Schists of the Central Alaska Range

By CLYDE WAHRHAFTIG

CONTRIBUTIONS TO STRATIGRAPHY

GEOLOGICAL SURVEY BULLETIN 1254-E

Distribution of schists within Fairbanks A-2, A-3, and A-4 quadrangles and Healy D-2, D-3, and D-4 quadrangles

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SCHISTS OF THE CENTRAL ALASKA RANGE

By Clyde Wahrhaftig

ABSTRACT

The schist formations of the central Alaska Range lie in belts that trend east-west. The formations are deformed into a broad arch having steep limbs, and there is a belt of gentle dips in foliation along the north side of the arch. The Birch Creek Schist underlies a belt 6–10 miles wide along the axis of the arch and is flanked on the north by the Keevy Peak Formation, beyond which is the Totatlanika Schist. South of the Birch Creek Schist are metavolcanic rocks.

The most conspicuous structure is an axial-plane cleavage in the Birch Creek Schist and Keevy Peak Formation and a mineral foliation in the Totatlanika Schist. These are generally parallel to contacts between the formations and are deformed into the broad arch. The mineral foliation in the Birch Creek Schist and Keevy Peak Formation, as defined by oriented mica flakes and thin segregation laminae of quartz and sericite, is deformed into tight minor folds whose axial planes are parallel to the conspicuous cleavage and whose axes trend east and are nearly horizontal. The schists have been intensely deformed, and most formational contacts are thought to be thrusts whose original nature has been obscured by metamorphism.

The Birch Creek Schist is restricted to quartz-sericite schist and interbedded quartzite, black schist, and marble along the crest of the arch; it lacks original sedimentary structures. The Keevy Peak Formation is a newly named formation, between 2,500 and 4,000 feet thick, and is thought to be unconformable on the Birch Creek Schist. It consists of quartz-sericite schist, black schist and quartzite, purple and green slate, and thick lenticular bodies of stretched conglomerate.

The Totatlanika Schist is here divided into five new members, as follows: (1) At the base is the Moose Creek Member, 0–5,000 feet thick, which consists of three strongly contrasting lithologies—black schist, green chloritic schist, and yellow quartz-orthoclase gneiss and schist, (2) overlying this is the California Creek Member, at least 3,000 feet thick, which consists of white- to buff-weathering gray quartz-orthoclase gneiss and schist, one facies of which contains abundant megacrysts of orthoclase up to 2.5 centimeters long, (3) overlying and interfingering with the California Creek Member is the Chute Creek Member—1,300–1,500 feet of dark-green chloritic schist, (4) this in turn is overlain by the Mystic Creek Member—2,000–3,000 feet of predominantly fine grained purple, green, and yellow schist of rhyolitic origin, and (5) at the top is the Sheep Creek Member—400–1,000 feet of black schist, overlain by 2,000 feet of purple and green slate (probably metamorphosed tuff) overlain by 2,000 feet of epiclastic quartz-feldspar-sericite schist.

The Totatlanika Schist is predominantly of volcanic origin, and interbedded black schist and a fossiliferous limestone lens indicate a submarine origin. The chloritic schist may originally have been basaltic flows or basic intrusions, and the feldspathic schists may have originally been related to underwater pyroclastic eruptions.

The metavolcanic schists south of the Birch Creek Schist include a lower unit 800–2,000 feet thick of interbedded green chloritic schist and black schist, tentatively correlated with the Chute Creek Member of the Totatlanika Schist, and an upper unit at least 1,000 feet thick of quartz-feldspar-sericite schist of rhyolitic origin, tentatively correlated with the Mystic Creek Member.

The only fossil evidence on the age of the schists comes from a fossiliferous limestone lens in the Mystic Creek Member, which yielded *Syringopora* of Mississippian(?) age. The Totatlanika Schist is therefore assigned a Mississippian(?) age. The Birch Creek Schist and Keevy Peak Formation are considered to be Precambrian or Paleozoic.

INTRODUCTION

Schists and gneisses have been known from the central part of the Alaska Range ever since the pioneering explorations of Brooks and Prindle in 1902. In their reports (Prindle, 1907, p. 206–207; Brooks, 1911, p. 56–60, 149–150), they described two formations: (1) A belt of quartz-sericite schist, which they correlated with the Birch Creek Schist of the Yukon-Tanana Upland (Spurr, 1897), and (2) to the north of the quartz-sericite schist, a belt of quartz-orthoclase-sericite gneiss, which they regarded as metamorphosed rhyolite and assigned to the Silurian or Lower Devonian.

The Birch Creek Schist of the Mount McKinley area (fig. 1) was traced eastward to the Delta River by Capps (1912, pl. 2) and eastward from the Delta River by Moffit (1954, pl. 7) to a point that was near the Tanana River and only 3 miles distant along the strike from schist in the Yukon-Tanana Upland correlated by Mertie (1937) with the Birch Creek Schist of the type locality. These tracings confirm Brooks' and Prindle's long-range correlation. Mertie concluded that the Birch Creek Schist of the Yukon-Tanana Upland was Precambrian, probably early Precambrian, in age (Mertie, 1937, p. 55–59).

Strontium-87–rubidium-87 ages ranging from 120 m.y. (million years) to 1,170 m.y. were reported for biotite, muscovite, and whole-rock samples of the Birch Creek Schist by Wasserburg, Eberlein, and Lanphere (1963). However, Lanphere later wrote that all the isotopic data are compatible with a period of Mesozoic metamorphism if interpreted in the light of recent work on the redistribution of strontium during metamorphism. Thus, to date, no proof of a Precambrian age for the Birch Creek Schist has been found by isotopic methods, and the late age of the metamorphism suggested by the isotopic data renders Mertie's argument for a Precambrian age invalid. The uncertainties introduced by the new data have led to the assignment of the Birch Creek Schist to the Precambrian or early Paleozoic (Péwé, Wahrhaftig, and Weber, 1966).

Capps (1912, p. 22–26) mapped the distribution of the quartz-orthoclase-sericite schist and gneiss and named these feldspathic rocks the Totatlanika Schist, from their exposures in the lower canyon of the Totatlanika River (fig. 2). In the Totatlanika Schist, Capps included bodies of schistose conglomerate and quartz-sericite schist in the basin of the Wood River. He found no evidence regarding the age of the formation. In 1954 fossils were found in fragments of limestone weathering from a hill of Totatlanika Schist about three-fourths of a mile southwest of the junction of Rogers and Sheep Creeks in Healy D–2 quadrangle (fig. 3). These fossils included a *Syringopora* identified by Helen Duncan as being similar to a *Syringopora* in limestones of the Lisburne Group, and consequently the Totatlanika Schist was assigned a Mississippian(?) age (Wahrhaftig, 1958, p. 12).

An area of eight 15-minute quadrangles in the northern part of the central Alaska Range (fig. 1), including the type locality of the Totatlanika Schist and the area where the Birch Creek Schist was first seen in the Alaska Range, was studied by the author and his associates between the years 1944 and 1958, in conjunction with coal investigations in the Nenana coal field. The geologic mapping for a publication scale of 1:63,360 has made it possible in the Wood River basin to separate

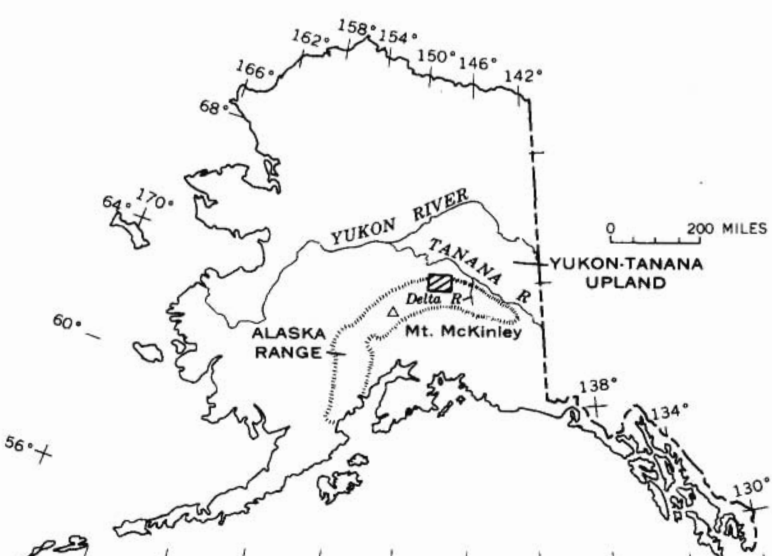


FIGURE 1.—Index map of Alaska showing location of area (crosshatched) of figure 2.

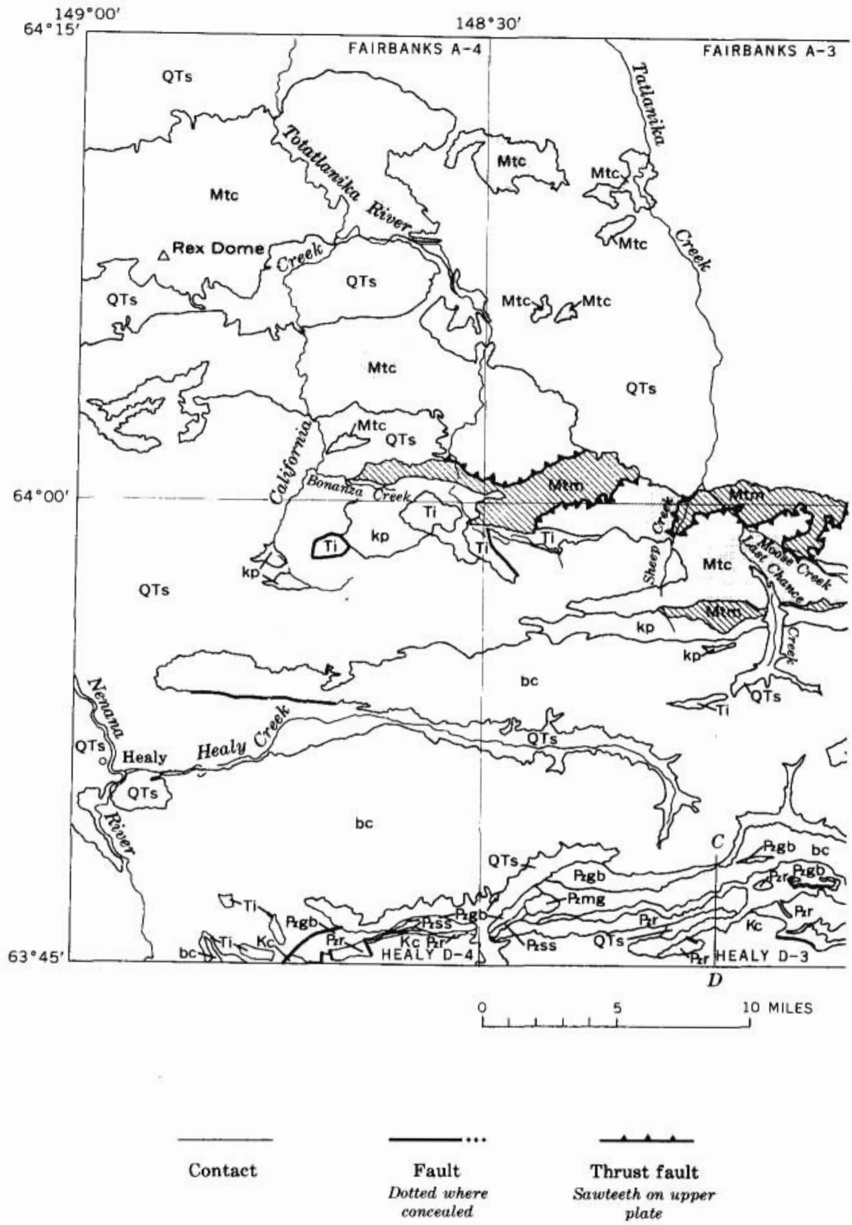


FIGURE 2.—Generalized geologic map of part of the central Alaska Range showing distribution of the schist formations in the Fairbanks A–2, A–3, and A–4 quadrangles and the Healy D–2, D–3, and D–4 quadrangles.

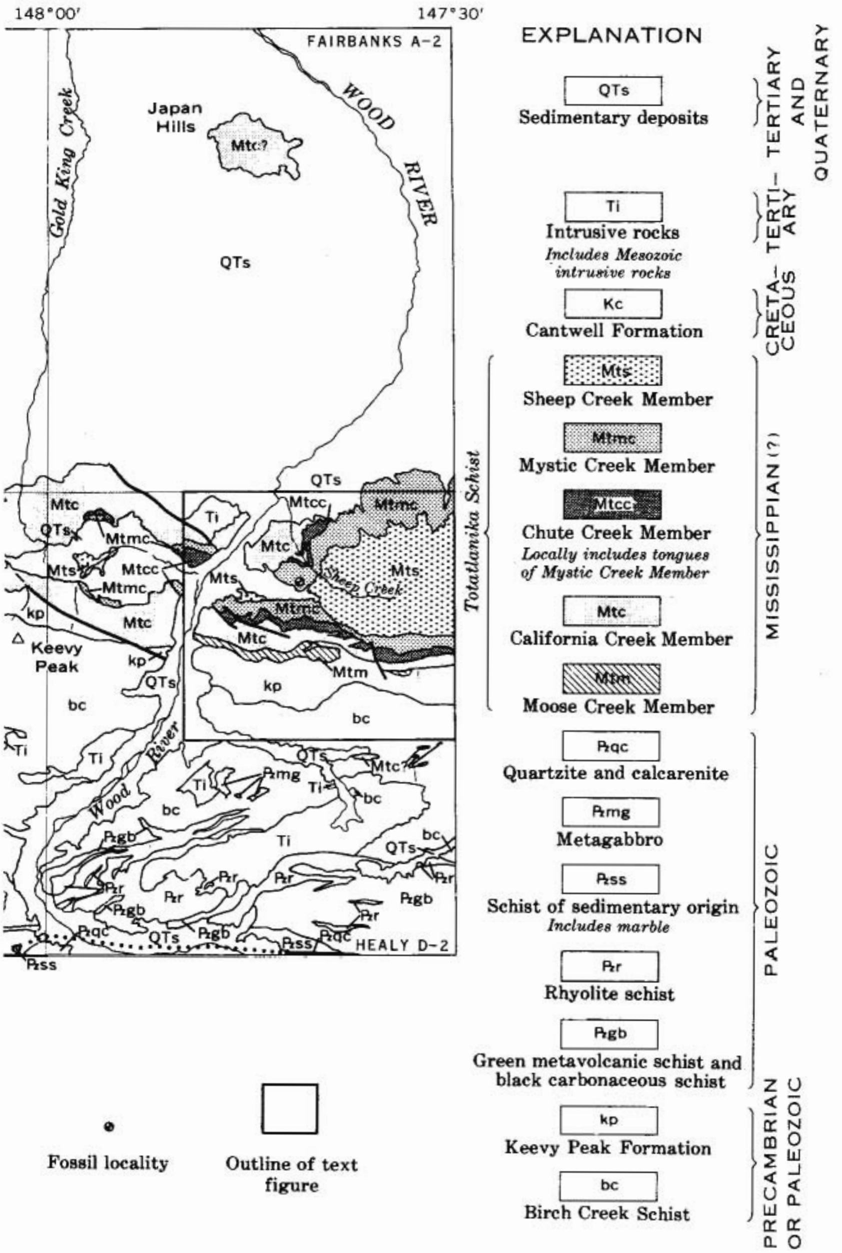
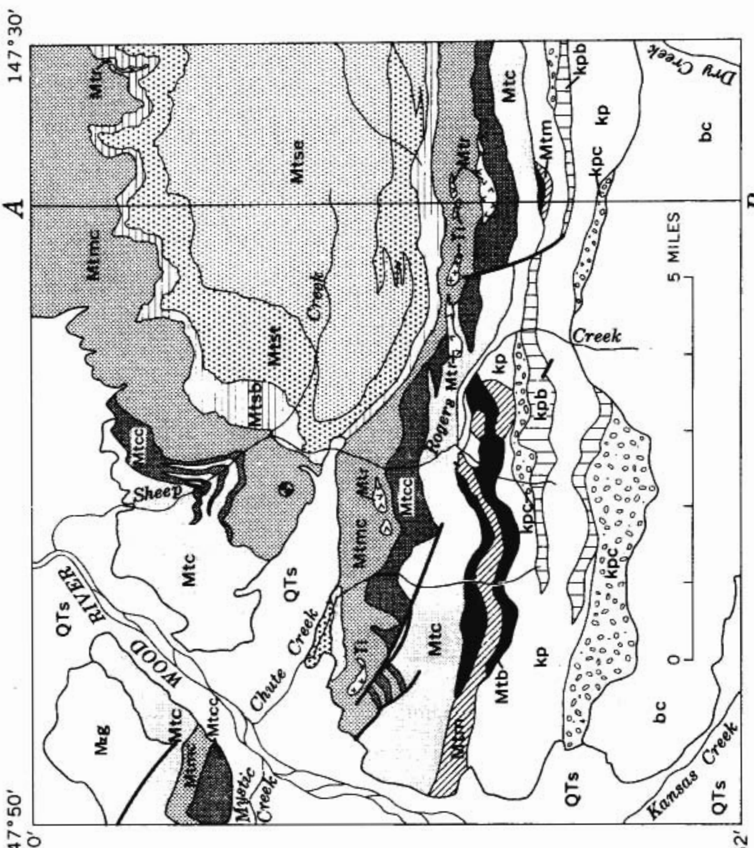


FIGURE 2.—Continued.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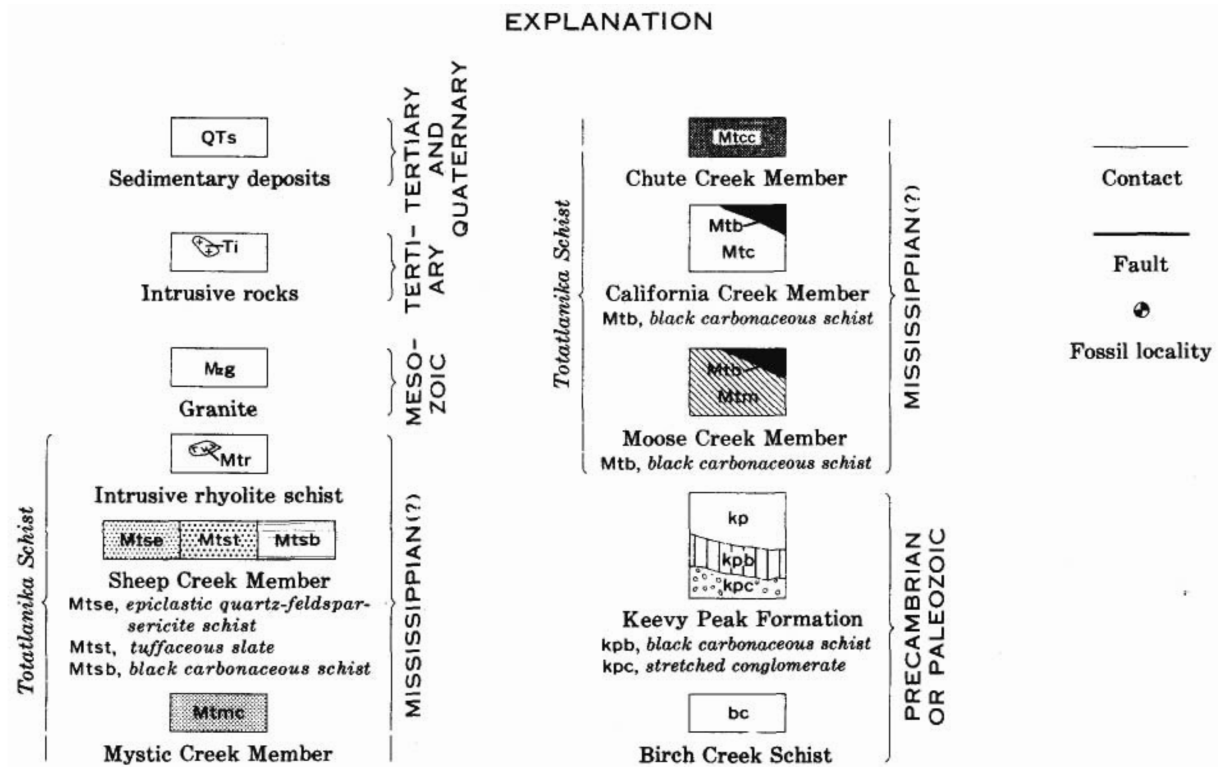

FIGURE 3.—Geologic map of the northeastern part of Healy D–2 quadrangle, showing the distribution of members of the Totatlanika Schist. Outline of area is shown in figure 2.

the Totatlanika Schist from the quartz-sericite schist and stretched conglomerate, although Capps (1912) originally included them in the formation. This quartz-sericite schist and stretched conglomerate are here named the Keevy Peak Formation. The Totatlanika Schist overlying the Keevy Peak is divided into five named members: Moose Creek, California Creek, Chute Creek, Mystic Creek, and Sheep Creek Members. Schists of volcanic origin, lying south of the Birch Creek Schist, have also been separated from the Birch Creek Schist as mapped by Capps (1940, pl. 2). These schists are not formally named, although they probably correlate with the Totatlanika Schist. The distribution of the schist formations in six of the quadrangles (Fairbanks A–2, A–3, A–4; Healy D–2, D–3, D–4) is shown in figure 2.

GENERAL STRUCTURAL AND AREAL RELATIONS

The schist formations lie in belts that trend east and west, parallel to the trend of the range. The Totatlanika Schist lies to the north; it is probably the basement rock in the southern part of the area shown on Fairbanks quadrangle map (scale, 1:250,000) (Péwé, Wahrhaftig, and Weber, 1966) and extends south into the northern parts of Healey D–2 and Healy D–3 quadrangles (fig. 2). Its exposures are limited, however, for over most of this area it is buried beneath Cenozoic deposits. South of the Totatlanika Schist, the Keevy Peak Formation crops out in a belt 3,500–7,000 feet wide in northern Healy D–2 and Healy D–3 quadrangles. Its extension to the west is largely buried beneath Tertiary rocks. The Birch Creek Schist lies south of the Keevy Peak Formation and makes up the rugged mountains of the northern part of the Alaska Range, including the ridge through which the Nenana River has cut its gorge between McKinley Park Station (south of fig. 2) and Healy. South of the Birch Creek Schist, in southern Healy D–2, D–3, and D–4 quadrangles, is a belt of metavolcanic and associated metasedimentary schists. This belt is cut off on the south by an immense zone of faulting. South of this fault the Paleozoic and Mesozoic rocks are relatively unmetamorphosed and undeformed as compared with the schists.

Within the schists, the most conspicuous structures are an axial-plane cleavage in the Birch Creek Schist and Keevy Peak Formation and a mineral foliation in the Totatlanika Schist. These structures appear to be roughly parallel to the contacts between the formations.

The planar structures and the contacts between the formations are folded into a broad east-trending arch whose core is the Birch Creek Schist. To the north of the arch is an area of rather gentle dips in the foliation of the Totatlanika Schist, in which at least one prominent syncline can be recognized. The flanks of the arch are steep, dipping from 45° to vertical. The steep north flank includes all the area of the

Keevy Peak Formation plus a considerable amount of Birch Creek Schist and Totatlanika Schist. The south flank includes part of the Birch Creek Schist and the metavolcanic schists south of the Birch Creek Schist. This simple structural pattern becomes even more pronounced if the overlying Tertiary rocks are "unfolded," for the moderately dipping foliation in the Totatlanika Schist of the northern foothills is generally nearly parallel to the dip of the overlying coal-bearing rocks.

These simple structures conceal much structural complexity within the schist formations, however. Original sedimentary structures are completely destroyed within the Birch Creek Schist, and the foliation within the formation is due to planar parallelism of sericite flakes and to segregation of quartz and sericite into sheets a millimeter or so thick. The rocks are tightly folded into minor folds with amplitudes and wavelengths of several inches to 20 feet. The axial-plane cleavage of these minor folds causes the conspicuous schistosity visible on canyon walls and distant outcrops. Lithologic layering in the Birch Creek Schist, as between quartzite layers and sericite schist, is generally parallel to the mineral foliation and the tight folds. Axes of the minor folds plunge gently or are horizontal and generally trend east or northeast, as does the mineral elongation and streaking in the Totatlanika Schist. Lineations that bend around the axes of the minor folds suggest a still earlier period of deformation, whose evidence has been all but destroyed.

Original sedimentary features, such as pebbles, graded bedding, and crossbedding, are locally preserved within the Keevy Peak Formation, but this formation, too, had undergone intense minor folding during more than one period of deformation. Both sedimentary schist formations are tectonites, and the pervasive minor folding probably developed in the manner described by Paterson and Weiss (1966).

Several features suggest that the schist formations of the central Alaska Range have been cut by numerous unmapped thrusts and that many of the mapped lithologic contacts between schists of different units are in fact tectonic contacts whose original nature has been obscured by subsequent metamorphism. These supposed thrust-fault contacts are parallel to the axial planes of the minor folds in the Birch Creek Schist and Keevy Peak Formation and to the mineral foliation of the Totatlanika Schist.

Slices of rocks characteristic of some members of the Totatlanika Schist lie above or below their normal stratigraphic position in the Totatlanika Schist or lie within the Keevy Peak Formation or the Birch Creek Schist (fig. 2). These are thought to be thrust slices. Although a tectonic origin for these bodies seems most likely, the

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possibility that they are metamorphosed intrusions cannot be ruled out.

Complicated stratigraphy of interbedded green metavolcanic schist and black schist characterizes one of the schist units south of the Birch Creek Schist and is repeated in at least two lenticular bodies separated by quartz-sericite schist continuous with the Birch Creek Schist (fig. 4, lower). This repetition is best explained as the result of thrusting, as is the increasingly complex pattern of rhyolite schist and basic metavolcanic schist as one proceeds eastward across the south part of Healy D–3 and D–2 quadrangles.

Although most of the unmapped thrusts suggested only by stratigraphic dislocation appear to have predated or to have been contemporaneous with the metamorphism, one mapped thrust in the north part of Healy D–3 and south part of Fairbanks A–3 quadrangles, between two members of the Totatlanika Schist, cuts the foliation and lithologic boundaries at a considerable angle and apparently postdates the metamorphism. It predates the deposition of the Tertiary rocks in the area.

The structural complexities of the schist formations make meaningful stratigraphic thicknesses impossible to obtain in most cases. Even the stratigraphic sequence between some of the formations is doubtful. The thicknesses given herein are present measured thicknesses of representative bodies perpendicular to their contacts or to the latest foliation. They may or may not be equivalent to the true stratigraphic thickness.

BIRCH CREEK SCHIST

The Birch Creek Schist in the central Alaska Range is restricted to the terrane that is predominantly quartz-sericite schist, quartzite, sericite schist, and quartz-sericite-calcite schist, with minor amounts of carbonaceous schist and marble. It is of sedimentary origin, probably as marine shales and sandstones. Typical schist consists of 60–80 percent quartz, 10–25 percent sericite, 5–10 percent calcite, and 5–15 percent albite and microcline. Pyrite is the most common opaque mineral. Tourmaline and zircon are rarely present and are probably detrital. A few bodies and layers of chloritic schist, chlorite-epidote, chlorite-actinolite, tremolite, and epidote-chlorite-albite schist that occur in the area mapped as Birch Creek Schist were probably sills or volcanic layers. They establish the metamorphic grade of the schist as that of the greenschist facies. Typical Birch Creek Schist is light gray to greenish gray in fresh exposures but weathers to buff or light brown. Its thickness measured perpendicular to the axial-plane cleavage of the minor folds (not a true stratigraphic thickness) is at least 10,000 feet.

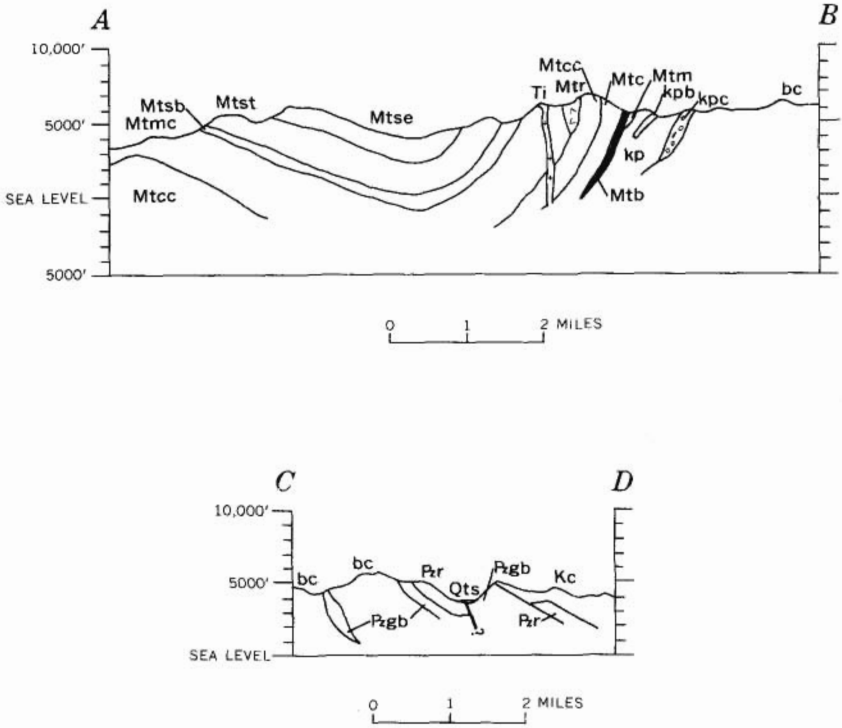

FIGURE 4.—Sections showing structural relations of the schist formations. Upper: Section through the Sheep Creek syncline showing structural relations in the Keevy Peak Formation and Totatlanika Schist. See figure 3 for explanation and location of section. Lower: Section through the metavolcanic schists in southern Healy D–3 quadrangle. See figure 2 for explanation and location of section.

KEEVY PEAK FORMATION

A belt of quartz-sericite schist, black carbonaceous schist, gray and green and purple slate, black quartzite, and stretched conglomerate, originally mapped by Capps (1912) with the Totatlanika Schist and earlier mapped by Wahrhaftig (1958, pl. 1) with the Birch Creek Schist, is here named the Keevy Peak Formation. Although the Keevy Peak resembles the Birch Creek Schist in lithology and structural complexity, it is thought to be unconformable upon it. Lenticular bodies of stretched conglomerate as much as 5 miles long and 1,200 feet thick, containing pebbles of quartz, chert, and phyllite, occur along its contact with the Birch Creek Schist, and are thought to be a basal conglomerate of the Keevy Peak derived in part from the Birch Creek Schist. Sedimentary structures, such as graded bedding, cross-bedding, and pebble beds, are present in places in the Keevy Peak Formation despite the intense deformation it has undergone. They have not been observed in the Birch Creek Schist.

Because of the deformation undergone by the Keevy Peak Formation, a type section is difficult to define. The type locality for the formation is in the Healy D–3 quadrangle on the northwest shoulder of Keevy Peak (fig. 2), from a point on the ridge crest 5,700 feet N. 40° W. of the summit, where mixed stretched conglomerate and black schist overlie quartz-sericite schist of the Birch Creek Schist, to the north side of a saddle on the same ridge about 10,000 feet N. 36° W. of the summit, where black schist of the Keevy Peak Formation is overlain by quartz-orthoclase gneiss of the Totatlanika Schist. The thickness of the Keevy Peak in this section is 2,500–3,000 feet, and the formation appears to dip 50°–65° N. The formation in this section consists of green and purplish slates, greenish-gray quartz-sericite schist, black schist, black quartzite, brownish-weathering calcareous schist, and a schist consisting of large bluish grains of quartz and feldspar embedded in a fine-grained matrix of quartz and sericite. This last schist is known in the field as grit. Stretched conglomerate occurs near the base.

Another typical section, designated a reference section, occurs at the headwaters of Rogers Creek in the Healy D–2 quadrangle (fig. 3): At the base, 1,200–2,000 feet of stretched conglomerate, overlain by 200–800 feet of black schist; about 1,000 feet of quartz-sericite schist and sericite schist; about 500 feet of black quartzite; 500 feet of quartz-sericite schist and stretched conglomerate; and, at the top, about 800 feet of interbedded black schist and quartzite. The section dips 35°–65° N.

Under the microscope, typical quartz-sericite schist from the Keevy Peak Formation is seen to consist of 60–90 percent quartz, 5–20 percent sericite, 5–30 percent calcite, and a few percent feldspar. Carbonaceous matter, chlorite, and rarely stilpnomelane may be present. Textures are cataclastic to crystalloblastic, and grain size ranges from 0.02 mm (millimeter) for the fine-grained matrix to 1 mm for the large bluish quartz grains whose presence gave rise to the term "grit" for describing the schist.

The Keevy Peak Formation is overlain by the Totatlanika Schist. If the stratigraphic relations reflect a depositional sequence, the Keevy Peak Formation might be Mississippian or older in age. However, until the field relations are better understood, the Keevy Peak is assigned to the Precambrian or Paleozoic.

TOTATLANIKA SCHIST

The Totatlanika Schist is the quartz-orthoclase-sericite schist and gneiss of the Northern Foothills of the Alaska Range (Wahrhaftig, 1965, p. 35) and is interpreted by Capps (1912, p. 22) to be metamorphosed rhyolite. Geologic mapping in the period 1954–57 showed that the typical gray to pale-buff quartz-orthoclase-sericite schist and gneiss of the type locality in the canyon of the Totatlanika River interfingered eastward in the Wood River valley with several stratigraphic units of great lithologic variety, although volcanic rocks predominate. In order to clarify the stratigraphic relationships, these stratigraphic and lithologic units are here grouped together into five members, whose relationships are shown in the panel diagram in figure 5.

MOOSE CREEK MEMBER

The lowest unit of the Totatlanika Schist, here named the Moose Creek Member, is made up of rock bodies of three sharply contrasted lithologies—black schist, green chloritic schist, and yellow quartz-orthoclase schist and gneiss. These rock bodies are generally lenticular and are tectonically disturbed, for in much of the area of exposure, this member underlies a thrust fault. The type locality is designated as a small canyon tributary to Moose Creek from the north (148°06′ W., 63°59′ N.), where all three lithologic types are exposed, but in obscure relationships. A reference section, also within the Healy D–3 quadrangle, is designated as the exposures along the ridge crest between the headwaters of Sheep Creek and Last Chance Creek, about 4 to 5 miles southwest of the type locality. In this section, 100–500 feet of black schist is overlain by a lens of dark-green chloritic schist about 2½ miles long and as much as 1,700 feet thick. This is overlain in turn by about 700 feet of black carbonaceous schist, 2,300 feet of pale-yellow quartz-orthoclase schist and gneiss, and about 300 feet of black schist to the base of the overlying California Creek Member. This is the thickest section of the Moose Creek Member but may be tectonically thickened (see fig. 5). It is not known whether the dark-green chlorite-schist bodies were originally thick basic extrusive piles or were diabasic sills. The Moose Creek Member pinches out eastward but is sporadically present beneath the California Creek Member east of Rogers Creek. It pinches out to the west at Sheep Creek (tributary of Tatlanika Creek) along the south border of the Totatlanika Schist but is present in the lower plate of a thrust fault along the north border of Healy D–3 quadrangle and in southernmost Fairbanks A–3 and A–4 quadrangles, as far west as the head of Bonanza Creek (fig. 2). Yellow slate present on Slate Creek near Ferry and quartz-orthoclase gneiss and yellow schist near the lower Teklanika River, both areas in Healy D–5 quadrangle west of the area shown in figure 2, may be part of the Moose Creek Member. The contact with the underlying Keevy Peak Formation is probably considerably faulted although it may have originally been an unconformity.

CALIFORNIA CREEK MEMBER

The California Creek Member is here named for rocks exposed at its type locality, California Creek, in the Fairbanks A–4 quadrangle (see fig. 2). The member comprises all the schist exposed at the type locality of the Totatlanika Schist in the lower canyon of the Totatlanika River. It consists of white- to buff-weathering gray quartz-orthoclase-sericite schist and gneiss which occurs in a coarse-grained and in a medium-grained facies; the two facies are commonly in sharp contact parallel to the foliation and are intimately mixed. The California Creek Member, the most widespread member of the Totatlanika Schist, is exposed from the mountains around Windy Creek in Fairbanks A–5 quadrangle (just west of the area shown in fig. 2) eastward and southward to the headwaters of the Totatlanika River and thence east across the Wood River at least as far as the east edge of Healy D–2 quadrangle. The Totatlanika Schist exposed in the Japan Hills in Fairbanks A–2 quadrangle is correlated with this member.

The coarse facies contains large augen of potassium feldspar, 2.5 to 25 mm in average diameter, and smaller augen of quartz, one-half to one-tenth the size of the feldspar, in a gray to greenish-gray matrix consisting of sericite, chlorite, quartz, feldspar, and calcite. Most of the feldspar is perthitic microcline, but albite crystals are also present. In some places the feldspar augen are well-formed megacrysts with sharp crystal faces against which the foliation in the groundmass ends abruptly; these megacrysts are oriented with the long axes at broad angles to the foliation; some may even be perpendicular to it. The best formed crystals were observed in the canyon of Last Chance Creek in Healy D–3 quadrangle. All gradations were found from well-formed megacrysts to crystals broken by lines of shearing and rounded or lenticular parallel to the foliation. In the vicinity of Rex Dome the megacrysts take the form of flat spindles several inches long.

The medium-grained facies consists of flattened to sharply angular grains of quartz and feldspar (feldspar predominating), 0.5 to 2 mm across, in a strongly schistose groundmass of sericite, orthoclase, and quartz. Texture is typically cataclastic. Other minerals present are stilpnomelane, zoisite, chlorite, and calcite. Feldspar is about equally albite (anorthite, less than 5 percent) and orthoclase.

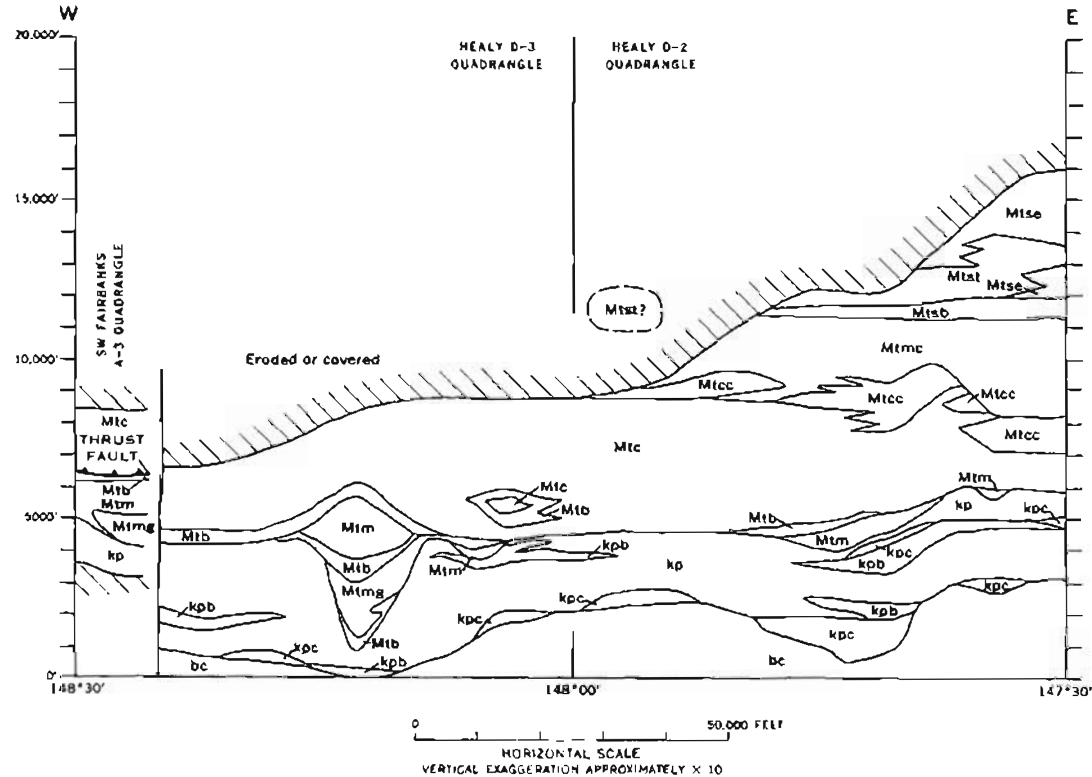

FIGURE 5.—Diagrammatic stratigraphic panel of the schist formations in the northern part of Healy D-2 and D-3 quadrangles and southwestern part of Fairbanks A-3 quadrangle. Modified from geologic map and sections to eliminate some structural complexities and to bring out interfingering relationships along Sheep Creek. Mtmg, dark-green metavolcanic schist of the Moose Creek Member of the Totatlanika Schist. For explanation of other formation symbols, see figure 3.

A fine-grained facies on California Creek about 6 miles above its mouth contains well-formed phenocrysts of feldspar and quartz, making up 2–5 percent of the rock, in an aphanitic yellow schistose groundmass.

Thin layers of black carbonaceous schist and slate, probably of sedimentary origin, are interbedded with the quartz-feldspar-sericite schist and gneiss of the California Creek Member.

The total thickness of the California Creek Member is unknown. Sections exposed in the walls of the canyon of Last Chance Creek measure 2,000–3,000 feet, and the lower and middle canyons of the Totatlanika River, each 2,000 feet deep, are cut entirely in this member. In these areas the top has been eroded. East of the Wood River, the California Creek Member interfingers with the overlying Chute Creek Member, and its thickness in the eastern part of Healy D–2 quadrangle is 1,000–1,500 feet. (See figs. 4 and 5.)

CHUTE CREEK, MYSTIC CREEK, AND SHEEP CREEK MEMBERS

The three uppermost members of the Totatlanika Schist are well exposed in a large syncline that makes up the mountains around Sheep Creek and Rogers Creek in the northeast quarter of the Healy D–2 quadrangle (fig. 3). The type sections of two of these, the Chute Creek and Mystic Creek Members, are on Rogers Creek, a tributary of Sheep Creek, on the south limb of this syncline. The type section of the uppermost member, the Sheep Creek Member, is on Sheep Creek above the mouth of Rogers Creek, on the north limb and axis of the syncline.

In addition to these three members, lenticular bodies of rhyolite schist, which apparently originated as shallow sill-like intrusions, are found in the Mystic Creek Member and basal part of the Sheep Creek Member, shown separately on figure 3. These bodies are probably close in age to the units which they intrude.

CHUTE CREEK MEMBER

The Chute Creek Member, here named after exposures on Chute Creek, consists largely of dark-green schist; under the microscope, typical specimens are seen to consist of chlorite, zoisite (or epidote), actinolite, albite, and biotite. One specimen showed relict pyroxene and plagioclase (the latter altered to albite). The Chute Creek Member is a metamorphosed basic volcanic rock in the greenschist facies of metamorphism and may have originated as basaltic flows. Its type section is along Rogers Creek from 8,500 feet to 10,700 feet south of the mouth. It is 1,300–1,500 feet thick on the limbs of the Sheep Creek syncline and interfingers to the west with both the underlying California Creek Member and the overlying Mystic Creek Member. Its westernmost exposure is on the north side of the Mystic Creek coal basin, in northwestern Healy D–2 quadrangle.

MYSTIC CREEK MEMBER

The Mystic Creek Member, as here named, consists of fine-grained purple, green, and yellow schist exhibiting conspicuous linear streaking on the foliation surfaces and containing abundant grains of a few millimeters in diameter that in hand specimen appear to be relict phenocrysts of quartz and feldspar. Under the microscope the schist is confirmed to be a metarhyolite containing 10–20 percent relict phenocrysts of beta-quartz, albite, and orthoclase in a fine-grained schistose groundmass of intergrown quartz, feldspar, sericite, chlorite, hematite, and stilpnomelane. Layers of fine-grained purple and pale-green schist of this member have euhedral megacrysts of feldspar (that appear to be phenocrysts) as large as one-fourth to one-half inch in diameter, which resemble the feldspar megacrysts of the California Creek Member. Float from one thin fossiliferous limestone bed was found in the area of the formation near the top of the hill west of the mouth of Rogers Creek (fig. 3).

The type section of the Mystic Creek Member is on Rogers Creek, from 5,000 feet to 8,500 feet upstream from its mouth (fig. 3). It is about 2,000 feet thick along Rogers Creek and is as much as 3,000 feet thick at the eastern end of the Sheep Creek syncline. In fault blocks on the south limb of the syncline between Chute Creek and the Wood River, it appears to interfinger westward with the underlying Chute Creek Member. Just north of the mouth of Mystic Creek, schist lithologically similar to the Mystic Creek Member, and mapped as part of that member (fig. 3), lies between dark chloritic schist of the Chute Creek Member and the underlying California Creek Member. A stratigraphic interpretation of these relationships is shown in figure 5. The Mystic Creek Member is exposed as far west as the upper part of Mystic Creek, in the Healy D–2 quadrangle, and is named for this stream.

SHEEP CREEK MEMBER

The uppermost member of the Totatlanika Schist, here named the Sheep Creek Member, underlies the axial part of the Sheep Creek syncline. The type section is defined as the section along Sheep Creek above the mouth of Rogers Creek, as far as the highest exposed beds in the trough of the syncline.

Four lithologic units are grouped in the Sheep Creek Member. At the base is a layer 400–1,000 feet thick of fine-grained black schist, which under the microscope is seen to consist of 60 percent quartz and

40 percent black carbonaceous material. This is overlain by about 2,000 feet of purple and pale-green slates thought to be metamorphosed tuffs. One thin section examined consisted of chlorite, sericite, epidote, and a little quartz. The slate unit interfingers upward with quartz-feldspar-sericite schist in which are preserved graded bedding and crossbedding. Thin sections of this rock reveal about 80 percent subangular grains of quartz, orthoclase, and plagioclase, in the ratio of about 3:1:1, averaging 0.5–2 mm in diameter, in a fine-grained matrix of sericite and crushed and recrystallized quartz. This rock was probably originally arkose. As much as 2,000 feet of this epiclastic schist lies above the purple and green slates. The top of the formation, in the center of the syncline, has been removed by erosion.

A fourth lithologic unit placed tentatively in the Sheep Creek Member is a body of thinly bedded dark-gray and light-gray slate, the color beds being only a few inches thick. This body lies in the center of the Mystic Creek coal basin and is surrounded on all sides by coal-bearing Cenozoic sedimentary deposits. Its relations to the other units of the Totatlanika Schist are unknown.

AGE AND ORIGIN OF THE TOTATLANIKA SCHIST

In the summer of 1954, the writer found fossils in float from a limestone ledge in the upper part of the Mystic Creek Member of this report. The fossiliferous fragments were found at an altitude of 4,100 feet, at the southeast end of the mountain west of the junction of Rogers and Sheep Creeks, at a point about 3,500 feet S. 65° W. of the junction (fig. 3). The report of Helen Duncan, who identified the fossils and assigned an age to the formation, is quoted below (from Wahrhaftig, 1958, p. 12):

> I examined all the pieces of rock in this collection and sawed and polished several. The only things I could find that I am sure are organic are crinoid columnals, a small gastropod in section, and several pieces of *Syringopora* that is closely similar to if not identical with a form that occurs in the Wachsmuth limestone of the Lisburne group. The specimens of *Syringopora* are a little distorted, but the internal structures are well preserved * * *.
>
> The presence of *Syringopora* (sensu stricto) indicates that the rock is post-Ordovician, and the chances are that it is not Silurian—at least I have not seen any good evidence that *Syringopora* in the strict sense occurs in the Silurian of Alaska. However, Silurian species of the genus have been described from the Arctic regions of the U.S.S.R. and might occur in Alaska. I have seen a few specimens from the Devonian of Alaska that I would refer to *Syringopora*, but they did not closely resemble the species in this collection. We do not have enough information on stratigraphic occurrences, however, to rule out the possibility of Devonian age in this case. Possibly because I am more familiar with the Mississippian Syringoporas of Alaska and because the species in this collection looks very much like a form that I know is common in the Mississippian, I favor a Mississippian assignment. Verification of that assignment will depend on getting other kinds of fossils.

On the basis of Helen Duncan's report, the Totatlanika Schist was assigned to the Mississippian(?).

The mineralogy and chemistry of the Totatlanika Schist point clearly to an igneous origin for the bulk of the formation. The interbedded layers of black carbonaceous schist and the occurrence of fossiliferous limestone in the Mystic Creek Member suggest that it originated as a series of submarine eruptions. The lateral persistence and thinness of the members and individual units make a flow origin unlikely for a rock as siliceous as the bulk of the Totatlanika Schist. An origin related to a series of submarine pyroclastic eruptions or ash flows seems most likely.

The origin of the feldspar megacrysts that characterize the Totatlanika Schist presents a special problem. The euhedral outline of many of the megacrysts, sharply crosscutting the foliation, suggests growth during metamorphism; in particular, the elongated spindle-shaped crystals showing strong parallel alinement in the plane of foliation, such as are found around Rex Dome, must have developed during metamorphism. The large size of the megacrysts, 2.5 cm or more in diameter, is also strong evidence for a metamorphic origin.

Yet, in the Sheep Creek syncline, in both the California Creek and Mystic Creek Members, layers of schist with large megacrysts are interbedded with layers of fine-grained schist with 1-mm-long phenocrysts of feldspar and quartz grains pseudomorphous after embayed beta-quartz. The factors that influenced crystal growth during the metamorphism must have been selective along certain beds, if megacrysts with these field relations are porphyroblasts.

Although large phenocrysts in volcanic rocks are rare, they are not unknown. They have been reported from the Galapagos Islands (McBirney and Aoki, 1966), Steens Mountain, Oregon, and Nunivak Island (Allan Cox, oral commun., Dec. 30, 1966), and the San Juan Mountains, Colo. (Larsen and others, 1938). It is not impossible, therefore, that some of the megacrysts did originate as phenocrysts; others are certainly porphyroblasts, but probably had phenocrysts as nuclei.

The medium-grained facies of the California Creek Member, likewise, has two possible origins. There is a strong suggestion of a cataclastic origin for the angular fragments of quartz and feldspar in many thin sections in that they appear to be tectonically broken fragments of much larger crystals. If so, the medium-grained facies originated through shearing of the coarse-grained facies along zones of intense deformation. On the other hand, the medium grain size may be an original feature, of at least part of this facies, and could represent medium-grained pyroclastic accumulations.

METAVOLCANIC SCHISTS AND ASSOCIATED ROCKS SOUTH OF THE BIRCH CREEK SCHIST

The metavolcanic schists south of the Birch Creek Schist form a belt ½ to 4 miles wide along the south border of Healy D–2, D–3, and D–4 quadrangles (fig. 2). In Healy D–4 quadrangle and in the western two-thirds of Healy D–3 quadrangle, where their structure is fairly simple, these schists dip 35°–50° to the south. They can be divided into two units—a lower unit of interbedded green metavolcanic schist and black carbonaceous schist and an upper unit of quartz-sericite-feldspar schist.

The lower metavolcanic unit, 800–2,000 feet thick, consists of interbedded green metavolcanic schist and black carbonaceous schist. The black schist beds, best developed in Healy D–3 quadrangle, are about 5–20 feet thick, make up about 5 percent of the section, and are spaced 50–200 feet apart. They consist of quartz, sericite, and carbonaceous matter, having a grain size of about 0.02 mm. Much of the green schist in Healy D–4 quadrangle shows well-preserved agglomerate textures on weathered or stream-polished surfaces. At one locality in Healy D–4 quadrangle, relict pillow structure was observed. In many thin sections of the green schist, the original igneous minerals such as hornblende, amphibole, and plagioclase are still partly preserved (probably as phenocrysts) but are sheared or drawn apart and are more or less replaced by chlorite, calcite, sericite, quartz, leucoxene, and albite. In some thin sections, tremolite and actinolite have also formed at the expense of the original igneous minerals.

The upper metavolcanic unit is a quartz-sericite-feldspar schist of rhyolitic origin. Its thickness is at least 1,000 feet, but it is overlain unconformably by the Cantwell Formation and its total thickness is unknown. There are no interbedded black schists in this unit. In outcrop at the west end of the belt, this schist also shows evidence of a pyroclastic origin. Farther east, recrystallization has been more extensive, and textures related to the origin, other than preserved phenocrysts, are lacking.

The metarhyolite schist is characterized by beta-quartz pseudomorphs with well-preserved phenocrystic form, including resorption embayments, and by phenocrysts of feldspar, generally orthoclase, having more or less completely preserved crystal form. The phenocrysts are 0.5 to 2 mm across and make up 15–25 percent of the rock. The beta-quartz pseudomorphs show strong strain shadows. The groundmass consists of quartz, sericite, and, generally, orthoclase and albite. It is strongly foliated, and the foliation, marked by sericite flakes and stringers, tends to bend around phenocrysts. Phenocrysts whose long axes are parallel to the foliation are well preserved, but many phenocrysts whose long axes were nearly perpendicular to the foliation have been nearly destroyed by shearing.

Interbedded with these two schist formations are bodies of schist of sedimentary origin, including gray marble and black carbonaceous schist. A fossil from a marble lens at the base of the green metavolcanic schist in southern Healy D–4 quadrangle was reported by Ralph Imlay (oral commun., 1953) as a badly deformed and unidentifiable gastropod. On the basis of this fossil find, these rocks are assigned to the Paleozoic.

Large, crudely equidimensional bodies of dark-green rock consisting of epidote, chlorite, quartz, sericite, calcite, and albite(?) are associated with the green metavolcanic schist or intrude the Birch Creek Schist. These bodies tend to be resistant to erosion and to form high peaks. They are interpreted as metagabbro.

Although no formal correlation of these schists is made in this paper, the most reasonable correlation is of the green metavolcanic schist with the Chute Creek Member of the Totatlanika Schist and the metarhyolite with the Mystic Creek Member. If this correlation is valid, the Keevy Peak Formation and part of the Totatlanika Schist are missing in the south flank of the Birch Creek Schist, either through unconformity or thrusting. The body of epiclastic schist near the head of the Wood River in Healy D–2 quadrangle may be part of the Birch Creek Schist, exposed on the south limb of a syncline.

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