WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES
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GEOLOGY OF PARTS OF THE UPPER PROTEROZOIC TO LOWER CAMBRIAN THREE SISTERS FORMATION, GYPSY QUARTZITE, AND ADDY QUARTZITE, STEVENS AND PEND OREILLE COUNTIES, NORTHEASTERN WASHINGTON

by

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WASHINGTON STATE DEPARTMENT OF
Natural Resources
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INTRODUCTION

The purpose of this report is to describe the stratigraphic and lithologic properties of the Upper Proterozoic to Lower Cambrian Three Sisters Formation, Gypsy Quartzite, and Addy Quartzite. This investigation was undertaken as part of my Ph.D. research at Washington State University (Lindsey, 1987). The objectives of my dissertation were to: (1) describe the stratigraphy of the Three Sisters Formation and Gypsy and Addy Quartzites; (2) explore correlations between these units; and (3) interpret the sedimentologic, paleogeographic, and tectonic conditions in which they formed. This report is a compilation of two reports originally submitted to the Washington Division of Geology and Earth Resources in 1984 and 1985 as part of the Washington State Geologic Map Project. The original two reports were comprised of geologic maps of the Three Sisters Formation, Gypsy Quartzite, and Addy Quartzite and texts containing stratigraphic descriptions of these units. The descriptions and interpretations in this report are those of the original reports, but where subsequent investigation suggested changes in the original descriptions and interpretations, these changes are noted in this text.

This report consists of two parts: (1) a text describing the Three Sisters Formation, Gypsy Quartzite, and Addy Quartzite, and (2) geologic maps of these units (Plates 1 - 5 and accompanying explanation sheet). The text is comprised of stratigraphic, lithologic, petrographic, and paleontologic

descriptions of the Three Sisters Formation, Gypsy Quartzite, Addy Quartzite, and adjacent units. The maps (Plates 1 - 5) illustrate the distribution of major lithostratigraphic and structural features noted while studying these strata.

For a discussion of previous studies in the Three Sisters Formation, Gypsy Quartzite, and Addy Quartzite, see Groffman (1986) and Lindsey (1987). These reports also present detailed interpretations of the origins of these rocks.

LOCATION OF STUDY AREAS

The Three Sisters Formation, Gypsy Quartzite, and Addy Quartzite crop out in northern and central Pend Oreille County, Stevens County, and northern Lincoln County (Fig. 1). For the Original mapping in 1984 and 1985 the Three Sisters Formation and Gypsy Quartzite were studied on and around Sullivan Mountain northeast of Metaline Falls, Washington (Fig. 2; Plate 3). During this period the Addy Quartzite was mapped in central and southern Stevens County on Dunn Mountain (Fig. 3; Plate 2), Stensgar and Huckleberry Mountains (Fig. 3; Plates 1 and 5), Adams Mountain (Fig. 3; Plate 5), and in the Iron Mountains (Fig. 3; Plate 4). These areas were chosen on the basis of accessibility and completeness of exposure.

MAP UNIT DESCRIPTIONS

The following stratigraphic, lithologic, petrographic, and paleontologic descriptions are meant to accompany the geologic maps that comprise the second part of this report. The text is divided into two sections, one corresponding to maps of the Addy Quartzite (Plates 1, 2, 4, and 5) and one corresponding to the Three Sisters Formation and Gypsy Quartzite (Plate 3). Units are described from oldest to youngest.

Section I: Description Of The Addy Quartzite And Adjacent Units (Plates 1, 2, 4, and 5)

Y

Deer Trail Group, undifferentiated--These rocks were mapped only in the Iron Mountains where they are in fault contact with the Addy Quartzite. Normally the Deer Trail Group unconformably underlies the Upper Proterozoic Windermere Group. The Deer Trail Group in the Iron Mountains is approximately 200 to 300 m thick and consists of two units: the Stensgar Dolomite and the McHale Slate (Miller and Yates, 1976). They were not differentiated during mapping due to the poor exposures. The lower unit, the Mchale Slate, consists of finely laminated brown and green phyllite with thin interlaminations of siltite. Small-scale folding and closely spaced cleavages are well developed in the Mchale Slate. The upper unit, the Stensgar Dolomite, consists of gray or tan dolomite with minor interbeds of argillite and siltite.

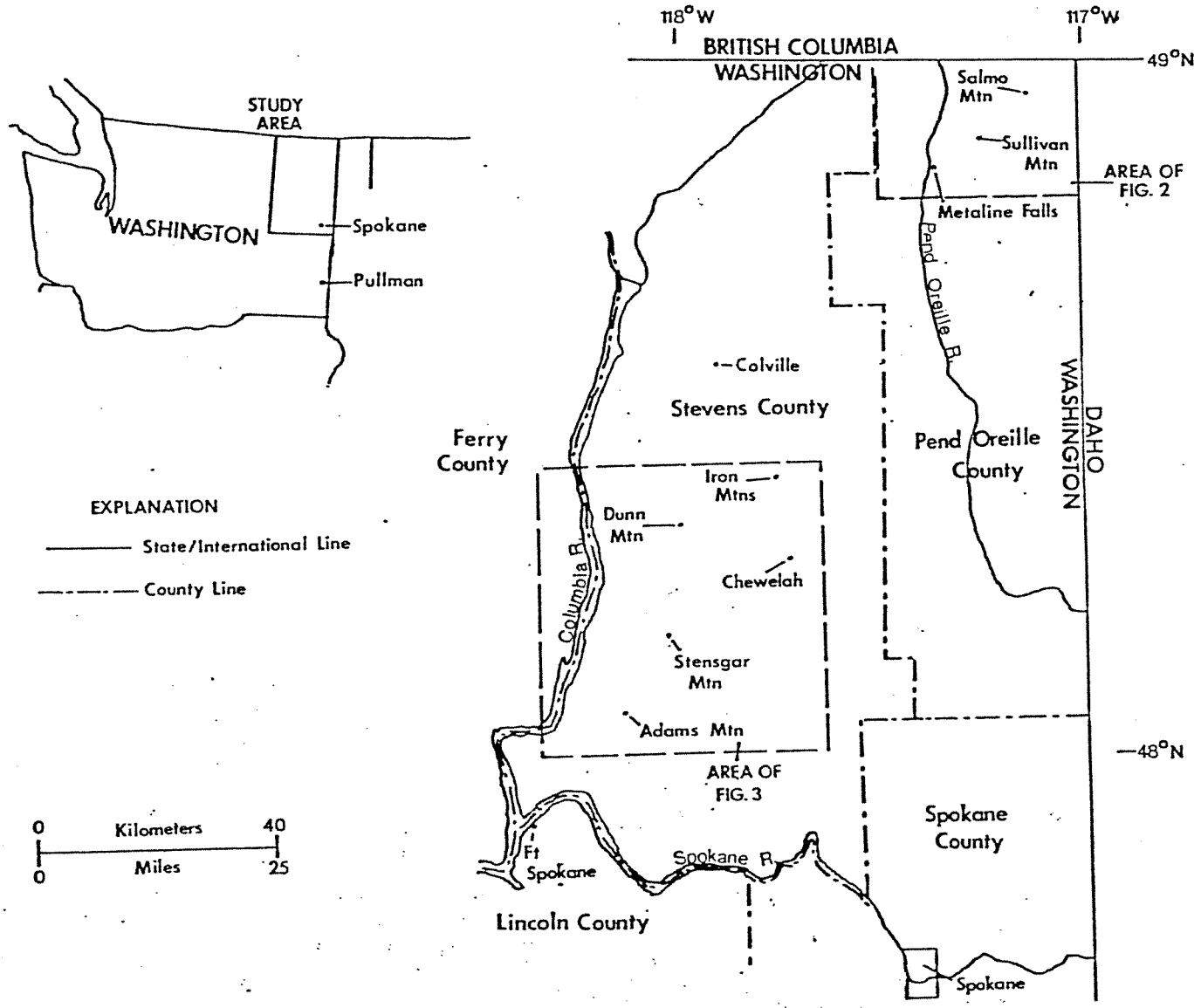

Figure 1. Geographic setting and locations in northeastern Washington.

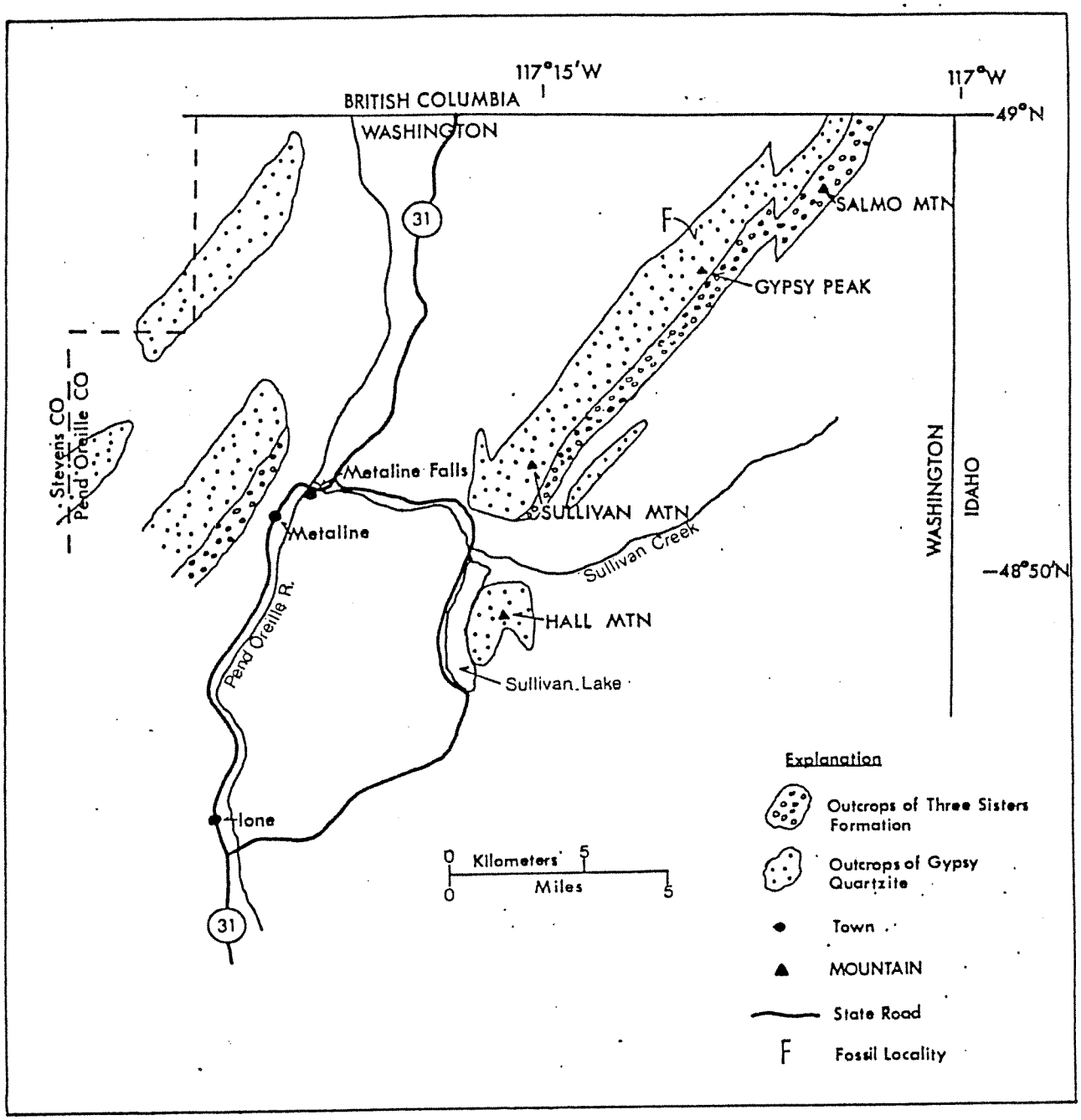

Figure 2. Generalized outcrop map of the Three Sisters Formation and Gypsy Quartzite near Metaline Falls, Pend Oreille County, Washington. Geology from Miller (1982), Burmester and Miller (1983), and Groffman (1986).

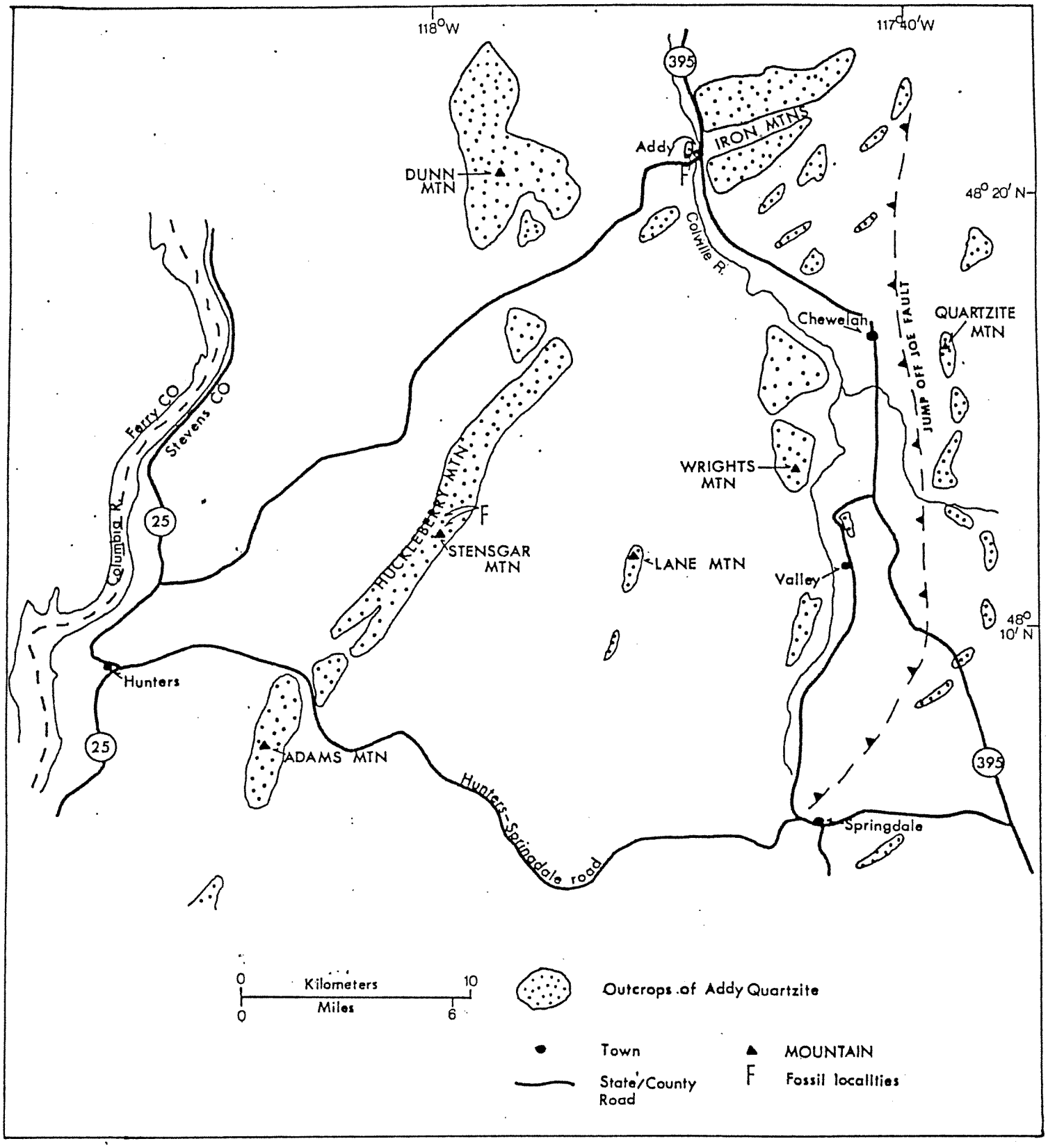

Figure 3. Generalized outcrop map of the Addy Quartzite in central Stevens County, Washington. Geology from Campbell and Raup (1964), Miller and Clark (1975), and Miller and Yates (1976).

Zh

Huckleberry Formation--The Huckleberry Formation and the overlying Monk Formation comprise the Windermere Group in Stevens County. The Huckleberry Formation directly underlies the Addy Quartzite in the southern Iron Mountains and on Dunn Mountain, Stensgar Mountain, Huckleberry Mountain, and Adams Mountain. The Huckleberry consists of two main lithologies--greenstone and conglomerate. It is divided into two members based on these lithologies: a lower conglomerate member (Zhc) an upper greenstone member (Zhg) and (Bennett, 1941; Campbell and Raup, 1964; Aalto, 1971; Miller and Clark, 1975; Miller and Yates, 1976).

Zhc

Conglomerate member, Huckleberry Formation--Where mapped, the conglomerate member is approximately 150 m thick and consists of diamictite (conglomerate in which the clasts are supported by a mud matrix). Clasts in the diamictite consist of small (<10 cm) quartz, quartzite, carbonate, and argillite pebbles. The matrix is highly chloritized and sheared. Coarse-grained chloritic sands are common near the top of the member. Both sands and diamictites are massive to crudely stratified. Foliation and sheared pebbles are well developed throughout the member. The conglomerate member unconformably overlies the Middle Proterozoic Deer Trail Group.

Zhg

Greenstone member, Huckleberry Formation--The greenstone member consists dominantly of green, chloritic, massive greenstone. However, at some localities, coarse-grained, chloritic agglomerates and breccias are common (Aalto, 1971; Miller and Clark, 1975). The member ranges from 100 to 400 m in thickness throughout the study area except on Adams Mountain where it pinches out. It sharply but conformably overlies the greenstone member with the contact placed at the base of the lowest thick (>2 cm) greenstone bed.

Zm

Monk Formation--The Monk Formation was found only in the northeast quarter of the Iron Mountains (Plate 4) where it thins from 75 m to 0 m in less than 10 km. It consists dominantly of thinly laminated to thinly bedded red, gray, and brown argillite and silty argillite except near the crest of the Iron Mountains where a sequence of greenstone pebble conglomerate is present. The trends displayed here by the Monk are very different from those it displays near Metaline Falls, Washington (see Section II), where it is more than 1,000 m thick and consists dominantly of argillite and interbedded carbonate (Miller, 1982). The contact between the Monk Formation and the underlying Huckleberry Formation was thought to be conformable during the original mapping in 1984 and 1985. However, it is now interpreted to be unconformable.

Ca

Addy Quartzite--The Addy Quartzite comprises a 1,100- to 1,450-m-thick quartzite-dominated sequence containing significant amounts of siltite and argillite in its upper one-quarter to one-third. Trilobites found in the Addy Quartzite near the town of Addy, Washington (Okulitch, 1951) and on Stensgar Mountain (Lindsey, 1987) indicate the Addy is Early Cambrian in age. Other fossils found in the Addy confirm this age (Okulitch, 1951; J.T. Dutro, Jr., oral commun., 1985). The term Addy is used informally in this report because a type section has not been defined for it in accordance with the North American Stratigraphic Code (North American Commission on Stratigraphic Nomenclature, 1982).

The easily recognized Addy Quartzite unconformably overlies either the Monk or Huckleberry Formations in central Stevens County. Outside the areas mapped for this report the Addy also unconformably overlies the Deer Trail Group (Becraft and Weis, 1963) and Belt Supergroup (Miller and Clark, 1975). In the study areas the Addy Quartzite is conformably overlain by Lower to Middle Cambrian strata.

The Addy Quartzite is easily divisible into four distinct, informal lithostratigraphic units over a fairly large area (Fig. 4). These units are the: (1) basal unit - Cab; (2) purple-banded unit - Cap; (3) coarse unit - Cac; and (4) upper unit - Cau (Fig. 4).

Cab

Basal unit, Addy Quartzite--The basal unit consists dominantly of fine- to medium-grained, medium to thick bedded, vitreous, white quartzite. Medium-grained to granular quartzite is locally abundant, especially in the Iron Mountains. On Adams Mountain the unit is commonly friable. The unit is approximately 300 m thick on Adams Mountain, 100 to 150 m thick on Stensgar Mountain, 200 m thick on Dunn Mountain, and 170 to 300 m thick in the Iron Mountains.

On Adams Mountain sedimentary structures are commonly lacking, whereas to the north, trough cross-bedding, medium- to large-scale planar cross-bedding, and channels are locally abundant. Argillite and siltite are rare and consist of thin (<10 cm thick) lenticular interbeds. Petrographically, the basal unit is a quartz arenite containing more than 98% quartz. Neither body nor trace fossils were found in the unit.

The base of the unit (and thus the Addy) is sharp and easily recognized. It lies at the base of the first quartzite bed overlying the very different lithologies of the Monk or Huckleberry Formations. Locally this contact appears disconformable, but regionally it is a low-angle unconformity.

Cap

Purple-banded unit, Addy Quartzite--The purple-banded unit is the most easily recognized unit in the Addy Quartzite, and purple banding has been

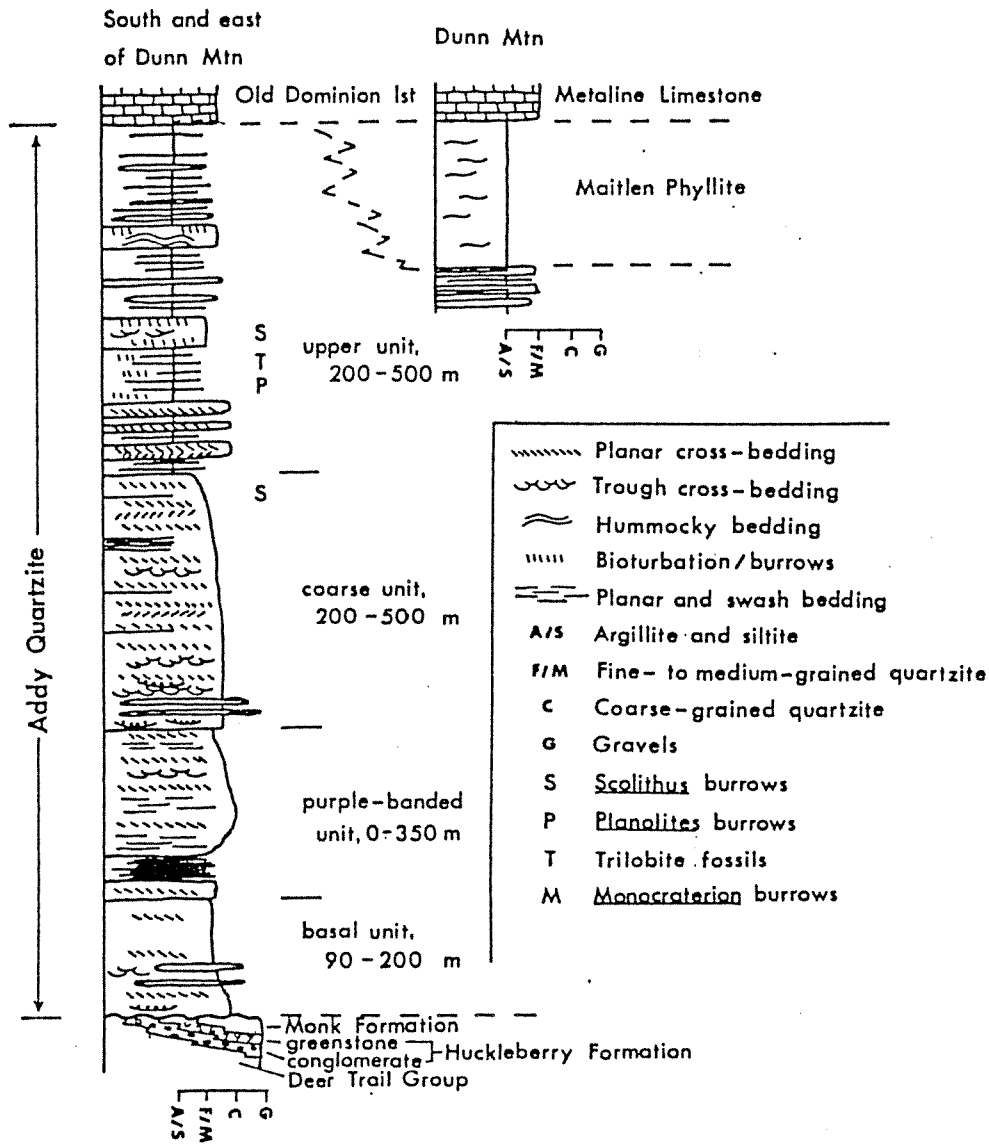

Figure 4. Composite stratigraphic section of the Addy Quartzite.

recognized repeatedly throughout the region (Vacher, 1969; Miller and Yates, 1976; Lucas, 1980; Lindsey, 1985, 1987). The unit consists dominantly of white, blue, and lavender fine- to coarse-grained quartzite. Petrographically, quartzites of the unit are classed as quartz arenites. Banding is the most diagnostic feature of the unit and consists of purple to red Liesgang bands and heavy mineral layers. Liesgang bands are 1 mm to 5 cm thick and lie parallel, subparallel, and transverse to bedding. Heavy minerals consist of detrital rutile, zircon, and magnetite or hematitic dust rims and pore fillings lying parallel to bedding. Where banding parallels bedding the two types of banding are indistinguishable in hand sample.

Purple argillite is scattered throughout the unit but is most abundant in the lower 50 to 100 m of the unit, where it forms beds 0.25 to 2 m thick. Throughout the rest of the unit argillite is restricted to thin (<2 cm) lenticular beds and discontinuous partings. Pebble beds are scarce in the unit and occur only locally as lenses less than 2 cm thick. The most common sedimentary structures in the unit are plane lamination and bedding and swash lamination that are defined by purple banding. Small- to medium-scale planar cross-bedding also is common. Other sedimentary structures in the unit include hummocky bedforms, draping structures, trough cross-bedding, ripple cross-lamination, and symmetrical ripples. No body fossils are found in the unit, but rare burrows of unknown affinity are observed locally. In the Iron Mountains the unit is 150 to 200 m thick, on Huckleberry Mountain it is 200 to 300 m thick, and on Dunn Mountain it is 300 to 400 m thick. On Adams Mountain the unit thins from 150 to 0 m. This thinning is notable because Becraft and Weis (1963) did not recognize purple banding in the Addy Quartzite south of Adams Mountain in the Turtle Lake quadrangle.

Cac

Coarse unit, Addy Quartzite--The coarse unit consists characteristically of white, tan, and light brown, medium-grained to granular, thin to medium bedded quartzite. Pebble conglomerate beds up to 10 cm thick are common in the lower 100 m of the unit but rare above. Argillites and siltites are scattered throughout the unit, forming thin, discontinuous, lenticular beds as much as 20 cm thick. Thicker beds (up to 50 cm thick) and partings are largely restricted to the upper one-half of the unit. The unit varies in thickness: 400 m on Adams Mountain, 250 to 400 m on Stensgar Mountain, 300 m on Dunn Mountain, and as much as 600 m in the Iron Mountains. However, in the Iron Mountains faulting is very common, and the section may be repeated.

Small-and medium-scale planar cross-bedding is the most abundant sedimentary structure in the unit, occurring throughout it. Trough cross-bedding also is common in the unit, especially in the lower one-half. Cosets of tabular and trough cross-bedding are 0.5 to 2 m thick. No body fossils are found in the unit. However, the vertical burrow Scolithus is found locally near its top. Petrographically the coarse unit is a quartz arenite to subarkosic arenite, containing 90 to 99% quartz in thin section. XRF analysis of coarse unit quartzites

indicates they are composed of more than 95% SiO_2. Granules and pebbles in coarser parts of the unit are mostly undulose, monocrystalline quartz. Other clast types include chert, quartzite, and metamorphic rock fragments.

The contact between the coarse unit and underlying units is gradational. On Adams Mountain where it overlies the basal unit, the contact is placed at the base of the lowest coarse-grained to granular, cross-bedded quartzite more than 2 m thick overlying finer grained, usually massive, friable quartzite. North of Adams Mountain the coarse unit overlies the purple-banded unit and the contact is placed in a transition zone 20 to 30 m thick at the base of the lowest coarse-grained to granular, cross-bedded quartzite more than 5 m thick.

Cau

Upper unit, Addy Quartzite--The upper unit is an interbedded sequence of quartzite, siltite, and argillite. In the Iron Mountains (Plate 4) the unit consists of beds of Targillite and siltite 5 cm to 3 m thick interbedded with quartzite beds 2 cm to 2.5 m thick. Intervals dominated by quartzite are as much as 15 m thick, and argillite-dominated intervals are 10 to 20 m thick. On Huckleberry Mountain, Stensgar Mountain, Dunn Mountain, and Adams Mountain (Plates 1, 2, and 5) the unit fines upwards. In these areas the lower 100 m of the unit consists of argillite and siltite interbedded with medium-grained to granular, planar cross-bedded quartzite. Granule layers 1 to 2 grains thick commonly lie at the tops of quartzite beds. The rest of the unit consists of argillite-dominated intervals 20 to 30 m thick alternating with fine- to medium-grained quartzites 1 to 20 m thick. On the southern one-half of Adams Mountain a large granitic intrusion situated just west of the mountain has apparently metamorphosed the upper unit, producing vitreous, recrystallized quartzite interbedded with strongly cleaved and foliated phyllite. Lenticular to wavy bedding, ripple cross-lamination, symmetrical ripples, hummocky bedding, and small-scale planar cross-bedding is common in the unit.

A marker bed (Caum) separating the lower coarser part of the unit from the finer upper part of the unit on Plates 1 and 2 consists of green, burrowed, cross-bedded quartzite. However, this marker bed could not be found and mapped with confidence in mapping for Plates 4 and 5 and has been dropped from use.

The medium-grained and coarser quartzites in the upper unit are quartz arenites containing 95 to 98% quartz. The fine- to medium-grained quartzites in the unit contain as much as 20% muscovite and chlorite and are classified as quartz wackes. Argillites are composed mostly of muscovite and chlorite, while many siltites are very quartzose. XRF analysis of argillites and siltites in this unit show high Al_2O_3, FeO_3, FeO, and K_2O contents as would be expected in pelitic rocks. Additionally, analysis of one slightly magnetic sample yielded a total Fe oxide content of approximately 28.5%.

Body and trace fossils are common in the upper unit. This study showed that the original fossil locality described by Okulitch (1951) near Addy, Washington, is in the upper unit of the Addy. Exposures of the unit near here contain the trilobite Nevadella addyensis, the brachiopod Kutergina sp., and the proto-mollusc Hyalithus (Okulitch, 1951; W.M. Schneck, formerly a student of Eastern Washington University, written commun., 1984; Lindsey, 1987). Trace fossils in these rocks include the vertical burrow Scolithus, horizontal burrow Planolites, trilobite trace fossils Rusophycus and Cruziana, and unnamed trails (W.M. Schneck, written commun., 1984; Lindsey, 1987). All these body and trace fossils except Kutergina were found in the upper unit near Stensgar Mountain (Lindsey, 1985, 1987) during the 1984 field season. Several examples of these trace fossils but no body fossils were found south of Stensgar Mountain in 1985.

The upper unit ranges from 250 to 450 m thick throughout its extent except in the Iron Mountains where its top is everywhere removed by faulting. Here, it is at least 300 m thick. The base of the unit is placed at the base of the lowest thick argillite bed (>1.5 m thick) overlying coarse-grained, cross-bedded quartzite. On and south Huckleberry Mountain the Addy Quartzite is conformably overlain by the Old Dominion limestone, whereas to the north it is overlain by the Maitlen Phyllite. Along the Colville valley, near Chewelah, Washington, the Addy is overlain by the Metaline Limestone (Miller and Clark, 1975).

Cmp

Maitlen Phyllite--On Dunn Mountain a 200 m thick sequence of argillite overlies quartzitic strata assigned to the Addy Quartzite and underlies the Lower to Middle Cambrian Metaline Limestone. Lucas (1980) assigned these argillites to the Maitlen Phyllite. With some reservations the term Maitlen is retained and used in this report. The Maitlen Phyllite on Dunn Mountain consists of brown to tan, micaceous, platy weathering argillite at the base that grades upwards into massive, brown to gray, mottled argillite at the top. It contains no quartzite. Park and Cannon (1943) and Miller (1982) give the Maitlen an Early Cambrian age. The base of the Maitlen Phyllite is sharp and easily recognized. It is placed at the base of the lowest thick (>10 m) sequence of micaceous argillite.

Similarities in lithology, thickness, and stratigraphic position suggest the Maitlen Phyllite may interfinger to the south with the uppermost 150 m of the upper unit of the Addy Quartzite on Stensgar Mountain. Except for the presence of rare, thin (<5 m) quartzite beds in the uppermost Addy, both sequences are argillaceous. Additionally, both are approximately the same thickness, 150 m for the uppermost Addy and 200 m for the Maitlen. Both sequences also occupy similar stratigraphic positions; that is they overlie quartzitic strata typical of the Addy and underlie Lower to Middle Cambrian limestones.

Cml

Metaline Limestone--The Metaline Limestone is one of two Lower to Middle Cambrian limestones in Stevens County that overlie the Addy Quartzite and Maitlen Phyllite (Campbell and Raup, 1964; Miller and Clark, 1975). The base of the Metaline Limestone on Dunn Mountain (Plate 2) consists of massive, gray, crystalline limestone with minor white dolomitic limestone. The base of the Metaline Limestone is placed at the base of the lowest limestone bed (>0.5 m) overlying thick argillites.

Cod

Old Dominion limestone--The Old Dominion limestone is the other Lower to Middle Cambrian limestone in Stevens County (Campbell and Raup, 1964; Miller and Clark, 1975). The lowest 100 m of the Old Dominion limestone consists of dark gray to black, thinly bedded (2 to 20 cm), micritic limestone. Near its contact with the underlying Addy Quartzite a poorly outcropping, light brown, very argillaceous limestone less than 2 m thick is locally present. The contact between the Old Dominion limestone and the Addy Quartzite is difficult to place because it is usually covered. However, the exposures available suggest the contact is sharp but conformable. Where exposed the contact is placed at the bottom of the lowest limestone bed (>1 m) which overlies interbedded argillite, siltite, and quartzite.

Pzu

Undifferentiated Paleozoic carbonate rocks--Rocks assigned to this unit consist of very poorly exposed gray limestone and gray to tan dolomite. These rocks do not have affinities with the Lower to Middle Cambrian Old Dominion limestone or the Metaline Limestone. Miller and Clark (1975) suggest these undifferentiated rocks are probably Devonian to Mississippian in age. Where this unit was mapped adjacent to the Addy, the contact was everywhere a fault.

Ki

Intrusive rocks, undifferentiated--The intrusive rocks in the map areas consist of Cretaceous quartz monzonite, granodiorite, and granite, of which quartz monzonite seems to be most abundant. These rocks are part of the Loon Lake Granite in the south (Becraft and Weis, 1963) and the Starvation Flat Quartz Monzonite in the north (Miller and Clark, 1975).

Qau

Unconsolidated sediment, undifferentiated--This unit consists of variable amounts of mud, silt, sand, and gravel of probable Quaternary age.

Section II: Descriptions of portions of the Gypsy Quartzite, Three Sisters Formation, and adjacent units (Plate 3)

Zm

Monk Formation--The Monk Formation conformably underlies the Three Sisters Formation. (The contact is now thought to be unconformable, see Groffman, 1986, and Lindsey, 1987.) It is part of the Windermere Group (Miller and others, 1973). The Monk Formation characteristically consists of gray to black phyllitic argillite with interbedded carbonate. It also contains significant amounts of quartzite and conglomerate. Exposures of the Monk in the map area are very poor, but where exposed the dark phyllitic argillite and interbedded carbonate characteristic of the Monk is easily recognized.

Zt

Three Sisters Formation--The Three Sisters Formation is 2,000 to 2,100 m thick and divided into two lithostratigraphic units. The lowest unit (Ztl) is dominantly argillite and the upper unit (Ztu) quartzite and conglomerate.

It is important to note that subsequent to the original compilation of these maps in 1984 and 1985 the argillaceous lower unit of the Three Sisters has been assigned to the Monk Formation (Lindsey, 1987). Therefore, the following descriptions of the Three Sisters Formation are out-of-date. The Three Sisters Formation as now described consists only of strata assigned to the upper unit in this report.

Ztl

Lower unit, Three Sisters Formation--The lower unit as originally defined in 1984 and 1985 consists dominantly of argillite and siltite with minor white and gray quartzite. The argillite and siltite is fissile, brown to gray, and forms very poor outcrops. Quartzite interbeds are generally fine grained and less than 5 m thick. The lower unit is approximately 700 m thick. These strata are now assigned to the Monk Formation. (See Lindsey, 1987, for explanation.)

In the study area exposures of the lower unit and the Monk Formation are very limited, and the contact between them difficult to place. Using Miller's (1982) criteria the contact between them is placed at the base of the lowest light colored, fine- to medium-grained quartzite bed. However, Miller (1982) and Groffman (1986) state that in many places the contact is often faulted and, due to the limited outcrop in the study area, it is possible it is also faulted near Sullivan Mountain.

Ztu

Upper unit, Three Sisters Formation--The upper unit is an easily recognized 1,300-m-thick sequence of coarse-grained to granular quartzite and pebble and small boulder conglomerate. Again, due to reassessment of the stratigraphy of the Three Sisters Formation subsequent to the original mapping in 1984 and 1985, the upper unit is now thought to comprise the

entire formation (Lindsey, 1987).

Conglomerates in the upper unit usually form thick (1 to 30 m) massive beds, and clasts consist dominantly of quartz and quartzite with minor limestone and argillite. A distinctive green, chloritic pebble conglomerate occurs in many places near the top of the unit in association with a poorly exposed, discontinuous mafic metavolcanic layer. Quartzites in the upper unit are dominantly coarse grained to granular, white to light-blue, and commonly display planar and trough cross-bedding, channelization, and crude fining-upward sequences. Quartzite beds also are usually thick bedded (0.5 to 1.5 m) to massive and form amalgamated sequences several tens of meters thick. Argillite and siltite occur in thin (<1 cm), discontinuous partings which decrease in abundance up-section. The base of the upper unit is placed at the base of the lowest conglomerate bed.

Cg

Gypsy Quartzite--On Sullivan Mountain the Gypsy Quartzite consists of at least 1,350 m of quartzite with minor siltite and argillite (Fig. 5). Park and Cannon (1943) and Miller (1982) placed an Early Cambrian age on the Gypsy based on the occurrence of trilobites on Gypsy Peak north of Sullivan Mountain. No trilobites were found on Sullivan Mountain where the Gypsy Quartzite is divided into five distinct lithostratigraphic units. In ascending order they are: (1) basal (Cgb); (2) lower argillite (Cga); (3) purple quartzite (Cgp); (4) coarse quartzite and argillite (Cgc); and (5) upper argillite (Cgu) (Fig. 5).

Cgb

Basal unit, Gypsy Quartzite--The basal unit is a homogeneous 210- to 215-m-thick sequence of white, massive, fine- to medium-grained quartzite. Large-scale planar cross-beds and trough cross-beds are common in the unit. Petrographically, quartzites in the unit are classified as quartz arenites. Argillite is rare in the unit, being restricted to thin (<10 cm), lenticular interbeds.

The base of the unit, and the Gypsy Quartzite, is placed at the top of the highest granular quartzite to conglomerate bed which underlies the white, fine- to medium-grained quartzite characteristic of the basal unit. Miller (1982) states that this contact is unconformable. However, except for grain size, the lithologies displayed by the uppermost Three Sisters and lowermost Gypsy are very similar and the limited outcrop available suggests the two units may grade into each other.

Cga

Lower argillite unit, Gypsy Quartzite--The lower argillite unit is a coarsening-upward sequence of argillite, siltite, and fine-grained quartzite 100 m thick. The lower half of the unit consists of poorly

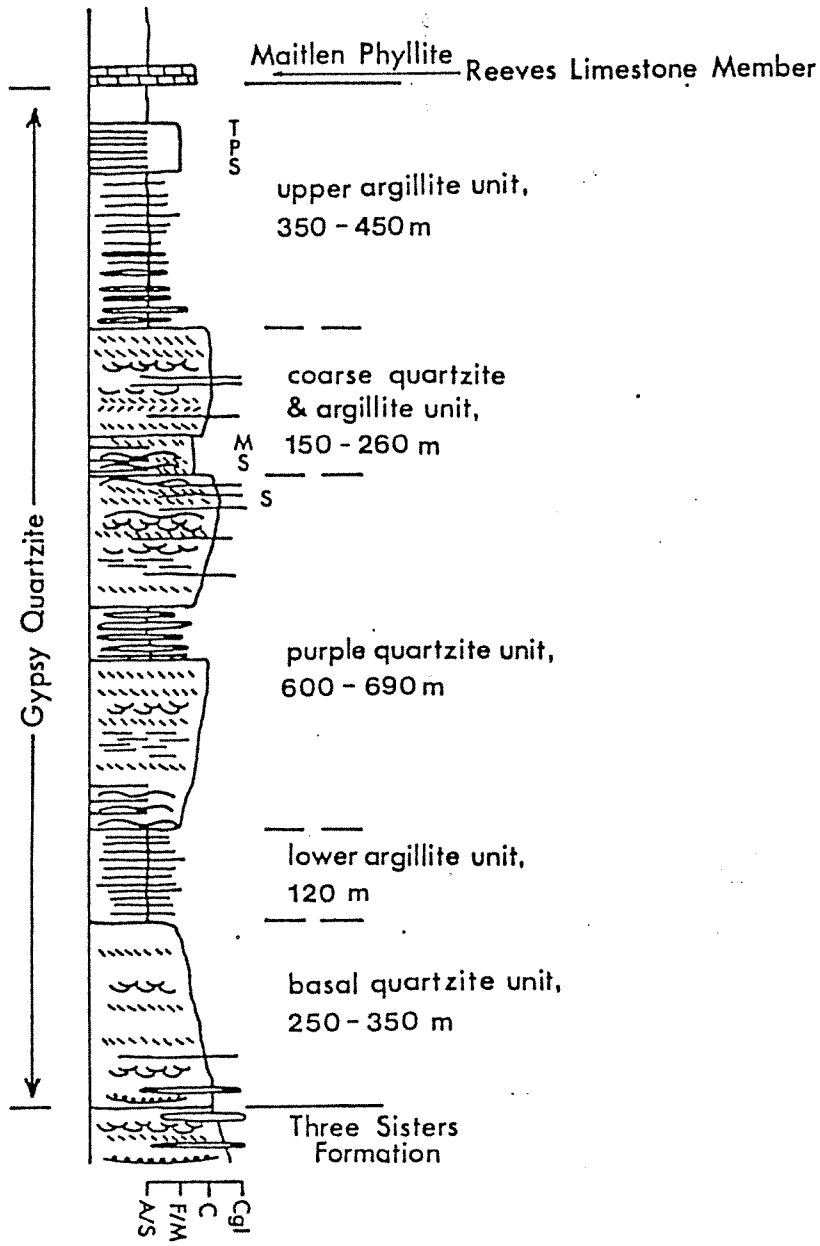

Figure 5. Composite stratigraphic section of the Gypsy Quartzite. See Fig. 4 for key to symbols.

outcropping olive siltite and argillite. The upper half consists of green and brown argillite and siltite with interbedded white to brown quartzite. Several 2 to 5 m-thick coarsening-up packages consisting of quartzite, siltite, and argillite are present in the lower half of the member. Quartzite beds are usually lenticular, 1 to 40 cm thick, and continuous for 15 to 25 m along strike. Some distorted bedding is locally present and commonly associated with beds containing unidentified sand filled burrows.

At elevations higher than 6,000 ft above sea level the lower argillite unit is easily located due to the lack of thick stands of trees in many places associated with its outcrop. The base of the unit is very sharp and placed at the base of the lowest argillite or siltite bed overlying mature quartz arenite of the basal unit.

Cgp

Purple quartzite unit, Gypsy Quartzite--The purple quartzite unit consists dominantly of light-blue to purple, fine- to coarse-grained quartzite with minor purple to gray argillite and siltite. Purple and red Liesegang bands and heavy- mineral layers are common in the lower half of the member, but less common in the upper half. Ripple cross-lamination and large-scale planar cross-bedding and trough cross-bedding become more abundant up-section in the unit. Scolithus is present and occurs in the upper most 50 m of the unit, and hummocky cross-bedding is common near the base of the unit. Purple argillite partings are common throughout the unit, and drape hummocky bedding surfaces. Thick beds (1 to 4 m) of gray argillite and siltite are common in the middle of the unit and seem to separate less banded quartzite above from more banded quartzite below. The unit is 700 m thick, and the base is placed at the bottom of the lowest purple to blue quartzite overlying the interbedded argillite, siltite, and quartzite of the lower argillite unit.

Cgc

Coarse quartzite and argillite unit, Gypsy Quartzite--This unit is 160 m thick and consists dominantly of white to tan, fine-grained to granular quartzite. Minor amounts of pebble conglomerate and brown to tan argillite and siltite are scattered throughout the unit. Quartzite beds are 0.5 to 3 m thick and commonly contain planar and trough cross-bedding and ripple cross-lamination in cosets 1 to 3 m thick. The rare pebble conglomerates form thin (<15 cm) lenses. Argillite usually occurs as partings and siltite as thin (<1.5 m) lenses which often have scoured tops. Low-angle cross-beds are common near the top of the unit, and Scolithus and Monocraterion burrows and disrupted bedding are common near the base. The contact between this unit and the underlying purple quartzite unit is placed at the base of the lowest white to tan quartzite below which blue to purple quartzite is dominant.

Cgu

Upper argillite unit, Gypsy Quartzite--The best exposures of the upper argillite unit lie 1 to 3 km southwest of Sullivan Mountain and are separated from the main outcrop of the Gypsy Quartzite on Sullivan Mountain by a fault. The middle of the upper unit consists dominantly of interbedded brown argillite and fine-to medium-grained, white to brown, mottled, micaceous quartzite containing abundant flaser beds, disrupted argillite partings, and large Scolithus burrows. This lithology grades upwards and downwards into argillite-dominated strata. The base of the unit consists of black and gray argillite containing thin (<2 cm), disrupted, lenticular quartzite laminations and thick (1 to 2 m), brown, massive quartzite beds. The uppermost part of the unit is a fining upward sequence grading from mottled, burrowed quartzite at the base, through black argillite, into the Reeves Limestone Member of the Maitlen Phyllite.

The upper unit is at least 200 m thick, but faulting makes determination of the thickness of the unit difficult. The base of the upper argillite unit is placed at the base of the lowest thick black argillite or mottled brown quartzite (>1 m thick) overlying white, coarse-grained, cross-bedded quartzite typical of the coarse quartzite and argillite unit.

Cmp

Maitlen Phyllite--The base of the Maitlen Phyllite is marked by the Reeves Limestone Member. This light-gray to tan limestone is an easily recognized marker that sharply but conformably overlies the upper argillite unit of the Gypsy Quartzite. The Reeves Limestone is assigned an Early Cambrian age due to the presence of archeocyathids in it (Park and Cannon, 1943; Miller, 1982). The base of the Reeves is placed at the base of the lowest thick (>2 m), gray limestone overlying the argillite and quartzite of the upper argillite unit.

Qau

Undifferentiated and unconsolidated sediments--These deposits consist of variable amounts of uncemented mud, silt, sand, and gravel of probable Quaternary age.

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Plate 1: Geologic map of the Addy Quartzite on Stensgar and Huckleberry Mtns., Stevens County, Washington.

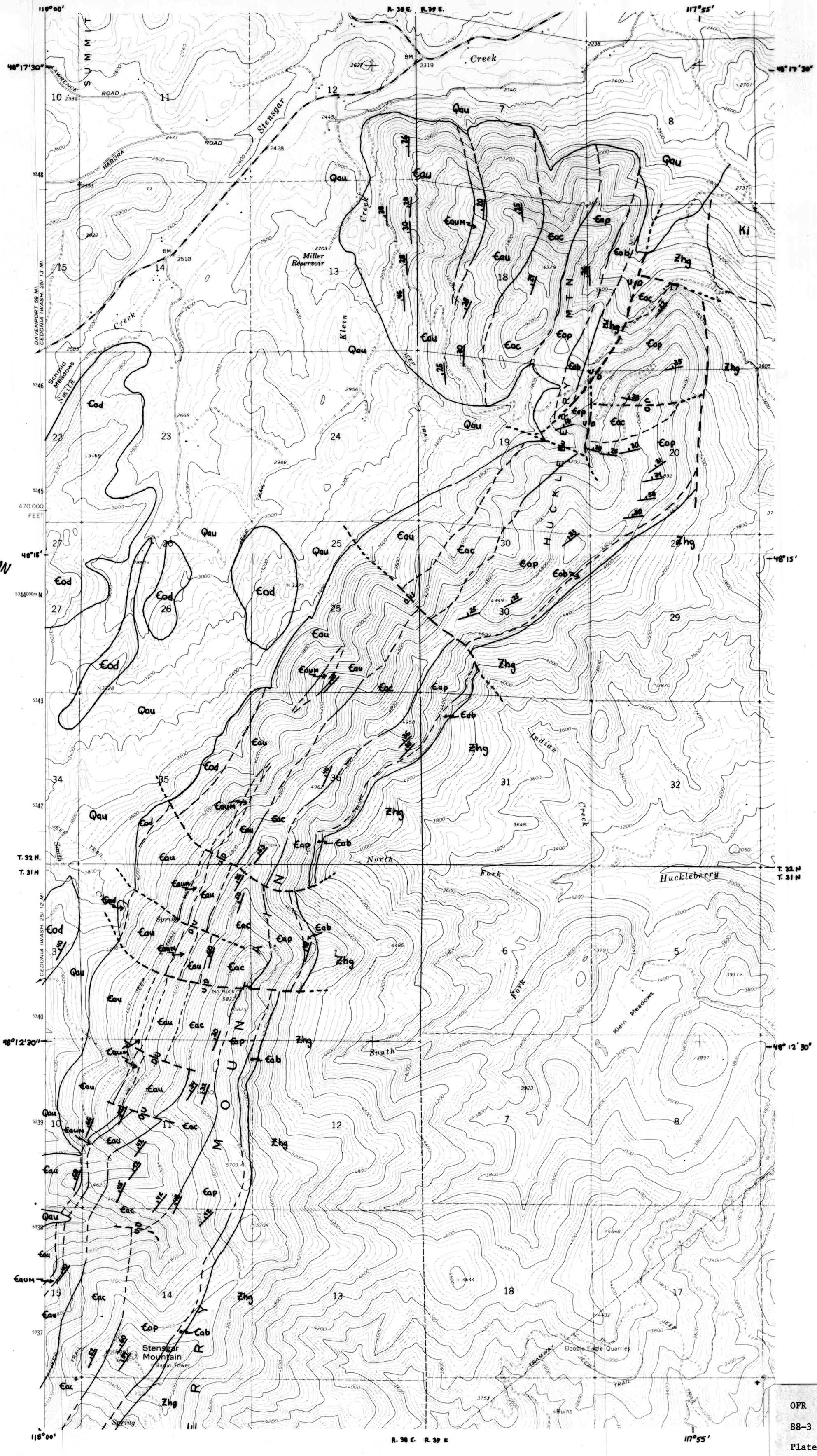

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Plate 1

Explanation For Plates 1-3: Geologic Maps Of Addy Quartzite, Gypsy Quartzite, and Three Sisters Formation, Stevens and Pend Oreille Counties, Washington

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ROCK UNITS

STENSGAR AND HUCKLEBERRY MTNS

SEDIMENTARY ROCKS | IGNEOUS ROCKS

QUATERNARY

Qau — undifferentiated alluvium

— UNCONFORMITY —

CRETACEOUS

Ki — intrusive rocks

MIDDLE CAMBRIAN

Ꞓod — Old Dominion Limestone

LOWER CAMBRIAN

Ꞓa: Ꞓau, Ꞓaum, Ꞓac, Ꞓap, Ꞓab

Ꞓa - Addy Quartzite
- Ꞓau - upper member
  - Ꞓaum - marker bed, upper member
- Ꞓac - coarse member
- Ꞓap - purple-banded member
- Ꞓab - basal member

— UNCONFORMITY —

PROTEROZOIC Z

Zhg — greenstone member, Huckleberry Formation

DUNN MOUNTAIN

SEDIMENTARY ROCKS | IGNEOUS ROCKS

QUATERNARY

Qau — undifferentiated alluvium

— UNCONFORMITY —

CRETACEOUS

Ki — intrusive rocks

MIDDLE CAMBRIAN

Ꞓml — Metaline Limestone

Ꞓmp — Maitlin Phyllite

LOWER CAMBRIAN

Ꞓa: Ꞓau, Ꞓaum, Ꞓac, Ꞓap, Ꞓab

Ꞓa - Addy Quartzite
- Ꞓau - upper member
  - Ꞓaum - marker bed, upper member
- Ꞓac - coarse member
- Ꞓap - purple-banded member
- Ꞓab - basal member

— UNCONFORMITY —

PROTEROZOIC Z

Zhg — greenstone member, Huckleberry Formation

SULLIVAN MOUNTAIN

SEDIMENTARY ROCKS

Quaternary

Qau — undifferentiated alluvium

— UNCONFORMITY —

Ꞓmp — Maitlin Phyllite

LOWER CAMBRIAN

Ꞓg: Ꞓgu, Ꞓgc, Ꞓgp, Ꞓga, Ꞓgb

Ꞓg - Gypsy Quartzite
- Ꞓgu - upper member
- Ꞓgc - coarse member
- Ꞓgp - purple member
- Ꞓga - argillite member
- Ꞓgb - basal member

- ?- UNCONFORMITY -?-

PROTEROZOIC Z

Z+: Ztu, Z+l

Zt - Three Sisters Formation
- Ztu - upper member
- Z+l - lower member

ZM — Monk Formation

MAP SYMBOLS

STRIKE AND DIP OF BEDS

15

LITHOLOGIC CONTACTS

- Exposed and/or sharp
- Covered and/or gradational
- Inferred

FAULTS

- Exposed
- Mappable but covered
- Inferred
- U - upthrown side; D - downthrown side

Plate 2: Geologic map of the Addy Quartzite on Dunn Mtn., Stevens County, Washington.

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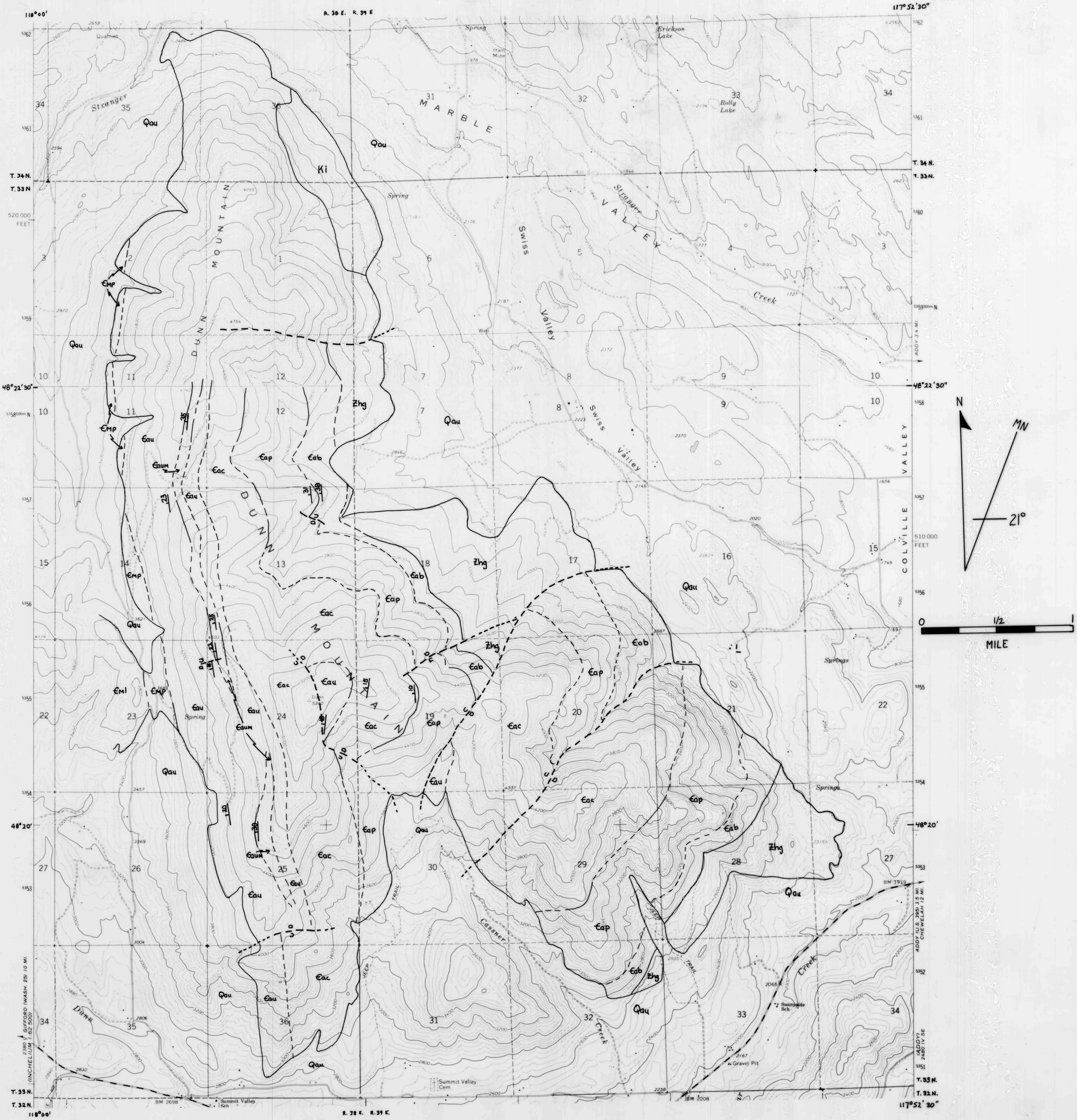

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Plate 2

Plate 3: Geologic map of the Gypsy Quartzite and Three Sisters Formation, Sullivan Mtn. area, Pend Oreille County, Washington.

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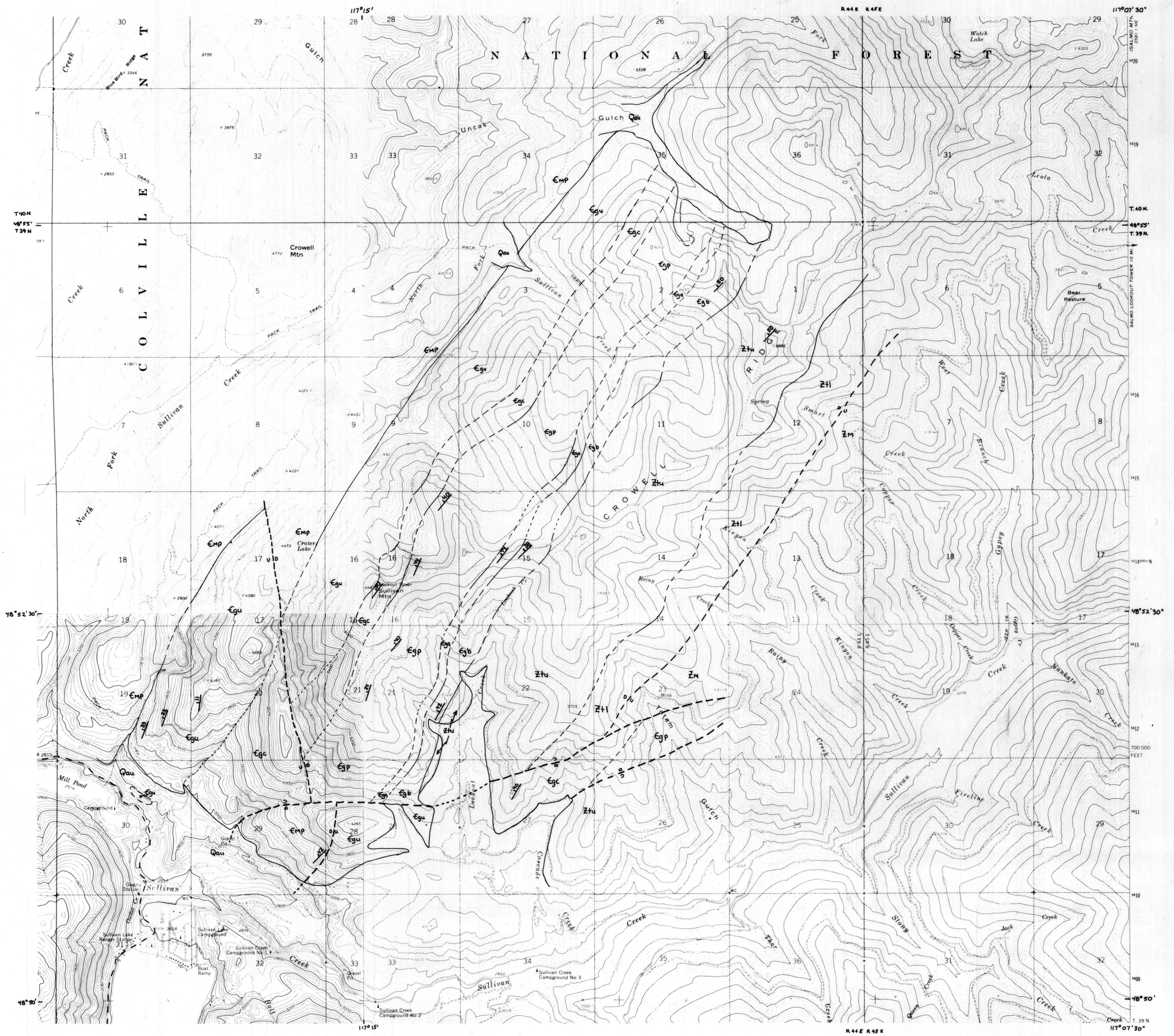

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Plate 4

GEOLOGY OF THE ADDY QUARTZITE, IRON MOUNTAINS AREA, CENTRAL STEVENS COUNTY, WASHINGTON.

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Stratigraphic column

Quaternary	Qau	- Undifferentiated alluvium
	- unconformity -	
Cretaceous	Ki	- Undifferentiated intrusive rocks
	- unconformity -	
Miss. or Dev.	Pzu	- Undifferentiated Paleozoic carbonate rocks
	- unconformity -	
Middle to Early Cambrian	Ꞓod	- Old Dominion Limestone
Early Cambrian	Ꞓa	- Addy quartzite
	Ꞓau	- upper unit
	Ꞓac	- coarse unit
	Ꞓap	- purple-banded unit
	Ꞓab	- basal unit
	- unconformity -	
Proterozoic Z	Zm	- Monk Formation
	Zh	- Huckleberry Formation
	Zhg	- greenstone member
	Zhc	- conglomerate member
	-unconformity-	
Proterozoic Y	Y	- Deer Trail Group, undifferentiated

N
MN
21.5

0 0.5 1
Mile

Map Key

- Strike and dip of beds
- vertical beds

Lithologic contacts

- Exposed
- Covered but mappable
- Inferred

Faults

- Exposed
- Covered but mappable
- Inferred
- U - Upthrown side
  D - Downthrown side

Thrust faults

- Exposed thrust, sawteeth on upper plate.
- Covered
- Inferred

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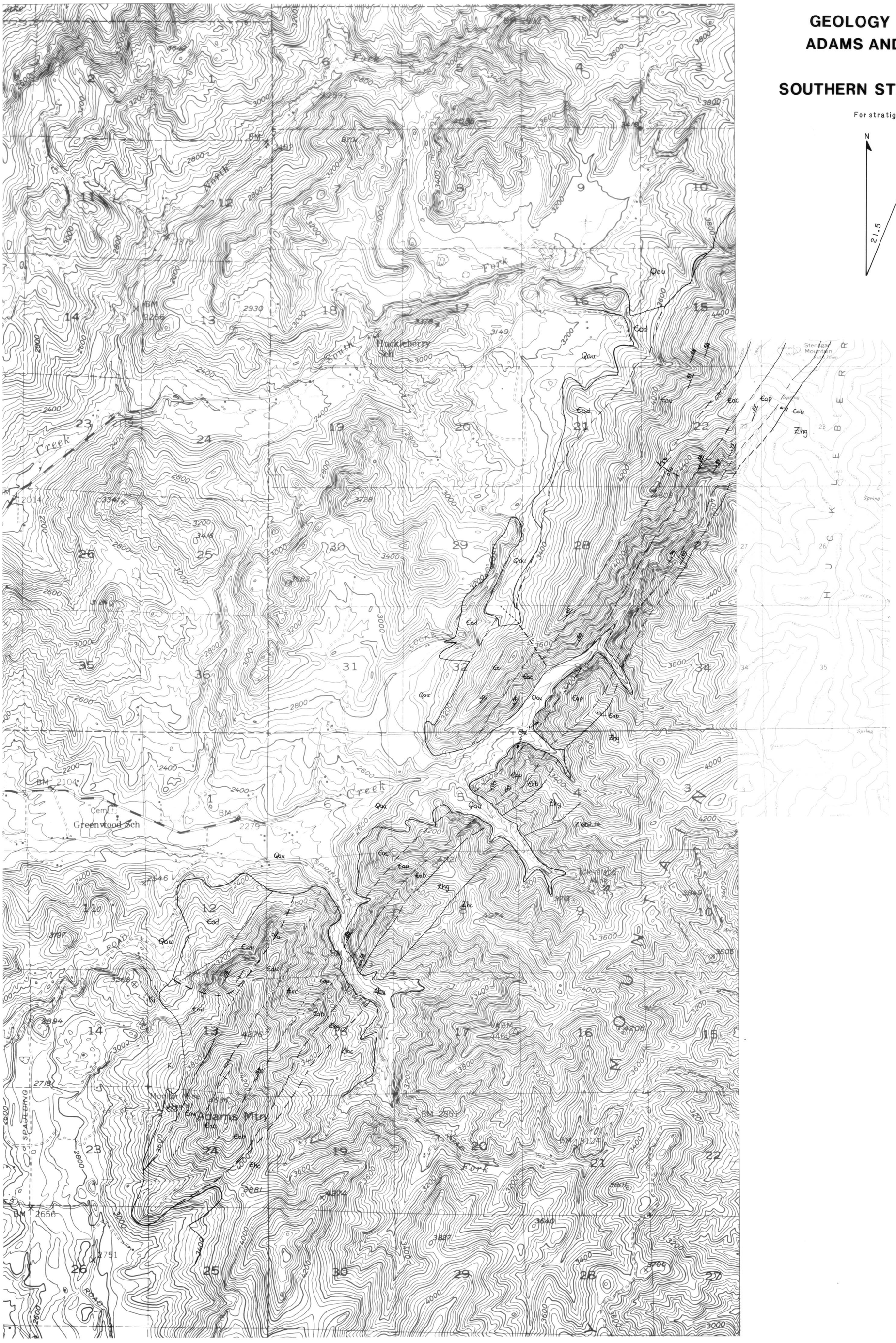
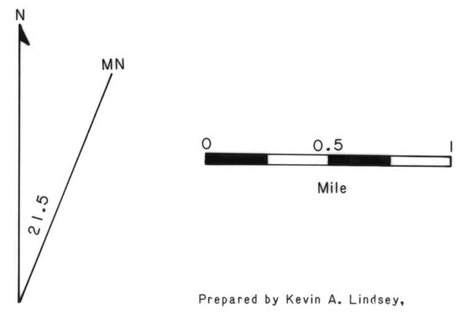
Plate 5

GEOLOGY OF THE ADDY QUARTZITE, ADAMS AND SOUTHERN HUCKLEBERRY MOUNTAINS, SOUTHERN STEVENS COUNTY, WASHINGTON.

For stratigraphic column and map key see plate 1.





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