State of Washington
Department of Natural Resources
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DIVISION OF MINES AND GEOLOGY
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Geologic Map GM–6

PRELIMINARY GEOLOGIC MAP OF THE LOON LAKE QUADRANGLE, STEVENS AND SPOKANE COUNTIES, WASHINGTON

By

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U.S. GEOLOGICAL SURVEY

Prepared cooperatively by the U.S. Geological Survey

STATE PRINTING PLANT OLYMPIA, WASHINGTON
1969

For sale by Department of Natural Resources, Olympia, Washington.
Price, $1.00.

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INTRODUCTION

The Loon Lake quadrangle is a 15-minute composite of the Valley, Nelson Peak, Springdale, and Deer Lake 7 1/2-minute quadrangles. The southern boundary is about 30 miles north of Spokane (fig. 1) in the southeast part of Stevens County and the northern part of Spokane County. The quadrangle covers the southwestern part of the mountains dividing the Pend Oreille and Colville River valleys. Mapping of the quadrangle was begun in 1965 by the U.S. Geological Survey in cooperation with the Division of Mines and Geology of the Washington State Department of Conservation.

The Loon Lake quadrangle is underlain by folded and faulted sedimentary and volcanic rocks apparently of three great Precambrian sections; folded and faulted Paleozoic rocks; Mesozoic(?) plutonic rocks of intermediate composition; and basalt and andesite of Tertiary age. Generally, bedrock is exposed in upland areas, but in much of the western half of the area, it is concealed beneath unconsolidated glacial deposits and alluvium. The lack of exposure in places does not permit projection and correlation of several important structural features and stratigraphic relations.

The Loon Lake quadrangle is a part of the area covered by Weaver's (1920) geologic reconnaissance of Stevens County. Jones (1928), who mapped the Chewelah 30-minute quadrangle, of which the Loon Lake quadrangle is the southeast quarter, prepared a much more detailed map, but retained most of Weaver's original units. The present investigations were begun by the author in 1965 with the assistance of J. C. Moore, continued in 1966, and completed in 1967 with the assistance of R. L. Reynolds.

PRECAMBRIAN

Most Precambrian rocks in the Loon Lake quadrangle belong to the Belt Series, which crops out extensively in western Montana and northern Idaho. All formations from the lower Prichard to the upper part of the Wallace Formation are represented. Lithologically the section is very similar to that in the Coeur d'Alene district (Hobbs and others, 1965), and the thicknesses of the various units are comparable.

In addition to the Belt rocks, the northwestern, and possibly western, part of the quadrangle is underlain by rocks belonging to the Deer Trail Group and correlatives of the Windermere Group in Canada. The Deer Trail Group, although less well known and less extensive than the Belt Series, is an important and thick section of argillite, siltite, quartzite, and carbonate rocks variously estimated at 30,000 feet (Bennett, 1941, p. 8), 10,000± feet (Campbell and Loofbourow, 1962, p. 7), and 25,000± feet (Becraft and Weis, 1963). The latter two estimates are smaller than the first, because they include only part of the group. Greenstone of the Huckleberry Formation unconformably overlies the Deer Trail rocks and is probably the same as the Irene Volcanics of the Windermere Group in Canada.

In this preliminary report, the Precambrian rocks are described under four headings: Belt Series, Precambrian rocks of questionable stratigraphic position, Deer Trail Group, and younger Precambrian rocks. The second group includes rocks that the writer is unable, at present, to assign to either the Belt Series or the Deer Trail Group.

BELT SERIES

Prichard Formation.—The Prichard Formation underlies approximately half of the northeastern quarter of the Loon Lake quadrangle. Alternating zones of argillite, siltite, quartzitic siltite, and quartzite make up a section more than 13,000 feet thick, the base of which is not exposed.

About 600 feet of medium-gray, well-bedded to laminated argillite marks the top of the formation. Most beds are from 1 to 6 inches thick. Below the argillite is a zone of quartzite, siltite, and gray argillite about 800 feet thick, which in turn is underlain by about 3,000 feet of argillite similar to that at the top of the formation. Approximately 3,200 feet of quartzite, siltite, and argillite lie beneath this thick argillite. Owing to poor exposure the stratigraphy below this zone is not well known, except that the various recurring lithologies continue.

Near the middle of the 3,200-foot quartzite, siltite, and argillite zone is a 150- to 250-foot-thick sill of metadiabase that crops out along the entire strike length of the Prichard exposure, and was probably a mafic-rich diabase originally. Two other sills occur about 4,500 feet and 6,500 feet below the first.

Burke Formation.— Light- to medium-gray siltite is the dominant lithology of the Burke Formation. The Prichard Formation grades upward through about 150 feet of alternating argillite and siltite beds into medium-bedded siltite. The top of the transition marks the base of the Burke Formation. A few hundred feet above the base, the siltite grades into a quartzite zone about 300 feet thick. This quartzite, in turn, grades upward into siltite characteristic of most of the formation. Other than quartzite beds of varying thickness, which are common throughout the unit, the only lithologic unit that interrupts the monotonous medium-gray siltite is a 100- to 300-foot zone of maroon to lavender argillite and quartzite found about 3,000 feet above the base. This zone is lithologically indistinguishable from most of the younger St. Regis Formation.

Thickness of beds ranges from less than an inch to more than 10 feet but averages about 6 inches to 1 foot. Some quartzite strata are crossbedded, and much of the siltite is finely cross-laminated. In the upper part of the formation are abundant oscillation and current ripple marks.

Thickness of the Burke Formation appears to vary slightly along strike, probably due to structure and to placement of the gradational contacts at different horizons at different localities. The average thickness is about 4,500 feet.

Revett Formation.—The Revett Formation is exposed in the central and eastern parts of the quadrangle from the north edge of the plutonic rocks to the central part of the Chewelah Mountain quadrangle. It is predominantly fine-grained, white, massively bedded, vitreous quartzite. Beds range in thickness from less than an inch to more than 20 feet; average thickness is about 1 to 2 feet. The transition with the Burke Formation is a zone about 200 feet thick, the widest gradational zone between formations in the Belt Series within the Loon Lake quadrangle. As might be expected, the lower part of the formation is siltitic. Above the siltitic base is about 1,000 feet of relatively pure, vitreous quartzite. Near the middle of the formation is about 500 feet of interbedded quartzite, siltitic quartzite, and siltite. Overlying the central siltitic part is quartzite that contains only a few siltite beds. Total thickness of the unit is approximately 3,100 feet. Near the middle and the lower part of the formation are some large-scale crossbeds, although they are not common. Below the central siltitic zone is 50 to 100 feet of dark, banded quartzite, some of which shows suggestions of crossbedding. Near the base of the unit, ripple marks are present, but not abundant. The lack of sedimentary features observed may be due, in part, to the poor exposure.

St. Regis Formation.—The St. Regis Formation is poorly exposed in the Loon Lake quadrangle, but it is composed of such distinctive lithologies that in most places it can be mapped on the basis of float. The base, where exposed at the north end of the quadrangle, is gradational into the Revett Formation over a zone about

50 feet thick. In this part of the unit, interbedded lavender quartzite and maroon argillite are gradational upward into sandy maroon argillite. The argillite in turn grades into the upper part of the formation, which is composed of about 300 to 400 feet of light-to-bright yellow-green argillite, siltite, and carbonate-bearing argillite and siltite interbedded with maroon argillite.

In the lower part of the formation, thickness of individual beds ranges from 1 inch to about 4 feet. Bedding characteristics of the central part of the formation are not known, as it is exposed only as float. In the upper, green carbonate-bearing part of the unit, bed thickness is slightly irregular (the beds thicken and thin along strike), ranging from less than an inch to about 1 foot. Thickness of the entire formation is about 1,600 feet.

Abundant mud cracks and mud-chip breccias are found throughout the St. Regis Formation, although ripple marks and cross-lamination, so abundant in this unit at Coeur d'Alene, Idaho occur only locally.

Wallace Formation.—In the Loon Lake quadrangle the Wallace Formation can be differentiated into upper and lower units similar to those in the Coeur d'Alene district. Very little of the upper unit is exposed, however, and there is some uncertainty as to whether the rocks shown on the map actually belong in the upper unit or are part of the Striped Peak Formation.

Lower Unit

The lower part of the Wallace Formation is composed of carbonate rock, carbonate-bearing quartzite, quartzite, siltite, and argillite. Although varied in lithology, it is moderately uniform in appearance due to extremely distinctive bedding characteristics.

Carbonate minerals form a larger percentage of the rock in the lower half of the lower unit than in the upper half. The gradational zone between the lower unit of the Wallace Formation and the light-green beds of the upper St. Regis Formation is probably less than 100 feet thick. Rocks in this interval, and those parts of both formations immediately above and below it, contain a large amount of carbonate.

Although the lower unit of the Wallace Formation is the chief carbonate-bearing unit in the western Belt Series, it does not have the appearance of a carbonate rock because it contains a large amount of noncarbonate minerals. The unit as a whole looks like an interbedded sequence of quartzite, siltite, black argillite, and impure carbonate. Thickness is highly variable from bed to bed and within a single bed; it ranges from fine lamination in black argillite layers to 5 feet in some quartzite beds. The most striking lateral changes in bed thickness occur in quartzite or carbonate-bearing quartzite beds, which, in the extreme, thin from 5 feet to a few inches within a lateral distance of less than 10 feet. Thickness of the entire member is about 3,500 feet.

The rocks become progressively more argillaceous in the upper part of the member, grading finally into argillite of the upper unit. At the one locality where this gradation is exposed, it is 150 to 200 feet thick.

Upper Unit

The upper unit of the Wallace Formation is predominantly dark-gray to black argillite with a few beds of impure carbonate rock, quartzite, and siltite. Some of the irregular bedding characteristics of the lower unit persist in the coarser grained beds, but most of the black argillite is finely laminated.

Exposures of the upper unit are sparse, and its upper contact appears to be a fault wherever seen. Some rocks shown on the geologic map as upper Wallace, especially near the north border of the quadrangle and east of Valley, may not belong to this unit, but may be part of the Striped Peak Formation or possibly the Deer Trail Group.

The maximum exposed thickness is 1,500 feet, but this section includes some of the questionable rocks. Only about 300 feet of upper Wallace has been positively identified as such.

PRECAMBRIAN ROCKS OF QUESTIONABLE STRATIGRAPHIC POSITION

Introduction.—Rocks that apparently overlie the Wallace Formation and are unconformably overlain by the Cambrian Addy Quartzite crop out from the north border of the quadrangle to just north of Loon Lake. Most of these rocks cannot be assigned with certainty to either the Belt Series or the Deer Trail Group, and may, in fact, constitute a transition from one to the other.

These rocks lying between the Wallace Formation and the Addy Quartzite are, unfortunately, in a poorly exposed, structurally complex area cut by many large and small faults that were probably active at different times. A through-going fault of large lateral displacement that separates them from the Belt rocks to the east may be inferred from the evidence at hand, but, unfortunately, with only a slight degree of certainty. Because of these uncertainties, this group of rocks is placed in a separate category until the field relations are better understood. It is important to assign these rocks to one section or the other, and to demonstrate the existence or absence of a facies transition.

The opportunity to work out the relation between the Deer Trail Group and the Belt Series seems best in this area where they are in the closest juxtaposition. Yet the field evidence found so far is in part contradictory. Some suggests a facies transition from Deer Trail to upper Belt, and some that the two groups were deposited at different localities and subsequently faulted together. Possibly the correct explanation involves both.

Three of the units in this section, a carbonate-rich one, a black siltite and argillite, and a maroon siltite and quartzite, have striking lithologic resemblances to parts of the upper three members of the Striped Peak Formation in the Clark Fork quadrangle (Harrison and Jobin, 1963). However, the carbonate and the maroon units together are very similar to the Stensgar Dolomite of the Deer Trail Group, suggesting a possible correlation between part of the upper Belt Series and the Deer Trail Group.

The rocks directly underlying the Addy Quartzite west of the fault, although lithologically similar to rocks on the east side of the Jumpoff Joe fault, are cut by numerous intrusive greenstone masses that appear to be feeders for the Huckleberry Formation volcanics. Greenstone of the Huckleberry Formation unconformably overlies the Deer Trail Group and in turn is unconformably overlain by the Addy Quartzite a few miles to the west. Nowhere has the Huckleberry Formation been observed resting on the Belt Series. No greenstone dikes have been found in the Belt or possible Belt rocks east of the Jumpoff Joe fault. The association of the rocks west of the fault with greenstone known to overlie the Deer Trail Group suggests that these rocks may be part of the Deer Trail Group. In addition, the association of volcanic rocks with one section and not the other would imply that the Belt rocks and Deer Trail rocks were spatially separated during the extrusion of the Huckleberry volcanics.

Carbonate rocks above the Wallace Formation.—Carbonate rocks of Precambrian age are best exposed on Parker Mountain and the mountain north of Beitey Lake. On their east side, these rocks are in fault contact with the upper unit of the Wallace Formation, and on the west appear to grade upward into a gray siltstone-argillite unit.

Most of the carbonate rocks are cream colored or light gray. Weathered surfaces are deep rusty red-brown, and soil developed on them is about the same color. Although finely bedded, the rock forms large, blocky outcrops and has a massively bedded appearance. The carbonate rock is impure; it contains abundant sand- and silt-size quartz grains and variable amounts of argillaceous material. Highly sheared argillaceous beds are present in the upper part of the unit on Parker Mountain and on the hill north of Valley. Thickness, as accurately as can be determined, is probably between 2,000 and 3,000 feet.

On the hill in the northern half of section 32, T. 32 N., R. 41 E., maroon dolomite of this unit grades into similar-colored siltstone that stratigraphically underlies it. About a mile north, the maroon dolomite appears to overlie the tan and gray dolomite that makes up the bulk of the carbonate unit. In both areas, the carbonate rocks are very similar to the Stensgar Dolomite, especially to the section exposed in the southwest corner of the Chewelah Mountain quadrangle. The contact between the maroon rocks and the tan and gray dolomite is not exposed, however, and may be a fault. If it is a fault, the carbonate described here, and shown as a single unit, may include rocks that should be divided into several different units.

Siltite-argillite.—Between 1,000 and 3,000 feet of gray siltite and argillite overlie the carbonate unit and may interfinger with it. The contact appears to be a bed-by-bed gradation from carbonate to siltite, but a significant width is masked by cover along the entire strike. The upper contact is gradational over a distance of about 100 feet into maroon siltite, argillite, and quartzite and is well exposed.

Bed thickness ranges from a fraction of an inch to about 5 feet; average thickness is about 2 inches. The thicker beds are gray quartzite with no internal stratification. Siltite beds commonly contain thin argillite laminations that show on weathered surfaces but not on fresh breaks.

West of the Jumpoff Joe fault, the rocks assigned to this unit are slightly more argillitic than those east of the fault. However, bedding characteristics, color, and gross lithology are similar. Possibly the argillite on Jumpoff Joe Mountain, the mountains north and south of Valley, and at the extreme north edge of the quadrangle are not a single unit as shown on the map, but three different units.

The thickest apparently homoclinal sections are on Jumpoff Joe Mountain, the mountain west of Jumpoff Joe Lake, and the mountain south of Beitey Lake. At these localities, the argillite is 2,500 to 3,000 feet thick.

Maroon argillite, siltite, and quartzite. At the southern edge of Parker Mountain and on the mountain south of Beitey Lake, 500 to 800 feet of maroon argillite, siltite, and quartzite is found conformably above the siltite-argillite unit, and unconformably below the Cambrian Addy Quartzite. This unit, because of its distinctive coloration, is the most easily recognized unit in the section between the Wallace Formation and the Addy Quartzite.

Most beds are less than an inch thick. Grain size is extremely variable, but the silt fraction is by far the most abundant. Argillite occurs abundantly as partings along bedding. Only minor amounts of quartzite are present. The maroon color is quite consistent throughout the unit. Debris from this unit is commonly platy or chippy.

Ripple marks, mudcracks, and saltcasts are abundant. Cross-lamination, channel and fill, and graded bedding are local and occur on a small scale.

DEER TRAIL GROUP

Stensgar Dolomite.—The Stensgar Dolomite is the only formation of the Deer Trail Group recognized in the Loon Lake quadrangle. Additional study may show the carbonate rock on the hill north of Valley to be part of this unit and the argillite above it to be the Buffalo Hump Formation. At present, however, the small outcrops in the northwest corner of the quadrangle are the only ones that can be definitely identified as Stensgar Dolomite.

Tertiary volcanic rocks conceal the lower contact, and the Huckleberry Formation unconformably overlies the dolomite. Bedding thickness ranges from an inch to about 2 feet. Maroon argillaceous partings occur between some beds but are not numerous. The dolomite is light tan with a distinctive pink cast. No sedimentary structures other than bedding were found. Exposure is too incomplete to estimate the thickness of the dolomite in the Loon Lake quadrangle, but in the southwest part of the Chewelah Mountain quadrangle the formation thickness is estimated at about 500 feet (Clark and Miller, 1968), and at the northeast end of the magnesite belt, about 1,200 feet (Campbell and Loofbourow, 1962, pl. 1).

YOUNGER PRECAMBRIAN ROCKS

Huckleberry Formation.—In the magnesite belt the Huckleberry Formation rests unconformably on several formations of the Deer Trail Group (Bennett, 1941, p. 8). Only two small hills in the northwest corner of the Loon Lake quadrangle are underlain by this formation. Here, no conglomerate occurs in the lower part of the formation as it does in both the magnesite belt and the southwest corner of the Chewelah Mountain quadrangle. In the Loon Lake quadrangle, the greenstone of the Huckleberry Formation includes flows, flow breccias, minor amounts of tuff, and possibly aquagene tuff. Even though different types of rocks are interlayered, complete lichen cover makes stratification difficult to recognize. Chemical analyses of the greenstone in the Chewelah Mountain quadrangle indicate that the flows are basalt.

North and east of Valley, several bodies of greenstone have intruded the siltite-argillite unit. These rocks are lithologically similar to the flows in the Huckleberry Formation and probably represent feeders for the flows. Similar dikes, too small to show on the geologic map, are present on the mountain west of Jumpoff Joe Lake and the mountain north of Springdale.

PALEOZOIC

CAMBRIAN

Addy Quartzite.—The Addy Quartzite rests with angular unconformity on several Precambrian formations. West of the quadrangle, for almost the entire length of the magnesite belt, the Addy Quartzite is underlain by the Huckleberry Formation, which becomes progressively thinner from northeast to the southwest to about the latitude of Springdale. Seventeen miles west of the quadrangle, at the latitude of Springdale, the Addy Quartzite rests directly on the Deer Trail Group.

The Addy Quartzite again overlies the Huckleberry Formation just outside the northwest corner of the Loon Lake quadrangle. Elsewhere, it unconformably overlies the Precambrian rocks of questionable stratigraphic position.

The Addy Quartzite is chiefly white, medium- to coarse-grained, vitreous quartzite composed of well-sorted and well-rounded quartz grains. At the base, or within 200 feet of the base, is 100 to 300 feet of black-striped purple quartzite, which grades upward through pink quartzite over a stratigraphic distance of about 150 feet into the white quartzite characteristic of the formation. The greatest thickness of the Addy Quartzite in the quadrangle is about 1,500 feet, on the mountain north of Beitey Lake. This section is incomplete due to faulting, as are all other sections of the quartzite in the quadrangle. About 14 miles due west of Valley, Campbell and Raup (1964) show a complete section about 5,500 feet thick on their map. About 12 miles southwest of that locality, Becraft and Weis (1963, p. 12) report that the formation is 3,900 feet thick.

Trilobites and gastropods of Early Cambrian age (Okulitch, 1951, p. 405) occur in argillaceous and quartzitic beds in the lower part of the Addy Quartzite near the town of Addy, about 13 miles north of Valley.

Metaline Formation.—About 1.5 miles south of Springdale, carbonate rocks tentatively assigned to the Cambrian Metaline Formation rest with apparent conformity on the Addy Quartzite. These rocks closely resemble the lower and middle parts of the Metaline Formation in the Deep Creek area, about 60 miles to the north (R. G. Yates, oral commun., 1966).

The base of the unit is gray to blue-gray limestone with irregularly shaped, yellow-brown-weathering argillaceous seams that occur uniformly throughout the rock in an interwoven network. Above the limestone is thick- to thin-bedded, tan to gray dolomite with thin beds of dark-gray shale. The whole unit is very poorly exposed and appears to be repeated by faulting. Because of poor exposure and uncertain structure, the thickness of these rocks is not known. As yet unidentified trilobites and brachiopods have been found in the upper(?) part of the unit.

MISSISSIPPIAN(?)

Dolomite.—About 1 1/2 miles northeast of Springdale, approximately 1/3square mile is underlain by a uniform light-gray dolomite. A smaller area of this unit is exposed about 3 miles east of Valley. The rock has a massive appearance, but close examination of weathered surfaces shows much of it to be thinly bedded. Most is light gray and weathers light gray to white. Oolites and coated carbonate lithoclasts in a matrix of smaller pieces of the same material suggest a shoaline environment for part of the carbonate. These shoaline rocks alternate with others containing algal structures suggestive of an intertidal environment (A. K. Armstrong, oral commun., 1967).

Thickness as taken from width of outcrop on the map is about 900 feet, but some repetition by faulting may be present. No fossils, other than the nondefinitive algae, have been found.

Dolomite and calcareous slate.—About 200 feet of light-tan dolomite and calcareous slate crop out 1 mile northeast of Springdale. Three miles east of Valley, about 100 feet of dolomite and slate probably belonging to the same unit crop out on the wall of a long, narrow canyon. The same lithologies are present on the east side of a small hill 3 1/2 miles northeast of Valley. All contacts of this unit with other bedrock units, except the lower contact east of Valley, are faults.

The dolomite is thin bedded to massively bedded and makes up the lower two-thirds of the unit. It is distinguished from the other Paleozoic carbonates by its tan to gray-tan color.

The calcareous slate is the most distinctive rock in the Paleozoic section, except for the Addy Quartzite. It is thin bedded and commonly laminated. Most of it is pale purple or maroon which grades into green toward the top and bottom. About 50 to 75 feet of slate is exposed, but as the top is covered by glacial material, the total thickness may be greater. Extensive search yielded no fossils.

MISSISSIPPIAN

Limestone.—The limestone is medium gray to blue gray and contains abundant chert. The best exposures are about a mile north of Valley, and at the north border of the quadrangle. Most beds are 2 to 3 feet thick, but some are more than 15 feet. Bedding is most commonly defined by interbedded chert, which occurs as pods and lenses up to 10 inches thick, but more commonly is 2 or 3 inches thick. Neither contact of the limestone unit is exposed in the quadrangle. Total thickness of the exposed part of the unit appears to be between 600 and 700 feet.

Fossils are found sporadically throughout the unit; only fenestellid bryozoans, pelmatozoan debris, and solitary corals are found in the lower part. Near the middle of the exposed section is a dolomitic bed containing corals, brachiopods, gastropods, and pelmatozoan debris. A. K. Armstrong, of the U.S. Geological Survey, examined the fossils and reports that the fauna suggests a Mississippian age. About 1 1/2 miles east of Valley, limestone presumably belonging to this unit contains Mississippian brachiopods and conodonts (A. J. Boucot, written commun., 1966). Associated with these fossils are Mississippian ostracodes reported by McLaughlin and Simons (1951, p. 515).

Paleozoic carbonate rocks undivided.—A number of additional isolated areas of carbonate rocks are present in the west-central part of the quadrangle. Outcrops in these areas are rare, and because exposures are very poor, the rocks have been lumped together as an undifferentiated group. All of these rocks, with the exception of those in two areas, probably belong to the previously described Paleozoic carbonate units. In the southern part of sec. 18, T. 31 N., R. 41 E., 2.5 miles east of Valley, fossils collected by R. H. B. Jones and J. P. Thomson were identified by J. T. Dutro, Jr. and H. M. Duncan to be Late Devonian in age. Enbysk (unpublished thesis, State College of Washington, 1954, p. 15) reported foraminifera, corals, bryozoans, brachiopods, and ostracodes of Pennsylvanian age from sections 23, 26, and 27, T. 30 N., R. 40 E. However, three of the Paleozoic carbonate units, in addition to carbonate rocks mapped as undifferentiated, are found in these sections. As this is the only report of Pennsylvanian strata in the quadrangle, every attempt is being made to find the collection localities.

CENOZOIC

Andesite.—About 1/4 square mile in the northwest corner of the quadrangle is underlain by a dark-gray to black andesite. No features were found that would indicate whether this rock is extrusive or intrusive. Olivine, hornblende, and biotite crystals are easily seen in hand specimen, and plagioclase and pyroxene crystals larger than the groundmass but smaller than the phenocrysts are abundant in thin section. These crystals are set in a fine-grained matrix of plagioclase, pyroxene, opaque minerals, and brown glass with a pilotaxitic texture.

Similar andesite in the Gerome Volcanics has been mapped by Becraft and Weis in the Turtle Lake quadrangle, to the west. On the basis of plant fossils in interbedded tuffaceous rocks, Becraft and Weis (1963, p. 37) assigned an Oligocene age to the Gerome Volcanics.

Basalt.—Patches of basalt cover several square miles in the western half of the quadrangle. The rock is black, nonporphyritic, and in places vesicular. Columnar jointing is well developed locally, but individual flows and flow thickness could not be discerned. Petrographically, the basalt has a hyaloophitic texture. Plagioclase and pyroxene crystals constitute about half the rock, and dark-brown, almost opaque glass the other half. Weaver (1920, p. 99) applied the name Camas Basalt to the rock, but recognized that it is more-or-less continuous with the Columbia River basalts to the south. Griggs (1966), on a reconnaissance map of the west half of the Spokane quadrangle, shows basalt of the Columbia River Group within 2 miles of the southwest corner of the Loon Lake quadrangle. D. A. Swanson, of the U.S. Geological Survey, examined several thin sections of basalt from the Loon Lake quadrangle and reported that they very strongly resemble Yakima Basalt of Miocene and possible Pliocene age (oral commun., 1966).

Glacial, lacustrine, alluvial, and talus deposits, undifferentiated.—Alluvial, glacial, and lake deposits are combined in a single map unit. Alluvium is confined to the immediate vicinity of modern streams. Glacial debris consists of sand and gravel in outwash plains and terraces and of thin deposits which mantle hillsides. Talus occurs primarily below areas of good quartzite outcrop.

Fine-grained lake sediments, some of which contain commercial deposits of clay, are present at several places in the quadrangle. In the southeastern part of the quadrangle, a bed from which high-grade, nearly white plastic clay has been produced in significant amounts appears to lie unconformably under the glacial material. It is discussed more fully in the section on Mineral Deposits.

INTRUSIVE IGNEOUS ROCKS

Plutonic rocks.—Six granitic plutonic bodies underlie about 50 square miles along the southern and eastern margins of the quadrangle. These plutons, together with three others in the Chewelah Mountain quadrangle, make up two apparent differentiation sequences, each of which ranges from granodiorite to quartz and alkali-rich quartz monzonite (see fig. 2).

All the plutonic rocks in the southern half of the Loon Lake quadrangle were previously included in the Loon Lake batholith (Weaver, 1920; Jones, 1928; Yates and others, 1966). In the Metaline quadrangle adjoining the northeast corner of the Chewelah Mountain quadrangle, Park and Cannon (1943, p. 24) described another large area of plutonic rocks, which they named the Kaniksu batholith. The Chewelah Mountain and Loon Lake quadrangles appear to lie on the boundary of these two batholiths. As originally described, both contain similar rock types. It now appears, however, that the individual plutons are separable into two petrologic groups, and that by doing so, the two batholiths can be defined on a petrologic basis.

In addition to belonging to unlike apparent differentiation series, the two batholithic groups are characterized by certain minerals, the Kaniksu batholith by either muscovite or muscovite and biotite, and the Loon Lake batholith by biotite or hornblende and biotite.

The relative ages of the six bodies in the Loon Lake quadrangle are not known, although questionable crosscutting relationships establish a possible order of intrusion for two pairs of the plutons. The youngest sedimentary unit intruded by the igneous rocks is Mississippian in age, and basalt of probable Miocene age overlies one of the quartz monzonites. Becraft and Weis (1963, p. 32) describe several Mesozoic plutons in the Turtle Lake quadrangle that have compositions and textures similar to those in the Loon Lake quadrangle.

Because the relative ages are not known, the rocks of the two batholiths are described below in the order of their apparent differentiation.

LOON LAKE BATHOLITH

Hornblende-biotite granodiorite.—A small elongate body of hornblende-biotite granodiorite, approximately 1 square mile in area, is situated 2 miles southeast of Springdale. The granodiorite is genetically related to, and occurs along, the northwest margin of a larger quartz monzonite mass, the Silver Point Quartz Monzonite. Although exposure is poor, the granodiorite appears to intrude the quartz monzonite. It is coarse grained, hypidiomorphic granular, and uniform in texture throughout. Average color index is 27, and hornblende and biotite are present in about equal amounts. Plagioclase averages about An_{35}, and K-feldspar appears to be microperthitic orthoclase. Numerous hornblende crystals contain pyroxene cores. Sphene is the most abundant accessory mineral and in some thin sections makes up as much as 0.5 percent of the rock.

Fine-grained quartz monzonite.—A small mass of fine-grained quartz monzonite is situated approximately on the northeastern projection of the granodiorite. The fine-grained rock underlies about 2 square miles and also wraps around the northern margin of the Silver Point Quartz Monzonite. This plutonic rock does not appear to be directly a part of the apparent differentiation sequence, but is almost certainly related to the granodiorite, possibly a local late-stage differentiate.

Most crystals are 0.04 inches or less in size, and the texture is hypidiomorphic granular. Plagioclase averages An_{25-30}. No microcline twinning is visible in the K-feldspar. Biotite is slightly more abundant than hornblende. The latter has cores of pyroxene in some crystals, although optic properties differ considerably from those of the hornblende in the granodiorite. Sphene is an abundant though not obvious accessory.

Silver Point Quartz Monzonite.—The large mass of plutonic rock occupying the southern fifth of the quadrangle is here named the Silver Point Quartz Monzonite. The name is for the exposures of this rock at Silver Point on the west shore of Loon Lake. On U.S. Highway 395 at the southeast corner of Loon Lake, new road cuts have created excellent, unweathered exposures of this rock.

The rock is porphyritic hornblende-biotite quartz monzonite with a distinctive texture resulting from two size groups of crystals. Large crystals, including hornblende, biotite, plagioclase, and K-feldspar, make up about 30 percent of the rock, and average 0.1 to 0.2 of an inch in size. They occur in a groundmass averaging about 0.02 to 0.06 of an inch in size, composed of all mineral phases in the rock. Color index averages about 15.

Plagioclase is An_{25-30}. K-feldspar is perthitic, and occurs in the groundmass and as phenocrysts up to 1 inch in length. Hornblende is more abundant than biotite and does not have pyroxene cores. Sphene is abundant and is visible in hand specimen.

Coarse-grained quartz monzonite.—The coarse-grained quartz monzonite is a widely but irregularly distributed biotite-quartz monzonite. It underlies about 12 square miles, including areas where the unit is covered by alluvium. The rock is extremely coarse-grained, the average crystal size being greater than 1/2 inch.

Pink phenocrysts of K-feldspar 2 inches long have been observed, although most of the rock is not obviously porphyritic. Plagioclase averages An_{16-20}. The biotite crystals commonly occur in clusters and are altered to chlorite around the borders. Large sphene crystals are the most abundant accessories. Northwest of Loon Lake, along cuts made by the Great Northern Railroad, dikes of the fine-grained quartz monzonite with chilled borders can be seen cutting the coarse-grained quartz monzonite. This exposure furnishes the only information concerning the relative ages of these rocks.

KANIKSU BATHOLITH

Two-mica quartz monzonite.—Along the northeastern border of the quadrangle, a muscovite-biotite quartz monzonite mass, underlying about 2 square miles, intrudes the Prichard Formation. The rock is nonporphyritic, with an average grain size between 0.1 and 0.2 of an inch. K-feldspar is microcline and appears, in part, to replace plagioclase. Muscovite averages about 2 percent by volume of the rock, and biotite about 9 percent. Contact metamorphic effects of this pluton extend more than a mile from the exposed contacts, although outcrop pattern does not suggest shallow dipping sides. The quartz monzonite is modally and texturally unlike another two-mica granitic rock that underlies most of the northeastern quarter of the Chewelah Mountain quadrangle. Whereas the rock to the north is slightly foliated and granodiorite in composition, the texture of the small stock in the Loon Lake quadrangle is hypidiomorphic granular and the rock is quartz monzonite.

Muscovite quartz monzonite.—Leucocratic quartz monzonite is exposed at three localities in the southeastern part of the quadrangle. Two large bodies are located east of Deer Lake, and a smaller mass is between the Revett Formation and the coarse-grained quartz monzonite south of Deer Lake.

The rock is medium- to coarse-grained, hypidiomorphic granular. It is pink to cream, depending upon the degree of alteration of the K-feldspar. Small spots of limonite a few inches to a few feet apart are present in most of the rock.

Plagioclase is about An_{10}. K-feldspar is pink or cream-colored microcline. Muscovite averages about 8 percent of the rock by volume and commonly is pale lime green. Due to the low iron and high alkali feldspar content, this rock, after only a minimum of processing, may be suitable as a feldspar source for local glass manufacturing.

OTHER IGNEOUS ROCKS

Metadiabase sills.—Amphibolite sills ranging in thickness from 50 to 250 feet intrude the Prichard Formation in the eastern part of the quadrangle. The sills are strikingly concordant over long distances. Blue-green hornblende makes up between 50 and 70 percent of the rock, quartz 20 to 30 percent, biotite 0 to 10 percent, and epidote 10 to 20 percent. Traces of albite and opaque minerals are found in most rocks. Grain size ranges from about 0.05 inch to about 1 inch. In places the centers of the sills are coarse-grained, suggesting either primary or metamorphic differentiation in place. Before metamorphism the sills probably were mafic-rich diabase.

Mafic dikes.—Fine-grained mafic-rich dikes are most abundant in the vicinity of the Mesozoic(?) plutonic and Precambrian sedimentary rocks; they have not been found in the Paleozoic rocks. Most dikes are between 2 and 20 feet wide and cannot be traced for very great distances. As a result, only a few of the larger ones near Buzzard Lake in the north-central part of the quadrangle are shown on the geologic map. One is nearly 1,000 feet wide at a bulge in the dike, and another is about 300 feet wide for a mile along strike.

All dikes coarse-grained enough for modal analyses are of quartz monzonite composition. Phenocrysts are hornblende, biotite, plagioclase, and in a few cases K-feldspar. The white to medium-gray matrix for these phenocrysts is a fine-grained mixture of plagioclase, K-feldspar, and quartz.

The lighter colored dikes appear to be related to the plutonic rocks, especially to the Silver Point Quartz Monzonite, on the basis of spatial relations and mineralogical similarities.

STRUCTURE

At least one period of folding and several periods of faulting can be recognized in the rocks of the Loon Lake quadrangle. The first large-scale deformation is recorded in the Precambrian rocks, and the last appears to have occurred before the extrusion of the Tertiary basalts. Within the interval between the first and last structural events the various periods of deformations can be classified only as Precambrian and post-Cambrian.

In the vicinity of Deer Lake, the lower part of the Belt Series forms a westward-dipping homoclinal section. Along strike to the north, the attitude of the rocks becomes progressively steeper, and at about the latitude of Benson Peak, much of the section is vertical. North of this latitude, the Belt Series is overturned to the east and becomes progressively more so toward the north border of the quadrangle. On the west side of Betts Meadow, the strata locally have been rotated through 220° (see section A-A′). In addition to the progressive westward overturning from south to north, the strike of the entire section changes from about N. 50° W. at Deer Lake to about N. 20° E. at the north border of the quadrangle.

The folded rocks are displaced along four and possibly five faults that trend N. 50° W. and have apparent left-lateral slip. These faults are considered younger than the folding because their strike appears to remain essentially unchanged from one area to another where the degree of folding greatly differs. This reasoning is not entirely valid, however, because the faults cannot be traced continuously through areas of poor exposure or glacial cover. The problem is considered further in the discussion of the westward tilt of the Addy Quartzite. Total apparent left-lateral displacement on the four faults in the northern half of the quadrangle amounts to over 4 miles. Some of the faults appear to have a greater amount of displacement at one end than at the other. Reference planes (primarily sills) in the Prichard Formation show lesser amounts of movement than offset features outside the Prichard Formation. Near the faults, the argillite of the Prichard Formation is phyllitic and apparently took up part of the strain along bedding planes.

None of the N. 50° W. faults in the quadrangle displace the Cambrian Addy Quartzite. In the Chewelah Mountain quadrangle, this quartzite is displaced about 1,000 feet along the projection of one of these faults, which displaces Belt rocks over 10,000 feet. The offset of the quartzite is considered to be renewed movement along a Precambrian fault.

It is not clear exactly what structures are responsible for the westward tilt of the Addy Quartzite, but high-angle faults trending approximately north-south appear to be the most likely cause. Because the attitude of the Addy Quartzite so closely approximates that of the Precambrian rocks it overlies, it is possible the attitude of both resulted from the same period of folding. An important conflict arises if the folding is post-Precambrian, for this would require that the northwest-trending faults truncated by the Addy Quartzite be folded also. Although the faults are shown on the map with straight traces, they are poorly exposed and their true configuration could actually be quite irregular. At least one of the faults, where it intersects the Addy Quartzite, appears to change strike about 20° (see geologic map). This change is far smaller than might be expected from the degree of folding, however.

Approximately north-south-striking faults appear to be the primary structural features in the western half of the quadrangle. Because this part of the area is largely covered by alluvial and glacial material, the existence and configuration of these faults is in large part interpretive. The largest fault of this group, here called the Jumpoff Joe fault, places Precambrian argillite against Paleozoic carbonate rock. It is exposed north of Springdale and west of Jumpoff Joe Lake. Because the upper part of the Precambrian stratigraphy is not well known, the amount of movement along this fault cannot be estimated. The displacement must be more than a few thousand feet, however, as the Addy Quartzite is completely removed. Although movement along the largest fault is relatively up on the west and down on the east, several of the smaller faults with the same strike appear to have the opposite sense of movement. If a major thrust fault juxtaposing the Belt Series and Deer Trail Group exists, large vertical movement along the Jumpoff Joe fault has probably downfaulted it on the east and upfaulted it well above the present terrane on the west.

About 3 miles northeast of Valley, a thrust fault places Cambrian Addy Quartzite over Precambrian strata. The amount of movement on this fault is not known, but probably is not large. A large northeast-trending fault in the northern half of the quadrangle appears to be one of the youngest structural features recognized. Because alluvial and glacial materials covers almost all areas where it intersects other structures, its age relative to many of the other faults is largely interpretive. From the outcrop pattern, it is apparently a high-angle fault with a relative upward movement on the northwest block. The fault displaces upper Paleozoic carbonate rocks, but does not cut the Miocene or possible Pliocene basalt. South of Deer Lake, two other faults with this same trend displace Belt rocks and have the same relative sense of movement. The southernmost fault strikes into, but does not cut, the straight southern contact of the coarse-grained quartz monzonite, and is probably the control for the configuration of that contact.

South and west of Loon Lake, two shear zones cut the plutonic rocks but do not appear to offset contacts. Within the shear zones the rock is highly granulated. Quartz and chlorite have filled all interstices and formed a hard, coherent rock. The shear zones are the only structures known to cut any of the igneous rocks in the Loon Lake quadrangle.

MINERAL DEPOSITS

Commodities of economic interest in the Loon Lake quadrangle include copper, silver, tungsten, barite, clay, quartzite, and possibly feldspar.

The Loon Lake copper mine, about 2 1/2 miles northeast of Jumpoff Joe Lake, is the only base-metal mine in the quadrangle to produce a significant amount of ore. Most of the production took place between 1916 and 1919 from a 200-foot-long and 500-foot-deep pay shoot within a 4- to 20-foot-wide quartz vein (Huntting, 1956, p. 99). The ore came chiefly from a secondary zone of azurite, malachite, and cuprite. Below the zone of secondary minerals, chalcopyrite associated with pyrite was the chief ore mineral (Weaver, 1920, p. 218). A total of about 7,317 tons of ore was processed, yielding 622,555 pounds of copper, 532 ounces of silver, and 25 ounces of gold. Except for a small shipment in 1952, production ended in 1920 (Fulkerson and Kingston, 1958, p. 45). All workings were inaccessible when the area was visited in June 1967.

Subcommercial tungsten deposits are present on Blue Grouse Mountain about 3 miles east of Deer Lake. Huebnerite, a manganese tungstate, is disseminated in quartz veins, greisen, and pegmatite segregations around the periphery of the muscovite quartz monzonite. Excellent descriptions of the deposits are given by Bancroft (1914, p. 130), Weaver (1920, p. 221), and Culver and Broughton (1945, p. 73). Only a small amount of production is recorded from this area. When the properties were visited in August 1967, all workings were inaccessible due to caving.

Three small barite deposits are located in the north half of the quadrangle: the Smith mine, about 1 1/2 miles north of Valley; the Bakie mine, about a mile east of Valley; and the Pease mine, a few hundred feet southwest of the Loon Lake copper mine. All the deposits are veins or series of veins. Veins of economic significance range in width from a few inches to 10 feet, and in length from 20 to over 300 feet. W. S. Moen (1964) gives an excellent, detailed description of all three deposits. The Smith mine produced 34 tons of barite for well-drilling muds in 1960, but has evidently been idle since. Moen calculated 400 tons of measured and indicated ore and 750 tons of inferred ore. The Bakie mine produced 200 tons of barite in 1958, used for sugar refining (Moen, 1964, p. 62). Moen reports 1,000 tons of measured and indicated ore and 6,000 tons of inferred ore in 1961. The largest barite deposit is at the Pease mine. In 1960, 400 tons of barite was mined for use as well-drilling mud (Moen, 1964, p. 63). At that time, Moen calculated 900 tons of measured and indicated ore and 15,000 tons of inferred ore.

High-grade, nearly white plastic clays are found in the southeast corner of the quadrangle. Two pits from which clay was mined are in the quadrangle about 4 miles east of Loon Lake; another is about 1/4 mile east of the quadrangle at the same latitude; and the largest one is about 1/4 mile south of the quadrangle at Clayton. S. L. Glover (1941, p. 280) describes these deposits and the commercially significant characteristics of the clays. All pits except for the one east of the quadrangle have been inactive for several years.

Glacial material ranging from less than a foot to more than 10 feet thick covers the clays almost everywhere. Underlying the glacial material is 5± feet of sandy yellow clay (Glover, 1941, p. 282). Of possible significance in finding new deposits of clay in this area is a 1-inch to 3-foot bed of bog iron that appears to be present in all pits exploited to date. According to Glover, the bog iron underlies the sandy yellow clay and marks the top of the high-quality clay beds.

Using the elevation of the top of the bog-iron bed in any three of the four pits mentioned, the attitude of the bed can be determined. It is assumed that the bed is continuous and planar, and that the bog iron found at each pit is the same layer. To test these assumptions, different combinations of the four bed elevations were used. In all cases, the attitude determined (strike N. 70° E.; dip 0°30′ S.) was about the same. Using this attitude, and the pit just east of the quadrangle as a starting point, a map (fig. 3) was constructed. The predicted "outcrop" of the bog-iron bed may vary within fairly large limits, however, because the elevations used to determine the attitude of the bed were interpolated from contours on topographic maps. Moreover, the "outcrop" is buried beneath a glacial cover of variable thickness.

Outside the quadrangle, about 7 miles west of Valley, the Addy Quartzite is mined for silica sand. The rock is friable, and with a minimum of treatment is suitable for glass manufacture. Although not friable, seemingly pure Addy Quartzite crops out over large parts of the quadrangle. The lower part of the unit contains an excessive amount of iron, but higher in the formation, white quartzite is predominant.

In addition to abundant quartzite, the muscovite quartz monzonite south and east of Deer Lake contains less than 1/2 percent iron and may be a suitable source of feldspar for glass manufacture. If both the quartzite and quartz monzonite proved suitable, the basic raw materials for a local glass industry are available and easily accessible.

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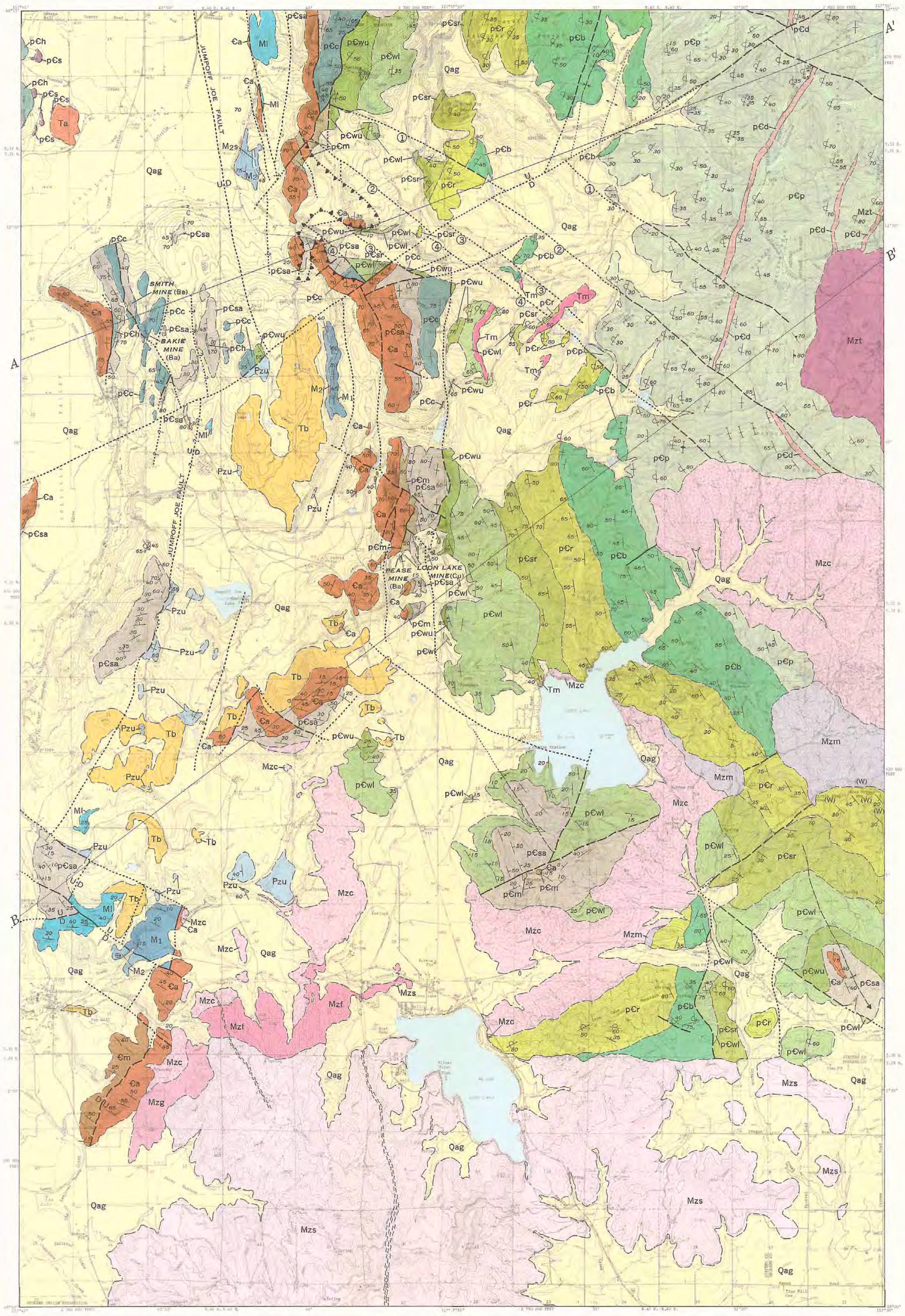
PREPARED COOPERATIVELY BY THE
U.S. GEOLOGICAL SURVEY



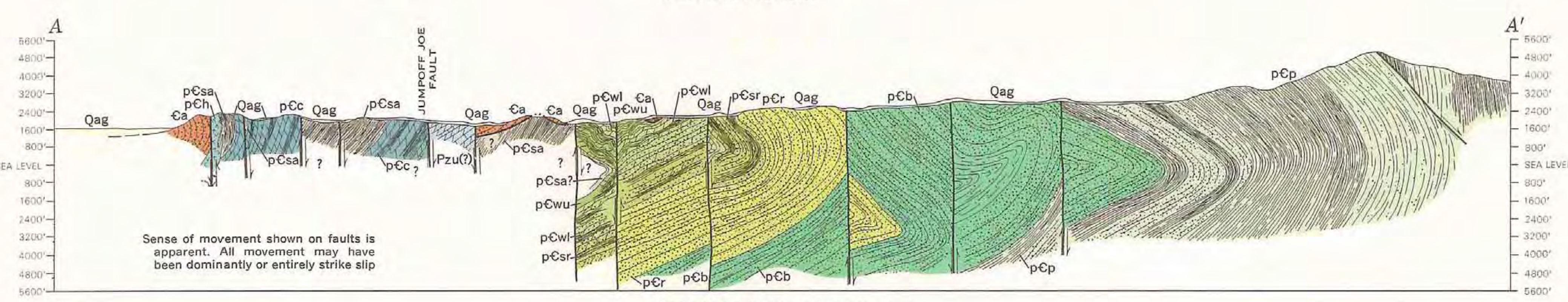
Base by U.S. Geological Survey, 1955

APPROXIMATE MEAN DECLINATION, 1969

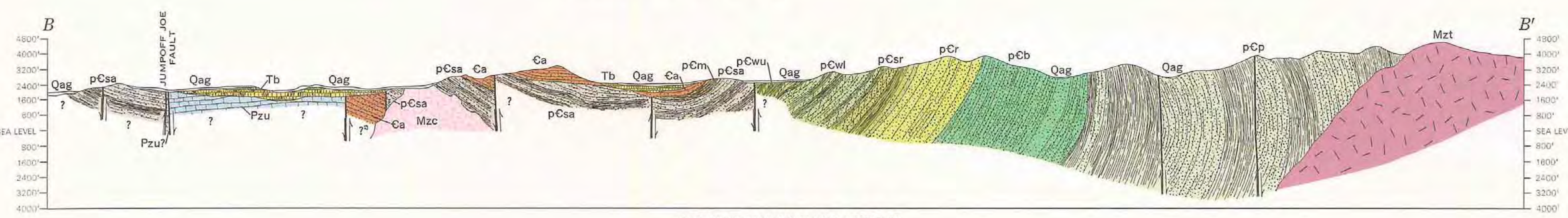
SCALE 1:62 500

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

Geology by F. K. Miller, 1965-1967; assisted by J. C. Moore, 1965, and R. L. Reynolds, 1967



GEOLOGIC SECTION ALONG LINE A-A'



GEOLOGIC SECTION ALONG LINE B-B'

EXPLANATION

STRATIFIED ROCKS

Qag — Glacial, alluvial, and talus deposits, undifferentiated
Chiefly unconsolidated gravel, sand, and clay (QUATERNARY)

UNCONFORMITY

Tb — Basalt (Miocene and Pliocene(?))
Black fine-grained nonporphyritic basalt. Mostly plagioclase, pyroxene, glass, and opaques. Yakima type

Ta — Andesite (Oligocene(?))
Hornblende-biotite-augite andesite. Abundant andesine and glass. Probably correlative with andesite of Gerome Volcanics (TERTIARY; CENOZOIC)

UNCONFORMITY

Ml — Limestone
Cherty medium-gray limestone and dolomitic limestone; contains Mississippian corals, brachiopods, and gastropods (MISSISSIPPIAN)

M2s / M2 — Dolomite and calcareous slate
Dolomite, light-tan, thick- to thin-bedded
M2s, *slate, calcareous, thin-bedded, light-purple and green; about 200 feet thick. Occurs about 300 feet above base*

M1 — Dolomite
Light-gray, thick- to thin bedded dolomite. Locally oolitic (MISSISSIPPIAN(?))

Pzu — Paleozoic carbonate rocks undivided
Limestone and dolomite. Greatest part probably belongs to other units described, but could not be positively assigned to a particular unit

Ꞓm — Metaline Formation
Light-gray, blue-gray, and dark-gray limestone and silty limestone. In part mottled with orange-brown-weathering argillaceous seams

Ꞓa — Addy Quartzite
Quartzite, white, medium- to coarse-grained, thin-bedded to massively bedded. About 100-200 feet of purple quartzite at base (CAMBRIAN; PALEOZOIC)

UNCONFORMITY

Younger Precambrian rocks

pꞒh — Huckleberry Formation
Greenstone. Slightly metamorphosed basalt flows and associated volcaniclastic rocks

UNCONFORMITY

Deer Trail Group

pꞒs — Stensgar Dolomite
Light-tan and pink dolomite. About 100 to 300 feet of maroon argilite; siltite and carbonate-bearing siltite at base

Precambrian rocks of questionable stratigraphic position

pꞒm — Maroon argillite, siltstone, and quartzite
Deep maroon color, well bedded, abundant mudcracks, ripple marks, and other shallow-water features

pꞒsa — Siltite-argillite
Medium-gray, dark-gray, and gray-green siltite with minor argillite. Abundant shallow-water sedimentary features

pꞒc — Carbonate rocks above Wallace Formation
Tan, gray, and maroon carbonate and carbonate-bearing siltite (PRECAMBRIAN)

Belt Series (PRECAMBRIAN)

pꞒwu / pꞒwl — Wallace Formation
pCwu, *upper part. Dark laminated argillite and minor amount of carbonate*
pCwl, *lower part. Irregularly interbedded quartzite, siltite, argillite, and impure carbonate rock*

pꞒsr — St. Regis Formation
Lavender and maroon argillite, siltite, and quartzite; light green and carbonate bearing at top

pꞒr — Revett Formation
Quartzite, white, fine-grained, well-bedded. Siltitic, especially near middle

pꞒb — Burke Formation
Siltite, medium and light-gray, well-bedded. Contains abundant quartzite beds and a zone of maroon siltite and argillite

pꞒp — Prichard Formation
Argillite, siltite, and quartzite, thin-bedded; commonly iron-stained weathered surfaces

INTRUSIVE IGNEOUS ROCKS

Tm — Mafic dikes (TERTIARY(?); CENOZOIC(?))
Euhedral phenocrysts of hornblende, biotite, and plagioclase in fine-grained matrix of K-feldspar, plagioclase, and quartz

Mzm / Mzt — Kaniksu batholith
Mzm, *muscovite quartz monzonite, medium- to coarse-grained*
Mzt, *two-mica quartz monzonite, medium-to coarse-grained; muscovite: biotite 1:5*

Mzc / Mzs / Mzf / Mzg — Loon Lake batholith (MESOZOIC(?))
Mzc, *biotite quartz monzonite, very coarse grained, slightly porphyritic*
Mzs, *Silver Point Quartz Monzonite, hornblende-biotite, medium- to coarse-grained*
Mzf, *hornblende-biotite quartz monzonite medium- to fine-grained*
Mzg, *hornblende-biotite granodiorite, medium-grained, even-grained, abundant sphene*

pꞒd — Metadiabase sills (PRECAMBRIAN)
Sills in Prichard Formation, 50-70 percent hornblende, 20-30 percent quartz, 0-10 percent biotite, 10-20 percent epidote

Contact
Dashed where approximately located

Fault
Dashed where approximately located; dotted where concealed; queried where uncertain. U, *upthrown side;* D, *downthrown side. Arrows indicate relative direction of lateral movement*

Thrust fault
Dashed where approximately located; dotted where concealed; queried where uncertain. Sawteeth on upper plate

Anticline Syncline
Fold, showing trace of axial plane
Dashed where approximately located; dotted where concealed

Shear zone

Inclined Vertical Horizontal Overturned
Strike and dip of beds

Inclined Vertical
Strike and dip of cleavage

Inclined Vertical Overturned
Strike and dip of parallel beds and cleavage
Where shown overturned, cleavage may or may not be overturned

Inclined Vertical
Strike and dip of slip cleavage

Strike and dip of overturned beds and slip cleavage
Cleavage may or may not be overturned

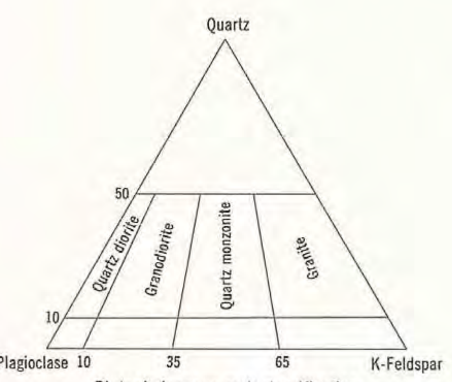
Inclined Vertical
Strike and dip of schistosity

Inclined Vertical
Strike and dip of parallel beds and schistosity

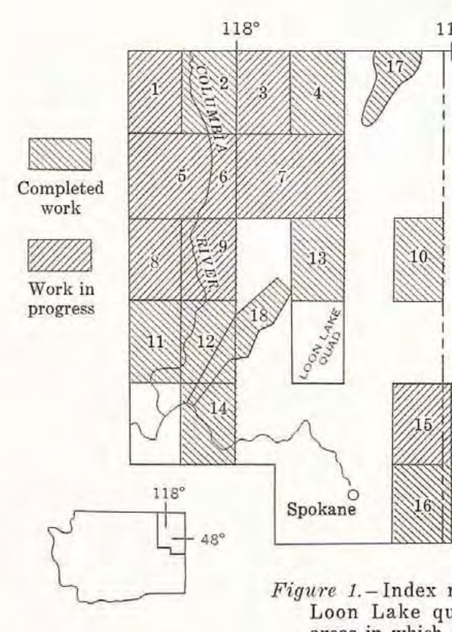
Bearing and plunge of minor fold axes

① ② ③ ④
Numbers used to identify northwest-trending faults

(W) (Ba) (Cu)
Commodity sought at mines shown on map



Plutonic igneous rock classification used in this report



1. Togo Mtn quad—R. C. Pearson
2. Orient quad—E. C. Bowman
3. Northport area—R. G. Yates
4. Deep Creek area—R. G. Yates (1964)
5. Kettle Falls area (west of river) —C. D. Campbell
6. Kettle Falls area (east of river) —J. W. Mills
7. Colville area—W. A. G. Bennett
8. Twin Lakes quad—G. E. Becraft
9. Inchelium quad—A. B. Campbell
10. Bead Lake area—M. C. Schroeder (1952)
11. Wilmont Creek quad—G. E. Becraft (1966)
12. Hunters quad—A. B. Campbell and O. B. Raup, (1964)
13. Chewelah Mtn quad—L. D. Clark and F. K. Miller (1968)
14. Turtle Lake quad—G. E. Becraft and P. L. Weis (1963)
15. Mt. Spokane quad—A. E. Weissenborn
16. Greenacres quad—P. L. Weis (1968)
17. Metaline area—M. Dings and D. Whitebread (1965)
18. Magnesite belt—I. Campbell and J. Loofbourow (1962)

Figure 1.—Index map showing location of the Loon Lake quadrangle and surrounding areas in which geologic mapping at a scale of 1:62,500 or larger is available or is in progress (Dates indicate published reports. See list of references in text.)

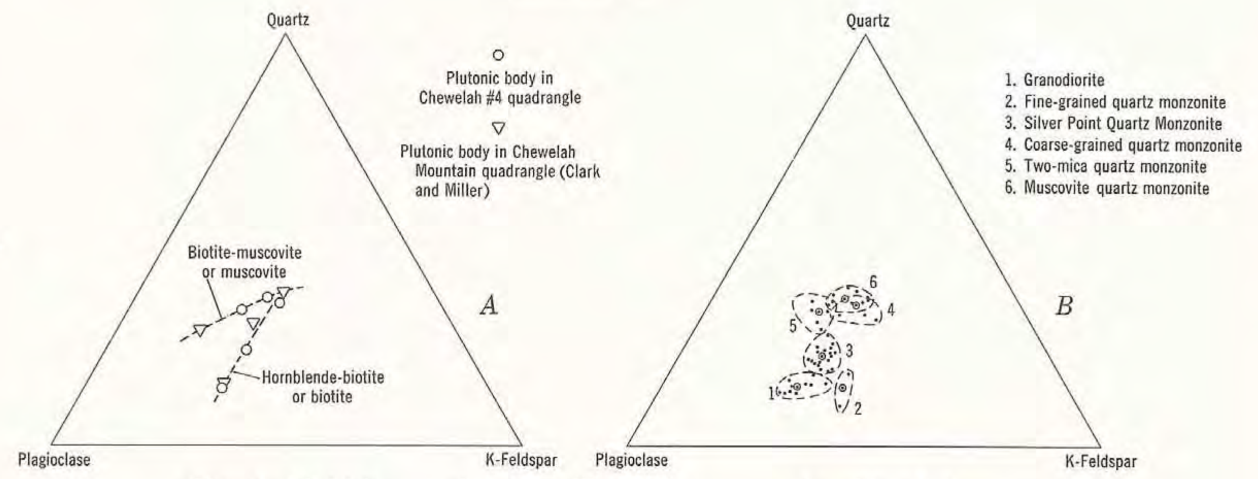


Figure 2.—Modal diagrams. *A*, apparent differentiation sequence of granitic rocks in Loon Lake and Chewelah Mountain quadrangles. One sequence characterized by biotite and muscovite or muscovite alone, the other by hornblende and biotite or biotite alone. *B*, composition and variation of granitic plutons in Loon Lake quadrangle. Circled point is the average for each pluton

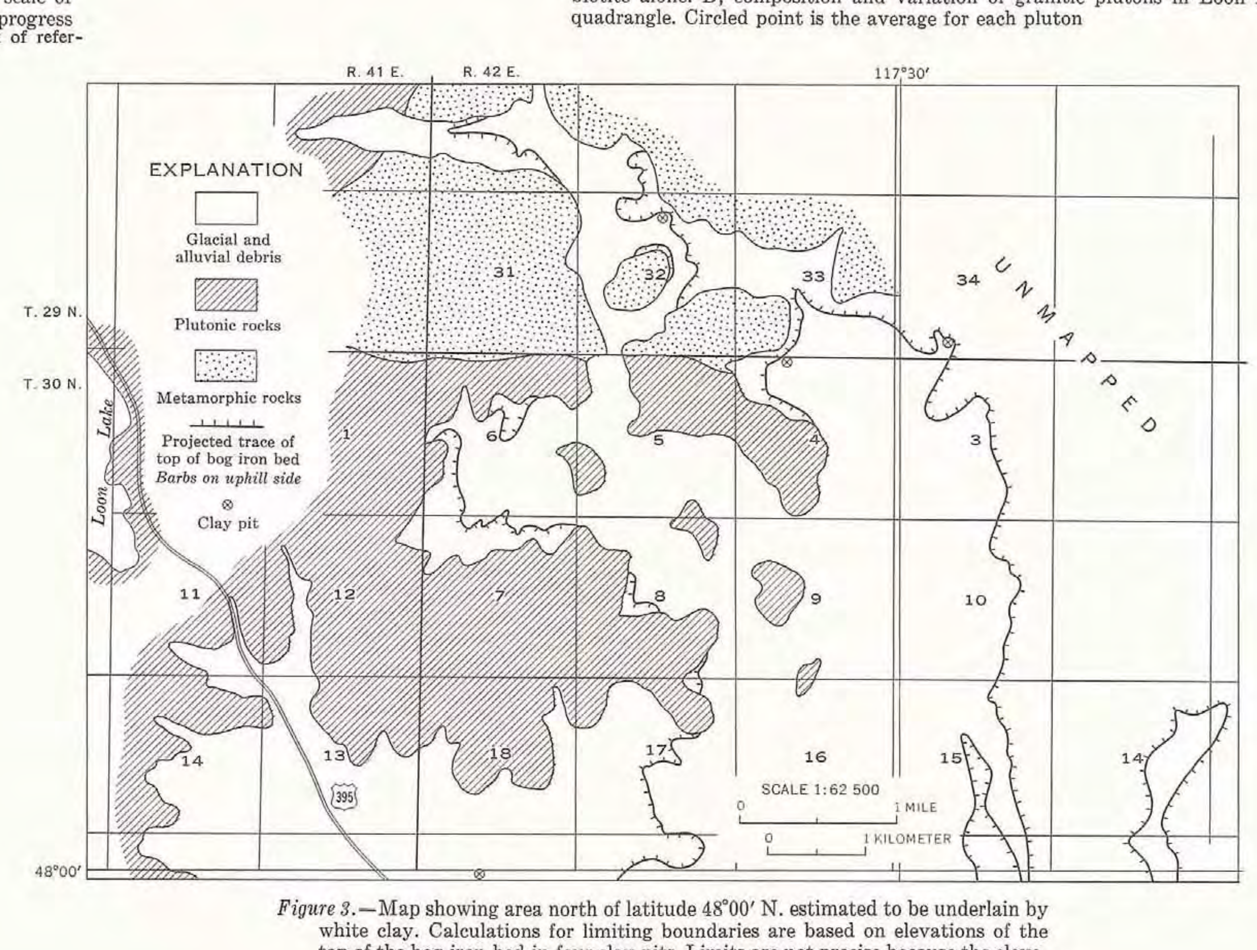


Figure 3.—Map showing area north of latitude 48°00' N. estimated to be underlain by white clay. Calculations for limiting boundaries are based on elevations of the top of the bog-iron bed in four clay pits. Limits are not precise because the elevations are not exact and the thickness of the mantle of glacial material is variable

PRELIMINARY GEOLOGIC MAP OF THE LOON LAKE QUADRANGLE STEVENS AND SPOKANE COUNTIES, WASHINGTON

By
F. K. Miller
U.S. Geological Survey

1969

For sale by Department of Natural Resources, Olympia, Washington
Price, $1.00