. Ridges and higher areas often end at the boundary of a certain type of rock giving way to lower levels on a less resistant type of rock. However, in some instances there appears to be little connection between rock type and topography. For example, granite and syenite stand high in some areas, but low in others.

METHODS USED IN THIS SURVEY.

Profiles were drawn for the area studied on a horizontal scale of one mile to one inch, the scale on the topographic maps used. The vertical scale used was one thousand feet to one inch, giving a vertical exaggeration of 5.28. Some of these profiles are shown on appended sheets. The contour interval on the maps used was 25 feet.

Initially profiles were drawn at five mile intervals in a northwest-southeast direction across the regional strike. In several cases additional profiles were drawn in areas where the first profiles seemed to show evidences of erosion surfaces.

On a number of map sheets the heights of all the hills were marked on a line taken across the strike, in order to find the elevation ranges into which the greater number of the hills fell. Terraces were also examined along the various rivers, and signs of rejuvenation noted. Finally hilltops were coloured, different colours being used for each range in elevation of one hundred feet. Any areas in which the hills range to nearly the same elevation were outlined on the maps.

As most students of the Appalachian System in the United States have recognized remains of at least three erosion surfaces in the System, one would naturally expect to find much the same conditions prevailing in the Canadian part of the System. As also happens in the States, one would also naturally expect these surfaces to be much dissected by normal sub-aerial erosion. This certainly happened. Added to this erosion, however, the Canadian Appalachians have also suffered the great erosive effects of the Pleistocene glaciation.

This glaciation would greatly modify the drainage system and any remnants of the erosion surfaces. Stream valleys might be dammed and their courses changed. Large deposits of till would be left over much of the area, covering many of the lower hills. Hills and ridges would certainly be much eroded and rounded, and lowered in height. It is possible that the ridge and hill remnants of an erosion surface might each be lowered to about the same extent over a fairly wide area, and thus just represent this former surface at a lower elevation. It seems likely, however, that some of the hills and ridges would be lowered more than the other remnants of the surface, depending on their structure, location, rock type and size. Thus glaciation would greatly complicate the tracing out of erosion surfaces, and some of the methods that work successfully in non-glaciated regions may not be successful here.

Terraces were thought to be unreliable in this area, as it might happen thatthe streams were cutting through thick till deposits, or cutting through the remains of deposits laid in temporary lakes formed by glacial damming of rivers. Signs of rejuvenation might be due to much the same causes. Obviously field investigation would be necessary to check these features.

It was felt that the near accordance of tops of hills was the most reliable criterion to use as, due to the heavy glaciation, few ridges and flat-topped hills could be expected, and terraces were unreliable. As it turned out little could be learned from the profiles. These would have to be drawn at very close intervals to be sure of crossing a majority of the hilltops. Projected profiles, while perhaps showing the earlier erosion surfaces, would likely lose some of the evidence of the later ones, as the areas containing hilltops representative of the several surfaces are greatly scattered and intermingled.

For these reasons it was felt that methods of colouring in hilltops and outlining areas in which they nearly accorded in elevation would be best in this region.

RESULTS OBTAINED FROM THIS SURVEY.

The areas in which marked accordance of summit levels is indicated are shown on the index map. On the whole these areas are more extensive and more clearly defined towards the north. In the Sutton and Memphremagog map-areas (see index sheet) the summit elevations are variable and no clear indication is given of any accordance of heights. In Arthabaska, St. Sylvestre and Thetford map-areas there is some rough accordance of summits at several elevations, apparently showing several incomplete erosion cycles.

For the three higher surfaces the areas indicated on the map are those in which the summit levels are at about the elevations indicated. The two lower surfaces are more lowland districts, rising in the hills to about the levels indicated. Usually the rivers and streams are now actively cutting below these elevations. Over much of the area in which these two lower surfaces are indicated they appear as a widespread kind of terrace often sloping towards the major rivers.

On the whole the higher hills seem to have been less affected by the glacial erosion than those of lesser height. The hilltops ofthe higher surfaces are often flatter than those of the lower surfaces and agree more closely in height.

The highest elevation that could be recognized as a surface remnant is found in the west half of the St. Magloire sheet and in the east side of the St. Malachie sheet, near the northeast portion of the area studied. Here several hills rise to a general height of about 2,800 feet. The highest point reached in them is 3,000 feet, and their are some portions that are 2,700 feet, but the major part of the tops of these hills stand at about 2,800 feet. Though forming the highest elevation recognized as a former surface, these hills are fairly flat-topped and show less local relief than any other of the hilltop areas. It proved impossible to trace this accordance of summits farther, though there are hills at widely scattered points which rise to approximately this elevation. One of these, farther south in the Woburn sheet and on the Maine border, goes by the suggestive name of 'Flat Top'.

The indications of the next highest surface are more widespread. Though it shows little difference in elevation, the slope, if any, seems to be towards the southwest. This surface varies from about 1,800 feet to about 2,200 feet, and is largely found in two northeasterly trending regions. One, in the Thetford, St.Sylvestre and St. Joseph sheets, rises to a general height of about 2,100 feet, with a few hills rising to 2,200 feet, and a number to only about 2,000 feet. The majority of the hills are at about 2,100 feet, however. Farther northeast, in the St. Malachie, St.Magloire and Ste. Justine sheets, the indications of this surface show greater variation in height, and range from about 1,900 to 2,200 feet, still, perhaps, having an average of about 2,100 feet. Farther southwest, in the Arthabaska and Warwick sheets, possible remnants of this surface are found at an elevation of about 1,800 to 2,000 feet. This section of the surface is near the St. Lawrence Plain, in the northern part of the area studied.

The other northeast trending area in which this leval of summits is found is in the southeast part of the region under study. It lies mainly along the border of Maine and New Hampshire, in the Armstrong, Megantic, Woburn, La Patrie, Malvina and Coaticook sheets. Here it is more difficult to trace, especially in the border regions where hills often rise to much greater heights. Here the indications of the surface show greater variability than the part previously described, with hills rising to heights between 1,900 and 2,200 feet, being perhaps highest in the Woburn and La Patrie sheets. In Coaticook and Malvina, though some of the hills rise to 2,000 and 2,100 feet, the majority rise to but 1,900 feet. In Woburn and La Patrie, on the other hand, many of the hills rise to about 2,200 feet, and the great majority of them are above 2,000 feet. In Armstrong the usual height of the summits in this surface is about 2,100 feet, and in Megantic, near where the Chaudiere River flows, about 1,900 to 2,000 feet.

Some other scattered hills may represent this surface also. These are found in the Dudswell, Worford and Memphremagog sheets, and they, too, have a more or less northeast trend. Here there is yet greater variation in the hill heights, but on the average they are lower than in the areas mentioned previously. In Dudswell the height is about 1,900 to 2,000 feet, and about 1,800 to 1,900 feet in Orford and Memphremagog.

Evidences of the next oldest surface are yet more widespread and also show more variation in height than those of the surface just described. The summits in the areas that have been assumed to belong to this surface range between 1,400 and 1,800 feet, usually being lower towards the west and southwest.

Near the St. Lawrence Plain this surface is shown by hilltops of 1,600 to 1,800 feet in St. Sylvestre 1,600 to 1,800 feet in Thetford, 1,500 to 1,700 feet in Arthabaska, and of about 1,500 to 1,700 feet in the northern part of Warwick. Towards the northeast in Ste. Justine and St. Joseph, this surface is indicated by hills ranging from about 1,600 to 1,800 feet, and some hills of about the same height in St. Malachie may be remnants of this surface. The situation is rather obscure in this last sheet, there being a wide range of hill heights. Near the Maine border in the St. Zacharie sheet there is an area with hills of about 1,700 to 1,800, and perhaps 1,900 feet of height which may represent a continuation of this surface.

In the eastern half of the Scotstown sheet there are wide areas in which hills range from 1,600 to 1,800 feet. These areas continue into the west of the Megantic sheet at an elevation of about 1,700 to 1,800 feet. They also run into the south part of the Disraeli sheet in a much eroded curved ridge with hills rising to 1,400 - 1,600 feet. In the northwestern part of the Disraeli sheet and in the eastern part of the Warwick sheet, areas with hills of about 1, 400 to 1,700 feet occur. Nearer the Maine border, in Armstrong, St. Evariste, Megantic and Woburn, there are patches showing hills representing this surface with a height of about 1,700 to 1,800 feet. In La Patrie the height is from 1,600 to 1, 800 feet. In the Dudswell and Orford map areas, farther west towards the St. Lawrence Plain, the height seems to be around 1, 400 to 1,600 feet.

To the southwest in the area studied, in the Sherbrooke, Coaticook, Memphremagog and Sutton map areas, the situation is again obscure. The range of hill heights in these areas near the elevations at which the surface might be expected to occur is too varied to allow the surface remnants to be followed.

Traces of erosional surfaces at lower levels are less definite. This is largely due to glaciation, which seems to have had more effect on the lower hills than on the higher ones, and which has also left till deposits and terraces which obscure the remains of these lower surfaces. Nevertheless, the lower terraces and hilltops seem divisible into two former surfaces. The higher of these is largely found along the drainage system of the Chaudiere River, the second is met with in areas nearer the St.Lawrence Plain. These surface remnants on the whole slope towards the main rivers and drainage systems.

In the Woburn and Megantic map areas the remnants of the higher of these two former surfaces are found in districts near the Chaudiere River at elevations of about 1,400 to 1,500 feet. Following the Chaudiere River the remnants are at about 1,200 -1,400 feet in St. Evariste, and fall to about 1,100 - 1,300 feet in Beauceville and to 1,000 - 1,200 feet in St.Joseph. In Armstrong remains at this surface appear at about 1,400 - 1,500 feet, sloping westward towards the Chaudiere. In the St. Zacharie sheet they are found at about 1,400 feet in the south, and 1,200 - 1,300 feet in the northwest. Farther north in Ste. Justine and St. Magloire there are large areas at 1,300 - 1,400 feet. Farther west, in St. Malachie a northeast trending central band at about 1,200 feet is found. In eastern Thetford and in the Disraeli sheets the indications of this surface are at about 1,200 - 1,300 feet. In this latter sheet the drainage is towards the St. Francis River. In Arthabaska levels between 1,100 and 1,300 are thought to represent this surface.

In the western part of the La Patrie

sheet, in the eastern section of the Sherbrooke and in the southeast part of the Scotstown sheet, the surface is represented at about 1,200 to 1,400 feet.

In the southwest of the area studied the surface is less well represented and much of the area is lower. In the Sutton, Memphremagog, Orford, Richmond and Warwick sheets there are scattered areas with hills at 1,000 to 1,200 feet which may represent this surface.

The lowest of the former surfaces distinguished lies near the St.Lawrence Plain. Large areas of the Dudswell, Sherbrooke, Warwick and Richmond sheets lie around 800 to 900 feet elevation, with high points rising in some areas, such as in eastern Dudswell, to about 1,000 feet. In Arthabaska and St. Sylvestre a strip of around 800 to 900 feet borders the St.Lawrence Plain. In the Orford, Sutton and Memphremagog sheets there are areas of about 700 to 900 feet which have been included as representing this surface.

It was not found possible to correlate these surfaces with those found in the United States, largely as there is an intervening area in Maine, New Hampshire and Vermont in which these erosion surfaces have not been much studied. If, however, the Schooley surface reaches the northern New England area at about 2,000 feet, as seems likely, it is possible that the surface found in this study at about 1,800 to 2,200 feet may correspond to it. Also the remnants of this surface are widespread, as are those of the Schooley, and as they are the highest widespread surface remnants found in this area, it would seem to show fairly widespread peneplanation, as in the case of the Schooley peneplane.

If this surface identified at about 2,000 feet does correspond to the Schooley, there would thus seem to be in this area some evidence of a former erosion surface (at about 2,800 feet) higher than the Schooley. Whether this might correspond to the Kittatinny surface is not known. There would also in this case seem to be evidence for three erosion surfaces lower than the Schooley, the two lower of these being found near rivers, and the other being more widespread. With which previously recognized surfaces these would correspond is not known.

C O N C L U S I O N S.

Five former erosion surfaces can thus be discerned in the Eastern Township area of the Province of Quebec. The districts where evidences of these surfaces occur are shown on the index map.

1. The highest, at about 2,800 feet, is seen in only one small sector in the northeast part of the area studied, in the form of a number of flat topped hills.

2. The second highest surface is shown by hilltops having a height range of 1,800 to 2,200 feet,

including many at 2,100 feet. A slight slope to the southwest may be indicated. This surface may correspond to the Schooley peneplane found farther south.

3. The third highest surface is indicated by hills having a height range of 1,400 to 1,800 feet. Many of the hills representing this surface reach to about 1,700 feet in elevation. It would seem to slope gently towards the west and the southwest.

4. The next surface, indicated largely near the rivers, especially the Chaudiere, lies at an elevation of about 1,200 to 1,500 feet. This surface, in the main, slopes towards the main rivers.

5. The lowest surface indicated, (above the present) lies at approximately 700 to 900 feet. The areas where evidence of this surface is found are near the St.Lawrence Plain. The surface slopes gently towards this plain and the various rivers in the area.

The evidences of these former surfaces are best seen towards the northeast of the region studied. It is not possible to correlate definitely these surfaces with those found in the United States, though it seems likely that the second highest corresponds to the Schooley peneplane.

In a heavily glaciated area, such as the one studied, hilltops give the most reliable evidence of erosion surfaces.

BIBLIOGRAPHY

(References to the bibliography from the text are made by means of the numbers in front of each reference).

1: Alcock, F.J. Geology of Chaleur Bay Region. Geol. Survey of Canada Memoir 183, 1936, pp. 109-126.

2: Ashley, G.H. Age of the Appalachian Peneplanes. Geol. Soc. America bull. vol. 41, 1930, pp. 695-700, (abstract p.101.)

3: Ashley, G.H. Studies in Appalachian Mountain Sculpture. Geol. Soc. America. bull. vol. 46, 1935, pp. 1395 - 1436.

4: Barrell, Joseph. Piedmont Terraces of the Northern Appalachians. Geol. Soc. America. bull. vol. 24, 1913 p. 688 (abstract).

5: Barrell, Joseph. Post-Jurassic History of the Northern Appalachians. Geol. Soc. America bull. vol. 24, 1913 pp. 690 - 691.

6: Barrell, Joseph. Significance of Present Valley Forms. Rhythms in Denudation. Geol. Soc. America bull. vol.28, 1917 pp. 761-765.

7: Barrell, Joseph. The Piedmont Terraces of the Northern Appalachians. (edited by H.H. Robinson). American Jour. Science. Vol. 49, 1920.
In three installments:-
No. 292, pp. 227-258.
No. 293, pp. 327-362.
No. 294, pp. 407-428.

8: Bascom, F. Cycles of Erosion in the Piedmont Province of Pennsylvania, Jour. of Geol. Vol. 29 pp. 540-559, 1921.

9: Campbell, M.R. Geographic Development of Northern Pennsylvania and Southern New York. Geol. Soc. America bull. vol. 14, 1903, pp. 277-296.

10: Clark, T.H. Structure and Stratigraphy of Southern Quebec. Geol. Soc. America bull. vol.45, pp. 1-20, 1934.

11: Cole, W.S. Identification of Erosion Surfaces in Eastern and Southern Ohio. Jour. of Geol. vol. 42, 1934, pp. 285-294.

12: Cole, W.S. Development and Structural Control of Erosion Surfaces. Jour.of Geol. vol. 45, 1937, pp. 141-157.

13: Cole, W.S. Erosion Surfaces of Western and Central New York. Jour. of Geol. Vol. 46, 1938, pp. 191-206.

14: Cole, W.S. Nomenclature and Correlation of Appalachian Erosion Surfaces. Jour.of Geol. vol. 49, 1941, pp. 129-148.

15: Cooke, H.C. Physiography of the Canadian Shield. Royal Society of Canada Trans.
vol. 23, 1929, sec.4, pp. 91-120.
vol. 24, 1930, sec.4, pp. 51-87.
vol. 25, 1931, sec.4, pp. 127-180.

16: Daly, R.A. The Physiography of Acadia. Museum Comp. Zoology bull. vol. 38, pp. 73-103, 1906.

17: Davis,W.M. The Peneplain. American Geologist vol. 23, 1899, pp. 209-210.

18: Davis W.M. The Rivers and Valleys of Pennsylvania. The Rivers of Northern New Jersey. With notes on classification of rivers in general. Both these articles in 'Geographical Essays'. Ginn and Company, 1909.

19: Fenneman, Physiography of the Eastern United States, McGraw - Hill Co, New York, 1938, various parts.

20: Fridley, H.M. Identification of Erosion Surfaces in South Central New York. Jour. of Geol. 1929, vol. 37, pp. 113-134.

21: Fridley, H.M. and Nolting J.P. Jr. Peneplanes of the Appalachian Plateau, Jour. of Geol. vol. 39, 1931, pp. 749-755.

22: Goldthwaite, J.W. Physiography of Eastern Quebec and the Maritime Provinces, 12th. International Geological Congress Guide Book, No. 1, pt. 1, 1913.

23: Goldthwaite, J.W. Remnants of an Old Graded Upland on the Presidential Range of the White Mountains, paper presented by W. Nowers Ashbury. American Jour. of Science. 4th. series, 1914, No. 221, article 37, pp. 451-463.

24: Goldthwaite, J.W. Physiography of Nova Scotia. Geological Survey of Canada memoir 140, 1924.

25: Hichock, W.O. Erosion Surfaces in South-Central Pennsylvania. American Jour.of.Science vol. 25, 1933, pp. 101-122.

26: Johnson, D.W. Physiographic Notes on the White Mountains, (Abstract) Geol. Soc. America bull. vol. 27, 1916, p.108.

27: Johnson, D.W. Physiography of the Atlantic Coast of North America. International Geological Congress, Cambridge report, pp. 85-100, July 1928.

28: Johnson, D.W. Appalachian Studies 1 (New England Upland) (abstract). Geol. Soc. America. bull. vol. 40, No. 1, pp. 131-132, March 1929.

29: Johnson, D.W. and Ver Steeg, K. Appalachian Studies 2, (abstract) Geol. Soc. America bull, vol. 40, No. 1, pp. 132-133, March 1929.

30: Johnson, D.W.A Theory of Appalachian Geomorphic Evolution. Jour. of Geol. vol. 39, No. 6, pp. 497-508, 1931.

31: Johnson, D.W. Stream Sculpture on the Atlantic Slope. Columbia University Press, 1931, 142 pages.

32: Johnson, D.W. Origin of the Blue Ridge Escarpment. (Abstract) Geol. Soc. America bull. vol.44, 1933, pt. 1, p.87.

33: Knopf, E. Correlation of Residual Erosion Surfaces in the Appalachian Highlands, Geol. Soc. America bull vol. 35, 1924, pp. 633-668.

34: Lane, A.C. White Mountain Physiography. American Jour. of Science, 5th. series, vol. 1, 1921, pp. 349-354.

35: Lobeck, A. The Position of the New England Peneplane in the White Mountain Region. Geog. Revue. vol.3, pp. 53-60, 1917.

36: MacKim, J. Hoover. The Origin of Appalachian Drainage. American Journal of Science. vol.36, 5th. series, July 1938, pp. 27-53.

37: Meyerhoff, H.A. and Olmstead, E.W. The Origin of Appalachian Drainage, American Journal of Science, vol. 32, 5th. series, 1936, pp.21-42.

Nolting, J.P. Jr. see No. 20.
Olmstead,E.W. See No. 35.

Perkins, G.H. The Physiography of Vermont. Science vol. 49, 1919, pp. 77-81.

Russell, I.C. North America. D. Appleton and Company, New York, 1904.

Shaffer, P.R. Correlation of the Erosion Surfaces of the Southern Appalachians. Jour. of Geol. vol. 55, 1947, p.343.

Sharp, H.S. The Geomorphic Development of Central Ohio. Denison Univ. Bull. vol.27, 1932, pp. 1-46.

Spencer, J.W. Recent Elevation of New England (abstract) Am. Assoc. Advancement of Science. vol. 44, 1895, pp. 139-140, also in Am. Geologist vol. 16, pp. 249-250, 1895.

Spencer J.W. Evidence of Recent Great Elevation in New England (abstract) Am. Association for the Advancement of Science, proceedings vol. 47, 1898, p. 301, also in American Geologist vol. 22, 1898, p. 262.

Spencer, J.W.High Level Terraces of New England (abstract) Science News 28, 1908, p. 382.

Toppan, F.W. Physiography of Maine, Jour. of Geol. vol 43, 1935, pp. 76-87.

Ver Steeg K, Wind and Water Gaps of the Northern Appalachians. Annals New York Academy of Science, vol. 32, 1930, paper presented by W.G. Robinson.

Ver Steeg, K. Erosion Surfaces of Ohio. Pan American Geologist vol. 55, 1931, pp. 93-102, 181-192.

Ver Steeg, K. Correlation of Erosion Surfaces in Western Pennsylvania and Eastern Ohio. geol. Soc. America bull, vol. 50, 1939 p. 1990. (abstract).

Ver Steeg, K. Geomorphology of the Catoctin Belt. Geol. Soc. America bull vol. 50, 1939, p. 1991 (abstract).

Ver Steeg, K. Correlation of Appalachian Peneplanes, Pan-American Geologist vol. 73,1900, pp. 203-210.