Reconnaissance Geology of the Eagle A-1 and A-2 Quadrangles Alaska

GEOLOGICAL SURVEY BULLETIN 1271-G

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By HELEN L. FOSTER

CONTRIBUTIONS TO GENERAL GEOLOGY

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A brief description of the geology of the Eagle A-1 and A-2 quadrangles, a part of the Fortymile placer gold mining country

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RECONNAISSANCE GEOLOGY OF THE EAGLE A-1 AND A-2 QUADRANGLES, ALASKA

By Helen L. Foster

ABSTRACT

The Eagle A-1 and A-2 quadrangles are underlain primarily by strongly deformed metamorphic rocks. These consist of a unit of amphibolite facies rocks and two units of greenschist facies rocks. The age of the metamorphic rocks is unknown, but some of them are Paleozoic. Mesozoic granitic rocks intrude the metamorphic rocks, and a mass of serpentinized ultramafic rock of Paleozoic or Mesozoic age also appears to be intrusive.

Sedimentary rocks of Tertiary age unconformably overlie the metamorphic rocks in three localities. Basalt was erupted after the early Tertiary rocks were deposited.

The Fortymile River and its tributaries are entrenched, and terraces as high as 500 feet above the present streams are conspicuous, particularly along the South Fork. Erosion and altiplanation are suggested as the processes which formed the relatively uniform surfaces in the southeastern part of the A-1 quadrangle.

Gold placer mining continues on a small scale on several streams. Little new ground for placer mining remains except on the high terraces.

INTRODUCTION

The Eagle A-1 and A-2 quadrangles, Alaska, are in the eastern part of the Yukon-Tanana Upland. They are included in the region locally known as The Fortymile. The topography of these quadrangles is hilly to mountainous, and relief is as much as 1,600 feet. The main streams—Dennison Fork, Mosquito Fork, South Fork, and Walker Fork (tributaries of the Fortymile River)—are deeply entrenched. The area has not been glaciated.

The Taylor Highway provides access to both quadrangles and extends north from the Eagle A-1 quadrangle to the village of Eagle on the Yukon River and south from the Eagle A-2 quadrangle to Tetlin Junction where it joins the Alaska Highway. A branch of the Taylor Highway extends east to the Canadian border and is continuous with a Canadian highway to Dawson City in the Yukon Territory.

The Eagle A–1 and A–2 quadrangles have long been of geologic interest because gold was discovered on the Fortymile River in 1886 and shortly thereafter on many of its tributaries, including Walker Fork, Jack Wade Creek, and Chicken Creek.

L. M. Prindle did considerable geologic work in the Fortymile region from 1903 to 1907 (Prindle, 1909). Later J. B. Mertie, Jr., did additional geologic mapping and continued studies of the mineral deposits (Mertie, 1937). Very little new geologic information has been published on the Fortymile region since the work of Mertie, although interest among prospectors and miners has remained high.

This report is the result of reconnaissance mapping done primarily in the summer of 1965, but includes data collected in 1963–64 during the course of investigations for the Military Geology Branch, U.S. Geological Survey.

In the summer of 1963 the author was assisted by Beverly Marsters, and in the summer of 1964, by Terry Keith. The latter also made other contributions, including X-ray analysis of several rocks and minerals. Their competent assistance is gratefully acknowledged.

The author headquartered at Cathedral Bluffs Lodge on the Alaska Highway, and the many services and excellent assistance rendered by the proprietor, Marvin Warbelow, and his family are much appreciated. Local people in the area were helpful, especially William Meldrum on Stonehouse Creek; George Robinson at Jack Wade; the late Fred Purdy and his wife, Anne, at Chicken; Mr. and Mrs. Robert McCombe at South Fork Lodge; Mr. and Mrs. Fred Hapeman on Fortyfive Pup; and Mr. and Mrs. Jack Wilkey on Canyon Creek. Mrs. John Fisher, formerly at Chicken, loaned material from her fossil collection and gave other assistance.

BEDROCK

Most of the A–1 quadrangle and a large part of the A–2 quadrangle are underlain by metamorphic rocks (pl. 1). The metamorphic terrane has been intruded by small stocks, dikes and sills, and a part of the Taylor Mountain batholith. Small areas of Tertiary sedimentary and volcanic rocks unconformably overlie metamorphic or igneous rocks in the vicinity of Chicken, at the mouth of Napoleon Creek, and on Baby Creek.

All the Tertiary and older rocks have been folded and faulted to some extent. The metamorphic rocks are isoclinally folded, and some large recumbent folds have been recognized (fig. 1). Faults are abundant but largely concealed. Because of the reconnaissance nature of the mapping, details of structure were not worked out and are not shown on the map. Only a few of the many suspected faults are shown.

FIGURE 1.—Folds in quartzite and limy quartzite of the gneiss and schist unit. Massive light-colored rock in the lower part of the picture is a pegmatite dike, which cuts folded quartzite and limy quartzite interlayered with a little quartz-biotite gneiss. The outcrop is in the Eagle A–1 quadrangle on the west side of Canyon Creek 5 miles upstream from the mouth.

METAMORPHIC ROCKS

For mapping, the metamorphic rocks have been divided into three groups of different overall lithologies: the gneiss and schist unit, the quartz-graphite schist unit, and the metamorphic rocks of the Chicken area. However, there are lithologic and structural similarities among rocks in these units, and at some localities where distinctive rock types are not present, the units cannot be distinguished with certainty; in places there seems to be transition from the rocks of one unit to another. It is not known to what extent these units correspond with stratigraphic units, and their validity for more detailed mapping in the future is uncertain.

The gneiss and schist unit is the most extensive in area and, together with the quartz-graphite schist unit, corresponds to Mertie's (1937, p. 48) "Birch Creek Schist and associated igneous rocks." Mertie used the designation Birch Creek Schist to include all the older Precambrian metamorphic rocks that were originally of sedimentary origin, but his original basis for assigning these to the Precambrian may no longer be valid because of structural complications; particularly because the large Tintina fault north of the mapped area separates unmetamorphosed rocks of known age on the north side of the fault from metamorphic rocks of unknown age on the south side (Roddick, 1967).

Also, because the Birch Creek Schist, as mapped by Mertie, includes many different lithologies of several origins, several metamorphic facies, and probably rocks of different ages, workers in widely separated areas have formed different concepts of the Birch Creek Schist. Detailed studies and more detailed mapping of the rocks included in Mertie's Birch Creek Schist are underway but are not sufficiently advanced to permit a satisfactory redefinition of the formation. Therefore, the designation "Birch Creek Schist" is not used in this paper.

In the Chicken area the areal extent of Mertie's undifferentiated rocks of Devonian age corresponds closely to the metamorphic rocks of the Chicken area of this report. This latter designation without an age connotation is used here because fossil evidence that the rocks are of Devonian age is lacking, and their correlation with rocks elsewhere of Devonian age is uncertain. Mertie also recognized this uncertainty.

Both the quartz-graphite schist unit and the metamorphic rocks of the Chicken area continue south for a short distance into the Tanacross quadrangle. Rocks similar to those of the gneiss and schist unit also occur in the Tanacross quadrangle, but there are some distinctive differences in lithology, which will be described later. The quartz-graphite schist unit extends east into Canada and corresponds to the B and C units mapped by Green and Roddick (1962) and to the Klondike Series and Nasina Series mapped by Cockfield (1921). The C unit, or Nasina Series, corresponds most closely in lithology to the quartz-graphite schist unit. However, a few rocks similar to those of the B unit, or Klondike Schists, were found in the Eagle A–1 quadrangle but could not be mapped as a separate unit. Rocks of the gneiss and schist unit probably also extend into Canada (L. H. Green, oral and written commun., 1967), but a lack of field information makes correlation difficult. Green and Roddick (1962) tentatively included rocks which would correspond to the gneiss and schist unit in their unit C.

The rocks of the quartz-graphite schist unit are similar in lithology to rocks in the northern part of the Eagle B–1 and the southern part of the Eagle C–1 quadrangles, and the rocks of these two areas may be correlative.

The time and number of metamorphic events which affected the rocks of these three units is not known, but the major regional metamorphic events occurred before the Mesozoic intrusions. The Mesozoic intrusions cut the regional metamorphic structures in rocks of all the metamorphic rock units, and fragments of the metamorphic rocks, with foliation and other metamorphic structures, occur as xenoliths near the margin of the Taylor Mountain batholith. Contact metamorphic effects from the Mesozoic instrusions are minor and are only detected locally, except for a thermal effect which hampers radiometric dating of these rocks (see p. 9).

GNEISS AND SCHIST UNIT

The gneiss and schist unit consists dominantly of quartz-biotite gneiss and schist (fig. 2) interlayered with a lesser amount of amphibolite, quartzite, hornblende-bearing gneiss, and marble. Some of the hornblende and quartz-biotite rocks have garnet as a major constituent. Augen gneiss was found in a few localities but is a minor rock type in this area. A rock composed principally of pyroxene, probably diopside, was found in a few localities. A high content of biotite and (or) hornblende, an abundance of garnet, and the occurrence of sillimanite are mineralogical characteristics which distinguish the rocks of the gneiss and schist unit from the other two units of metamorphic rocks. The rocks of the gneiss and schist unit are all completely recrystallized, most have excellent foliation, and original sedimentary or igneous structures have been obliterated. Their present metamorphic grade is mostly middle to upper amphibolite facies and is higher than that of the quartz-graphite schist unit or of the metamorphic rocks of the Chicken area. The rocks of the gneiss and schist unit are polymetamorphic, but details of their metamorphic history are not known.

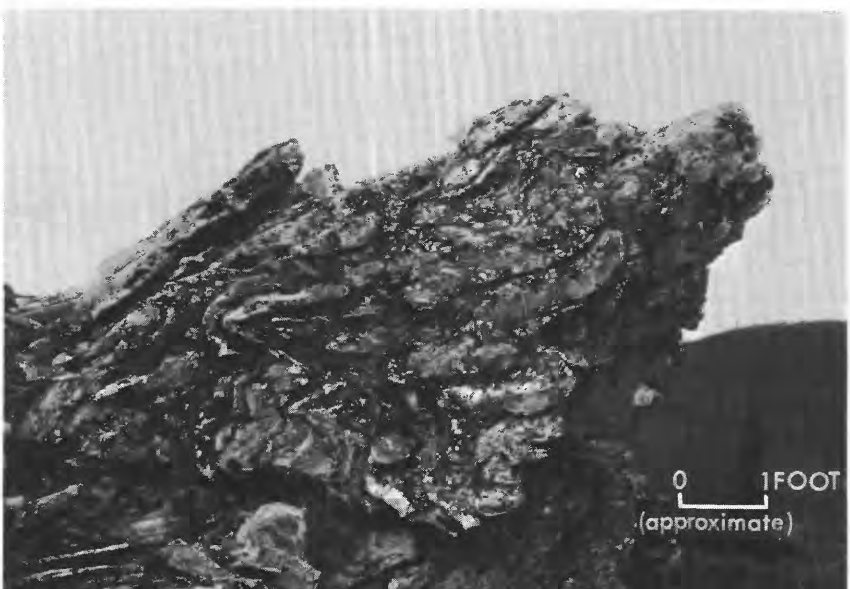

FIGURE 2.—Tightly folded quartz-biotite gneiss outcrop in Eagle A–1 quadrangle 1½ miles south of Jack Wade.

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No practical way was found to distinguish in the field the meta-igneous and metasedimentary rocks or to break down the gneiss and schist unit into smaller mappable units. A stratigraphic sequence could not be established in these metamorphic rocks because of complex folding and faulting. Mapping to date suggests that there may be only one main group of marbles and quartzites with individual layers of marble ranging in thickness from less than an inch to at least 50 feet. The marbles are interlayered and infolded with thick sequences of quartz-biotite and hornblende gneisses and schists. Marble layers, which may be thicker, crop out just north of the map along the Fortymile River.

The rocks in this unit are similar in metamorphic grade to rocks in a biotite gneiss and schist unit in the Tanacross quadrangle to the south, but there are some lithologic differences. Augen gneiss and granite gneiss, which are common to the south, are minor rock types in the Eagle A–1 and A–2 quadrangles, and marble, which is rare to the south, is a common rock type to the north. The amount of quartzite is also greater in the rocks to the north.

The quartz-biotite gneiss ranges in color from light to dark gray, and grain size is fine to coarse. The principal minerals are quartz, biotite, and plagioclase. Apatite and sphene are nearly always abundant accessories, garnet ranges in amount from a scarce to major constituent, and hornblende may be present. Opaque iron minerals are generally abundant.

The hornblende gneisses and amphibolites range in color from light gray to greenish black, depending upon the amount of hornblende present (fig. 3). Grain size is fine to very coarse, but medium- and coarse-grained hornblende gneisses are most common. In thin section under plane-polarized light, the hornblende is generally bright bluish green. Biotite, sphene, and opaque iron minerals are abundant accessories, and garnet is scare to very abundant. Hornblende gneisses with long (½ to 2 inches), black, needlelike hornblende crystals, scattered without orientation through a medium- to fine-grained light-colored matrix of quartz and feldspar, are found associated with marble and quartzite and commonly occur directly beneath a marble bed.

A gneiss from Squaw Gulch contained a little kyanite (seen only in thin sections), and tiny sillimanite needles have been noted in a few thin sections of gneiss from the central parts of the A–1 and A–2 quadrangles. Microcline, epidote, and rutile are also present in some specimens, but microcline was not recognized in the rocks containing kyanite and sillimanite.

The marble is white, pink, or locally white with light-green streaks and patches (fig. 4). It is finely to coarsely crystalline, but coarsely

FIGURE 3.—Dark-greenish-gray hornblende gneiss with light-colored quartz-feldspar bands crops out in the south-central part of the A-1 quadrangle. A few white sills of quartz and feldspar are infolded in the gneiss.

FIGURE 4.—Fold in white, sugary marble (same locality as fig. 1) differs in shape from fold in the more resistant quartzite shown in figure 1. Marble is included in the gneiss and schist unit.

crystalline marble is most abundant. Thin layers of marble are interbedded with quartzite and thick layers, 10 to 50 feet, crop out near Eagle Junction and a few other places.

The quartzite is mostly light tan or light gray and occurs in thin layers less than an inch thick as well as in layers several feet thick. In places it grades into quartz-biotite gneiss. Where associated with marble, the quartzite may grade into siliceous marble and commonly has many small voids because calcium carbonate has been leached out. Quartzite breccia crops out in the A–1 quadrangle 1½ miles north-northeast of Eagle Junction.

Rocks of probable igneous origin in this map unit include three small areas of augen gneiss, one in the southern Eagle A–2 quadrangle and two in the Eagle A–1 quadrangle (pl. 1). There are also minor amounts of light-colored quartz-feldspar gneiss, some of which appears to have been intruded as dikes and sills. Some amphibolites are probably derived from mafic igneous rocks.

Locally, as in many places along Jack Wade Creek, the foliation of the gneiss and schist unit is nearly horizontal and is mainly parallel to compositional layering. These places are generally on the limbs of large recumbent folds. Small crinkles and folds are common, as clearly exhibited in the quartzite bluff at the mouth of Jack Wade Creek. At least three sets of minor folds are recognized.

The age of the rocks of the gneiss and schist unit is unknown. Age measurements on biotite from four localities in the area by the Sr^{87}/Rb^{87} method gave ages ranging from 182 to 187 m.y. (million years), according to Wasserburg, Eberlein, and Lanphere (1963) and G. D. Eberlein (written commun., 1963).

The following isotopic dates on metamorphic rocks have been obtained from the area of this report. The specimen localities are shown on plate 1.

Locality	*Mineral*	*Date in million years*	*Method*
60AR1	Biotite	180	Sr^{87}/Rb^{87}
2	do	180	Sr^{87}/Rb^{87}
3	do	187	Sr^{87}/Rb^{87}
ACh100	do	182	Sr^{87}/Rb^{87}
	do	177	Ar^{40}/K^{40}
	Muscovite	164	Sr^{87}/Rb^{87}

These ages are close to that of the Taylor Mountain batholith (180–190 m.y.) and are probably indicative of fairly widespread thermal effects associated with plutonic activity. Although Mertie (1937, p. 55) considered these rocks (his Birch Creek Schist) as Precambrian, a Paleozoic age is also a possibility for all or part of it.

QUARTZ-GRAPHITE SCHIST UNIT

The quartz-graphite schist unit consists primarily of dark-gray quartz-graphite schist and dark-gray quartzite with some light-tan and light-gray quartz-muscovite and quartz-sericite schist and dark-gray phyllite. The rocks of this unit are distinguished from those of the gneiss and schist unit by the dominance of quartz-graphite schist and gray quartzites over quartz-biotite and hornblende gneisses. Hornblende and garnet are rare to absent, and biotite is uncommon as compared with its abundance in the gneiss and schist unit. The mineralogy of these rocks indicates that most of them belong to the greenschist facies.

The quartz-graphite schists consist primarily of strained quartz grains with varying amounts of carbonaceous and graphitic material. Some have feldspar as a major constituent. They grade into quartzites with decreasing amounts of graphite. Minor amounts of muscovite may be present in both the schists and quartzites, and rutile, chlorite, and feldspar are among the other accessory minerals in schists. Opaque iron minerals are also abundant in some schists.

The light-colored schists consist dominantly of strained quartz, sericite, and muscovite. Minor amounts of chlorite, carbonate, tremolite, and feldspar occur in some. Small flakes of brown biotite can be seen in thin sections of some schists but are rarely visible megascopically.

A schistose rock containing bluish-gray quartz "eyes" crops out a few hundred feet south of the highway and is about three-fourths of a mile southwest of Davis Dome. Green and Roddick (1962) mentioned this type of rock in their unit B. Similar rock crops out in Canada about 3 miles to the northeast.

In some of the schists between Cherry Creek and Younger Creek along Walker Fork and on the ridge south of Walker Fork, considerable biotite is present, and some of the rocks are like those of the gneiss and schist unit. Also, a few light-green quartz-muscovite-chlorite schists, which resemble the schists of the Klondike Series (Cockfield, 1921, p. 12; L. H. Green, oral commun., 1967), crop out on the ridge. Because exposures are poor, the kind and location of contacts between these mixed rock types are uncertain, and aspects of their mineralogy are unexplained.

The fact that rocks of the quartz-graphite schist group are complex in structure suggests long-continued deformation with processes of crystallization and rupture alternately predominating. Multiple sets of folds and crinkles occur in these rocks as well as in those of the gneiss and schist unit, but some of the quartz-graphite schists display them even more prominently than do the rocks of the gneiss and schist unit.

No information is available on the age of the rocks of the quartz-graphite schist unit. Although of lower metamorphic grade, they could be a part of the same sequence of metamorphosed rocks as is the gneiss and schist unit. However, there are sufficient differences in lithology and mineralogy to suggest that they could be from an entirely different part of the stratigraphic section.

METAMORPHIC ROCKS OF THE CHICKEN AREA

Greenstone, massive to slightly foliated, is the dominant rock type of the metamorphic rocks of the Chicken area. Other rock types include gray and white banded fine-grained marble, pink marble, chert, quartzite, dolomite, phyllite, and light-green and greenish-gray banded mylonite. Cataclastic textures are common. The rocks are greenschist facies, which, along with their different lithology, distinguish them from the rocks of the gneiss and schist unit. The abundance of greenstone and the minor amount of gray quartzite and quartz-graphite schist distinguish them from the greenschist facies rocks (quartz-graphite schist unit) near the settlement of Boundary. Foliation is not well developed in many of the metamorphic rocks of the Chicken area, in contrast to the rocks of the other two units. On the ridge on the north side of Napoleon Creek and on ridges on both sides of Wall Street Creek, metamorphic rocks, typical of those in the Chicken area, can be traced without abrupt but, rather, with seemingly gradual change into rocks of the gneiss and schist unit over a distance of ¼ to 1½ miles. This suggests the possibility of a metamorphic facies change, but the rocks may be faulted.

The greenstones consist primarily of epidote, chlorite, plagioclase, and abundant opaque iron minerals. Secondary quartz and (or) carbonate may be present, and actinolite was noted in some varieties. The quartz grains are strained. Plagioclase has commonly altered to sericite, and sericite may occur along foliation planes. Hornblende has been replaced by epidote and pennine. Many of the greenstones appear to be derived from mafic tuffs and lavas, and some may have been diorite. Relict tuffaceous and vesicular texture can be seen in thin section.

Dolomite mixed with calcite occurs in a yellowish-brown or cream-colored, massive, brecciated rock along the Taylor Highway about 1 mile northeast of the South Fork bridge and also crops out at stream level near the South Fork bridge. The marbles are coarsely to finely crystalline and range from fairly pure calcium carbonate to impure varieties with quartz, muscovite, epidote, and opaque (carbonaceous) material. In outcrops along the Taylor Highway, between mileposts

77 and 79, the marble is tightly folded and broken by many small high-angle reverse faults.

Fine-grained siliceous rocks which resemble chert may be, at least in part, derived from siliceous volcanic rocks. They are mostly light gray or light green, and some are banded. Much of the quartzite is impure and includes chlorite, sericite, and carbonate. Sedimentary layering is preserved, and some thin sections show an elongation of quartz grains in a direction almost perpendicular to the layering.

The metamorphic rocks of the Chicken area are considered Paleozoic in age on the basis of fossil crinoid columns found by Prindle (1909, p. 19) in pink marble along the South Fork of the Fortymile River near the mouth of Napoleon Creek. The crinoid columns are not sufficiently diagnostic for a closer determination of their age. This rock was also checked for presence of conodonts, but none were found (John W. Huddle, written commun., Apr. 20, 1965).

IGNEOUS ROCKS

Igneous rocks which intrude the rocks of the three metamorphic map units are ultramafic, granitic, and basaltic. The ultramafic intrusion is in the eastern part of the area and may be slightly metamorphosed. The granitic and basaltic rocks are most abundant in the western part of the area and are unmetamorphosed. The sedimentary rocks are intruded and overlain by basalt. The ultramafic rocks are probably the oldest, and the basalts are the youngest.

INTRUSIVE IGNEOUS ROCKS

The northeastern part of the Taylor Mountain batholith extends into the southwestern part of the A–2 quadrangle. Several small intrusive masses occur to the north and east of it and either may be separate intrusions or may be connected with the batholith at depth. Pegmatite, aplite, granite, and alaskite dikes are fairly abundant throughout much of the quadrangle. Stream rubble indicates that granitic rock, which is not mapped, probably comprises parts of some ridges, particularly those which extend to Walker Fork along its eastern end.

ULTRAMAFIC ROCKS

A small body of serpentinized rock crops out in the southeastern corner of the A–1 quadrangle. X-ray analysis indicates that the rock is principally serpentine (antigorite) with magnetite and chlorite. Magnesite and talc occur in several specimens, and brucite was found in one. The magnetite occurs as large grains surrounded by alteration rims of brucite and chlorite, and the matrix is antigorite with relicts of olivine. No evidence of pyroxene was noted. Late veinlets of magnetite and magnesite occur. The rock is probably a metamorphosed serpentinized dunite. Locally the serpentine is somewhat fibrous, but no asbestos was found. The extent of serpentinized rock is approximately outlined on the map on the basis of the distribution of rubble, because outcrops are rare and contacts are not exposed. The age of the intrusive body is believed to be Paleozoic or Mesozoic.

A few small ultramafic dikes were noted elsewhere in the eastern part of the area, but their relation, if any, to this intrusive body is not known.

GRANODIORITE OF THE TAYLOR MOUNTAIN BATHOLITH

The rock of the Taylor Mountain batholith in its easternmost exposures in the Eagle A–2 quadrangle is dominantly medium to coarse grained granodiorite (fig. 5). Along its margins to the west and north there is considerable variability in both composition and texture, and the rocks range from quartz monzonite to diorite. Some of these compositional variations may be due to separate, small intrusive bodies, but on the map they are not differentiated from the main body of the Taylor Mountain batholith. However, most of these occurrences are believed to be marginal facies of the batholith. For instance, near the head of Stonehouse Creek, quartz monzonite crops out, and along Dennison Fork and in the vicinity of Lost Chicken Creek, local areas of diorite and quartz diorite occur.

The margin of the batholith is irregular with many dikes extending into the country rock. For instance, along Mosquito Fork the network of dikes and sills is very complex, and without detailed mapping a definite boundary cannot be determined for the batholith. In places the country rocks have been hornfelsed and even partly absorbed into the igneous mass. There is also local shearing, crushing, and faulting. This complex marginal zone is shown on the map by a special pattern.

In the granodiorite the principal minerals are plagioclase (oligoclase to andesine), potassium feldspar, quartz, green hornblende, and brownish-green biotite; generally abundant accessories are sphene, apatite, and opaque iron minerals. Small amounts of myrmekite, epidote, and clinozoisite were seen in a few thin sections. Most of the plagioclase is strongly zoned, and much of it is sericitized. Quartz is strained, and the margins of some quartz crystals are granulated. Hornblende is generally more abundant than biotite, and part of the biotite has altered to chlorite. Small amounts of secondary carbonate are evident in a few thin sections. In some of the granodiorite near the margin of the batholith, potassium feldspar is irregular in its distribution and is locally concentrated in areas an inch or so in diameter.

Five specimens from near the margin of the batholith were stained for potassium feldspar, and point counts were made (1,000 points per

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FIGURE 5.—Tor of granodiorite of the Taylor Mountain batholith clearly shows slightly inclined sheeting. Tor is on the ridgetop near the head of Stonehouse Creek in east-central Eagle A–2 quadrangle.

specimen). The variations in the amounts of the major minerals, given in percentage, are shown below:

Specimen	752	80	299	404	118
Quartz	19	31	28	14	25
Potassium feldspar	28	23	22	19	8
Plagioclase	46	42	42	59	58
Hornblende and biotite	7	4	7	8	9
Opaque minerals	<1	<1	<1	<1	<1
Sphene	<1	<1	<1	<1	<1
Epidote	<1			<1	

A single age measurement is available on granodiorite from along the Taylor Highway in the Eagle A–3 quadrangle for the Taylor Mountain batholith. Sr^{87}/Rb^{87} determinations on biotite gave an age of 190 m.y. (Wasserburg and others, 1963, p. 258). The other granitic rocks have not been dated.

GRANITIC ROCKS

The small igneous bodies north and east from the Taylor Mountain batholith differ slightly from one another in mineralogy. The one along Walker Fork is quartz diorite, granodiorite, and quartz monzonite. The principal minerals are andesine, microcline, quartz, and biotite with apatite, epidote, and opaque iron minerals as accessories. Myrmekite occurs, some of the feldspar is zoned, and quartz is strained. The interior of many plagioclase crystals has altered to sericite, and some biotite has altered to chlorite. The mineralogy of this igneous body differs from that of the main body of the Taylor Mountain batholith in that (1) biotite is the mafic mineral and hornblende was not found, (2) sphene is much less abundant or absent, (3) apatite is much less abundant, and (4) the plagioclase may be slightly more calcic.

Modal analysis by point counts (1,000 points per specimen) showed the following mineral composition, given in percentage:

Specimen	24	22a
Quartz	27	30
Plagioclase	53	42
Potassium feldspar	12	18
Biotite	7	9
Opaque minerals	1	1

The small igneous body between Napoleon and Uhler Creeks is quartz monzonite. The principal minerals are plagioclase, potassium feldspar, quartz, and green hornblende; accessories are apatite, sphene, and opaque iron minerals. Myrmekite is present. Quartz is strained, and many crystal margins are granulated. Feldspar has partly altered to sericite, and some epidote has formed from alteration of hornblende. Carbonate and chlorite are also minor alteration products. This intrusion has less quartz than the intrusion along Walker Fork, and hornblende, rather than biotite, is the mafic mineral.

Modal analysis by point counts (1,000 points per specimen) showed the following mineral composition, given in percentage:

Specimen	529	303
Quartz	6	7
Plagioclase	44	43
Potassium feldspar	33	36
Hornblende	16	13
Opaque minerals and sphene	1	1

EXTRUSIVE IGNEOUS ROCKS

BASALT

Basalt occurs in the vicinity of Chicken and on Napoleon Creek, and a few basalt and diabase dikes crop out in widely separated parts of the area. Near Chicken, basalt unconformably overlies granodiorite of the Taylor Mountain batholith and the Tertiary sedimentary rocks. Also, it appears to have invaded the Tertiary tuffs and tuffaceous sandstones, because these light-colored rocks are found in small patches between dikes and stringers of black basalt. In places the basalt is covered by high-level terrace gravels.

The basalt is fine to very coarse grained, and some of the fine-grained rock is vesicular. It consists primarily of augite, plagioclase (labradorite) olivine, and glass. In a few specimens the olivine is fresh, but in others it is completely altered. The augite is commonly slightly brown or purple. Exsolution laths of ilmenite and magnetite may be present, and a little carbonate also occurs in some.

SEDIMENTARY ROCKS

Sedimentary rocks, consisting mostly of conglomerates, sandstone, and shale, crop out in three separate localities—the Chicken area, near the mouths of Napoleon Creek and Walker Fork in the A–2 quadrangle, and on Baby Creek and Squaw Gulch in the A–1 quadrangle. They have been folded and faulted but not metamorphosed.

In the Chicken area the sedimentary rocks are largely covered by the alluvial deposits of Chicken Creek, by tailings from placer mining, and by Tertiary(?) basalt flows. Only a few small exposures were found, but in the process of gold dredging along Chicken Creek, considerable sedimentary rock has been brought up by the dredge from the valley bottom.

Along the South Fork near Walker Fork and near Napoleon Creek, the sedimentary rocks unconformably overlie metamorphic rocks of the Chicken area, and along Baby Creek, conglomerate rests unconformably on rocks of the gneiss and schist unit. In the Chicken and Napoleon Creek areas basalt overlies the sedimentary rocks.

The rock types in the Chicken area are dominantly sandstone, tuffaceous sandstone, ferruginous sandstone, siliceous siltstone, shale, conglomeratic sandstone, tuffaceous shale, and lignitic coal. A little silicic lava and tuff is interbedded in places. No information is available on either the thickness of the beds or their structural relationships. Mertie (1937, p. 262–263) stated that "a 35-foot shaft near Chicken disclosed 22 feet of coal, in a vertical position, but neither the top nor the bottom of the seam was seen."

The sandstone is brown, tan, white, or reddish brown. Some sandstone is very soft and friable, but there are also hard ferruginous types. Carbonaceous streaks occur in some.

Cobbles and boulders of a black, glassy siliceous tuff which contain abundant plant fragments are common in the Pleistocene gravel deposits of Chicken and Stonehouse Creeks, but no outcrops of this rock have been located. Its distribution in the stream gravel would suggest that the float may originate in the upper part of Chicken Creek and in the lower part of Stonehouse Creek, because the float in Stonehouse Creek ends abruptly just below the contact of the sedimentary rocks with the metamorphic rocks of the Chicken area.

The sedimentary rocks near the mouths of Walker Fork and Napoleon Creek are breccia, conglomerate, gray and tan sandstone, shale (including a splintery "pencil" shale), 1-inch-thick coal beds, olive-green fine-grained cherty rock with distinct conchoidal fracture, arkose, coarse- to fine-grained wackes, and laminated siltstone (figs. 6, 7, and 8). Well-indurated basal conglomerate and breccia range from coarse, with boulders as much as 2 feet in diameter, to fine, with fragments 4 inches or less in diameter (fig. 9). The fragments are angular to well-rounded gneiss and schist, greenstone, green and gray phyllite, quartzite, chert, black shale, granitic rock, and lava. Thickness of the basal conglomerate ranges from 15 feet to over 100 feet. Thin conglomerate beds, a few inches to a few feet thick, are interbedded with the other rock types higher in the section. Carbonaceous material is common in some interbedded sandstones and shales. Bedding is absent or indistinct in most of the coarse conglomerates, but some of the fine conglomerates have distinct tilted bedding. The total thickness of the sedimentary section is probably more than 400 feet.

The sedimentary rocks on Baby Creek are mostly conglomerate with only a few interbedded layers of sandstone and shale (fig. 10). The conglomerate consists of angular boulders, several feet in diameter, mixed

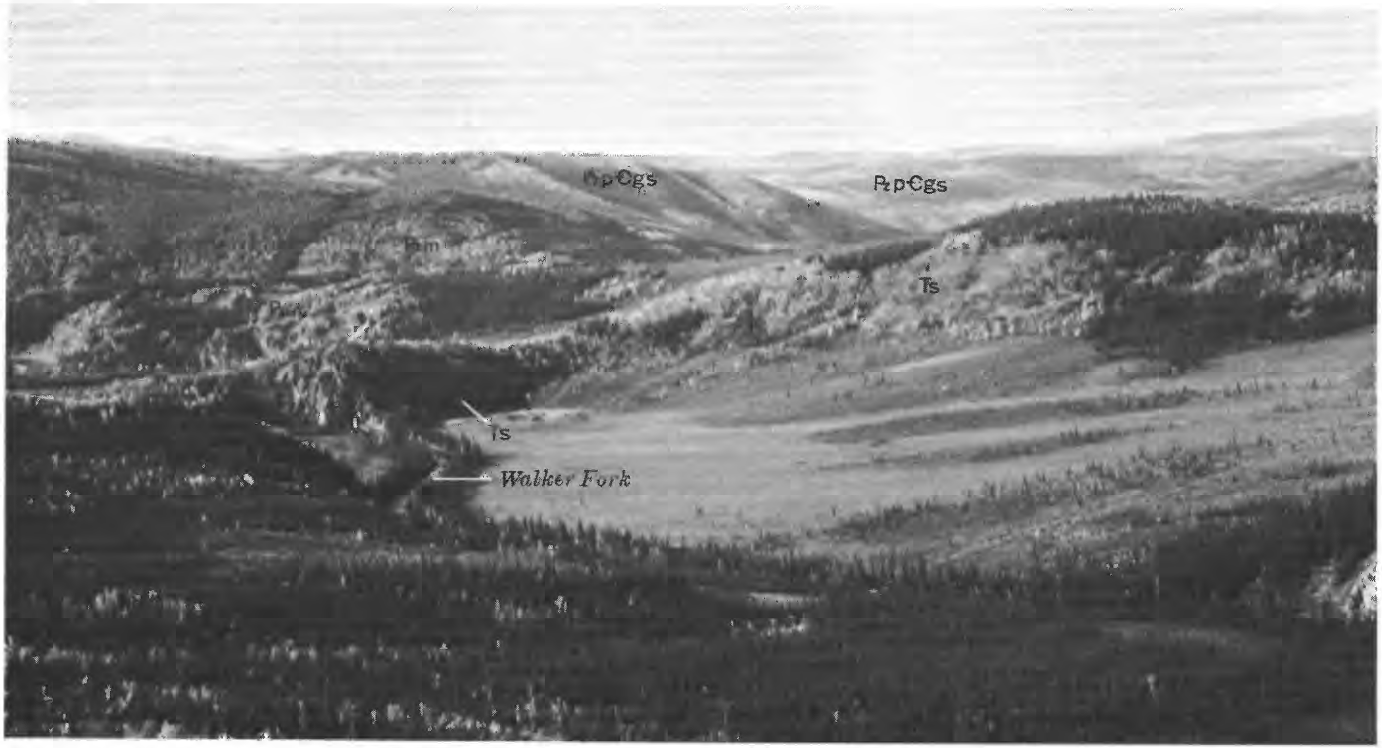

FIGURE 6.—View northwest from the Taylor Highway of Tertiary conglomerate and breccia along Walker Fork. The ridge ending in a sharp cliff along Walker Fork is coarse, well-consolidated breccia and conglomerate (Ts). The wooded hills in the background are metamorphic rocks of the Chicken area (Pzm) and rocks of the gneiss and schist unit (PzpЄgs).

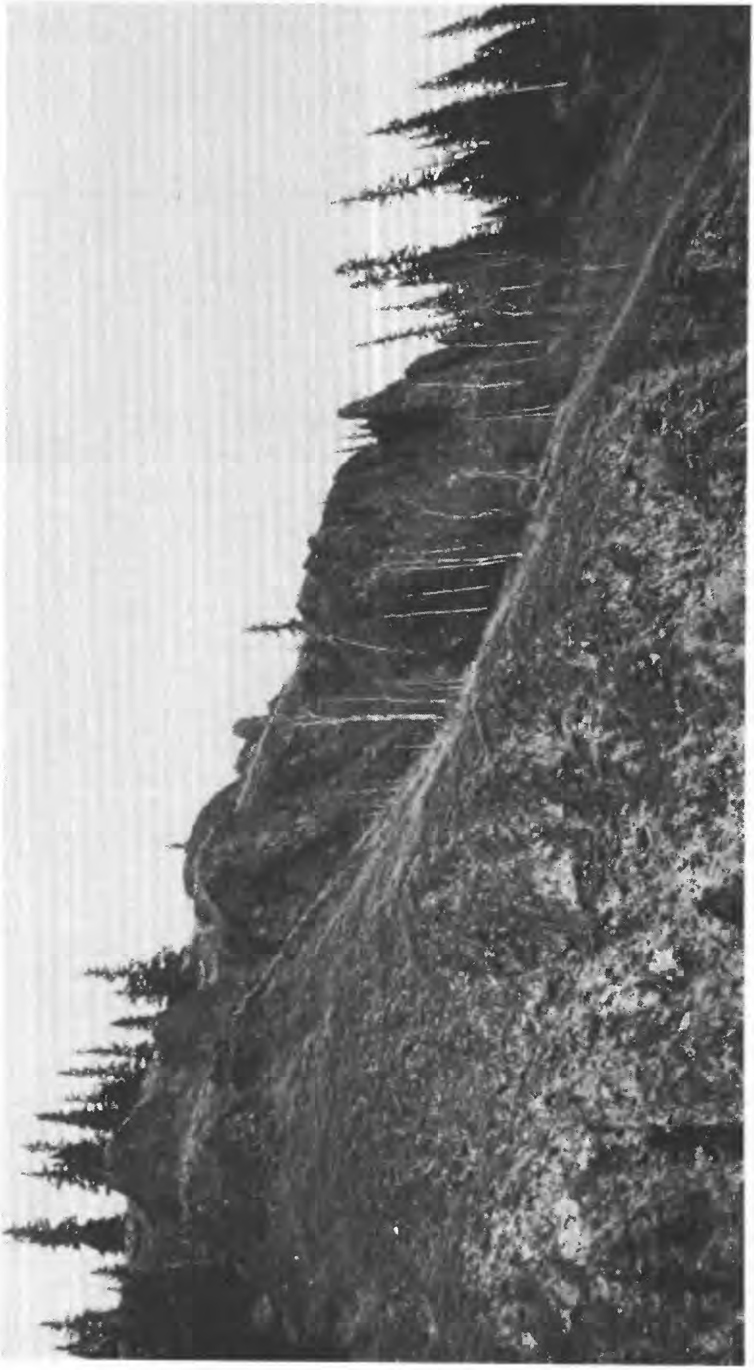

FIGURE 7.—Tertiary conglomerate resting unconformably on metamorphic rocks of the Chicken area. Slope in foreground is composed of metamorphic rocks partly covered by talus. View east-southeast along east side of South Fork a few hundred feet north of the mouth of Napoleon Creek.

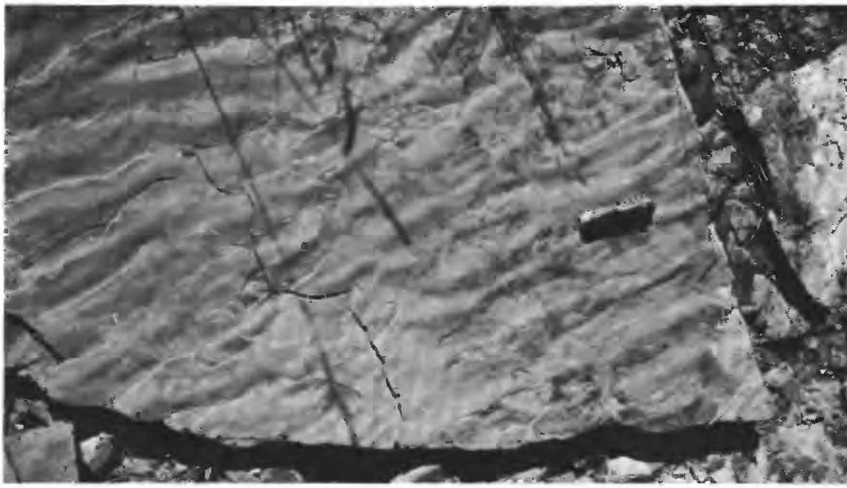

FIGURE 8.—Tan, medium- to fine-grained ripple-marked Tertiary sandstone, exposed by placer mine cuts, along the north side of Napoleon Creek about 1 mile above the mouth.

with well-rounded rocks, a few inches to a foot in diameter, in a greenish-gray sandy, micaceous matrix. Quartz-biotite gneiss is the most abundant constituent, but dark-gray mafic gneiss and a little granitic rock are also present. Bedding is not evident in most places, but along Baby Creek, where a few layers of sandstone are interbedded, the beds appear to be vertical. A small outcrop of similar conglomerate and sandstone occurs along Squaw Gulch (pl. 1), and conglomerate float was found on the ridge south of the second tributary to Hall Creek southeast from the mouth of Hall Creek.

The sedimentary rocks are considered to be of Tertiary age on the basis of fossil plants and pollen. Leaves of *Metasequoia glyptostroboides* Hu and Cheng and *Alnus evidens* (Hollick) Wolfe were preserved in sandstone brought up by the dredge from the lower part of the valley of Chicken Creek (USGS Paleobotany loc. 10031). *Alnus evidens* is a species thought to be characteristic of the Seldovian Stage and probably is late Oligocene or early Miocene in age (Wolfe and others, 1966; J. A. Wolfe, written commun., Feb. 17, 1965). Poorly preserved palynomorphs found at two localities in the Chicken area (USGS Paleobotany locs. D-3346 and D-3347) included the genera *Carya*, *Ulmus*, *Alnus*, *Acer*, *Abies*, *Juglans*, *Tilia*, *Tsuga*, *Larix*?, and *Osmunda*. R. H. Tschudy (written commun., June 9, 1964) believes that an early Tertiary age is indicated.

A few grains of well-preserved pollen, obtained from a sample of matrix of the conglomerate from the east side of Baby Creek (USGS Paleobotany loc. D-4009), were identified by E. B. Leopold (written

FIGURE 9.—Tertiary conglomerate in cliff along Walker Fork. The rocks composing this poorly stratified conglomerate include chert, granitic rocks, black shale, and andesite. This is a close view of rock exposed in cliff shown in figure 6.

FIGURE 10.—Coarse, poorly stratified conglomerate on the east side of Baby Creek is composed dominantly of fragments of quartz-biotite gneiss, dark-gray mafic gneiss, and a little granitic rock.

commun., Nov. 22, 1967) as: *Picea* cf. *engelmanni*, *Alnus* (5–6 pored), *Rhododendron* type, and *Betula*. The sandstone interbedded in the conglomerate along Baby Creek (USGS Paleobotany loc. D–4010) contained sparse, moderately well preserved pollen, also identified by E. B. Leopold (written commun., Nov. 22, 1967), which included: *Picea*, *Pinus*, *Sciadopitys* type, *Larix* type, *Juniperus* type, *Osmunda*, *Selaginella* cf. *densa*, *Pteridium* type, and Polypodiaceae. A late Tertiary age is most likely for these deposits.

Pollen from the black cobbles and boulders from Stonehouse Creek and Chicken Creek (USGS Paleobotany loc. D–1161, E. B. Leopold, written commun., July 10, 1964; USGS Paleobotany loc. D–3345, R. H. Tschudy, written commun., June 9, 1964) includes *Picea* or *Abies*, *Osmunda*, Rosaceae type, Gramineae, Polypodiaceae, ?*Juniper* or ?*Sequoia*, monocots, undet. E. B. Leopold concludes that a late Cenozoic age is indicated by the pollen, and the rock could be as old as late Tertiary and is probably no younger than early Pleistocene.

The scant fossil data suggest that two or three ages of sedimentary rocks are present in the Eagle A–1 and A–2 quadrangles. The sedimentary rock that crops out around Chicken may be the oldest and may be of early or middle Tertiary age; the Baby Creek conglomerate may be late Tertiary; and black boulders from Stonehouse Creek may be about the same age or a little younger than the Baby Creek deposits. Also, the sedimentary rocks around Chicken are not the same as, and are probably younger than, the sedimentary rocks in the Tanacross quadrangle 15 miles to the south (Foster, 1967, p. B6).

UNCONSOLIDATED DEPOSITS

The unconsolidated deposits of the area have been mapped as high-level terrace deposits, alluvium, and colluvium. They have been significant economically because they contain gold.

The high-level terrace deposits are those at elevations of 25 to 500 feet above the present stream levels, and they are particularly well developed along the South Fork of the Fortymile River. The deposits are irregularly distributed and are mostly remnants of more extensive terraces which have been partly removed by stream erosion. They consist mostly of coarse gravel with stringers, lenses, and beds of sand and silt. The gravel is mostly fairly well sorted and poorly stratified; but locally, stratification is good. The pebbles are derived from rocks now exposed in the present drainage basins except for the black siliceous tuff pebbles found in the drainage of Stonehouse, Chicken, and Lost Chicken Creeks. Some gravel deposits are stained by limonite, and lower parts of thick sections may have local areas where they are weakly cemented. The thickness of the gravels is very irregular but ranges from 1 to at least 50 feet.

Fossils, physiographic and stratigraphic relationships, and the degree of weathering of the deposits indicate that the high-level terraces are of Pleistocene age, and two ages of Pleistocene gravel may be exposed in mine cuts at Lost Chicken Creek. The lower terraces are younger and presumably Holocene.

Mammal bones are fairly common in the peat, silt, and gravel deposits of Chicken, Lost Chicken, Jack Wade, Canyon, and other creeks. *Equus*, Elephantidae, and *Bison* are the most abundant, but many other genera occur. A lower mandible of *Panthera atrox*, a large Pleistocene cat, was found on an alluvial flat near the mouth of Lost Chicken Creek and is believed to have washed out of frozen organic silt along the creek (Whitmore and Foster, 1967, p. 247). A bone of *Equus* from the flood plain of Lost Chicken Creek was dated as 26,760 ±300 years by carbon-14 at the laboratory of the Smithsonian Institution (SI 355, 1967).

Colluvium, a few inches to several feet thick, covers many slopes. In small stream valleys colluvium is mixed with alluvial deposits. Only some of the most thickly covered areas are shown on the map. On some ridges, considerable loess is included in this map unit.

Valley alluvium along the present streams consists of silt, organic silt, sand, and gravel. Some of the silt and organic silt deposits are frozen. Placer mining over a period of 100 years has changed the appearance and disrupted the valleys of many streams. Large amounts of fines from the placer mining have been carried downstream from their original place of deposition, and piles of coarse gravel and boulders line the margins of the streams. Some streams have been artificially diverted from their original courses. On Canyon Creek, ancient beaver dams have been uncovered by placer mining operations. A piece of *Populus*, from a beaver dam buried about 15 feet below the surface in frozen muck, was dated as 3,750±380 years by carbon-14 at the laboratory of the Smithsonian Institution (SI 356, 1967). There are no beavers at the present time on Canyon Creek.

Throughout much of the area a thin (¼ to 5 inches), irregular layer of grayish-white fine-grained volcanic ash lies just beneath the soil. The ash is best preserved on ridge tops. In places where it has been covered by recent alluvium or loess, it may be at a depth of several feet. The ash is believed to be derived from volcanic eruptions which occurred about 1,600 years ago to the southeast in the Yukon Territory (Fernald, 1962).

STRUCTURAL SETTING OF METAMORPHIC ROCKS

The area described in this report is a small part of an extensive and structurally complex metamorphic terrane which is sharply cut off on both the north and the south by major faults (fig. 11). On the north

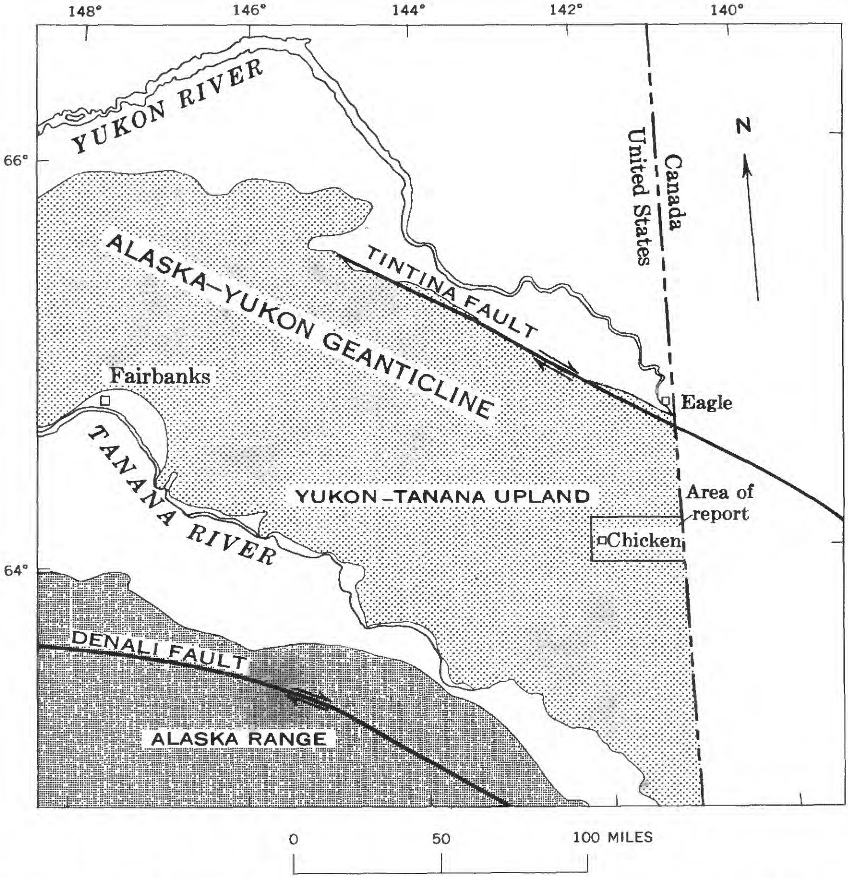

FIGURE 11—Index map of major structural features of eastern interior Alaska.

the Tintina fault or trench, a possible continuation of the Rocky Mountain trench, separates the metamorphic rocks of the Yukon-Tanana Upland from unmetamorphosed Precambrian and Paleozoic rocks. Roddick (1967, p. 29) estimated that there is 220 to 260 miles of right-lateral displacement along the Tintina fault. On the south the metamorphic rocks of the Alaska Range are separated from unmetamorphosed rocks by the Denali fault (St. Amand, 1957, p. 1351), a part of an extensive fracture system which is continuous with the Shakwak fault.

In the eastern part of the metamorphic terrane, the highest grade metamorphic rocks yet recognized (with the exception of granulite inclusions in the lava of Prindle Volcano about 27 miles southeast of Chicken) are the sillimanite-bearing amphibolite facies rocks of the Eagle A–1 and A–2 quadrangles. On either side of the amphibolite facies rocks, greenschist facies rocks crop out (H. L. Foster, unpub. data (1967)).

Two possible interpretations of the relationships of these metamorphic rocks are:

1. The metamorphic rocks of the eastern part of the metamorphic terrane between the Tintina and Denali faults are different metamorphic facies of rocks of the same general stratigraphic sequence, and the age of the rocks is not necessarily related to their degree of metamorphism.
2. The area of the metamorphic terrane may be a geanticline (Eardley, 1962, p. 607); the more highly metamorphosed rocks are mostly near the center of the geanticline, and the lower grade metamorphic rocks are mostly on the flanks. The rocks in the center of the geanticline might also be the oldest metamorphic rocks, although this is not necessarily so. The finding of eclogites near Fairbanks by Forbes (Forbes and others, 1968, p. 345; R. B. Forbes, oral commun., 1968), which are at least as old as early Paleozoic and possibly of Precambrian age, lends some support to this possibility. However, faulting, including thrusting, folding, and igneous intrusions within the metamorphic terrane, adds to the complexity in any interpretation.

GEOMORPHIC FEATURES

The most conspicuous geomorphic feature of the area is the entrenchment of the Fortymile River and its tributaries to a depth of more than 500 feet. Entrenched meanders and broad terraces above present stream level are spectacular evidence of Pleistocene and (or) Holocene downcutting of the Fortymile River. Mertie (1937, p. 30–31) attributed these features to a probable late Pleistocene northward tilting.

Some of the streams, such as Franklin Creek, Uhler Creek, and Canyon Creek, have exceptionally straight courses and are probably structurally controlled, although definite evidence of the control is not yet known.

Ridgetops range in altitude from about 2,500 to 4,000 feet; most of those in the eastern A–2 and A–1 quadrangles range between 3,500 and 4,000 feet. Many ridgetops are relatively flat with local relief of only 200 or 300 feet. The tendency toward some uniformity of altitude and relatively small relief may be due to erosion surfaces, presumably of late Tertiary or early Pleistocene age. This is particularly suggested for the southeastern part of the A–1 quadrangle.

Altiplanation surfaces are not particularly well developed in this area, but a few high, benched surfaces, particularly in the southeastern corner of the A–1 quadrangle, may be of such origin (fig. 12).

FIGURE 12.—Flat, terraced, rubble-covered altiplanation surfaces in the southeastern part of the Eagle A–1 quadrangle have formed at altitudes above 4,000 feet. The rubble is gray quartzite and quartz-graphite schist. View is north toward the bench mark called Ptarmigan.

SUMMARY OF GEOLOGIC HISTORY

In Precambrian(?) and Paleozoic times, extensive and thick deposits of sediments were laid down. Locally, these were intruded by granitic rocks, and volcanic deposits accumulated and became interlayered. During one or more periods of mountain building, they were severely deformed and metamorphosed. At present, the number of separate periods of deposition, deformation, and metamorphism of the several groups of metamorphic rocks is not known. During the Mesozoic Era, the metamorphic rocks were intruded by granitic batholiths, stocks, dikes, and sills. In places, the rocks along the margin of intrusions were hornfelsed and brecciated. The thermal imprint of the igneous activity was left on metamorphic rocks throughout the area. Mineralizing solutions associated with these or later instrusions are probably responsible for the gold in the area. Ultramafic rocks were also intruded, but the time of intrusion is unknown and could have been in the Paleozoic or early Mesozoic Era.

Uplift and erosion followed intrusion of the granitic rocks, and at several intervals from the late Cretaceous through late Tertiary terrestrial sediments were deposited in small, local basins. In early Tertiary time, volcanic materials, primarily silicic, were erupted and incorporated in the sediments. Faulting and perhaps folding followed by uplift and erosion occurred at the end of the Tertiary and possibly continued into the early Pleistocene. Also, basalt was erupted in either late Tertiary or early Pleistocene time and covered some of the Tertiary deposits.

In Pleistocene time the overall pattern of the present drainage system developed. Warping occurred and the streams became entrenched in deep valleys, leaving numerous remnants of terraces several hundred feet above the present valley floors.

ECONOMIC GEOLOGY

MINERAL DEPOSITS

Gold was first discovered on the Fortymile River in 1886 (Prindle, 1905, p. 39), and in the 10 years following, practically all the gold-producing localities in the area were discovered. Chicken Creek and its tributaries—Lost Chicken Creek, Jack Wade Creek, Canyon Creek—and Fortyfive Pup (tributary to Buckskin Creek) have small placer operations, and in 1967 a dredge was working on Chicken Creek. Sporadic mining and prospecting takes place on other creeks (fig. 13). No reliable estimate is available of the value of gold now being extracted from the area, but excluding that from the dredge at Chicken, it is probably under $25,000 per year, even in good years. In years of drought or heavy floods, it may be under $10,000.

The streams of the area have been quite thoroughly prospected, and little new ground for placer mining is available at or near stream level. Much of the present mining consists of reworking old ground. The principal virgin ground for placer mining lies in the high-level terraces. One high terrace has been mined on Napoleon Creek where rich streaks were found. Some prospecting has been done on the high terraces, but the difficulty of getting water to these elevations and other problems, such as permafrost, irregular thickness of gravels, and irregular distribution of gold, have discouraged development. However, these terraces are worthy of further consideration and exploration.

A rich vein of gold in calcite and quartz, which extended to a depth of about 6 feet, was discovered and mined by Fred and Arthur Purdy on a ridge between Myers Fork and Stonehouse Creek. The vein cuts across phyllite of the metamorphic rocks of the Chicken area. Extensive prospecting has exposed only a few additional thin discontinous calcite veinlets, which contain specks of gold, although bull quartz veins are common.

Scheelite is found in the placer concentrates at certain localities along Jack Wade Creek. Barite occurs there and in several other creeks.

FIGURE 13.—Abandoned placer mining property on Uhler Creek. The light-colored patch in foreground is gravel tailings from placer mining. Steep, wooded hills of rocks of the gneiss and schist unit, intruded by granitic rock, rise behind the mining camp. View north.

The coal at Chicken was mined for a brief period and used locally. Future coal mining is unlikely because the deposits are expensive to mine and no local market exists. Reserves are unknown but probably small.

BUILDING MATERIALS

Local rock and terrace gravel has been used as fill and for road surfacing. Most of the available gravel is coarse and not conveniently located. Some of the material will continue to be used for local road maintenance and construction, but no deposits of other economic significance are known.

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WALTER J. HICKEL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

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[Letters designate the separately published chapters]

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