



Stratigraphy in the Methow Quadrangle, Washington

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THE UNITED STATES GEOLOGICAL SURVEY topographic sheet of the Methow quadrangle, Washington, includes part of the eastern flank of the northern Cascade Range as well as part of the western Okanogan Mountains. It is bounded by north latitudes 48° to 48°30' and west longitudes 121° and 121°30'. The area was selected because it is thought to offer valuable information on the geological history of the Northern Cascades. It represents the farthest southward extension from Canada of a peninsula of sedimentary rocks surrounded on three sides by the granitic rocks of the Cascades and the Okanogan Range. Parts of the summers of 1939, 1940, 1941, and 1946 were spent in the area.

SUMMARY OF EARLIER WORK

The only published report on the geology of the area was made by Russell (1) as a result of his reconnaissance trip from Leavenworth via Glacier Peak to the Skagit drainage and the Cascade Crest in the vicinity of Hart's Pass (Crater Pass), thence down the Methow drainage to the Columbia River. Russell gave formal names to two lithologic units occurring in the northern part of the Methow quadrangle: the *Winthrop sandstone* (p. 117) of Upper Cretaceous age and the *Ventura system* (p. 113) of Jurassic(?) age. The latter was unfossiliferous and its doubtful age was assigned on the basis of its red color and inferred relation to other rocks north of the Methow quadrangle. Work in the quadrangle by the author confirms the Winthrop sandstone as a mappable unit of Upper Cretaceous age, but the position of the red beds, when they are present, is normally above the Winthrop and apparently gradational into overlying andesitic tuffs, breccias, and flows.

GRANITIC ROCKS

Chelan batholithic complex.—The northeastern contact of a batholithic complex makes a remarkably straight line North 40–45 West across the Methow quadrangle from near its southeast corner. The granitic rocks of the complex occupy approximately one half of the map area and can be followed southwest into the area mapped by Waters (2, p. 605) as the Chelan granodiorite. The author has not attempted to study the granitic rocks in the Methow quadrangle in detail, but samples taken along the contact and in one traverse extending four miles into the batholith all show textural and mineralogical similarity. The rock is a true biotite granodiorite of medium grain and is quite different from the typical Chelan basic granodiorite described by Waters (3, p. 767). The latter is characterized by hornblende and augite in the border phases and is gneissic in character. Further investigation will be necessary to determine the spatial and the age relationships of the various rock types within the Chelan batholithic complex.

Waters (3, p. 767) tentatively assigned the Chelan granodiorite of the type area to Jurassic(?) age. Some of the granitic rocks of the Chelan complex in the Methow quadrangle apparently cut formations as young as Upper Cretaceous.

Okanogan batholithic complex.—Several stock-like masses of hornblende quartzdiorite, biotite quartzdiorite, and biotite-muscovite granodiorite invade the sedimentary and metamorphic rocks along the eastern border of the Methow quadrangle. These are part of a granitic terrane which makes up the Okanogan Mountains and extends northward into Canada. Sufficient evidence is not available in the Methow quadrangle for working out the age relationships of these rocks.

FORMATIONS PROPOSED FOR THE METHOW QUADRANGLE

NAME	AGE	APPROXIMATE THICKNESS (feet)
Weststone Canyon formation	Eocene (?)	2,300
Unconformity		
Wright Peak formation	Upper Cretaceous	8,000
Winthrop sandstone*	Upper Cretaceous	2,500
Wahluke Ridge formation	Lower and Middle Cretaceous (?)	10,000-12,000
Unconformity		
Wahluke formation	Triassic (?)	14,000
Fault contact		
Methow gneiss	Pre-Chelan batholith	
Other metamorphics	Pre-Chelan batholith	
Named by Russell (1, p. 117)		

LEECHER METAMORPHICS

Occurrence and composition.—The best exposures of a series consisting of distinctly banded hornblende schist, quartz-oligoclase-hornblende gneiss, biotite-quartz-oligoclase gneiss, and calc-silicate rocks occur in a curving belt from 1 to 3 miles wide east of the Methow River in the Leecher Creek drainage and in the vicinity of the town of Carlton. This area is considered the type locality of the formation. West of the Methow River the outcrops are poor, but there is evidence of intense shearing and the production of mylonites and phyllitic-appearing rocks derived from the medium-rank gneisses and schists. The strike of the foliation east of the Methow changes south of Carlton from nearly east-west to N. 45° E. northeast of the town. The predominant easterly dip varies from 25° to vertical. There is a macroscopically visible preferred orientation of the hornblende and mica within the gneissic banding, but statistical studies have not been attempted.

The pronounced banding and the rapid alternation of rocks of diverse mineral and chemical compositions suggest that these are paragneisses derived from a series of impure arkosic sandstones and shales, basic lava flows, and, more rarely, limy sediments. Thin section study reveals evidence of both pre- and post-crystalline deformation of the gneisses.

Geological relations and age.—The Leecher metamorphics are in fault contact on the west with a series of black shales, siltstones, and metavolcanics and breccias of the Newby formation. The rocks are invaded from the east by granitic rocks of the Okanogan complex, and are in contact on the south with the Methow gneiss.

Gneisses similar to the Leecher outcropping in the vicinity of Pateros at the junction of the Methow and Columbia Rivers can be traced into migmatites and breccias described by Waters (3, p. 771) from the area near the south end of Lake Chelan.

METHOW GNEISS

Occurrence and composition.—The Methow River has cut a narrow valley for over fifteen miles from Carlton south through the town of Methow in a distinctive "biotite-granite" gneiss. This area is designated the type locality of the Methow gneiss. The diamond-shaped outcrop pattern measures roughly seven by fifteen miles. The gneiss has a marked foliation emphasized in outcrop and hand specimen by clots of biotite some of which are as large as a half

dollar. The clots may be irregularly drawn-out ovoid areas of paper thinness or single ragged books of black biotite up to 2 mm. in thickness. Outcrops paralleling the schistosity have a leopard-spot appearance.

The gneiss is remarkably uniform in mineral composition when viewed in thin section. The feldspar is notably untwinned, clear and fresh, and within the oligoclase range. No potash feldspar has been found. The quartz is of consistently smaller grain size than the feldspar and appears in floods along the planes of shear. Some grains are unstrained but others show strain shadows. Associated with the quartz is epidote and brown biotite. Much of the epidote is in prismatic euhedral form and has grown simultaneously with the biotite. Both minerals are for the most part post-shearing in age. Apatite and magnetite are the common accessory minerals.

Geological relations and age.—The Methow gneiss shows a concordance in structure with the overlying Leecher metamorphics north and east of the Methow River. Development of the gneissic structure in both formations was apparently accomplished at the same time, but there are details in the relationship of the remarkably uniform Methow gneiss with the heterogeneous Leecher metamorphics not understood.

NEWBY FORMATION

Occurrence and composition.—The best exposures of a series of black shales, tuffs, and breccias, and metalavas of andesitic and possibly basaltic composition lie along Lookout Ridge from the forest lookout tower west to Black Pine Lake. Lookout Ridge forms the south boundary of Poorman Creek drainage, tributary to the Twisp River in the north central part of the Methow quadrangle. This is considered the type locality for these rocks, which are designated the *Newby formation*. The name is taken from Newby Ridge, the northern boundary of Poorman Creek drainage, since the name *Lookout* is previously used. The rocks along Lookout Ridge strike North-South and dip from 70° E. to vertical. No evidence of repetition can be recognized. A tentative total thickness of 14,000 feet is assigned to the formation.

The lowest exposed part of the Newby formation is composed of black shale which outcrops at the head of Poorman Creek and in the vicinity of Black Pine Lake. The beds of shale vary from 2 to 6 inches in thickness. No fossils were found in the shale, but its regularity of bedding over wide extent suggests a marine origin. Shales very similar in appearance also outcrop on both sides of the Methow River in the vicinity of Winthrop in a belt 3 to 5

miles wide. The shales are repeated in a series of tight folds the axes of which trend North 20–30 West. The thickness of this section is estimated to be approximately 2000 feet.

The breccias and tuffs of the Newby formation are typically black, dark gray, or greenish rocks with occasional interbedded black shales and siltstones. Weathering on strongly glaciated surfaces brings out the fragmental texture of the rocks not seen on freshly broken surfaces. The angular to sub-rounded fragments making up the breccias are well sorted and are seldom over 4 inches in diameter.

In thin section the tuffs and breccias are seen to have been completely altered in mineral content, but a ghostly texture of porphyritic lava fragments can be recognized. Phenocrysts of feldspars are now saussuritized and the dark minerals altered to patches of chlorite and iron ores. A few examples of vesicular and amygdaloidal bands trending in the same direction as the bedding were found with massive greenstones suggesting true flow rocks. It should be emphasized, however, that the Newby formation is a predominantly non-quartzose sedimentary section derived from volcanic rocks and interbedded with minor amounts of true flow rocks, sharply folded and faulted but only moderately metamorphosed.

Geological relations and age.—At no place has the base of the Newby formation been recognized in the quadrangle. The formation is in fault contact with the metamorphic rocks of the Leecher and Methow gneisses in the central part of the quadrangle. The granitic rocks of the Chelan batholithic complex intrude the Newby on the southwest indurating the shales and breccias for at least a mile from the contact. Fault contacts delimit the outcrop of the formation on both east and west in the northern part of the map. There is a marked angular unconformity exposed at several places between the Newby and the overlying fossiliferous Cretaceous Virginian Ridge formation, but the structural trend of the Newby is in general not greatly different from the trend of the younger rocks.

The rocks of the Newby formation most closely resemble those described by Cairnes (4, p. 52) as part of a series outcropping along the Pasayten and Similkameen Rivers just north of the International Boundary in the vicinity of 120°33' W. longitude. These rocks were assigned by Cairnes to the Tulameen (?), Triassic(?) in age. Rice (5, p. 10), who has recently remapped the area, assigns these same rocks to the Nicola group, Upper Triassic in age, which he describes as a large and varied assemblage consisting of many-colored volcanic

rocks of andesitic to basaltic composition which have interbedded with them belts and lenses of sedimentary and pyroclastic rocks. Most of the Nicola rocks are said not to be strongly metamorphosed, although they have been folded into tight north to northeast trending anticlines and synclines.

Until contrary fossil evidence is found, the Newby formation is tentatively assigned to a Triassic-Jurassic(?) age on the basis of lithologic character, and its relation to the unconformably overlying Cretaceous rocks.

VIRGINIAN RIDGE FORMATION

Occurrence and composition.—The best outcrops of a great thickness of steeply dipping black siltstones, graywackes, and silica pebble conglomerates are found in Wolf Creek and along Virginian Ridge between Wolf Creek and the west fork of the Methow River in the northwestern part of the quadrangle. These outcrops are designated the type locality of the Virginian Ridge formation. The basal conglomerate of the Virginian Ridge formation can best be studied, however, along the Twisp River 3 1/2 miles west of Twisp. Here several hundred feet of conglomerate unconformably overlies the Newby formation and contains well-rounded pebbles and boulders of black shale, breccia, tuff, and metavolcanic rocks seldom over 6 inches in diameter, derived from the underlying formation. There is no indication of granitic boulders in the conglomerate. The conglomeratic facies varies from a few hundred to over 1000 feet in thickness and contains marine fossils above its upper limit as exposed on the hill east of Patterson Lake 3 1/2 miles southwest of Winthrop.

The bulk of the Virginian Ridge formation is composed of a spheroidally weathering black to dark greenish siltstone occasionally interbedded with dark graywacke. This section makes poor outcrops. There are at least five beds of well-sorted pebble conglomerate from 10 to 30 feet in thickness which can be found throughout the area of Virginian Ridge outcrop. Complete absence of granitic debris characterizes the conglomerates which are made up of well-rounded gray to black chert and white vein quartz pebbles seldom over 2 inches in diameter. The rocks are strongly folded, and because of steep dips and resistance to weathering the conglomerates stand out on the canyon walls like gaunt ribs.

Approximately 12,000 feet of section can be measured above the conglomeratic facies at the base. Another section exposed northwest of the type area gives a total thickness of 10,500 feet above the conglomerate. These thick-

nesses are measured from cross-sections constructed with topographic map elevation and location control.

Geological relations and age.—The Virginian Ridge formation, resting unconformably on the eroded Newby formation and grading into the overlying Winthrop sandstone, has been sharply folded into a series of anticlines and synclines trending roughly N. 30 W. which can be followed into the High Cascades. The folds are broken by minor thrust faults trending the same direction as the folds and by cross faults nearly at right angles to the regional strike.

The only fossils discovered in the Virginian Ridge formation were found at the top of the basal conglomerate facies in outcrops on the hill east of Patterson Lake, 3 miles S. 65 W. from Winthrop. Two collections have been made. The fossils collected in 1941 were examined by Dr. Ralph Stewart of the United States Geological Survey. The preservation is very poor, but he was able to list the following partially identified forms: *Trigonia* sp. cf. *T. evansana* Meek; *Trigonia* sp. cf. *T. leana* Gabb; ?*Etea angulata* Packard (as *Meretrix*); ?*Trigonarca* sp.; *Venerid* sp.; *Turritella* sp.; ?*Cyclothyris* sp.

Another collection was made in 1946 from the same locality. Dr. W. P. Popenoe of the University of California at Los Angeles was able to recognize the following similarities: *Trigonia* sp. cf. *T. evansana* Meek; *Trigonia* sp. cf. *T. leana* Gabb; *Trigonia* sp. cf. *T. maudensis* Whiteaves; *Trigonia* sp. cf. *T. diversicostata* Whiteaves; *Turritella* sp.; *Cucullaea* sp. cf. *C. ponderosa* Whiteaves. The material is admittedly poor and the specific identifications uncertain, but the fauna suggests a Cretaceous age, probably not older than Middle Cretaceous.

The Virginian Ridge lithology has been traced northwest for 27 miles to Harts Pass on the Cascade Crest where cephalopods were collected by the author from near the top of the section as exposed in road cuts a few hundred feet east of the pass. The cephalopod-bearing beds are approximately 10,000 feet stratigraphically above the *Trigonia* beds, and underlie approximately 2000 feet of light colored arkose in the Harts Pass area. Professor S. W. Muller of Stanford University has examined the fossils. Several specimens are too fragmentary for identification, but one can be identified as belonging to the genus *Puzosia*, very similar to some of the Albian species such as *P. mayorianana* (D'Orbigny) or *P. sharpei* Spath. Numerous fragments and several almost complete specimens of the genus *Hamites* collected from the same outcrops further support the Albian age of these beds.

The Virginian Ridge formation is thought to be correlative with the lower part of the section exposed in the vicinity of Harts Pass (Crater Pass) and the old mining town of Barron. These rocks were named the *Similkameen system* by Russell (1, p. 114). Subsequently, Smith and Calkins (6, p. 28) proposed the name *Pasayten formation* for these rocks which they first encountered near the Canadian border. Daly (7, p. 479) modified the title to *Pasayten series* for the twenty-mile section of Cretaceous rocks exposed between the Pasayten River and Lightning Creek along the Forty-ninth Parallel, dividing the series on the basis of lithology into twelve members from east to west. He designated the members by letters from *A* to *L*, the former being the oldest member. Cairnes (4, p. 55) found evidence that Daly's upper member *L* is in reality older than the other members and separated from them by a fault. He named the rocks corresponding to Daly's *L* member the *Dewdney Creek series* of Jurassic(?) or possibly Lower Cretaceous age.

Rice (5, p. 18), in his recent mapping, found fossils in the upper members of Daly's Pasayten series and includes all these members (*C* to *L*) west of Chuwanten Creek (Chuchuwanten of Daly) in the Dewdney Creek group, which he considers of Jurassic(?) and Lower Cretaceous age. He retains the name *Pasayten group* for the section east of Chuwanten Creek consisting mainly of grit and shale (the *B* member of Daly) and which he considers younger than the Dewdney Creek group but of Lower Cretaceous age. Rice points out the considerable difference in lithology between the Dewdney Creek and the Pasayten groups, the latter consisting mainly of grit and shale, while the former is argillite, conglomerate, grit, tuff, and volcanic breccia. In view of the fact that just such a difference exists in the Methow quadrangle between the Winthrop and the Virginian Ridge formations, it is thought that the Virginian Ridge formation of the Methow quadrangle is probably the southeastern extension of the upper part of Daly's section, now called the *Dewdney Creek group* by Cairnes and Rice, but the fossil evidence in the sections studied by the author points to a Cretaceous rather than a Jurassic(?) age for these beds.

WINTHROP SANDSTONE

Occurrence and composition.—The name *Winthrop sandstone* was given by Russell (1, p. 117) to nearly white massive arkosic sandstones and light gray sandy shales outcropping on the north border of the Methow Valley, 5 miles northwest of Winthrop. Russell estimated the thickness to be 2000 feet. The beds were said to strike N. 20 E. and dip 80° E. There was evidently an

error in printing; the beds dip 75–80° W. The type locality lies just north of the border of the Methow quadrangle and the southern continuation of these arkosic sandstones can be found on the north side of Virginian Ridge which forms the south side of the Methow Valley. Similar arkoses can be mapped in the northwest trending folds from which the type section is separated by faults of minor stratigraphic displacement. These beds have a stratigraphic thickness of 2500 feet.

The fresh rock of the Winthrop formation is commonly greenish gray to mottled greenish arkose which weathers to light buff or white. The grain size varies in the different beds from fine sand to pebbles up to 1/2 inch in diameter, although lenses of the latter are rare. Thin shaly partings emphasize the cross bedding which characterizes the formation. Beds vary in thickness from a few inches to 10 to 12 feet. Some of the thick beds are separated only by very thin partings of shale; the outcrops formed by several of these beds are massive and attitudes are obtained with difficulty if at all. Because of its highly feldspathic nature, hand specimens of the arkose have been mistaken by students for fine-grained granitic rocks. Under the microscope, quartz and altered feldspar are seen to be present in about equal amounts. Muscovite, biotite, chlorite derived from biotite, and occasionally hornblende are present in minor amounts. Fragments of chert and volcanic rock are present in relatively minor amounts in the lower and middle portions of the formation, but the volcanic debris becomes more important in the upper beds as the Winthrop grades into tuffaceous beds of the overlying formation.

Geologic relations and age.—The Winthrop sandstone rests conformably upon the Virginian Ridge formation and is overlaid with apparent conformity by the thick series of andesitic tuffs, breccias, and flows of the Midnight Peak formation.

Plant fossils were collected by Russell from the shales at the type locality of the Winthrop and were identified by Knowlton, who correlated them with the forms described from the Upper Cretaceous of Greenland (1, p. 117).

Supplementary collections were made by the author in outcrops behind the old school house on the Boesel Ranch, approximately seven miles from Winthrop on the Harts Pass road. This is the type locality referred to by Russell. Dr. Roland W. Brown of the United States Geological Survey identified the fossils as follows: *Anemia* cf. *supercretacea* Hollick; *Cladophobis* sp.; *Gleichenites* cf. *geiseckiana* Heer; *Pseudocycas steenstrupi* Heer; *Cyparissidium gracile* Heer or *Sequoia fastigiata* Heer; *Menispermites* sp. or *Nelumbium* sp.,

?palm fragment and fragments of dicotyledons. Leaves collected from an outcrop of arkose on the ridge 2 miles due north of Bench Mark 2806, Twisp River road, Methow quadrangle were also identified by Dr. Brown as: *Cladophobis* cf. *septentrionalis* Hollick; ?*Sapindopsis* sp., and other fragments of dicotyledons. Both collections, in the opinion of Dr. Brown, indicate Upper Cretaceous age; but because the species in most cases are not clearly defined, no closer evaluations can be made at this time. Closely comparable, if not identical, species have been described from the Cretaceous of Western Greenland, and the Upper Cretaceous of Alaska. The arkose in the Twisp River drainage occupies the same general position in the section as does the Winthrop sandstone at the type section.

The Winthrop sandstone is the only thick arkose section outcropping in the Methow quadrangle and most closely resembles the arkose described by Daly (7, p. 480) as the oldest sedimentary member (B) of the Pasayten series. Penhallow (7, p. 487) considered the plant fossils collected by Daly from two localities in Member B to give evidence of both a Lower and Upper Cretaceous age (Shasta-Chico). Daly accepted the Upper Cretaceous age.

MIDNIGHT PEAK FORMATION

Occurrence and composition.—The major synclines of the northwest part of the Methow quadrangle and of the area to the northwest have as their upper exposed beds a thick series of andesitic tuffs, breccias, and flows. Midnight Peak, the highest point on a northwest trending ridge lying between the Twisp River and its tributary, Canyon Creek, is eroded from the south limb of a major syncline involving this andesitic series. Rocks of similar lithology outcrop on both sides of the Methow River at Twisp and also from Goat Wall and Goat Peak on the north side of the Methow River near the town of Mazama.

A distinctive red siltstone, tuffaceous sandstone, and pebble conglomerate forms the lowest member of the Midnight Peak formation and is exposed in the Bridge Creek tributary of the Twisp River. The thickness of the member here is approximately five hundred feet. The rocks are near the vertical but good outcrops of the underlying Winthrop sandstone can be found conformably beneath the red tuffaceous deposits. The red sediments have not been found on the southwest side of the Midnight Peak syncline, but dark tuffs and breccias directly overlie the light weathering Winthrop arkosic sandstone.

The breccias and flows above the basal tuffs and sandstones are dark gray to green in color with fragments of red and purple porphyritic rocks emphasize

ing the dominance of brecciated volcanics over flows. The whole series is now well consolidated and makes such massive outcrops that attitudes are not possible above the basal sediments. Epidote veinlets cut the rocks, and epidote also appears as a coating on slickensided joints where the volcanic series has fractured in adjusting to the tight folding, but the rocks are not highly metamorphosed.

Under the microscope, the feldspars are usually saussuritized, and the dark minerals changed to a mat of chlorite and other alteration products. There are preserved, however, sufficient phenocrysts of both feldspar and dark minerals to designate the rocks as flows and breccias of hornblende andesite.

The rocks of the Midnight Peak formation are estimated to be over 8000 feet thick in the Methow quadrangle. Comparable thicknesses have been found in the synclines to the northwest.

Geological relations and age.—The eroded Midnight Peak formation, occupying the troughs of the major synclines, characteristically forms the highest peaks in the area. The gradational nature of its contact with the underlying Winthrop sandstone indicates that deposition did not cease, but that with the incidence of large-scale volcanism andesitic materials displaced the weathered granitic debris entering the basin of deposition.

The red tuffaceous sandstones and shales at the base of the formation were named by Russell the *Ventura* and tentatively assigned to the Juratrias(?) on the basis of red color. The studies of the author convince him that the Midnight Peak sediments and volcanics are younger than the plant-bearing Winthrop sandstone of Upper Cretaceous age. Since no unconformity is recognized between the Winthrop and the Midnight Peak formations, the Midnight Peak is assigned to an Upper Cretaceous age until evidence to the contrary is found.

Daly (7, p. 484) described as member C of the Pasayten series 600 feet of red argillaceous sandstones, grits; gray feldspathic sandstones, and gray, red, and green conglomerates overlying member B, the thick arkose section. Daly found no volcanics in this part of the section, but Rice (5) has mapped at the top of his Pasayten group, north of the section mapped by Daly, a member consisting mainly of purple, lava, tuff, and breccia. The volcanic section is cut out north of the boundary by the Chuwanten fault and would not have been seen by Daly. The sequence arkose, redbeds, and volcanics of the revised boundary section coincides, lithologically, with the Methow section of Winthrop sandstone overlaid by the red beds and volcanic Midnight Peak formation, and strengthens the author's conviction that the plant-bearing arkoses of the Methow and the boundary section are correlatives.

PIPESTONE CANYON FORMATION

Occurrence and composition.—Approximately five miles northeast of Twisp there is exposed in the walls of Pipestone Canyon a series consisting of arkose, shale, and conglomerate overlying an eroded coarse-grained dark granitic rock. Vertical jointing in the gently dipping sediments controls weathering and erosion to form a striking topography that gives the name to the canyon. This sedimentary section is repeated three times in a series of fault blocks. One of the blocks makes the bold cliff seen from the highway on the east side of the Methow River two miles north of Twisp. The type locality, however, is considered to be in Pipestone Canyon.

The basal member of the Pipestone Canyon formation at the type locality is a poorly sorted conglomerate of fairly well rounded pebbles and boulders varying in diameter from a fraction of an inch to over 12 inches. The bulk of the material is seldom over 6 inches in diameter. The conglomerate consists of quartz, chert, light gray felsite, and light-colored granitic fragments in a matrix of arkose, and is in a massive bed approximately 20 feet thick. The succeeding sandstone is light gray to buff in color in beds from 6 inches to 4 feet thick interbedded with siltstone beds from 6 inches to 8 inches thick. These beds are often tinged with purple and contain carbonized plant remains. The upper portion of the formation is shaly and makes poor outcrops, but there is sufficient evidence to show that there are approximately 2300 feet of section preserved at the type locality.

Geological relations and age.—The unconformity at the base of the Pipestone Canyon formation is exposed in each of three fault blocks. The sediments at the type locality overlie an eroded dark hornblende-biotite granitic rock; in the other two blocks the underlying rock is eroded andesitic breccia and associated volcanics which most closely resemble those of the Midnight Peak formation.

No recognizable fossils have been found, but doubtful Tertiary(?) age is assigned to the Pipestone Canyon formation on the basis of its unconformable relation with the Midnight Peak volcanic rocks.

CONCLUSIONS

The great thickness of dark colored siltstones, graywackes, tuffs, breccias, and conglomerates outcropping in the Methow quadrangle indicate that this part of the Mesozoic basin of sedimentation derived most of its sediment from a non-granitic terrane. It was not until Upper Cretaceous time that the batholithic

masses were de-roofed and arkosic debris contributed to form the Winthrop sandstone. The andesitic volcanic series of tuffs, flows, and breccias which conformably succeed the arkose represents a later phase of sedimentation in the basin prior to the tight folding, faulting, and uplift which took place in the early Tertiary.

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