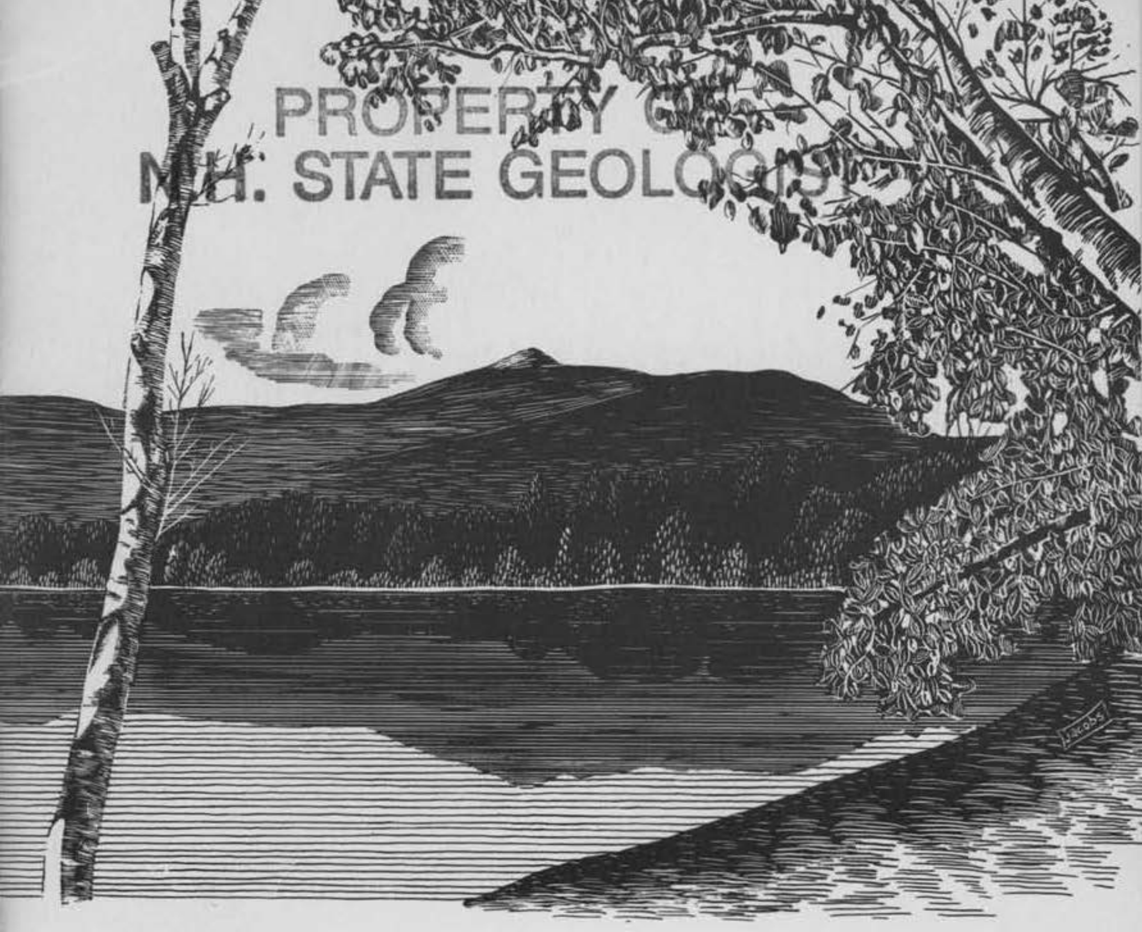

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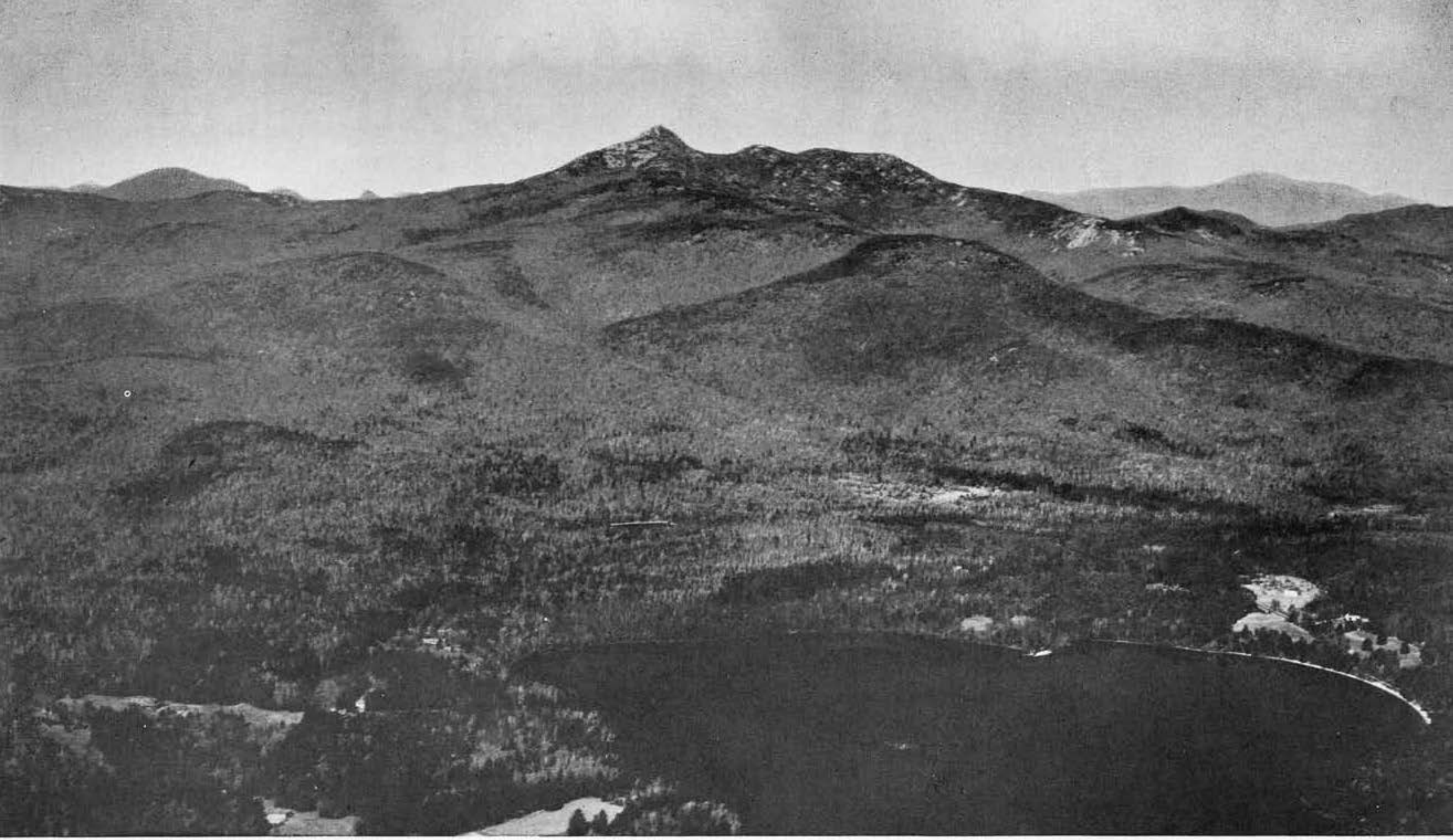
THE GEOLOGY OF
Mt. Chocorua Quadrangle
NEW HAMPSHIRE

BY

Althea Page Smith, Louise Kingsley, and Alonzo Quinn

PUBLISHED BY THE NEW HAMPSHIRE PLANNING AND DEVELOPMENT COMMISSION

1939



AIRPLANE VIEW OF MT. CHOCORUA, LOOKING WEST OVER LAKE CHOCORUA

Photo by H. B. Washburn, Jr., courtesy of Society for the Protection of New Hampshire Forests

Geology

of the

Mt. Chocorua Quadrangle

New Hampshire

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Published by the

State Planning and Development Commission

CONCORD, NEW HAMPSHIRE

1939

Reprinted in 1965

New Hampshire Division of Economic Development

Foreword

This pamphlet is designed to appeal to the intelligent layman and is not intended to be an elaborate scientific report for the professional geologist. The text is written in simple language and few scientific names are used. The map accompanying the pamphlet shows the details of the geology of the region, with a key for reading it. All that need concern the layman are the formation names and it is not essential for him to read or understand the detailed mineral and rock descriptions. The fascinating story of the rocks can be understood without these details.

The field work was carried on under the auspices of the Division of Geological Sciences of Harvard University, the Department of Geology of Brown University and the Department of Geology of Bryn Mawr College. The geological map was contributed by the New Hampshire Highway Department, and the publication of this pamphlet was financed by a special revolving fund set aside in 1934 from the State Highway Fund for that purpose.

Geology of the Mt. Chocorua Quadrangle New Hampshire

By Althea Page Smith, Louise Kingsley, and Alonzo Quinn

THE LANDSCAPE

MOST people, as they gaze upward at majestic Mt. Chocorua, see only a pile of granite lifting its lofty summit to the sky. Few indeed are those who, looking backward through countless centuries, can see the long history of the mountain: the rise of molten rock from the depths of the earth; the cooling of this molten rock to form solid granite; eons of erosion by rain, frost, wind and ice. For the hills and mountains are not eternal. The Sandwich Range has not been here since the beginning of time. The landscape is always changing and it is the aim of the geologist to read from the rocks the story of their life.

The present landscape is a heritage from the past. In the northern third of our quadrangle, a map of which is in the pocket at the back of this pamphlet, is the Sandwich Range. At the east end of this range is Mt. Chocorua (3,475 feet) with its sharp rocky summit rising precipitously above gentler, wooded slopes. Farther west is irregular, ledgy, fire-swept Mt. Paugus (3,200 feet). Symmetrical Mt. Passaconaway (4,060 feet) occupies the center of the range. To the southwest is Mt. Whiteface (3,985 feet), so named from the great white scar on its southern slope. To the northwest of Mt. Passaconaway is Mt. Tripyramid (4,140 feet), a wooded triple peak and the highest moun-

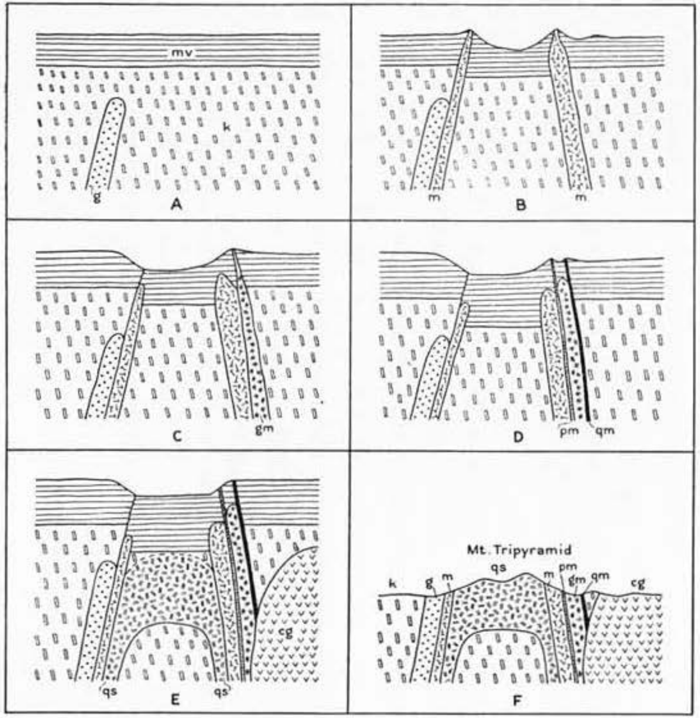

Figure 1. Origin of Mt. Tripyramid. Compare with structure section A-A′ on geological map. k=older rocks (Littleton, Kinsman and Norway formations); mv=moat volcanics; g=gabbro and hypersthene diorite; m= monzodiorite; gm=gray monzonite; pm=pink monzonite; qm=quartz monzonite; and qs=quartz syenite. See page 19 for discussion.

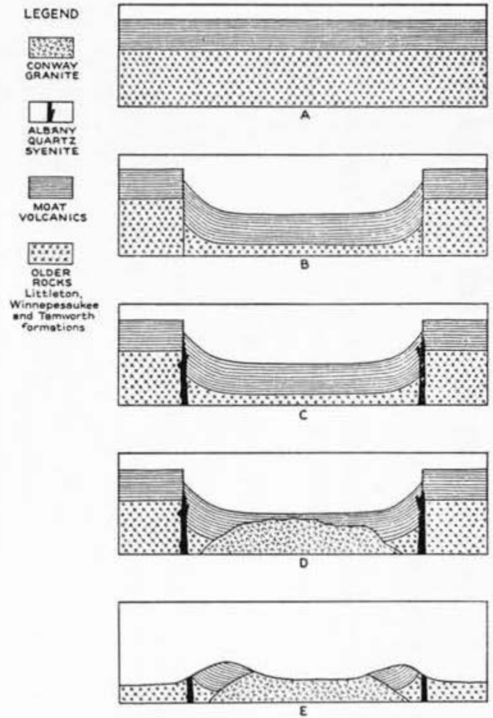

Figure 2. Origin of Ossipee Mountains. Compare with structure sections B-B′ and C-C′ on geological map. See page 20 for discussion.

tain of the Sandwich Range. Along the western border of the quadrangle is Sandwich Mt. (3,993 feet), a wooded domical mass.

The central part of the Mt. Chocorua quadrangle is a relatively low area, 500 to 1,000 feet above sea level, and occupied by swamps, ponds and sluggish streams. In the southwest corner of the quadrangle is Red Hill (2,029 feet) whose smooth wooded slopes are in places interrupted by steep cliffs. In the southeast corner of the quadrangle is the northwestern part of the Ossipee Mountains, a circular mass rising 2000 feet above the surrounding lowlands. The explanation of the circular shape of the Ossipee Mountains is one of the most fascinating stories of the Mt. Chocorua quadrangle.

THE STORY OF THE ROCKS

The Sea

As the geologist looks backward through the vista of time he sees a great ocean extending scores of miles in all directions beyond the borders of the Mt. Chocorua quadrangle. It is early Devonian time, 325,000,000 years ago. To the east, in what is now the Gulf of Maine, a mighty mountain range is being assailed by the rain, the frost and the wind. Streams flowing westward from these mountains carry tiny particles of mud and sand to the sea of the Mt. Chocorua region where they drop their load. Currents and waves gradually shift the sand and mud and great storms stir them. Alternating layers of mud and sand thus accumulate on the sea floor and, although each layer is only an inch or a few inches thick, the total thickness is many thousands of feet. In this way the rocks now known as the Littleton formation were deposited. But additional changes took place before the rocks assumed their present appearance. These changes destroyed all traces of the fish, shell fish and sea weed which lived in this sea.

The Folding

After many thousands of feet of sand and mud in alternating layers had accumulated in the sea and hardened, they were squeezed as in the jaws of a gigantic vise. The hardened clay and sand were thrown into a series of folds of various sizes. Layers that were deposited horizontally were in places tipped up on end, and some were even overturned. This folding probably took place at the end of the Devonian period, about 290,000,000 years ago.

The First Invasion by Molten Rock

During the folding of the beds of the Littleton formation, and shortly after, great masses of molten rock rose from the interior of the earth but did not reach the surface. They pushed aside and jammed apart the hardened sands and muds of the Littleton formation, taking their place in large parts of the Mt. Chocorua quadrangle. These molten rocks slowly froze at some depth below the surface to form granites and granite-like rocks. They invaded the area in slow succession, taking many hundreds of thousands of years. The oldest was the Winnepesaukee quartz diorite, followed in succession by the Kinsman quartz monzonite, the Norway quartz monzonite, the Tamworth granite and the binary granite. It was at this time that the sands and muds of the Littleton formation, subjected to the great pressures from folding and the heat from the rising molten rock, were gradually transformed or metamorphosed into mica schists, composed of such minerals as quartz, mica and, in places, garnet.

The First Erosion

How high the mountains may have been directly after the folding and rise of the molten rock is impossible to say. By analogy with younger mountain ranges, like the Alps, it is likely that they were very high, but this cannot be proved. In any case, we may believe that the landscape did not look the least bit like the modern one. As soon as the mountains began to rise from the ancient sea, erosion began to demolish them. The air and rain water began to attack the rocks chemically. Water, freezing in tiny cracks, slowly broke the minerals and rocks into smaller fragments. Little rivulets flowing down the mountain slopes carried the tiny particles to the brooks and rivers, and the rivers removed them to the sea. And so, slowly but surely, the first mountains of the Mt. Chocorua quadrangle were worn down. In the millions of years that ensued thousands of feet of rock were worn away and the original mountains destroyed.

The Volcanoes

Volcanoes burst into eruption—volcanoes as violent as any in activity at the present time anywhere on the face of the earth. Lava flows slithered down mountain slopes. Volcanic ash and dust were hurled into the air. The volcanoes were in eruption for a long time—for hundreds of thousands of years and were widespread all over New Hampshire. Thousands of feet of volcanic material thus accumulated formed the Moat volcanics. Although these volcanic rocks are now preserved in the Mt. Chocorua quadrangle, in the area of the Ossipee Mountains only, they undoubtedly at one time covered the whole quadrangle. These volcanoes were probably in eruption during the Mississippian period, about 250,000,000 years ago.

The Second Invasion by Molten Rock

Accompanying and following the volcanoes there was a second great invasion by molten rock. This molten material solidified at some depth below the surface to form granite and granite-like rocks. The rocks of Mt. Tripyramid and Red Hill, as well as the Passaconaway syenite, the Albany quartz syenite, the Mt. Osceola granite and the Conway granite were formed at this time.

The Second Erosion

Then, as before, erosion attacked the rocks. They gradually wore away under the constant attack of the rain, wind and frost. Finally, after hundreds of millions of years, just before the Great Ice Age, the mountains and valleys began to resemble those now found in the quadrangle. The major forms resembled those of the present day and differed merely in detail.

The Great Ice Age

But the normal processes of erosion by the wind, rain, air and frost were to be interrupted. About one million years ago a great Ice Cap accumulated in northern Canada. As this Ice Cap grew bigger, it slowly spread out in all directions. Its southern border crept steadily southward. It reached the White Mountains and passed through the Notches into the lowlands beyond. As it grew thicker, it overwhelmed the higher mountains, pushing southeastward across the Mt. Chocorua quadrangle. Sand and boulders, embedded in the ice, polished and scratched the bed rock. Many of the scratches have since been destroyed by erosion but in a few places they may still be seen. As the ice advanced it piled up beneath it large masses of boulder-filled clay, known as glacial till. Ice-scratched pebbles and boulders may be found in this till. As the ice melted, heaps of sand and gravel accumulated in small temporary pools beneath and between the ice and steep slopes of the hills. Only twenty-five thousand years have elapsed since the ice sheet disappeared and the landscape has been little modified since then.

HOW TO READ THE MAP

In the envelope at the back of this pamphlet is the geological map. To the right of the map is the legend, that is, the explanation of the colors and patterns used for the various geological formations. Underneath the map are the structure sections. The use of the map, legend and structure sections will be explained in the ensuing paragraphs.

The various colors and patterns are printed over the regular topographic map with which most readers may be familiar. One inch on the map represents approximately one mile. Roads are shown as double black lines. Trails are single dashed lines; however, certain geological boundaries are shown by a similar broken line. Buildings are solid black squares. Lakes and rivers are blue; swamps are blue tufts.

On the bottom of the map is an angle labelled "approximate mean declination, 1928". One direction shows true north, the other, magnetic north, and the angle between them is 16 degrees. It means that the compass needle points 16 degrees west of true north.

The slope of the ground is shown by brown contour lines. The number on a contour line indicates the altitude (number of feet) above sea level of every point on that line. For instance, between Bearcamp Pond and Red Hill Pond is a hill called Top of the World. The hill is crossed by a north-south road and an east-west road. At the northern edge of the hill, about an inch above the printed words "Top of the World", is "700" written on a dark brown contour line. This means that if one walked in a path following this contour line one would not go down hill or up hill at all, but would remain on the same level all the way around the hill. This level path would lie exactly 700 feet vertically above the level of the ocean. However, if one walked across the contour lines one would travel either up hill or down hill. The summit of Top of the World is represented by a small egg-shaped contour line just to the right and above "d". At the bottom of the Mt. Chocorua map you read "Contour interval 20 feet", which means that every 20 feet of altitude is represented by a brown line. By counting up from the 700 foot contour line on Top of the World we ascertain the height of the summit to be over 820 feet above sea level. Every hundred-foot change in altitude is shown by a heavy brown line. Thus, in going from the top of the hill to the 700-foot level, one would descend 120 feet to the east, the west or to the south. Where the contour lines are farther apart the slope is gentler than where they are closer together. If one went down the north-northwest slope of the hill from the summit by "d" toward where 700 is written on the map, one would first descend 80 feet to just below the 640-foot contour line, and then come up over the 640-foot contour line again and then climb 20 feet to the road which crosses the edge of a second, lower summit of the hill. The second summit is 760 feet above sea level. Continuing north-northwest one would walk on a nearly flat surface for almost a quarter mile (a quarter-inch on the map) and then would descend 60 feet to the 700-foot brown line, or 100 feet to the river. Of course, the contour lines are not marked on the ground.

The various colorpatterns indicate different kinds of rock, and letters standing for each kind of rock are printed on each colorpattern. Thus by referring to the legend it is possible to tell the nature of the bed-rock at any locality. Actually, of course, the bed-rock is exposed only in a small percentage of the area. Sand, gravel and glacial till in places many scores of feet thick commonly hide the bed-rock. The geological map, therefore, is the geologist's interpretation of the distribution of the bed-rock, based on the knowledge he gathers from the actual exposures. Each geological formation is described in some detail under the legend, but these descriptions are largely for the benefit of the professional geologist and need not concern the layman. Geological legends are generally arranged, in so far as possible, with the youngest rocks on top and the oldest at the bottom. Thus, in the Mt. Chocorua quadrangle the oldest rock is the Littleton formation, the youngest the Conway granite. It does not hold, however, that the rocks of Red Hill are necessarily older than those of Mt. Tripyramid. In this case the order was adopted merely for convenience. However, within the Red Hill complex and the Mt. Tripyramid complex the rocks are arranged with the oldest at the bottom, youngest at the top. The geological age of the rocks is given by the vertical printing. Carboniferous is the time when most of the coal of eastern United States was deposited; the highest types of animals were those related to frogs. Devonian time, which has been known as "the age of fishes", was still earlier than the Carboniferous. Lower Devonian is the earliest part of the Devonian.

The symbol used for "strike and dip of bedding" (lower right hand column of legend) needs explanation. Although when sand and clay are first deposited the layers or beds are horizontal, later folding may cause them to be inclined at various angles. If a fold is compared to the roof of a house or the top of a ridge-pole type tent, the "strike", or the longer line of the symbol, corresponds to the ridge-pole. However, most measurements of strike in the folded rocks are made in positions which correspond with a place part way down one side of a roof. The strike is still parallel to the ridge-pole, but geologists are also interested in which way the rocks are tilting, or dipping, or whether a given place is on the right or left side of the ridge-pole. The arrow on the symbol indicates the direction of dip, or downward tilting. Some rocks are steeply folded, some gently, just as some roofs are steeper than others. The number of degrees printed beside the symbol indicates the steepness of the dip; the larger the number, the steeper the tilt of the rocks. Zero (though never used) would indicate horizontal, flat-lying layers of rock; 90 degrees (a right angle) would mean vertical rocks. A special symbol for vertical rocks is shown in the legend. An 80-degree dip would be nearly vertical.

The structure sections at the bottom of the map show what we consider the inside of the mountains to be like. If a ditch almost a mile deep were dug along the line A-A′ on the map (extending from the northwest corner to the east central edge of the quadrangle), the distribution of the rocks seen along the wall of such a ditch would probably be that shown by section A-A′. The same holds true of the other two sections.

INTERESTING LOCALITIES AND ITINERARIES

Waterfalls, Cascades, and Flumes

Sabbaday Falls. These falls, in the north-central part of the quadrangle, and about two and one-half miles west of the village of Passaconaway, are reached by a broad, smooth, gently sloping trail. Although smaller, the gorge at the foot of the falls is similar to the famous Flume of Franconia Notch and was formed in the same way. In the process of cutting its valley Sabbaday Brook encountered a long narrow strip of weak rock which extends deep into the earth. This weak rock is fine-grained dark gray and is known as trap. The narrow body of trap is a dike, and part of it may be seen at the base of the falls. A dike forms when a crack is filled by molten rock from below. The molten rock cools relatively rapidly to a fine-grained solid rock.

Valleys are made by the sand and gravel carried in the stream. After a rain the water flows with considerable force and pounds and abrades the stream bed with sand and gravel. Those who follow brooks notice how smoothly worn the rock is. Soft rock wears down fastest, and, where weaker rock lies adjacent to stronger rock, the valley in the weaker rock is deepest. At Sabbaday Falls the strip of weak trap rock is nearly parallel to the trail. The brook has worn away the weaker rock to form a miniature canyon. Some blocks of the stronger rock have broken off the walls of the canyon, and so widened the gorge which is still only a few feet across. The right-angled turn in the brook is caused by the water falling over the edge of the more resistant Conway granite into the narrow depression in the weak rock.

How streams erode the rocks is shown at the base of the Sabbaday Falls flume where there are several cylindrical holes a foot across and a foot deep, some larger than others. These are potholes and were formed in time of high water by the swirling currents which carry gravel and sand around and around in the same place, gradually carving the hole deeper. Although the Conway granite is more resistant than the trap rock of the dike at Sabbaday Falls, Conway granite is itself weaker than the rocks which make the higher mountains.

Champney Falls. These falls in the northeastern part of the quadrangle are likewise due to a dike. A deep trench, 10 to 35 feet deep, 20 feet wide and 100 feet long, trends northeasterly, following the soft dike. The two forks of Champney Brook, flowing northwesterly, plunge over the hard Mt. Osceola granite into the trench. The westerly brook forms Pitcher Falls, ten feet high; the more easterly branch forms Champney Falls, 35 feet high.

The Flume. The Flume in the northwest corner of the quadrangle is about two and half miles by trail from Depot Camp, which is three-fourths of a mile by road beyond the Waterville Inn (Plymouth quadrangle). This flume is controlled by vertical joints rather than a weak trap dike. Joints are straight cracks in the rock, and, where closely spaced, make the rocks weaker. The rock at The Flume is a fine-grained pink contact variety of the Conway granite. Many rock bodies are finer-grained at their margins, for adjacent to cold rock the molten rock cools most quickly.

The Cascades. The Cascades, in Cascade Brook, in the northwest corner of the quadrangle are a mile from the Waterville Inn (Plymouth quadrangle) by trail. Below the lower cascade the brook is bordered for fifteen or twenty feet by low cliffs parallel to vertical joints. The whole series of Cascades lies on the Norway quartz monzonite.

Norway Rapids. These rapids on Avalanche Brook, in the northwest corner of the quadrangle, are the type of locality for the Norway quartz monzonite. Not only may this rock be well seen here, but also dark trap dikes and white pegmatite dikes. Pegmatite is a very coarse rock with essentially the same chemical and mineral composition as granite. Large crystals of feldspar, quartz and mica may be observed here.

Fletcher Cascades. These cascades, in the northwest corner of the quadrangle, are more than a mile up the Drakes Brook trail, which leaves the road about one mile south of Waterville (Plymouth quadrangle). The rock of the upper cascades is Kinsman quartz monzonite, one of the older rocks of the region. It contains spectacular white feldspar crystals an inch long. In places these are subparallel, indicating the direction in which the rock flowed at the time it was molten. The lower cascades are pink Conway granite. Between the two cascades one may see the contact of the Kinsman quartz monzonite with the Conway granite. The pink granite cuts across the quartz monzonite perpendicular to the direction in which the latter flowed when molten. This shows that the pink Conway granite came in later than the Kinsman quartz monzonite.

Falls above Jose Bridge. About a mile up the Sandwich Mountain trail from Jose Bridge, falls in Pond Brook show the Winnipesaukee quartz diorite with fragments of mica schist of the Littleton formation. The schist is darker than the diorite and was broken off the wall and the roof of the chamber of molten diorite. Both the diorite and its schist inclusions contain much black mica (biotite).

Mountains

Mt. Chocorua. Mt. Chocorua is one of the most delightful mountains in New Hampshire. Its rocky summit has a fascination that enthralls countless mountain climbers. The views are superb. The mountain is composed of Mt. Osceola granite which is particularly well exposed on the main summit, on the Three Sisters, and on the ridge leading toward Bald Mountain. On the lower part of the Hammond trail the Mt. Osceola granite has disintegrated to a coarse sand, composed of fragments one-eighth to one-quarter inch across.

Glacial markings may be observed in several places. On the Hammond trail, just above the junction with the Brook trail, glacial striations or scratches, not quite large enough to hold a pencil lead, trend southeasterly in the direction of ice motion. Glacial striations are made by stones frozen in the bottom of a moving glacier.

Mt. Paugus. A pleasant route up Mt. Paugus is via the Kelley trail from Ferncroft. Rocky crags and pleasing woods are passed in climbing beside a gentle stream bed. Most of the ledges are composed of Mt. Osceola granite. The Lawrence trail is attractive and the upper part of the climb is over ledges of Mt. Osceola granite which forms brown disintegrated "crumbs" on the trail in one place. Return may be made via Old Paugus trail and Mt. Mexico. The fresh green Mt. Osceola granite may be seen in Whitin Brook not far from the trail crossing. On the north slope of Mt. Mexico the trail passes huge rocks made up of Mt. Osceola granite, formed by the breakup of a former cliff. The breakup was probably caused chiefly by frost (the wedging action of water in cracks freezing and expanding), but partly by decay of the dark minerals in the rock.

Mt. Mexico. On the south slope of Mt. Mexico, a few hundred feet north of the Bickford trail and an equal distance west of the Bickford house, which is one-quarter of a mile N 15° W from B. M. 1024, are "boulders of disintegration" several feet high. Glaciation left the top of a ledge at the level of the tops of these boulders, possibly higher. Since the ice melted, the Mt. Osceola granite has disintegrated except in a few places. The crumbled rock has slid and been washed down the slope, leaving the resistant parts of the former ledge in place as boulders of disintegration. Such residual boulders are relatively common in unglaciated regions, but rare in New England. The base of these residual boulders may be seen to be continuous with the ledge beneath, which shows that they are not glacial boulders, and have never been moved by ice, water or gravity. Crumbled rock has been hauled from this place for use on the road.

Potash Mountain. Perhaps the most rewarding climb in the area for the amount of effort involved is the eastern trail (from Downes Brook) up Potash Mountain. Numerous ledges give views of Mt. Passaconaway and its slide, little Hedgehog Mountain, Mt. Paugus and the tip of Mt. Chocorua to the east. On the southeast edge of the summit, about fifteen feet from the trail, is a glacial rocking stone about eight feet high. This huge boulder may be rocked back and forth by pushing with the hand. When the glacial ice melted, this boulder was set down in an unstable position. The rocking stone apparently was not carried far by the ice for it is of the same type of rock as the ledge beneath, i. e., Conway granite.

Mt. Passaconaway. The Kelley and Walden trails form a pretty route to Mt. Passaconaway from the south. From the north the Slide trail, the Passaconaway cutoff, and the Square Ledge trail are all pleasing. At Square Ledge are cliffs of Conway granite. Mt. Passaconaway occupies the northern part of a circular mass of Passaconaway syenite. This syenite is shown on many slides, including those heading down the walls of The Bowl from the Rollins trail and those shown on the map as entering Downes Brook.

Mt. Whiteface. Mt. Whiteface is a most rewarding and accessible mountain; all of its approaches are pleasing, though Downes Brook is perhaps the least so. The lowest of the upper ledges are Littleton mica schist, cut by a little Kinsman quartz monzonite, with big, white feldspar grains; on the geological map this is all shown as Kinsman quartz monzonite. The uppermost ledges and the summit are Passaconaway syenite. Just below the summit of Mt. Whiteface on the south side is a small "cave", formed when a large slab of rock slid over an open vertical joint.

Rock climbers on the south cliff, or "white face", of the mountain have been impressed by a natural flight of steps about a foot wide. This crude "staircase" is a dike. A vertical north-south crack developed in the syenite; molten rock rose from below and froze quickly. Although water expands when it freezes and may break pipes, molten rock is different. Rock contracts when it freezes. Consequently, after the molten dike had forced the rock walls apart, it had more space than would be needed after solidification. When the dike froze, open cracks or joints developed. These were perpendicular to the walls of the dike for there was more contraction in the long up-and-down direction than in the short crosswise direction. Contraction in dikes makes horizontal columns whose margins are roughly hexagonal. It is due to this type of jointing that the "steps" have formed, by the breaking out of horizontal columns, probably by water freezing in the cracks, and their removal by gravity. This cliff is not safe for climbing except by experienced rock climbers using ropes.

Mt. Tripyramid. This mountain is of unusual geological interest because of the circular rock bodies composing it. Most of the rocks may be seen on the east side of the mountain. The approach from the village of Passaconaway is a good trip although the first few miles are through rather monotonous woodlands. Where the trail goes north one-half mile east of Middle Peak, both the gray monzonite and the pink monzonite may be seen in Sabbaday Brook. On the west side of the Foolkiller is an easily accessible slide, at the bottom of which the gray monzonite is well exposed, and at the top of which the quartz monzonite is exposed. Both rocks contain angular fragments of trap rock, apparently lavas related to the Moat volcanics. Returning now to the trail up Mt. Tripyramid, one passes over the monzodiorite, well exposed on the East Slide. The quartz syenite of Mt. Tripyramid is apparently a very resistant rock for it forms the three summits and is well exposed at the top of the North and South Slides.

Mt. Tripyramid from Waterville is a good climb, especially the circuit over the North and South Slide trails. At the base of the North Slide there is a lot of loose rock. This is debris brought down by the slide, which has not yet been washed downstream by Avalanche Brook, as most of the debris has been. The lowermost part of the Slide is pale gray monzodiorite; the upper part is pink quartz syenite. On the South Slide the same rocks are seen. One quarter of a mile upstream from where Cold Brook crosses the South Slide trail the hypersthene diorite is exposed.

Downstream the gabbro is well exposed and the contact of the diorite and gabbro may be observed. The gabbro is very black and gives the name to Black Cascade.

Figure 1 shows the origin of Mt. Tripyramid by a series of vertical sections. In stage A molten rock rises; some solidifies at depth to form gabbro, some comes out on the surface to form the Moat volcanics. In stage B a great cylindrical crack a mile and a half in diameter isolates a huge block; this block sinks and molten rocks well up around it, then solidifies to form a cylindrical dike, known as a *ring-dike of* monzodiorite. This central block sinks again and again and the gray monzonite (Stage C), pink monzonite (Stage D), quartz monzonite (Stage D), and quartz syenite (Stage E) form in succession. To the east of this area molten rock rises and solidifies to form the Conway granite (Stage E). In the last diagram (Stage F) the whole superstructure has been removed by erosion.

Sandwich Mountain. This mountain, unlike any of the other mountains in the Sandwich Range, is composed of the mica schists of the Littleton formation. These rocks, it will be recalled, were laid down when the region was covered by the sea. Structure section B-B′ shows that the rocks are thrown into a series of folds overturned toward the southeast. Exposures of these schists are not particularly good.

Ossipee Mountains. The Ossipee Mountains are of interest because of their volcanic rocks. Within the Mt. Chocorua quadrangle, one of the best places to observe the geological relations is by following Cold Brook upstream from South Tamworth. At first one is on the Tamworth granite, one of the older granites. A short way to the south, however, the Albany quartz syenite appears and is well exposed for one-half mile along the stream. A few hundred feet north of B.M. 836 lavas of the Moat volcanics appear, somewhat contorted, but in general dipping very steeply to the southeast. Some of the lavas show the original flow lines. The Albany quartz syenite is also well exposed on Larcom Mountain. The trail to Black Snout is a good one, but the view is not particularly good nor are outcrops on the trail abundant. Excellent exposures of the Moat volcanics may be seen, however, by following Pollard Brook up to its source.

The origin of the Ossipee Mountains is shown in Figure 2 by a series of vertical sections. In stage A the Moat volcanics have been erupted onto a land surface composed of older formations (largely Winnepesaukee quartz diorite). In stage B a great cylinder, nine miles in diameter, has commenced to settle along a circular fracture. In stage C molten rock rises along the fracture and solidifies to form a ring-dike of Albany quartz syenite. In stage D molten rock rises in the center and solidifies to form the Conway granite. In stage E the superstructure has been removed by erosion to give the present surface profile.

Red Hill. Red Hill is unique among the mountains of New Hampshire in that it is composed in part of nephelite-sodalite syenite. This rare rock may be seen in the woods just north of Watson Ledge and at various other places indicated by the map, but the best place to study it is the "Horne Quarry" on the Winnepesaukee sheet to the south. The quarry consists of a few shallow pits from which disintegrated rock was dug years ago for roads. The pits are on a small knoll about eight hundred feet south of the site of the Horne house, now a cellar hole beside the trail.

The rock here is well exposed and fresh specimens may be obtained.

Associated with the nephelite-sodalite syenite of Red Hill are several syenites and a granite. At the fire tower are good exposures of syenite and back of the fire warden's house is a trap dike. On Eagle Cliff are excellent outcrops of coarse syenite with an irregular texture. Watson Ledge is a large bluff of quartz syenite. The quartz occurs in small cavities and is partly crystallized. Near the base of Watson Ledge and to the northwest may be found blocks and small outcrops of amphibole (hastingsite) pegmatite. The hastingsite forms large blades up to six inches long and is in some cases arranged radially. Good exposures of fine-grained granite may be seen by following up the brook from the northeast.

Red Hill with its great variety of syenites has long been a place of great interest to geologists and specimens of the nephelite-sodalite syenite, especially, may be seen in the geologic collections of many universities.

USEFUL MINERALS

Rocks and minerals of economic value in the Mt. Chocorua quadrangle are not abundant. It must be remembered, however, that over large areas the bed-rock is buried under sand, gravel and glacial till, and there is always the possibility of some hidden resource that will be discovered only by penetrating through this surficial material. At present there is no evidence of precious metals in the Mt. Chocorua quadrangle in sufficient abundance to be of economic value.

Although granite and similar rocks are abundant in the Mt. Chocorua quadrangle, most of it is too jointed or too weathered to be of any economic value. Even that of potential value would have to face the competition of quarries operating elsewhere in the state and of other more readily worked rocks.

The gabbro west of Mt. Tripyramid and exposed along Slide Brook would make a pleasing dark monumental stone. The feldspar of this rock is iridescent in reflected light and gives a bluish color. The market for such a rock is small, however, and further investigation would be necessary in order to ascertain that the rock could be readily quarried.

There is a large amount of trap rock in the Moat volcanics of the Ossipee Mountains, more than anywhere else in the whole State. If it were economically feasible to build highways with trap rock instead of gravel, it would be highly advisable to investigate the possibilities of these mountains.

The nephelite-sodalite syenite of Red Hill has distinct economic possibilities. The ceramic industry wants rocks rich in alumina, and this rock fulfills most of the requirements. Red Hill is the only place in the whole State where nephelite syenite is found and it is in sufficient quantity to make exploitation possible. The chief objection to its use is the fact that the dark iron-bearing minerals are so intricately mixed with the light constituents that it is difficult to separate them.

The name of Diamond Ledge sounds intriguing. Actually the "diamonds" are crystals of quartz, of no economic value. This quartz is part of a barren vein system, shown on the geological map, that may be traced for several miles to beyond White Church one mile north of the village of North Sandwich.

The sand and gravel are probably the most valuable resource of the quadrangle.

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U. S. G. S. Quadrangle Maps. May be purchased at Division Office at 35¢ each. Large quantities of one map should be purchased directly from Director, U. S. Geological Survey, Washington 25, D. C.

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