Probable Permian Age of the Rampart Group, Central Alaska

By W. P. BROSGÉ, M. A. LANPHERE, H. N. REISER, *and* R. M. CHAPMAN

CONTRIBUTIONS TO STRATIGRAPHY

GEOLOGICAL SURVEY BULLETIN 1294-B

Fossil collections and rock samples from a limestone bed within the volcanic sequence of the Rampart Group show that the group is probably Permian in age

UNITED STATES DEPARTMENT OF THE INTERIOR

WALTER J. HICKEL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON : 1969

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 20 cents (paper cover)

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PROBABLE PERMIAN AGE OF THE RAMPART GROUP, CENTRAL ALASKA

By W. P. Brosgé, M. A. Lanphere, H. N. Reiser, and R. M. Chapman

ABSTRACT

The Rampart Group, consisting largely of volcanic rocks, was assigned by Mertie in 1937 to the Mississippian System because of bryozoans found in a limestone bed thought to be in or below the Rampart. Examination of new collections as well as the old collections shows that this limestone bed is within the volcanic sequence and is more likely to be Permian than Mississippian in age. The limestone itself is composed largely of pelecypod prisms and in this respect resembles one of the Permian(?) limestone beds in the partly volcanic (Carboniferous? to Lower Cretaceous) Gemuk Group of southwestern Alaska. Hornblende from gabbro that seems to intrude the Rampart volcanic rocks near the fossil locality has a potassium-argon age of 205±6 million years (Triassic). Thus, the age of the Rampart Group is considered to be Permian(?).

INTRODUCTION

Volcanic rocks crop out along the margins of the Yukon Flats, and magnetic data indicate that volcanic rocks underlie most of the flats themselves (Zietz and others, 1960). The volcanic assemblages have been known only from reconnaissance mapping, and until recently there has been little direct evidence of the age of any of them except for the Rampart Group. This group of bedded volcanic and sedimentary rocks was described by Mertie (1937, p. 122) in his regional summary of early investigations. He assigned a Mississippian age to the Rampart, mainly on the basis of identification of Bryozoa that he collected from a limestone bed on the north bank of the Yukon River 12 miles northeast of Rampart. Reiser, Lanphere, and Brosgé, using radiometric methods, recently dated another assemblage of volcanic rocks of presumed Paleozoic age on the northeast edge of the Yukon Flats as Jurassic (Reiser and others, 1965). This suggested that the Rampart Group might also be Mesozoic rather than Paleozoic in age.

In 1965, the authors visited the fossil locality in the Rampart Group described by Mertie (1937, p. 126) in order to collect more fossils as well as samples of the volcanic rocks for radiometric dating. Scanty fossil collections were made at the limestone outcrop described by Mertie and also from another outcrop of the same bed about a mile downstream. Helen Duncan (written commun., 1968) examined the two fossil collections and Mertie's original collection and found the bryozoans to be Carboniferous or Permian, but probably Permian, in age. Examination of thin sections shows that the limestone itself is composed mainly of pelecypod prisms like those of the Mesozoic *Inoceramus*. Similar prisms were also found, however, in Permian limestones of the Gemuk Group and Tahkandit Limestone, southwest and east of the area underlain by the Rampart Group. The volcanic rocks of the Rampart Group were too altered for radiometric dating, but hornblende from a gabbro body that seems to intrude the Rampart Group yielded a Triassic age of 205$\pm$6 million years. The Permian(?) age of the bryozoans, as determined by Duncan, indicates that the age of the Rampart Group should be revised to Permian(?). The Triassic age of the intrusive rock would be compatible with a Permian(?) age for the Rampart Group.

REGIONAL STRATIGRAPHY OF THE RAMPART GROUP AND ASSOCIATED ROCKS

The Rampart Group, as redefined by Mertie (1937), consists of basaltic to andesitic flows; basaltic, andesitic, and rhyolitic tuffs and breccias; and a slightly smaller amount of interbedded chert, shale, argillite, and sandstone. Locally, the rocks are calcareous, but the only limestone mentioned by Mertie is the limestone bed at the fossil locality. Figure 1 shows the distribution of these rocks as mapped by Mertie (1937, pl. 1) south of the Yukon River and similar rocks that had previously been mapped by Eakin (1916) north of the Yukon. Mertie included these northern rocks in the Rampart Group and described their good exposures along the Yukon for about 60 miles northeastward from the town of Rampart.

No complete section of the Rampart Group is known. It is much folded and broken by faults, and no upper limit was specified by Mertie. The oldest beds known to overlie it are Tertiary conglomerates; they rest unconformably upon it and contain pebbles of the volcanic rocks. The beds thought to underlie it are an assemblage of sparsely fossiliferous Mississippian clastic rocks and unfossiliferous limestone. These rocks dip north beneath the Rampart Group near Rampart. Farther east they dip southward away from the Rampart Group in an area where the Mississippian and older rocks are believed (Prindle, 1913) to be overturned.

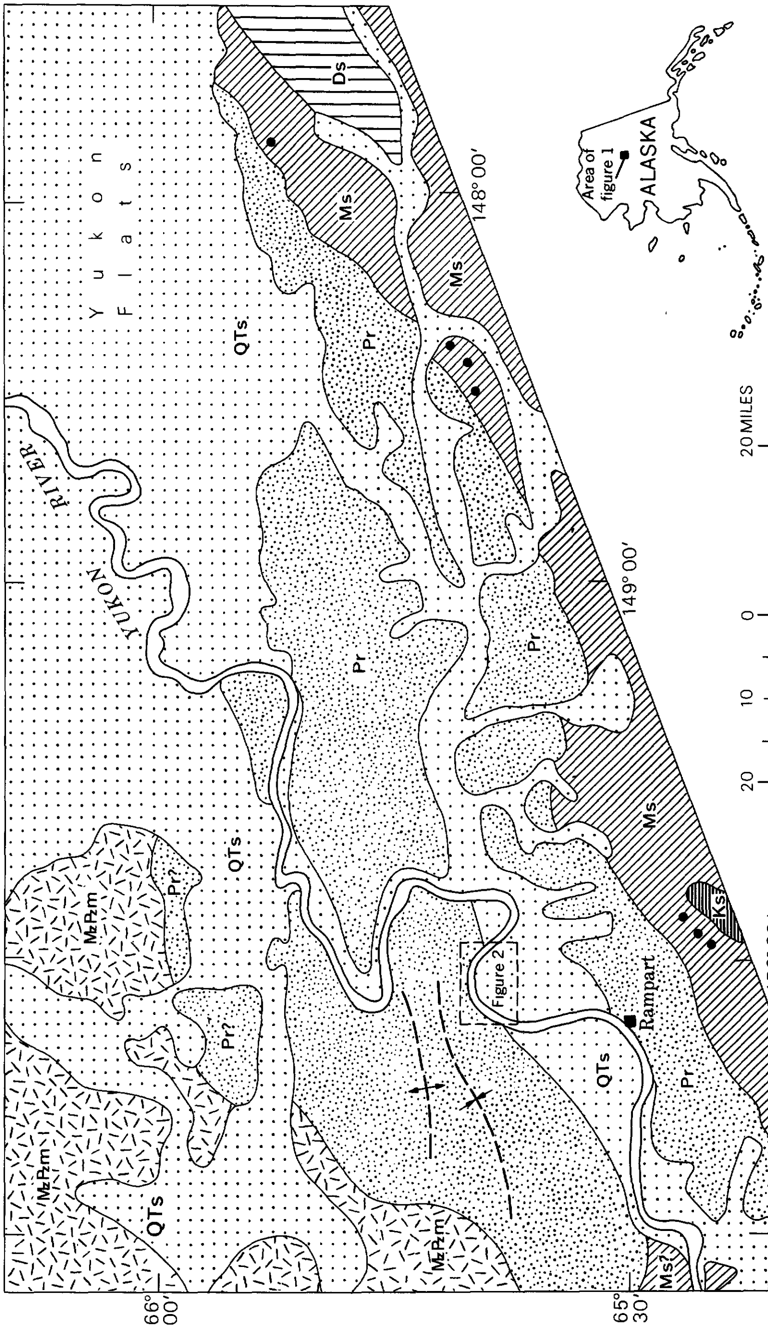
The relation of the Rampart Group to the mica schist and granite to the north (fig. 1) is uncertain. Eakin, who crossed the northern contact of the Rampart Group at two places, suggested (1916, p. 33) that in the eastern part of the area the interbedded sedimentary and volcanic rocks have been altered by the granite and might grade northward into the schist. Photointerpretation suggests that the contact he saw near the west edge of the area may be a high-angle fault.

Diabase dikes and larger bodies of gabbro and augite diorite are common within the mapped boundaries of the Rampart Group, especially in the western half of the area shown in figure 1. Although for convenience these intrusive rocks were mapped as Rampart Group, Mertie excluded them from the Rampart Group as a stratigraphic unit. As described by Mertie, the intrusive rocks seem to have the same range in mineral composition as the basaltic to andesitic flows, and, like them, they contain no olivine but commonly contain a little quartz. Like the flows, the intrusive rocks have usually been altered, and albite, kaolin, sericite, chlorite, and calcite have been produced. However, a few of the intrusive rocks have been much less altered than the flows, and Mertie suggested that these might be considerably younger than the Rampart Group.

Mertie considered the Rampart Group to be of Mississippian age, partly on the basis of its apparent position above the supposedly Mississippian clastic rocks but mainly on the identification of three genera of Bryozoa from a limestone bed that underlies some of the volcanic rocks on the Yukon River (loc. A, fig. 2). Although Mertie assigned this limestone bed to the Rampart Group, he suggested that, because its stratigraphic position was uncertain, this bed might actually be older than the Rampart Group. He further suggested that, because the limestone is conglomeratic, it might be correlative with the fossiliferous conglomerate beds in the presumably underlying Mississippian clastic rocks. However, the provenance of the Rampart limestone is unlike that of the Mississippian conglomerates. Noncarbonate clasts in the limestone are almost entirely volcanic material and argillite, whereas the clasts in the Mississippian conglomerate are shown by Mertie's description and by examination of hand specimens and thin sections of matrix rock from the fossil collections to be mainly chert with minor amounts of quartz and black phyllite.

RAMPART GROUP AT THE FOSSIL LOCALITY

The fossiliferous limestone bed that Mertie (1937, p. 126) described forms a small cliff opposite Point No Point (loc. A, fig. 2) in the eastern part of a bend in the Yukon River, where the Rampart Group is exposed for about 4 miles. For a distance of about 10 miles above and below this bend, only alluvium and folded Tertiary rocks are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YUKON RIVER
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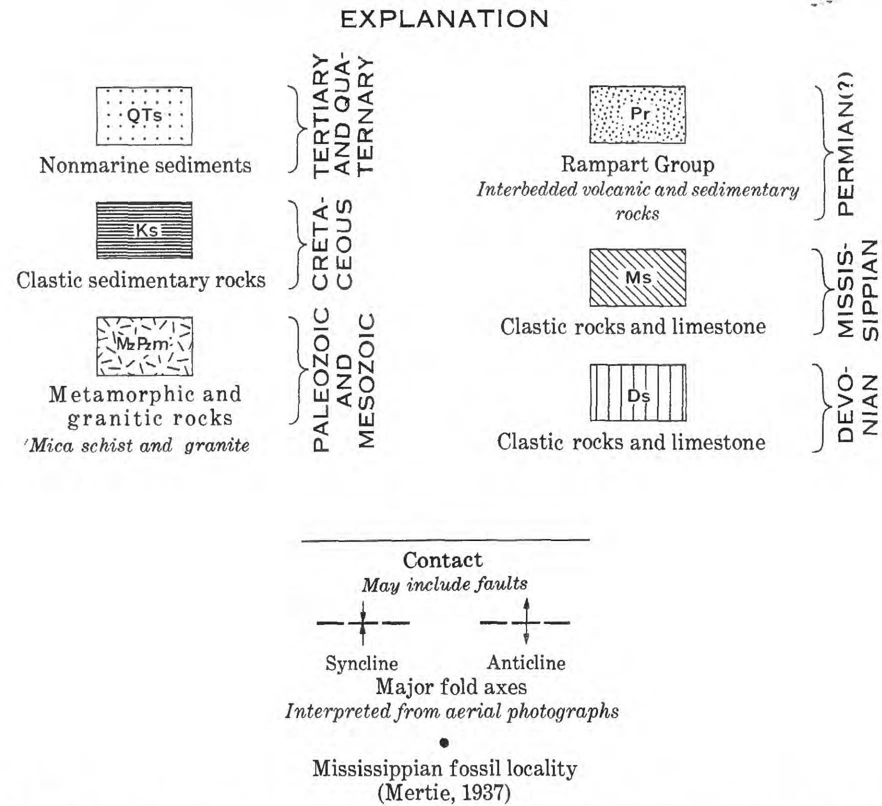

Figure 1.—Generalized geologic map of the Rampart region showing area of figure 2 and distribution of the Rampart Group and adjacent Mississippian rocks. From Mertie (1937) and Eakin (1916). Northwest boundary of Rampart Group partly from photointerpretation.

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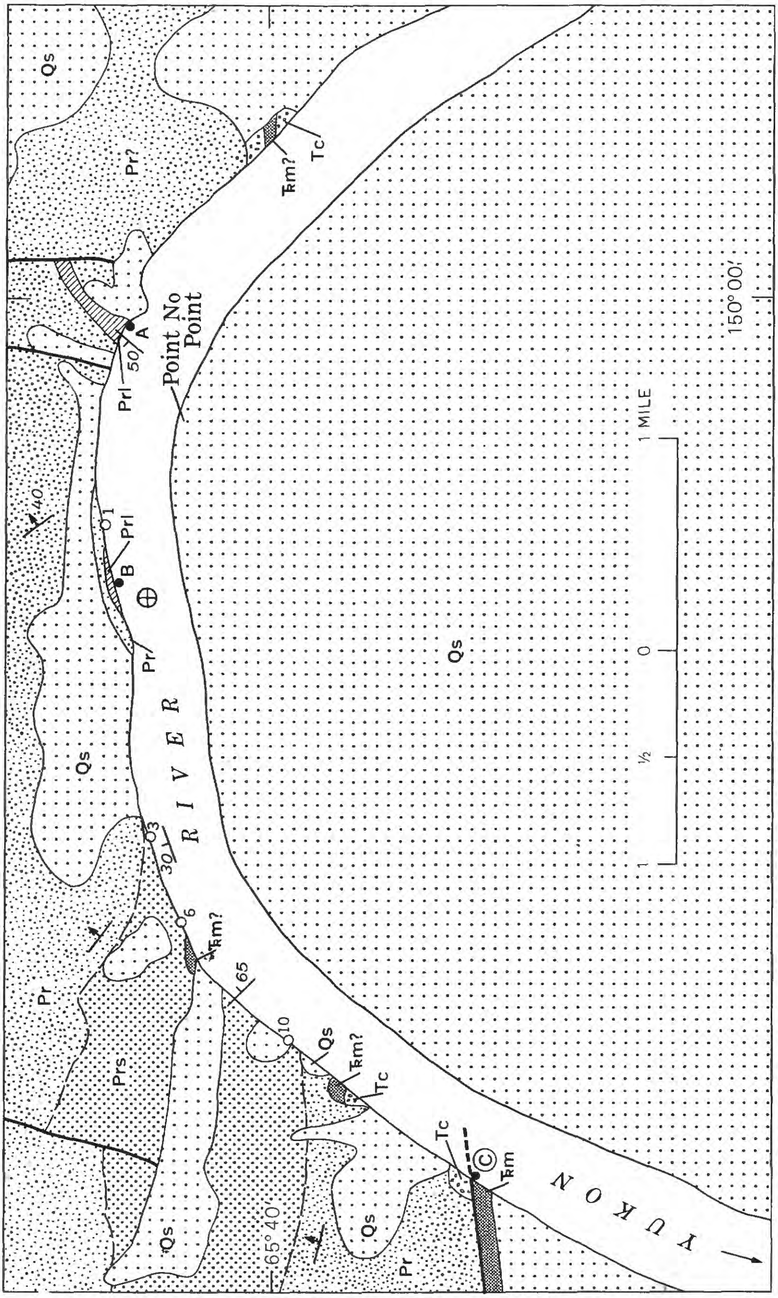
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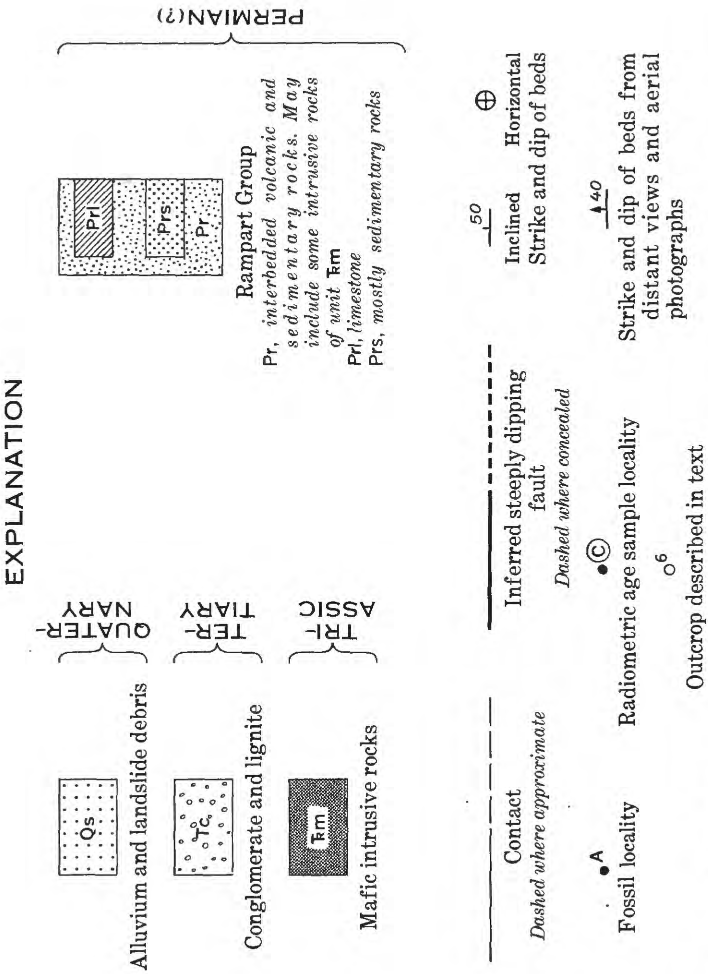

FIGURE 2.—Geologic map of the Yukon River shoreline near Point No Point. Geology away from the river inferred from aerial photographs.

exposed along the river. Within the bend, the Rampart Group crops out at intervals along the shoreline in wooded bluffs that rise about 800 feet above the river. Landslides from these bluffs, now covered, obscure most of the outcrop, and a small point is formed immediately upstream from the limestone cliff by a prominent fresh slide that came down about 1940. The surface of this slide is composed almost entirely of limestone blocks that are derived from the cliff formed by the steeply dipping fossiliferous limestone bed, mixed with some red argillite from the adjacent beds.

The geologic map (fig. 2) is based on a study of the outcrops along the shoreline and on interpretation of aerial photographs of the timbered slopes away from the river. In this area, the Rampart Group dips generally north into a large syncline (fig. 1). The rocks are broken by many faults too small to be shown on the map and by small folds overturned southward. The beds at fossil locality A are part of a structurally discordant block in which the beds dip northwest, almost normal to the other rocks. This block seems to be bounded by faults that are parallel to a system of north-south lineations visible on the aerial photographs. A small east-west fault at locality ©, where samples were collected for radiometric age dating, separates the steeply dipping intrusive rocks from a small outcrop of flat-lying Tertiary rocks in the riverbank, and this fault probably continues westward into the Rampart Group.

No section of the Rampart Group can be measured along the river because of the small-scale structural complexity and the discontinuous outcrops, but a general sequence can be suggested because of the northward regional dip. The best exposed part of the Rampart Group has been distinguished as a separate member of mostly sedimentary rocks in figure 2. The beds below this sedimentary member are not exposed along the river. The few beds exposed above it are mainly volcanic rocks but include the fossiliferous limestone bed. This bed crops out at locality B in the upper part of the apparently continuous sequence, as well as at locality A in the discordant block.

APPARENT LITHOLOGIC SEQUENCE

The fossiliferous limestone, judging from its position at locality B, is in the upper part of the north-dipping sequence exposed along the river. The rocks in this sequence are described below in the order in which they crop out going downstream from a point a quarter of a mile east of locality B. There is, however, no direct evidence of superposition between the outcrops. The rocks throughout the sequence are a similar volcanic-chert-argillite assemblage; even the limestone contains volcanic detritus. Only the carbonaceous wacke of unit 6 seems

anomalous in this respect, as the grains in this rock are mostly quartz and the only identifiable volcanic detritus is a minor amount of plagioclase.

The apparent stratigraphic sequence in the Rampart Group, as exposed along the Yukon, is as follows: (Locations of units 1, 3, 6, and 10, and locs. B and (C) are shown in fig. 2.)

1. Dark-greenish-gray and grayish-red lithic tuff and breccia consisting of rounded fragments of andesite(?) and of chloritized glassy(?) lava that contains amygdules of calcite and quartz. Dark-green trachyandesitic crystal tuff of plagioclase, pyroxene, and amphibole fragments in a matrix of chlorite and fine mosaic quartz (table 1). Interbedded minor amount of siliceous argillite, one lens of limestone, and a partly covered zone of spherical phosphatic concretions.

Covered interval.

2. Limestone at locality B. Fossiliferous limestone similar to that at locality A. Overlain by 25 feet of sheared silty argillite succeeded by volcanic breccia beds.

Covered interval.

3. Brown-weathering volcanic breccia with some pebbles and cobbles of green argillite and limestone. Interbedded dark-gray and red siliceous argillite with lenses of dark-gray calcareous siltstone. Forms upper beds of sedimentary member.

Covered interval.

4. Greenish-gray shale and chert and dark-gray bedded chert interlayed with basalt.

Fault (not shown in fig. 2).

5. Altered grayish-green vitric tuff(?) consisting of few fragments of plagioclase and volcanic quartz in cryptocrystalline chloritic matrix.

Fault(?).

6. Medium-dark gray very fine grained micaceous lithic wacke and siltstone with layers of carbonaceous pebbles. Interbedded micaceous silty shale with few carbonaceous partings and silty concretions.

Covered interval.

7. Outcrop of andesitic basalt; mapped as probable mafic intrusive rocks of Triassic age, but may be part of Rampart Group.

Covered interval.

8. White and yellow laminated to thick-bedded chert.

Fault (not shown in fig. 2).

9. Orange-weathering sheared silicified volcanic breccia, partly calcareous.

10. Grayish-red and grayish-green mottled siltstone, chloritic very fine grained sandstone and altered fine crystalline pyroxene andesite. Brecciated and exposed in landslide. Lowest exposed beds in the mainly sedimentary part of the Rampart Group. Outcrops downstream are only intrusive rocks and Tertiary conglomerate.

FOSSILIFEROUS LIMESTONE

Only the upper part of the limestone unit is exposed at locality B, but at locality A about 100 feet is exposed. The limestone unit consists of tuffaceous limestone in beds 5–10 feet thick interbedded with calcareous volcanic granule-to-pebble conglomerate in beds as much as 6 feet thick. The limestone grades vertically into the conglomerate, and both are composed of pelecypod prisms and calcite fragments, albite and andesine crystals, and fragments of green argillite and volcanic rocks, all cemented by carbonate. The limestone in its purest phase is pale-yellowish-brown to olive-gray pelecypod prism grainstone. The pelecypod prisms are generally about 0.4–0.8 mm (millimeters) long and 0.03–0.05 mm thick and are alined with their long dimension parallel to the bedding. (See fig. 3, left photo.) A few shell fragments were found; each was composed of about a dozen prisms of equal width alined normal to the shell edge. A transverse section of a shell fragment shows that these prisms are regular hexagons of uniform size. Extinction is subparallel ($\pm 15°$) to the prisms in the shell fragments and in most of the individual prisms in the rock.

Bryozoans occur as rare granule-to-pebble-size clasts in the limestone at both localities. Small fragments are visible in most of the rock samples, but the fossiliferous lens from which Mertie collected several large specimens was not found. One specimen large enough to be identified was collected at locality A and another, at locality B. The bryozoan fragments are water worn, and in thin section the pelecypod prisms are seen to be packed tightly against the abraded surface of the bryozoans. No matrix of older limestone was seen on any of the Bryozoa clasts.

Although the bryozoans are abraded clastic particles, it seems unlikely that they have been reworked from old rocks into a much later shell deposit. Helen Duncan suggests that the bryozoans were transported and deposited penecontemporaneously (J. T. Dutro, Jr., written commun., 1968). The bryozoans are no more damaged by wave action than are the completely disaggregated pelecypod shells that make up most of the limestone, and the fact that no matrix of preexisting rock was found on the bryozoans argues against their having been reworked from older rocks. Moreover, there is no other evidence of a nearby source area of pre-Rampart rocks. All clastic particles in

the limestone, as well as all clastic particles in the rest of the Rampart Group that were larger than very fine sand, could have been produced locally by volcanoes or organisms or could have been derived from underlying beds of the Rampart Group itself.

At both localities A and B, the limestone is overlain by argillite which, in turn, is succeeded by tuff and breccia. At locality A, this argillite is about 50 feet thick, is red, green, and black, and is silty and siliceous. The argillite contains lenses of sheared limstone and a few beds of crystal tuff composed of sodic plagioclase and secondary calcite after augite(?) in a matrix of glass and felted feldspar microlites. Above the argillite is rubble of andesine-bearing vitric tuff, lithic tuff, and volcanic breccia. The vitric tuff has the composition of alkali basalt (table 1). The breccia contains fragments of andesite and altered amygdaloidal quartzose lava as well as broken crystals of andesine, unstrained quartz, and pyroxene.

PALEONTOLOGY

The limestone contains pelecypod prisms, a few Bryozoa, some nondiagnostic fish teeth and fish plates (J. W. Huddle, written commun., 1965 and 1968), and an unidentifiable foraminifer. Conodonts were looked for in the limestone but were not found; samples collected for pollen from the carbonaceous wacke lower in the sequence were barren.

TABLE 1.—*Chemical analyses of volcanic rocks of the Rampart Group and associated intrusive rocks*

[Analyses by rapid-rock method described by Shapiro and Bannock (1962). Analysts· Leonard Shapiro, Lowell Artis, S. D. Botts, G. W. Chloe, P. L. D. Elmore, J. L. Glenn, James Kelsey, Hezekiah Smith]

	1	2	3	4	5	6
SiO_2	49.2	52	49.1	41.9	49.2	48.1
Al_2O_3	12.9	17.4	17.3	12.7	14.3	13.2
Fe_2O_3	5.8	2.9	1.6	7.9	1.5	2.9
FeO	9.4	5.7	6.1	11.4	10.3	12.4
MgO	5.3	3.2	7.2	6.7	6.4	4.7
CaO	6	5.1	10.1	10.5	10.8	8
Na_2O	3.2	4.7	2	1.4	2	2.7
K_2O	1.6	1.9	.52	.30	.32	.42
H_2O-	.47	1.1	.66	.39	.27	.31
H_2O+	2.6	3.3	2.9	2	2.2	2.8
TiO_2	2.1	.76	.89	3.1	1.8	3
P_2O_5	.27	.35	.10	.13	.20	.26
MnO	.16	.36	.17	.22	.21	.26
CO_2	<.05	.24	<.05	<.05	.20	.08
Total	99	100	100	99	100	100

1. Rampart Group, vitric tuff at loc. A (65ABe97C).
2. Rampart Group, crystal tuff a quarter of a mile east of loc. B (65ABe98).
3. Intrusive rock, andesine gabbro at loc. © (65ABe106CX).
4. Intrusive rock, diabase, radiometrically dated sample at loc. © (65ABe106CZ).
5. Intrusive(?) rock, diabase, 1 mile north of loc. © (65ABe105B).
6. Float, andesine gabbro, same loc. as 5 (65ABe105C).

The byozoans have been identified by Helen Duncan. The specimen from locality B (USGS 22401–PC) is a trepostomatous bryozoan aff. *Dyscritella Girty* that may be a new genus, and the smaller specimen from a limestone block in the slide at locality A (USGS 22400–PC) is probably of the same species (Helen Duncan, written commun., 1966). These specimens were originally referred to the Carboniferous or Permian (Helen Duncan, written comm., 1966). Helen Duncan (in J. T. Dutro, Jr., written commun., 1968) reexamined them and the specimens of other genera in Mertie's collection (USGS 5411–PC) and reported that the generic identifications published in Mertie's (1937) report proved to be erroneous and that "* * * they belong to genera commonly found in the Permian, although very rare reports of similar forms from the Triassic are on record."

The pelecypod prisms are by far the most abundant fossil material in the limestone; they constitute most of the rock in the thin sections examined. The genus represented by all this material is unknown because the few visible shell fragments are too small to be identified, but the very abundance of the prisms suggests that they might be Mesozoic in age. The only similar pelecypod-prism limestone previously reported in Alaska is the Nelchina Limestone of Early Cretaceous age (Jones and Detterman, 1966), composed mainly of *Inoceramus* prisms and fragments and some volcanic detritus. As in the Rampart Group, identifiable shells are rare compared with the total volume of disaggregated shell material in the rock (D. L. Jones, oral commun., 1968). In thin section the pelecypod prisms in the Rampart Group limestone (fig. 3, left photo) are similar in shape to those in the Nelchina Limestone (see fig. 3, right photo) and are similarly arranged within the shell fragments, but they are generally not as wide. Prisms as wide as 0.08 mm are common in the Nelchina but are rare in the Rampart.

Known pelecypod prisms in limestone beds, in addition to those of Mesozoic age, include prisms of *Atomodesma*, a guide fossil to the Permian in New Zealand, that locally forms a prism limestone bed 380 feet thick (Waterhouse, 1958; Wood and others, 1956), and prism limestones in rocks of probable Permian age in Alaska. Beds of pelecypod prism limestone occur in the Gemuk Group at two localities near Goodnews Bay, about 550 miles southwest of Rampart. The Gemuk Group is a sedimentary and volcanic sequence of Carboniferous to Cretaceous age that contains fossiliferous Permian limestone beds in the lower part (Hoare and Coonrad, 1961). One of these fossiliferous beds is a very fine grained tuffaceous limestone about 80 feet thick (J. M. Hoare, written commun., 1968). In a thin section provided by Hoare, this limestone appears to be composed mainly of slender pelecypod prisms similar to those in the Rampart Group (fig. 4).

At the same locality of the Gemuk Group, this limestone also contains productoid and spiriferoid(?) brachiopods of probable Permian age, a gastropod of probable Paleozoic age, and large pieces of unidentified prismatic pelecypod shells (Hoare and Coonrad, 1961, fossil loc. 16; J. S. Williams and E. L. Yochelson, written commun., 1953). In thin section, a probable Permian brachiopod valve from the fossil collection is seen to be enclosed in a matrix of closely packed pelecypod prisms, so there is no physical evidence that the Permian(?) fossils were reworked from a matrix rock older than the prisms.

A second bed of fine-grained pelecypod-prism limestone occurs in the undifferentiated rocks of the Gemuk Group on the south shore of Goodnews Bay. No identifiable fossils were reported from this bed, but a collection made by Coonrad from limestone in the same terrane 3½ miles to the east contains fragments of brachiopods of possible Permian age (Hoare and Coonrad, 1961, fossil loc. 23; J. S. Williams, written commun., 1954) and many fragments of unidentified pelecypod shells composed of parallel prisms 0.03–0.08 mm wide and 1–2 mm long.

These straight slender pelecypod prisms in the Gemuk Group have been found only in tuffaceous limestones with poorly preserved fossils of questionable Permian age, and they have not been found in the crinoidal limestone facies from which the better Permian fossil collections in the Gemuk were made. However, similar pelecypod prisms have been found in a specimen of sandy crinoidal limestone provided by E. E. Brabb from the type section of the Permian Tahkandit Limestone near Eagle about 250 miles east of Rampart. This specimen contains a few individual prisms and many small shell fragments composed of parallel prisms about 0.04 mm wide and 1 mm long.[1] Thus, the pelecypod prisms in the Rampart Group limestone are as likely to have been derived from some unidentified Permian form as from the Mesozoic *Inoceramus*.

AGE OF INTRUSIVE ROCKS

Four resistant bodies of basalt and gabbro crop out along the Yukon River near the Rampart Group fossil locality (fig. 2). No intrusive contact with the Rampart Group is exposed. However, judging from the aerial photographs, these intrusive bodies are on strike with the Rampart Group and probably intruded the lower part of the Rampart.

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[1] Pelecypod prisms also occur with productoid brachiopods in three collections (USGS 15820, 15827, and 15828) from the Permian Echooka Member of the Sadlerochit Formation of northern Alaska (J. T. Dutro, Jr., oral commun., 1969).

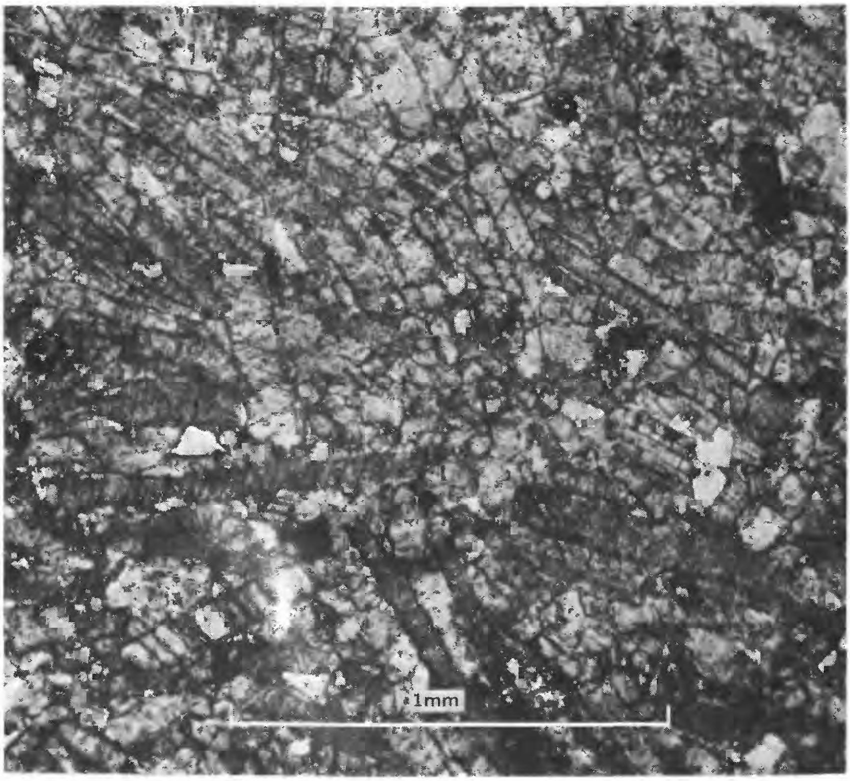
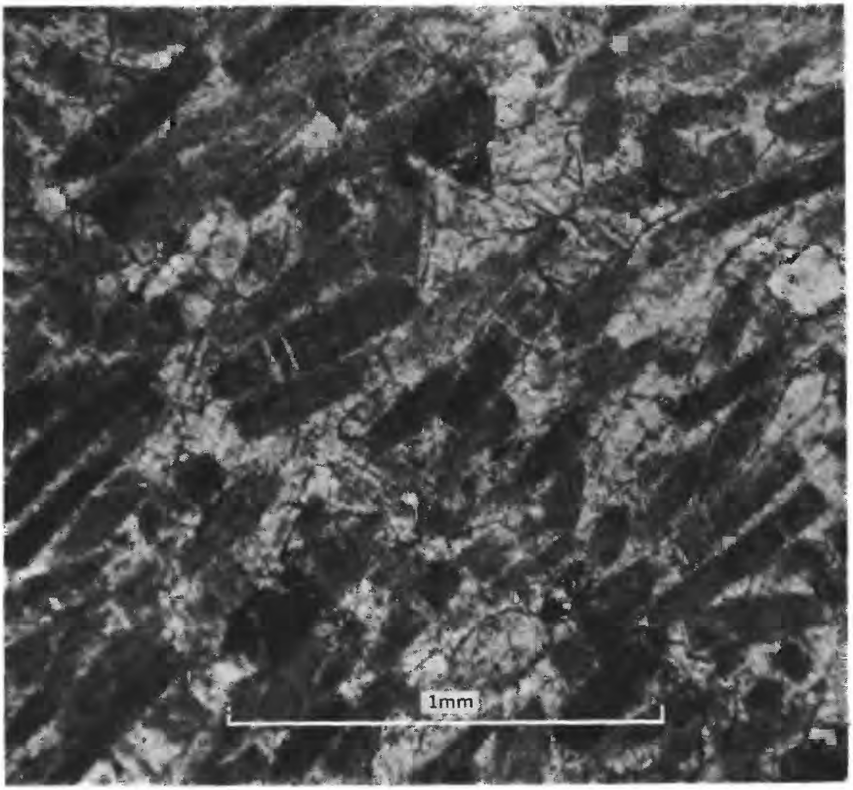


FIGURE 3.—Pelecypod-prism calcarenites. Above: Rampart Group, locality B of figure 2. Right: Nelchina Limestone, containing *Inoceramus* prisms. Specimen provided by D. L. Jones. Photomicrographs in plane-polarized light.

The body at locality © contains gabbroic zones in the outcrop and is thus clearly an intrusive. The other outcrops are fine-grained rocks that might be flows in the bedded volcanic sequence; they are thought to be intrusive because they are dikelike in shape and because they are associated with coarse-grained float that might be locally derived. Only the northernmost of the four bodies lies between outcrops of the Rampart Group, and that body may well be a flow. (See unit 7 in the sequence of bedded rocks.) The other three bodies lie outside the zone in which the Rampart Group crops out along the riverbank, and they were seen in contact only with flat-lying beds of Tertiary conglomerate, claystone, and lignite. At the easternmost locality, the Tertiary beds overlap a deeply weathered greenstone body; at locality ©, the contact with the Tertiary is a steep fault; elsewhere, the contact with the Tertiary is obscure or faulted.



Whereas chemical analyses indicate that pyroclastic rocks in the Rampart Group are alkaline, the intrusive rocks are modally or chemically tholeiitic. The body exposed about 1 mile north of locality Ⓒ is fresh fine-grained tholeiitic diabase with minor hornblende. (See table 1.) Boulders of tholeiitic andesine gabbro with a little late hornblende and micropegmatite were found nearby on the beach and may be related to the diabase. (See table 1.)

The intrusive body at locality Ⓒ forms a steep-faced promontory about 100 yards wide. It is mainly coarse-grained, light-gray-weathering andesine gabbro composed of fresh poikilitic augite, cloudy andesine, chlorite, and a little chloritized hornblende (table 1). The gabbro grades into darker and finer grained rocks in the middle of the body, and along the northern margin it grades into fine-grained tholeiitic augite diabase, which has a crude textural banding that dips steeply northeast and is parallel to the major joints. The augite diabase contains about 20 percent green and brown hornblende (table 1), and a single sample of this hornblende was used for the potassium-argon determination. Although a small part of the hornblende has been altered to chlorite and biotite, most of it is fresh; it surrounds

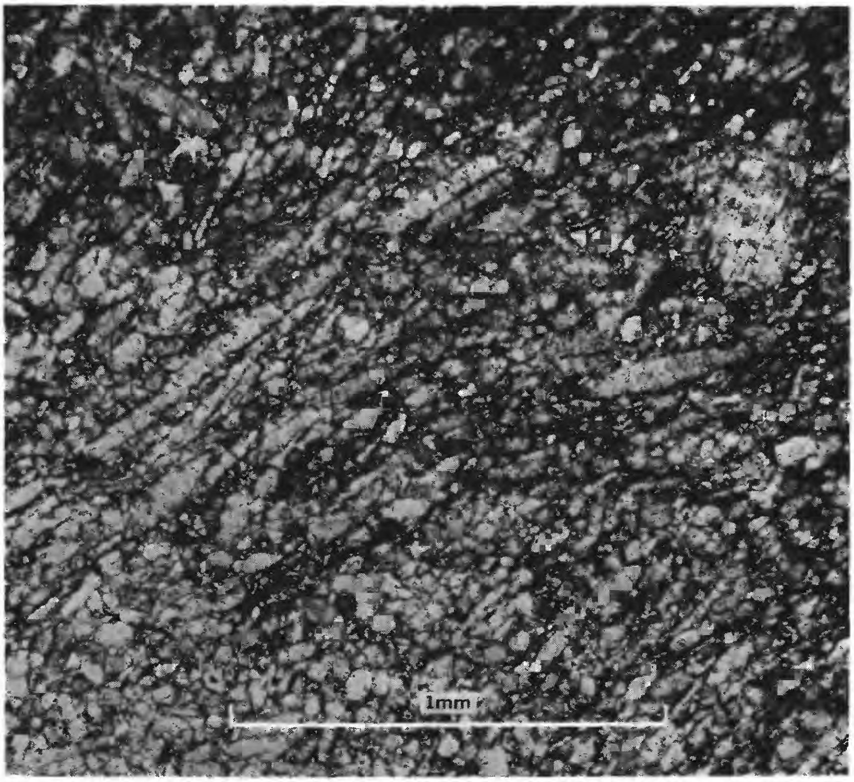


FIGURE 4.—Photomicrograph of pelecypod prisms in a Permian limestone in lower part of Gemuk Group near Goodnews Lake (Hoare and Cooonrad, 1961, fossil loc. 16). Specimen provided by J. M. Hoare. Photomicrograph in plane-polarized light.

the labradorite and is intergrown with the augite. The latest minerals in the diabase are interstitial quartz and abundant crosscutting magnetite.

POTASSIUM-ARGON ANALYSIS

Standard isotope dilution techniques were used for the argon determinations; the potassium determinations were done by flame photometry using a lithium internal standard. The hornblende used for the determinations contained less than 5 percent chlorite. Potassium was determined on two splits of the hornblende concentrate, and argon was determined on two other splits. The average potassium-oxide value was used with each argon determination in turn to calculate an apparent age (table 2). The plus-or-minus value for each calculated age is the standard deviation of analytical precision that is estimated using the method of Cox and Dalrymple (1967).

The average age for the hornblende from the gabbro at locality © is 205±6 million years, where the plus-or-minus value is the pooled estimate of the standard deviation. This age is Triassic according to all recent compilations of the geologic time scale. The age of the Triassic-Jurassic boundary has been placed at 180 million years by Holmes (1959), at 181 million years by Kulp (1961), and at 190–195 million years in the Phanerozoic time scale of the Geological Society of London (Harland and others, 1964).

TABLE 2.—*Potassium-argon data for hornblende from the gabbro at locality ©*

[Argon analyses and age calculations by J. C. Von Essen and M. A. Lanphere; potassium analyses by L. B. Schlocker. Decay constants for K^{40}: $\lambda_e=0.585\times10^{-10}$ year^{-1}; $\lambda_B=4.72\times10^{-10}$ year^{-1}. Atomic abundance of $K^{40}=1.19\times10^{-4}$]

K_2O (percent)	Ar^{40}_{rad} (10^{-10} moles per g)	$\frac{Ar^{40}_{rad}}{Ar^{40}_{total}}$	Apparent age (millions of years)
0. 174	0. 5656	0. 41	207±7
. 175	. 5528	. 54	203±6
0. 174 (avg)			205±6 (avg)

CONCLUSION

The fossiliferous limestone bed exposed in the Rampart Group along the Yukon River was originally thought to be Mississippian in age and was thought possibly to underlie the rest of the Rampart Group. Reexamination of the outcrop shows that the limestone bed is definitely within the volcanic sequence of the Rampart because it contains abundant clasts of volcanic rock and is overlain and apparently underlain by volcanic beds. The bryozoans in old and new collections from this limestone have been reidentified and are now believed to be Permian(?) rather than Mississippian in age. Examination of thin sections shows that this limestone is composed largely of pelecypod prisms like those of *Inoceramus;* similar prisms are equally abundant in the Permian part of the Gemuk Group of southwestern Alaska and occur in the Permian Tahkandit Limestone of east-central Alaska.

Gabbro and greenstone intrude the Rampart Group throughout much of its area of outcrop. A body of gabbro and diabase that probably intrudes the Rampart Group 4 miles from the fossil locality has a radiometric age of 205 million years. The age of this intrusive body probably indicates that the Rampart Group volcanic beds exposed along this part of the Yukon are no younger than Triassic. It also supports the Permian(?) age that is indicated for these volcanic beds by the fossil evidence.

The age of the beds that enclose the fossiliferous limestone is therefore revised from Mississippian to Permian(?). As these are the only

dated beds within the Rampart Group, the age of the Rampart is also revised to Permian(?). However, the Rampart may prove to contain beds younger than Permian, as its upper stratigraphic limit is not known, and the presence of Triassic intrusive rocks nearby suggests that there may also be Triassic eruptive rocks in the volcanic terrane.

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U. S. GOVERNMENT PRINTING OFFICE : 1969 O - 363-282