UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GEOLOGIC MAP OF THE MOUNT ABBOT QUADRANGLE CENTRAL SIERRA NEVADA, CALIFORNIA

GQ-1155

1975

Aerial photograph of Mount Abbot quadrangle, showing location of John Muir Trail. View is to north, and is strongly foreshortened.

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TO ACCOMPANY MAP GQ-1155

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By
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INTRODUCTION

The Mount Abbot quadrangle comprises about 240 square miles of high montane to alpine terrain straddling the Sierra Nevada crest between Fresno and Bishop, California. About three-fourths of the quadrangle lies in the John Muir Wilderness, and the famous John Muir Trail, travelled by thousands of vacationers each summer, crosses the full length of the quadrangle from north to south (Geologic map).

The geologic map of this quadrangle is one of a series across the central Sierra Nevada which have been prepared as background for continuing studies of the geologic history and mineral deposits of this majestic mountain range. This brief explanatory text, however, is written primarily for the non geologist vacationer who wants to familiarize himself with the rocks and geologic features of the quadrangle. Included in this explanation are a geologic guide to part of the John Muir Trail, a glossary of geologic terms used in this report, and annotated references to further reading.

GEOLOGIC HISTORY

The physiographic feature called the Sierra Nevada is a very young mountain range whose uplift, which allowed glaciers to sculpture its spectacular alpine scenery, may in fact be continuing today. Its history can be measured in a few million years.

In contrast to the youthful nature of the mountains, the rocks from which the Sierra Nevada has been carved span a period of earth's history stretching back at least half a billion years. The oldest were formed during the Paleozoic Era, about 570 to 225 million years (m.y.) ago, when a shallow ocean covered this region and a thick section of marine sediments was deposited. These rocks were compacted and gently folded, then were buried by a thick section of volcanic ash and lava as volcanoes began to erupt in this area early in Mesozoic time (about 225 m.y. ago). Following, and perhaps in part contemporaneous with the volcanic activity, all these rocks were complexly folded and metamorphosed. At about this same time granitic magma was forming at depth and began rising into higher levels of the earth's crust, further deforming and metamorphosing the metasedimentary and metavolcanic rocks. The age of the earliest granitic rocks in the Mount Abbot quadrangle is not known, although some granites are likely older than 150 million years. The granitic magma was probably formed in large part from the melting of the older metamorphic rocks. Generation of granitic magma continued over a span of perhaps 100 m.y. and ended throughout the Sierran region 75-78 m.y. ago.

As the magmatic fires cooled, the Sierra, which now consisted largely of granite overlain by mixed volcanic and metamorphic caprock, began to be uplifted. Streams and rivers cut deeply into the Sierran crust during Late Cretaceous time (90 to 65 m.y. ago), exposing the granite and older root rocks. Erosion continued, and by early Tertiary time (about 65 m.y. ago) the Sierra Nevada consisted of a relatively flat terrain of low rolling hills and broad valleys. About 12 m.y. ago, volcanic activity resumed, and extensive thin sheets of lava flowed over much of the Sierra. This coincided with renewed uplift and westward tilting. Radiometric age dating indicates that lava flows of the Mount Abbot quadrangle were erupted 3½ m.y. ago. After this eruption, westward tilting and uplift of the Sierra accelerated, and the present Sierran physiography began to develop. During the Pleistocene Epoch (2 m.y. to 10,000 years ago), extensive glaciers repeatedly formed and retreated, carving the rugged cirques and deep U-shaped valleys which characterize most of the Mount Abbot quadrangle. At its maximum extent, glacial ice covered most of the quadrangle (fig. 1). Only a few thousand years have elapsed since the last ice retreated, so modification of the glacially sculptured topography has been minor: some lakes at lower elevations have filled with sediment, forming beautiful alpine and sub-alpine meadows; rock has tumbled from high crags to form jumbled talus deposits; and a thin veneer of air-blown pumice has covered a small area in the northwest corner of the quadrangle. Otherwise, the area remains much as it was at the close of the Ice Ages.

DESCRIPTIVE GEOLOGY

Although the preceding history has been pieced together from observations made throughout the entire Sierra Nevada and adjoining area, by dozens of geologists, all essential parts of the story are recorded in the rocks of this quadrangle. The geologic map of the quadrangle shows that various types of granitic rocks constitute over 95 percent of the bedrock. These rocks are described briefly in the map explanation and in the geologic guide to John Muir Trail and other areas. The relative ages of the various granitic plutons were determined by field and laboratory studies and are shown by the position of each rock type in the map explanation column; younger rocks are at the top and older rocks are at the bottom.

Metamorphic rocks, the oldest rocks of the quadrangle, are preserved at only a few localities. The least deformed metamorphic rocks are found along the northern margin of the quadrangle (see p. 2). Paleozoic metasedimentary rocks are found only here and along the eastern margin of the quadrangle, where they occur as isolated blocks in granitic rocks northeast of Heart Lake. Mesozoic metavolcanic rocks are found along the northern margin of the quadrangle, and in the quadrangle's southwest quarter, where they form a rim around part of an old quartz monzonite body.

The younger volcanic rocks are restricted to the north half of the quadrangle. They occur as thick lava flows overlying the granitic rocks north and east of Edison Lake, and as narrow dikes which cut granitic rocks in the northwest corner of the quadrangle and immediately north of Mount Abbot.

The young sedimentary rocks are mostly of glacial origin, and will be briefly described in the following section. The direction in which the glaciers moved is shown in figure 1, which also shows localities frequently mentioned in this text.

ROCKS ALONG THE JOHN MUIR TRAIL

As typical outcrops of all principal rock formations of the Mount Abbot quadrangle are well exposed along the John Muir Trail, an informal geologic guide to that section of the trail which crosses the quadrangle was prepared. The geology is described as it would be seen on a south-to-north traverse across the quadrangle.

South of the Mount Abbot quadrangle, the John Muir Trail lies in the valley of the South Fork of the San Joaquin River. Climbing up the steep north wall of this valley, the trail crosses a strongly sheared granodiorite body and into a series of varicolored metavolcanic schist and hornfels. These metamorphic rocks are part of the Goddard pendant, a northwest-trending, 35-mile-long belt of older rocks surrounded by younger granitic plutons. The metavolcanic rocks, now steeply inclined, were deposited in nearly horizontal layers of light-colored volcanic ash, breccia, and lava flows approximately 235 to 135 m.y. ago. They are highly deformed in this area, and original textural features are almost entirely destroyed.

Just below the southern boundary of the quadrangle, the metamorphic bedrock is obscured by glacial deposits, through which the trail winds for about 2 miles. The glacial boulders so abundant along this part of the trail belong to lateral moraines deposited along the margins of an ice mass over 2,000 feet thick, which flowed along the South Fork of the San Joaquin River during the Ice Ages. They include a wide variety of rock types, and some have been transported over 15 miles by ice from Piute and Goddard Canyons. Before reaching Sally Keyes Lakes the trail crosses several boulder piles which represent lateral moraines from small tributary glaciers. The Sally Keyes Lakes were formed by ponding behind natural glacial moraine dams.

At the north end of Sally Keyes Lakes, bedrock crops out once again and can be seen for the next 10 miles. This first rock is the medium-grained, light-colored quartz monzonite of Bear Dome, one of the oldest granitic rocks in the quadrangle. Dikes of dark diorite cut this rock immediately north of Sally Keyes Lakes. Continuing northward toward Selden Pass, the trail crosses a mixed zone in which a very light colored rock, the quartz monzonite of Jackass Dike, is mixed with fragments of grey metavolcanic schist. High on the rugged arête east of this zone (200 yards southeast of Selden Pass), one can see angular blocks of dark metavolcanic rock surrounded by another quartz monzonite. Eighty million years ago these blocks were floating in a 700°-800°C hell of molten rock far below what was then the earth's surface. When the enclosing magma cooled, the blocks became frozen in place and remained buried until less than a million years ago, when glacial erosion exhumed them.

Selden Pass, the second highest pass crossed by the John Muir Trail in the Mount Abbot quadrangle, is carved in the quartz monzonite of Turret Peak, a coarse-grained rock containing numerous large crystals of potassium feldspar. This pass offers a splendid view of the quadrangle. To the northeast higher peaks of the Sierran crest are visible. Mount Abbot (13,715 ft) is the flat-topped peak at a compass bearing of N. 37°E. Directly to the north lie the numerous large lakes of the Bear Creek drainage, all of which were carved by Pleistocene glaciers. With a little imagination, one can picture the frozen arctic landscape here 10,000 years ago. The entire area, except for the highest peaks (fig. 1), was covered by a sea of ice which flowed slowly northward, covered Bear Ridge, and then moved westward down the South Fork of the San Joaquin River. The thick cover of ice polished and scratched underlying bedrock, and throughout the area to the north highly polished and striated outcrops along the trail serve to constantly remind the traveller of this period in which ice ruled the Sierra.

Descending from Selden Pass to Marie Lake, the trail stays within the porphyritic quartz monzonite of Recess Peak, although metavolcanic rocks crop out only a few feet to the west. It crosses the metavolcanic rocks near the north end of Marie Lake, and then crosses into the Lamarck Granodiorite, a dark granitic rock characterized by abundant large black hornblende crystals and a strong foliation. The foliation is defined by abundant dark inclusions that are generally tabular in shape. Radiometric studies of the Lamarck Granodiorite south of the Mount Abbot quadrangle show that the rock crystallized about 90 m.y. ago. Two miles further north, the trail passes into the granodiorite of Lake Edison, a fine-grained rock characterized by abundant small crystals (about 1/16 in. across) of dark honey-brown sphene. The fine-grained, marginal facies of the granodiorite of Lake Edison contains included fragments of the Lamarck Granodiorite; the Lamarck is thus the older of the two plutons. The trail descends along Bear Creek for about 4 miles, across an area in which a pervasive system of northeast-trending joints is developed in the granodiorite of Lake Edison. Erosion is concentrated along these joints throughout the quadrangle, and as a result they are prominent features commonly marked by linear stream channels, long deep trenches, or parallel lines of trees and shrubs which cross otherwise barren rock. Lateral movement has occurred along many of these joints, and at several places along the trail dark inclusions and light-colored dikes are truncated and offset by fault displacements of a few inches to several feet. The orientation of joints throughout the Mount Abbot quadrangle, including those along which lateral offsets were observed, is shown in figure 2.

Climbing the north wall of Bear Creek, the trail crosses a narrow belt of glacial moraine which marks the upper edge of the ice river which filled Bear Creek only a few thousand years ago. The next mile crosses blocky rubble of a basalt flow erupted only about 3½ m.y. ago from a vent or vents on Volcanic Knob, 2 miles to the east. Rivers of red-hot lava spilled into both Bear and Mono Creeks, and flowed many miles to the southwest. After the lava cooled the Sierra Nevada was uplifted again and, with renewed energy and erosive power, water and ice carried away all but a few patches of the once extensive basalt. This patch over which the trail passes is the largest remnant of basalt in the quadrangle.

Past this basalt field, the trail descends over the granodiorite of Lake Edison into the valley of Mono Creek. To the east, there are several good views of the steep-walled Main Fork of Mono Creek. The "U" shape of this canyon is typical of glacially carved valleys in the Sierra. To the north, the alaskite of Graveyard Peak forms the jagged orange wall known as Vermilion Cliffs. This alaskite is the oldest known granitic rock in the Mount Abbot quadrangle, as it is penetrated by dikes of all other granitic rocks with which it is in contact; it is probably over 150 m.y. old. The trail follows Mono Creek upstream for a mile, passing a somewhat foul-smelling mineral spring just below the Mono Creek bridge. From here, it crosses a complex series of minor intrusive rocks and abundant aplite dikes, and turns up the North Fork of Mono Creek. Just before reaching Pocket Meadow, the trail passes into the quartz monzonite of Mono Recesses. This quartz monzonite, dated at about 78 m.y., is the youngest and largest pluton in the quadrangle. It is strongly porphyritic, and where the trail crosses the contact, potassium feldspar crystals reach several inches in length

and form zones consisting almost entirely of jumbled feldspar crystals.

A few hundred feet beyond Pocket Meadow, a side trail leading to Mott Lake passes a delightful soda spring of ice-cold carbonated mineral water. The main trail climbs through the quartz monzonite of Mono Recesses toward Silver Pass. West of the trail, along the arête southwest of Silver Lake, the old alaskite of Graveyard Peak is cut by numerous sub-horizontal aplite dikes, and looks like a giant layer cake. If time, energy, and weather permit, the three-quarter mile Class 2 climb from Silver Pass to the summit of unnamed Peak 12221 will provide a spectacularly scenic panorama reflecting virtually all major episodes in the long geologic history of the Sierra Nevada. Peak 12221 itself is composed of the uniform, porphyritic quartz monzonite of Mono Recesses, but a few miles to the northeast one can see the oldest known rocks in the Sierra Nevada, forming the brilliantly variegated red-orange and gray peaks of the Mount Morrison pendant (Red Slate Mtn., Bloody Mtn., Mt. Morrison, etc.). Paleozoic marine fossils collected from those metasedimentary rocks are almost 500 m.y. old and are part of the evidence that a shallow ocean basin persisted in this area for perhaps 250 m.y. Immediately to the north, and further to the northwest, the light- to dark-gray peaks are composed of the same sort of 235 to 135 m.y.-old metavolcanic rocks seen along the south margin of the quadrangle. To the northwest, 20 miles distant, the jagged dark-gray peaks of the Ritter Range are also formed of similar metavolcanic rock. In every direction one can see the light yellowish-gray and white granites which intruded the older metamorphic rocks as fiery, molten magma and then froze in place 150 to 80 m.y. ago. Across the quadrangle to the southwest, the flat tops of Mount Abbot and nearby peaks of the Sierran crest are remnants of the gently undulating erosion surface produced across the Sierra Nevada prior to about 10 m.y. ago. To the south, the 3½-m.y.-old basalt flows of Volcanic Knob are clearly visible.

North of Silver Pass, the trail descends through the quartz monzonite of Mono Recesses and a younger, fine-grained quartz monzonite, into Fish Creek and north into the metavolcanic rocks of the Mount Morrison quadrangle. In their winding 30-mile trip across the Mount Abbot quadrangle, travellers on the John Muir Trail have also traversed about half a billion years of earth history.

ROCKS NOT SEEN ALONG THE JOHN MUIR TRAIL

Rock Creek Area.—Just east of the eastern margin of the Mount Abbot quadrangle, a paved road leads up Rock Creek from Highway 395 nearly to the quadrangle boundary. The lower parts of this road are lined with spectular lateral moraines of glaciers which once extended from the high peaks of the Mount Abbot quadrangle well onto the valley floor near Tom's Place. From the road's end, a major trail leads south to the Little Lakes Valley, a glacial basin carved in the granodiorite of Chickenfoot Lake. This granodiorite is an old, intensely sheared pluton that is cut by both dark and light-colored granitic rocks, and is extensively altered to reddish yellow in places. In such alteration zones, small pockets of pyrite (fool's gold) are common. East of Mount Abbot and north of Bear Creek Spire the granodiorite of Chickenfoot Lake forms steep dark-grey cliffs cut by a spectacular array of bright white aplite dikes. These dikes are derived from the younger quartz monzonite of Mono Recesses, which form all the high white peaks along this part of the Sierran crest.

Graveyard Lakes Basin.—The Graveyard Lakes basin, north of Lake Edison, is a popular camping area which offers some of the most complex and spectacular geology of the entire quadrangle. The alaskite of Graveyard Peak, which is white here but weathers orange elsewhere, surrounds the Graveyard Lakes basin, and is cut here by an incredible variety of darker rocks and some light-colored dikes. The darker rocks include fine-grained diorite as well as black hornblende diorite in which individual hornblende crystals reach several inches in length. Between two of the diorite bodies at the uppermost Graveyard Lake, beautiful mineral layering of a rare type in which layers of black hornblende and white feldspar alternate is well developed.

Bear Creek.—One of the principal access trails to the John Muir Trail passes along the north bank of Bear Creek. At lower elevations this trail crosses the Mount Givens Granodiorite, one of the largest individual plutons in the Sierra Nevada, approximately 500 square miles in area. Near Bear Diversion Dam, the trail crosses into a thick section of metavolcanic rocks. At the well-exposed contact, large blocks of metavolcanic schist are enclosed in porphyritic Mount Givens Granodiorite, trapped there as the once molten granitic magma solidified 80 m.y. ago. After traversing more than a mile of varied metavolcanic rocks, the trail crosses the Lamarck Granodiorite and joins the John Muir Trail on the granodiorite of Lake Edison.

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GLOSSARY

Alaskite = A very light colored granitic rock in which dark minerals are nearly absent.

Aplite = A fine-grained, light-colored granitic rock with a sugary, equigranular texture. Generally occurs as thin dikes.

Arête = A steep-sided, knife-edge ridge separating two cirques.

Basalt = A dark volcanic rock.

Biotite = Black mica.

Breccia = A rock composed of angular fragments.

Cirque = A small, semicircular, steep-walled basin carved in a mountain by glacial erosion.

Cretaceous = A period of geologic time in the Mesozoic Era, extending from about 65 to 135 m.y. ago.

Diorite = A dark granitic rock composed of sodium-rich feldspar and dark minerals, with no appreciable potassium feldspar.

Feldspar = A series of light-colored aluminosilicate minerals with varying amounts of calcium, sodium, and potassium.

Foliation = Planar structure in any rock.

Granodiorite = A granitic rock composed of quartz, sodium-rich feldspar, a little potassium feldspar, and dark minerals.

Hornblende = A black, prism-shaped, calcium-magnesium-iron aluminosilicate mineral typically occurring in granodiorites.

Hornfels = A very fine grained, flinty metamorphic rock.

Joint = A straight or slightly curved fracture or crack in solid bedrock. Usually occurs in sets.

Magma = Molten rock–usually contains suspended crystals.

Mesozoic = An era of geologic time extending from about 65 to 225 m.y. ago.

Metamorphic = Pertains to rocks that have been recrystallized as a result of heat and pressure.

Metasedimentary = Pertains to metamorphosed sedimentary rocks.

Metavolcanic = Pertains to metamorphosed volcanic rocks.

Paleozoic = An era of geologic time extending from about 225 to 570 m.y. ago.

Pleistocene = An epoch of geologic time extending from about 10,000 to 2-3 million years ago–characterized by widespread and repeated episodes of glaciation.

Pluton = An individual body of intrusive igneous rock. Different plutons have their own individual characteristics and histories of emplacement.

Porphyritic = Pertains to igneous or metamorphic rocks which contain large scattered crystals much larger than the rocks average grain size.

Quartz monzonite = A light-colored granitic rock composed of biotite, quartz, and nearly equal amounts of sodium-rich and potassium feldspar.

Schist = A metamorphic rock in which numerous flakes of mica cause the rock to split into slabs and plates.

Sphene = A honey-colored mineral, calcium titanium silicate.

Tertiary = A period of geologic time extending from about 3 to 65 m.y. ago.

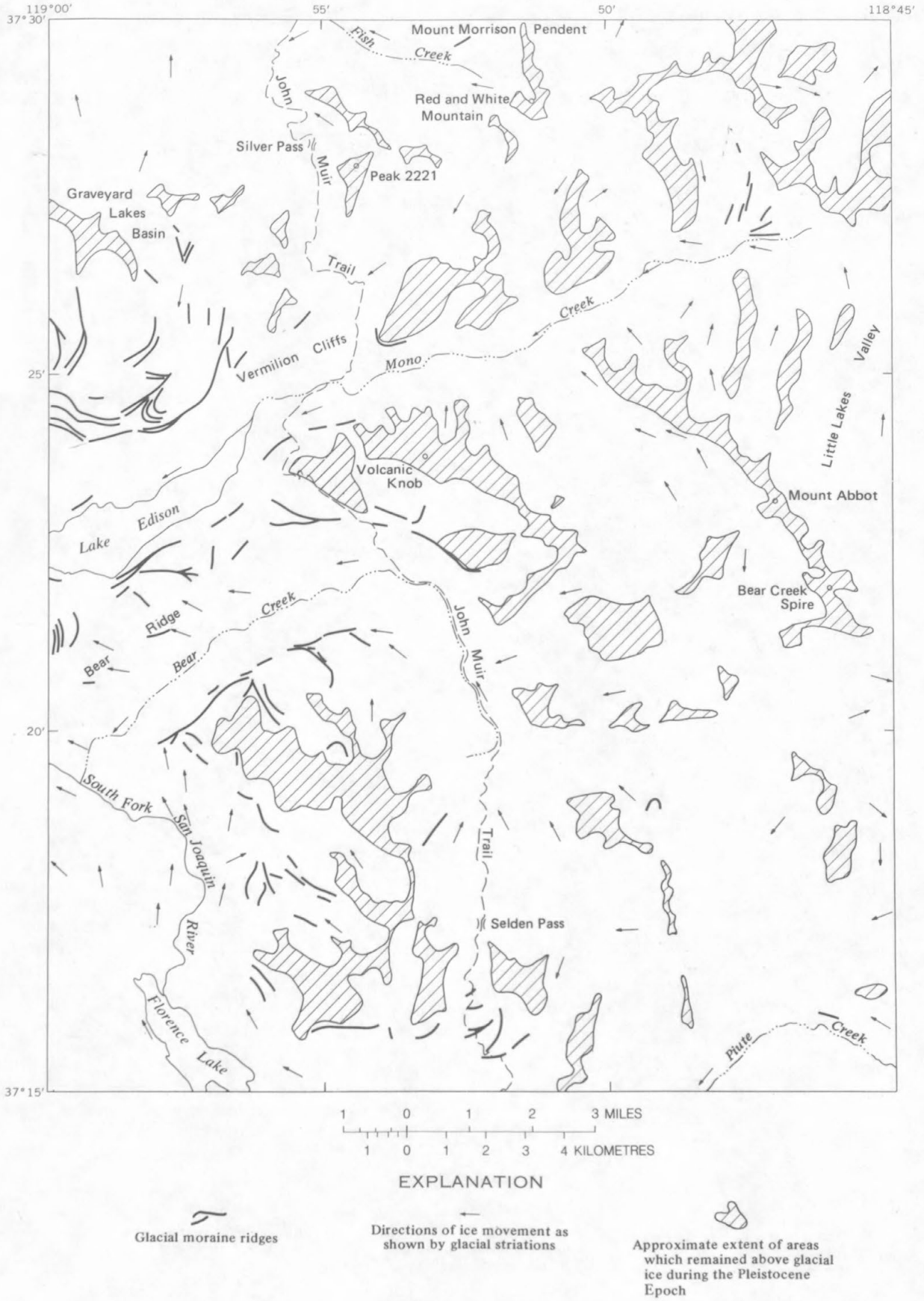
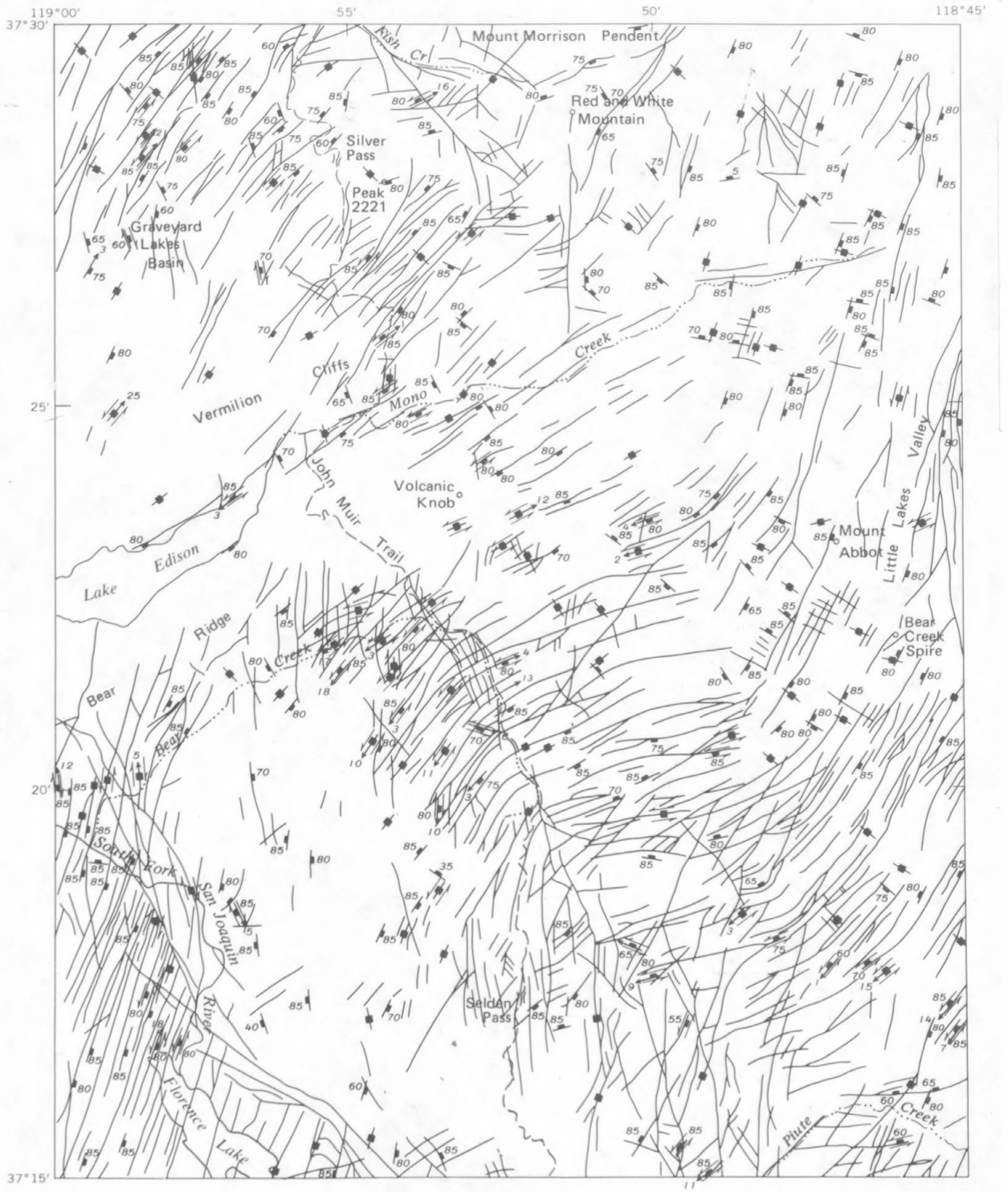


Figure 1. – Map showing glacial features of the Mount Abbot quadrangle, and locations of geographic features mentioned in text.



EXPLANATION

Traces of steeply inclined joint lineaments—no dips or offsets measured

Trace of inclined joint lineament, showing dip and direction of observed offset

Altitude of vertical joint—no offset measured

Altitude of inclined joint along which offset has occurred

Altitude of inclined joint, showing direction of offset and plunge of slickensides on joint surface

Figure 2. – Attitudes of joints and traces of joint lineaments in the Mount Abbot quadrangle, showing offset along some joints.