Glaciers.

Although not every one can observe the action of glaciers in this immediate locality, for they exist only in elevated latitudes and on mountain sides, yet the subject is fascinating and our mountain travel is much more interesting and instructive if we possess some knowledge concerning them.

Long before man made his appearance upon the earth, in the Cenozoic Era, during the time known as the Glacial Epoch, the whole northern part of this continent was elevated to such a height that the Canadian Highlands were one thousand to two thousand feet above their present level. The entire expanse of territory was covered with an ice sheet which was several thousand feet thick. This huge mass of ice then moved forward to the south-east, south and south-west, extending down into what is now the United States as far as the Ohio river, then continuing to the west, including the northern half of Missouri, running across the north-east corner of Kansas, the eastern part of Nebraska, most of Dakota and off into

the British Possessions. All over this extent of country we find unmistakable proofs of the presence of glaciers in deposits which they left and also in the markings left on the rocks in the ground.

While all this was taking place on this continent, at the same time extensive phenomena of similar character were occurring in Europe. The British Isles and a large portion of the main land show convincing evidence of the former presence of these mighty forces.

Thus we see that nearly all the land above water at that time was enveloped in this thick mantle of ice. The entire landscape at that period would have presented to the eye of the traveler, could he have been present, nothing but a dreary, bleak, unbroken expanse of ice with no sign of life upon its surface.

At the present day glaciers exist high up in the mountains and in the elevated valleys. All through the Alps and Himalayas, in Greenland, in northern Norway and Sweeden, in Alaska and California, all over northern British America and

covering vast expanses in the Antarctic regions we find these powerful agents of nature still at work. The most noted glacier in the world is the Mer de Glace in the Alps of Switzerland. Its note is due more to its beauty and the fact that it has been visited and studied more than any other, than to its size. It is ten miles long and three hundred fifty feet deep, while some of the Greenland glaciers are twelve hundred miles long, fifteen hundred miles wide, and three thousand feet deep.

As one stands on a mountain peak and looks down upon a glacier, he can hardly convince himself that it is not a mighty river. Far down in the valley below is seen a gleaming, glistening stream, now widening, now narrowing as it conforms to the valley through which it takes its way. Turning toward the head of this stream we see, entering it on either side the tributaries which go to make up this great ice river. On descending the mountain side and approaching the subject of observation, we find that the surface does not present one solid expanse of ice as we at first supposed, but

instead is broken and seamed with immense fissures or crevasses. These are usually perpendicular to its side, very deep and occur principally where the declivity of the glacial bed is great, being most numerous around projecting points under the glacier. These crevasses have undoubtedly been produced by the snapping of the ice, it being unable to resist the strain or tension produced by stretching out. At first the crack may be very narrow, only wide enough to admit a knife blade, but gradually it widens until frequently it yawns into an impassable chasm. The origin of these crevasses is due to the unequal or differential motion of the ice, the glacier moving faster at the surface and the center than it does at the bottom and the sides, thus bringing tension into play. It is to these crevasses that so much of the danger of glacial exploration is due. Heavy snow storms falling upon the surface of the glacier, frequently form bridges from side to side of the crevasses and the unsuspecting traveler, attempting to cross on what seems to be a perfectly safe mass of snow and ice, suddenly feels the whole give way beneath him and is plunged headlong hundreds of feet onto the rocks and ragged surfaces of the

ice below.

On approaching the sides of a glacier, one is impressed with the immense accumulations of debris, composed of rock-fragments of all sizes from mere pebbles up to many hundred tons in weight. These accumulations of debris, called lateral moraines are often twenty to thirty feet high and are situated on the ice ridge formed by the protection of the ice beneath from the melting power of the sun. The rocks and earth from the cliffs on either side the glacier are constantly crumbling off and falling onto the surface below, thus forming the lateral moraines.

Accumulations exactly like the lateral moraines are also found in the center of the glacier, and their presence is thus explained. When two tributary glaciers unite to form a trunk glacier, the two interior lateral moraines of the tributary unite and from the angle between the two tributaries will train off as a continuous ridge of debris along the middle of the trunk glacier to its point. This is called the medial moraine. The number of these medial moraines depends upon the complexity of the glacial system for there

will be one for every tributary," and the more tributaries the more numerous the medial moraines.

Still another accumulation found in connection with glaciers is termed the terminal moraine. This is situated at the foot of the glacier and is composed of the same materials as those found in the lateral and medial moraines. In fact it is really formed from the heaping up for ages of these lateral and medial moraines, together with the material pushed out from the bed of the glacier.

From the base of this terminal moraine issues, winter and summer, a stream of water caused by the melting of the ice. This river flows on down the valley, across the plain and finally traces its way to the sea. Sometimes when the fall of snow has been very heavy and the melting more rapid than usual, these streams become foaming torrents, and rushing down the valley destroy every thing in their path. Upon the glacier itself in the middle of the day we find streams of varying size. "During night, and at early morn, dead silence reigns among the snow peaks; no streams are heard, no water trickles over the

surface of the ice; but when the power of the sun begins to be felt, then the noise of water running, leaping and falling grows upon the ear; soon the glaciers are dashed by numberless little streams; great avalanches, wreathed in snow-smoke, rush down-wards with a roar like thunder; masses of rocks wedged in by the frost of the previous night are now loosened by the sun, and dash headlong down the precipices, while long trains of debris hurry after them, and are scattered far and wide along the flanks of the glacier."

Upon close inspection of the sides of the crevasses we find that glaciers are composed of layers or strata. Usually we find about three of these strata, one a layer of dust and leaves, another of clear, solid ice and the third a sheet of snow. This stratification has evidently been caused by a layer of snow falling and becoming packed, then leaves and dust are scattered over the surface by the winds, after which the snow becomes porous from melting. Another snow-storm comes burying the leaves and dust, it in turn becomes packed, leaves and dust are again carried to it by the winds,

melting begins and so the process continues.

That glaciers have a constant motion similar to that of rivers has long been known to scientists.

One of the most common methods of proof of this fact is by setting out stakes in a line across the glacier. In a few hours it is seen that those in the center of the glacier are completely out of line with those nearer the sides, the former having moved down after being set. Another way by which glacier motion is known is by observing some object on the glacier with a transit. These observations are taken from the top or sides of some cliff near by.

Not only the fact but the laws of motion have been determined. It has been learned that glaciers move more slowly at night than in the day and faster in summer than in winter. Like rivers they move faster in the middle than at the sides, like rivers they move faster on the top than near the bottom and like rivers also they move faster on steep than on gentle slopes and the velocity increases with the depth.

We must then conclude that the glacier

is not one solid mass of ice but exactly like a stiffly viscous body with a current motion.

The glacier's progress down the valley varies from one and a half to sixty feet per day. Theory upon theory concerning the cause of the glacial motion has been advanced but the one most generally accepted by scientists of the present day is that of Mr. J. Croll's. "Heat can be transmitted through a slab of ice at thirty-two degrees and yet the ice as a mass will still continue solid. This has been explained thus. When heat is applied to the surface of the slab it can not possibly raise the temperature of the ice. The surface molecules merely pass from the solid or crystaline state into the fluid condition. The heat is therefore converted into a certain amount of energy which enables the molecules to overcome their tendency to assume the crystaline form. Heat is given out in the act of freezing. The same process is repeated with the next adjoining molecules. No sooner have their neighbors resumed the crystaline form than the heat given out attacks the others and forces them to melt. This process goes on from molecule to molecule till the energy is transmitted through to the opposite side and the ice is left in its

original solid state. Such are the phenomena that take place during the transmission of heat through ice. Let us now see what light they throw on the origin of the motion of glaciers. "Glaciers receive heat from the sun, from warm winds and rains and from the friction of the ice and stones on its bed." In summer time the cracks and fissures that penetrate the ice in all directions are filled with water that has trickled down from the surface. Thus heat is transmitted from one portion of a glacier to another. And just as heat when applied to a slab of ice at thirty-two degrees be transmitted through that slab without the ice as a mass changing condition so must heat pass right through the solid ice of a glacier. But in so doing it will compel the icy mass to change its position and the whole body of the glacier moves gradually downward impelled by gravitation in the same way as fluids and semi-fluids are urged forward upon a slope. It is transmition of heat through a glacier which by momentarily converting each atom of its substance into water renders motion possible. The temperature of the ice itself can not rise, but every atom of its bulk is set in motion and slowly and gradually

the solid mass creeps down the valley, the progress being accelerated or retarded according to the degree of heat acting upon and passing through it. Thus we see why a glacier moves more rapidly in the day than at night and faster in the summer than in the winter." No sooner does a molecule which has momentarily melted resume the solid state than it immediately unites to the other solid particles by which it is surrounded; hence the continuity of the whole is preserved and throughout its entire bulk the ice remains a solid body.

Of the powerful work done by glaciers much might be said. In traveling through the mountains one often sees huge rocks tilted in the most unaccountable positions and far from any other rocks of their composition. Upon examination we find their surfaces to be polished with deep scratches or scars. This is an unmistakable evidence of glacial action, for as the glacier moves upon itself and along its bed, it has a grinding motion which scratches and polishes all the rocks within and under it. Again, one often sees great piles of stones heaped up indiscriminately. These are evidently remains of some terminal moraine and

have been stranded, as it were, by the glacier receeding and finally disappearing altogether.

Many and wonderful are the facts concerning this powerful engine of Nature, but if each one will but observe the natural world all around him, he will soon learn more than could be contained in volumes.

Nature has done her share toward educating us in many lines, by placing so much of deepest interest directly in our paths, and we can surely do no less than accept the proffered assistance she so persistently holds before us.

Nora Newell.