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HENRY LANDES, State Geologist

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The Mineral Resources of Stevens County

By CHARLES E. WEAVER

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LETTER OF TRANSMITTAL.

Governor Louis F. Hart, Chairman, and Members of the Board of Geological Survey.

GENTLEMEN: I have the honor to submit herewith a report entitled "The Mineral Resources of Stevens County," by Charles E. Weaver, with the recommendation that it be printed as Bulletin No. 20 of the Survey reports.

Very respectfully,

HENRY LANDES,
State Geologist.

University Station, Seattle, December 1, 1919.

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INTRODUCTION.

LOCATION AND AREA OF THE REGION.

Stevens County, located in the northeastern corner of Washington, has an area of approximately 2,493 square miles. It has an average width of about 32 miles and a length north and south of 84 miles. It is separated from Ferry County on the west by Columbia River for a distance of over 50 miles and by Kettle River for a distance of 25 miles. The approximate crest of the divide between Columbia and Colville rivers on the west and the Pend Oreille on the east constitutes the eastern boundary of

FIG. 1. Index map of Washington, showing (by shading) location of area covered by this report.

the county with Pend Oreille and Spokane counties. The southern boundary of the county is determined by Spokane River and the northern by the international boundary at the forty-ninth parallel of latitude.

The eastern boundary of the county is approximately 117° 30′ west longitude and the western boundary ap-

proximately 118° 15′ west longitude. The southern boundary is about 47° 50′ north latitude. The county includes Tps. 27 to 40 N. and Rs. 35 to 42 E.

FIELD WORK AND ACKNOWLEDGMENTS.

The investigation of the geology and mineral resources of Stevens County was begun on June 14, 1914, and field work was carried on continuously until September 15 of the same year. Field work was again resumed on June 15, 1917, and continued until October 1 of the same year. Portions of the winter months during the years 1914-18 were devoted to a study of the rocks and ores of the county in the laboratories of the State Geological Survey and in the preparation of this report.

During the summer of 1914 the field work was confined to an investigation of the ore deposits in the Chewelah, Orient, Myers Falls, and Metaline mining districts. An effort was made to examine each mine and prospect within these districts and to determine the origin and relations of the ore deposits. During the summer of 1917 an attempt was made to areally map the geology of the county in as accurate a manner as time would permit. An examination was made at this time of the mines and prospects in the Deer Trail, Northport, and Fifteen-Mile Creek districts, as well as other ore deposits scattered through the county.

Many claims within the county have not been worked for several years and others have been abandoned; and some claims may have been overlooked unintentionally. A number of mines and prospects in which considerable development has been done in the past, but which have been idle in recent years, are more or less caved and inaccessible. In such cases only a surface examination of the rock formations and ore deposits has been possible.

No topographic maps have as yet been made within Stevens County. A base map of the county has been

constructed upon a scale of one-half inch to the mile, and upon this the areal distribution of the several formations has been outlined. Much of the area within the county is heavily covered with deposits of glacial drift which often completely conceals the underlying bed rock. Wherever the evidence warranted it, the pre-glacial formations have been given preference in mapping. The contact lines between the formations as indicated upon the map in many places have been drawn with considerable exactness. In other areas, which at present are of little economic importance, these contact lines are more or less generalized.

The writer was assisted in the field work during portions of the summer of 1914 by F. M. Handy and H. W. Smith, and during a part of the season of 1917 by R. R. Hornor, Olaf Stromme, and Virgil Kirkham. The writer wishes to extend his sincere thanks to the many gentlemen interested in the mining industry who have rendered aid and cooperation in carrying out this investigation.

BIBLIOGRAPHY.

1884. Bauerman, H. Report on the Geology of the country near the forty-ninth parallel of north latitude, west of the Rocky Mountains, from observations made in 1859-1860. Geological and Natural History Survey and Museum of Canada, Reports and Maps of Investigations and Surveys.

The field work upon which this report is based was carried on in connection with the Boundary Commission Expedition of 1859-61. A reconnaissance survey was extended over the trails both north and south of the present international boundary, from the Gulf of Georgia eastward to Montana. A brief description is given of the formations encountered in Stevens County from the international boundary southward to Spokane River. The gneisses along Kettle River are described and referred

in age to the Archean. The metamorphosed sedimentary rocks occurring from Kettle River southeasterly to Colville Valley and along the Columbia River to the Spokane are referred to and a generalized cross-section is outlined. Bauerman regarded these formations as Paleozoic in age. The intrusive granites and dike rocks southeast of Colville are described, as well as the basalts in the southern portion of the county near Spokane River. This report was not published until 1884.

1891. Bethune, George A. Mines and Minerals of Washington. First Annual Report of State Geologist, pp. 25-26, 76-85.

This report includes a brief description of several mining properties within the county and notes concerning their development.

1896. Burdsal, C. W. Cedar Canyon Mining District. Mining, Volume 1, pp. 191-192.

This article was written shortly after the opening of the Cedar Canyon or Deer Trail mining camp. The country rock is described as granite, syenite, and quartzite, which are cut by fissure veins, standing nearly vertical, and having a northeast and southwest course. The ores are said to be a fine-grained galena carrying copper and sulphurets of silver.

1897. Hodges, L. K. Mining in the Pacific Northwest. Seattle, pp. 105-116.

This report describes several of the mines in the different districts and is of value chiefly in connection with the early history of mining in the county.

1901. Salisbury, Rollin D. Glacial Work in Western Mountains. Journal of Geology, Volume 9, pp. 718-731.

This report gives the results of field work carried on by Messrs. George H. Garrey and Eliot Blackwelder in northeastern Washington, Montana and Idaho. In Stevens County the moraine of the ice lobes which occupied Columbia and Colville River valleys are outlined.

One ice lobe occupied Columbia River valley from its junction with Spokane River, northward to Kettle Falls. East of Gifford, at about latitude 48° 15′ it crossed the Huckleberry Range and united with the ice lobe which occupied Colville Valley from Springdale on the south to Old Dominion Mountain on the north. A lobe from the Colville glacier is believed to have extended across the Pend Oreille Mountains at approximately latitude 48° 35′ N.

1902. Thyng, William S. The Metalliferous Resources of Washington, except Iron. Washington Geological Survey, Annual Report for 1901, Volume 1, pp. 8-12.

This report describes the mines and ores in the Cedar Canyon district of Stevens County.

1902. Landes, Henry. Metalliferous Resources of Washington, except Iron. Washington Geological Survey, Annual Report for 1901, Volume 1, Part 2, pp. 4-8.

A brief description is given of the broader topographic and geologic characteristics of the county, and an account of the more important mines in the Northport, Myers Falls, Flat Creek, Colville, Chewelah, and Springdale mining districts.

1902. Landes, Henry. Non-Metalliferous Resources of Washington, except Coal. Washington Geological Survey, Volume 1, Part 3, pp. 10-12, 23, 28.

A brief description is given of the limestone quarries at Valley and Springdale and the clay plant at Clayton.

1902. Shedd, Solon. The Iron Ores of Washington. Washington Geological Survey, Annual Report for 1901, Volume 1, pp. 17, 36-39.

This report includes a brief discussion of limonite and hematite ores in the Clugston Creek and Valley areas. A description is given of the several mines and prospects, with chemical analyses of the ores.

1903. Shedd, Solon. Building and Ornamental Stones of Washington. Washington Geological Survey, Volume 2, Annual Report for 1902, pp. 32, 48, 51-54, 83, 132.

The limestones of Stevens County are described, as well as their distribution and utilization. A description is given of the tufa occurring near China Bend, on the Columbia River. A microscopic examination was made of the rock by J. P. Iddings, who pronounced the rock a dacite tuff.

1903. Clarke, Frank Wigglesworth. A pseudo-serpentine from Stevens County, Washington. American Journal of Science, Fourth Series, Volume 15, pp. 397-398.

This report gives the laboratory results of a rock which to the unaided eye appeared to be ordinary yellowish-green serpentine. Chemical and petrographical analyses were made and the rock was found to be not serpentine, but rather a mixture of four minerals, including hydromagnesite, brucite, clinochlore and serpentine.

1905. Eckel, Edwin C. Cement Materials and Industry of the United States. United States Geological Survey, Bulletin No. 243, pp. 324-325.

Crystalline limestone or marble is described as occurring in Stevens County and of probable Carboniferous age. Mention is made of the high content of magnesium carbonate in many of the samples.

1906. Rathbun, J. C. Marble in the Northwest. Mining World, Volume 24, No. 14, p. 441.

This article is of a generalized character and reference is made to the occurrence of crystalline limestones in Stevens County which are quarried for marble.

1906. Leith, Charles Kenneth. Iron Ores of the Western United States and British Columbia. United States Geological Survey, Bulletin No. 285, p. 195.

In this report deposits of limonite and martite are described as occurring in association with limestone and

igneous rocks at several localities in Stevens County. A possible genetic relation to diorite intrusives and andesite extrusives is suggested.

1906. Landes, Henry. Cement Resources of Washington. United States Geological Survey, Bulletin No. 285, pp. 381-383.

This report contains a brief general statement concerning the general geology of the county. He states, "The rocks of the county are chiefly metamorphic in character, consisting mainly of limestone or marble, slate and quartzite. These have been greatly disturbed by folding, as well as by intrusions of granite, basalt and other igneous rocks." There is a brief discussion of the limestones and their relations to the manufacture of cement.

1907. Collier, Arthur J. Gold-bearing River Sands of Northeastern Washington. United States Geological Survey, Bulletin No. 315, pp. 56-70.

This paper deals primarily with the occurrence of placer gold in the gravels and sands along Columbia River. The foundations upon which the gravels rest, as well as those in the mountains to the east and west, are referred to as of probable Paleozoic age. Columbia River is thought to have flowed south over this area in the Tertiary epoch and to have had its course modified during the glacial epoch. The gold is believed to have been derived from veins in the metamorphic rocks in Stevens and Ferry counties.

1908. Ransome, Frederick Leslie. An Apatitic Minette from Northeastern Washington. American Journal of Science, Fourth Series, Volume 26, pp. 337-341.

This report gives the results of a petrographic and chemical examination of a dike rock occurring on the west side of Columbia River opposite Northport. The dike is described as being composed of a dark, greenish-gray rock, made up of crystals of biotite, pyroxene, apatite,

and titanite. The feldspar is orthoclase and the pyroxene augite, near diopside, in composition.

1910. Bancroft, Howland C. Notes on Tungsten Deposits near Deer Park, Washington. United States Geological Survey, Bulletin No. 430, pp. 214-216.

This paper describes the geology of certain tungsten deposits on Grouse Mountain, about six miles northeast of Loon Lake. The rock formation is described as being composed of quartz-mica schists, which have been intruded by granite. The tungsten ore is hübnerite in a quartz gangue, forming veins lying parallel to the bedding planes of the schist. With the mineral hübnerite is the mineral cosalite whose chemical composition is given. The deposits are thought to have been derived from waters which accompanied the intrusion of the granite rocks.

1910. Shedd, Solon. Clays of the State of Washington, their geology, mineralogy, and technology. Pullman, Washington. Published by the State College of Washington, pp. 198-212.

This report involves a discussion of the clays of the state, including those of Stevens County. Special attention is devoted to the clays occurring in the vicinity of Clayton. These clays are thought to owe their origin to the leveling of the granite and the deposition of the kaolin as clay mixed in with other impurities in the bodies of standing water. Mention is made of the clay deposits in Colville Valley, at Colville, Chewelah and Valley.

1911. Bancroft, Howland C. Lead and Zinc Deposits in the Metaline Mining District, Northeastern Washington. United States Geological Survey, Bulletin No. 470, pp. 188-200.

The Metaline district is situated in the extreme northwestern corner of Pend Oreille County. The foundations are a "thick series of dynamometamorphosed sedimen-

tary rocks composed essentially of shale and dolomite." These rocks are thought to be of Paleozoic age. They are the extensions of the metamorphic rocks which have been mapped in the northeastern part of Stevens County. Ore deposits in the form of irregular, disseminated replacements of lead and zinc occur in the dolomite. The mines and ore deposits of the district are described.

1911. Landes, Henry. Road Materials of Washington. Washington Geological Survey, Bulletin No. 2, pp. 168-178.

This report involves an investigation of the building stones of the state and their field occurrences. Those described from Stevens County are situated mostly along the line of the railway in the valleys of Colville and Columbia rivers. Exposures of granite, quartzite, schist and basalt are described and their relative values for road metal discussed.

1912. Stiles, A. H. Deer Trail Mining District. Northwest Mining News, Volume 8, No. 2, pp. 15-16.

This is a short general article concerning the mines in the Deer Trail Mining District. The ores are said to be composed of "High grade silver ore of a siliceous character, containing small amounts of lead and zinc as sulphides. The surface ore contains chloride of silver."

1912. Hill, James M. Mining Districts of the Western United States. United States Geological Survey, Bulletin No. 507, pp. 41-42, 285-287.

In this report the several mining districts in Stevens County are enumerated and descriptions given of the types of veins present and the general character of the country rock.

1912. Daly, Reginald A. Geology of the North American Cordillera at the Forty-ninth Parallel. Department of Mines, Geological Survey of Canada, Memoir No. 38, Parts 1, 2 and 3, pp. 1-940.

This report deals with the geology of a belt about 10 miles wide on the Canadian side of the international boundary, with some discussion of the formations immediately south of this line. It is a very comprehensive report and has a direct bearing upon the geologic problems in Stevens County.

1913. Weaver, Charles E. Geology and Ore Deposits of the Covada Mining district, Washington. Bulletin No. 16, Washington Geological Survey, pp. 1-87.

The area involved in this report is in Ferry County but it borders on the Columbia River about midway between the north and south ends of Stevens County. The formations are of the same general character, including Paleozoic metamorphic sedimentary rocks which have been intruded by granites.

1914. Shedd, Solon. Cement Materials and Industry in the State of Washington. Bulletin No. 4, Washington Geological Survey, pp. 120-162.

This paper gives the results of a field and laboratory examination of the lime and clay deposits of the state, including Stevens County, and their availability for the manufacturing of Portland cement. A short discussion is given concerning the geology of the county and a detailed description of the more important limestone, clay, and shale deposits, together with chemical analyses of the same.

1914. Bancroft, Howland. The Ore Deposits of Northeastern Washington. United States Geological Survey, Bulletin No. 550, pp. 51-133.

This report involves a discussion and description of the ore deposits and the local geology of the more important mines in Ferry, Stevens, and Pend Oreille counties. The Orient, Chewelah, Northport and Deer Trail mining districts are described, each as a unit, as well as several of the scattered mines and prospects. The local

geological conditions in each district are described as well as a detail of each of the more important mining properties. Formations of Pre-Cambrian, Paleozoic, Mesozoic, Tertiary and Quaternary ages are recognized. These are cut by intrusive and extrusive igneous rocks. A grouping or classification of the ores is given. The ores in the Orient district are described as being associated mainly with volcanic formations of Tertiary age, while those of the Northport, Chewelah and Deer Trail districts are chiefly in the Paleozoic metamorphic formations.

TOPOGRAPHY AND GEOGRAPHY.

GENERAL STATEMENT.

In order to describe the topography of the area involved in Stevens County it becomes necessary first of all to designate its relations to the topographic provinces of the Cordillera in the vicinity of the forty-ninth parallel.

The mountains which compose the western part of North America and which extend from the western limits of the Great Plains of the Mississippi Basin as far as the Pacific Ocean, are referred to as the Cordilleran system, or Cordillera.[1] Upon a purely topographic basis the Cordillera are grouped into a series of mountain systems which have a prevailing north and south trend and which are separated one from the other by elongated topographic depressions which have been referred to by Daly[2] as trenches. The term is used in a broad sense and includes subdivisions which have been designated as ranges and mountains. The mountain grouping which has been so carefully worked out and described by Daly[3] is adopted as the basis of classification in this report.

SUBDIVISIONS OF THE CORDILLERA.

On the basis of their topographic features the mountains of the Cordillera in the vicinity of the forty-ninth parallel fall into three broad divisions. A series of broad and somewhat rugged elevated plateaus trending north and south lies between two more highly elevated mountainous areas on the east and west. This middle area has been termed the Inter Plateaus province. To the south of the forty-ninth parallel and south of the Columbia River it becomes confluent with the Columbia Lava plateau.

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(1) Daly, R. A., Geology of the North American Cordillera at Forty-ninth Parallel, Department of Mines, Geological Survey of Canada, Memoir No. 38, p. 22, 1912.

(2) Idem, p. 25.

(3) Idem, pp. 23-43.

To the west of the Interior Plateaus Belt and trending parallel to it lies the Coastal system of mountains. This system includes the Cascade Range of Washington, the Vancouver Range, the Olympic Mountains and the Coast Range of British Columbia. The Interior Plateaus Belt is separated on the east from the Rocky Mountains system by a broad intermontane depression which has been referred to by Daly as the Rocky Mountain trench. This trench is occupied at the present time by several promi-

FIG. 2. Map of Northern Washington and Southern British Columbia, showing subdivisions of the Cordillera.

nent river valleys. Among the more important of these rivers are the headwaters of the Kootenai, Columbia and Fraser. South of the forty-ninth parallel and for some distance to the north three composite mountain systems lie between the Inter Plateaus Belt and the Rocky Mountain system. These mountain systems from west to east are termed the Columbia system, the Selkirk system and the Purcell Range. They trend approximately north and south and are *en axe* with the Rocky Mountain system

along the Rocky Mountain trench. These three systems are separated from one another by well marked erosion-troughs which are occupied by portions of several valleys.

The Selkirk system is limited on the east by the Purcell trench, in which lies Kootenai Lake and a portion of Kootenai River. Its western limit is the Selkirk Valley which contains the Columbia River. On the south it extends into Washington as far as the Columbia Lava plateau and into Idaho to Pend Oreille Lake. It may also possibly be regarded as confluent with the Cour d'Alene Mountains of Idaho.

The Columbia system has for its eastern boundary the Selkirk Valley as far south as the junction of the Columbia and Spokane rivers. On the south it is limited by the Columbia Lava plateau and on the west by the interior plateaus.

RELATION OF THE MOUNTAINS IN STEVENS COUNTY TO THE SUBDIVISIONS OF THE CORDILLERA.

The area within Stevens County lies partly within the Selkirk system and partly within the Columbia system. Each of these systems includes subordinate ranges of mountains which are separated by erosion-troughs. North of the northern limits of Stevens and Pend Oreille counties in Washington, and north of Idaho, a subordinate trench runs north and south through the Selkirk system and is occupied by Salmon River. The portion of the system lying east of the trench is designated as the Nelson Range and that on the west as the Bonnington Range. That division of the Columbia system situated between the lower Kettle Valley and Columbia River is termed the Rossland Mountains.

The portion of Stevens and Pend Oreille counties bounded on the east by Clark Fork, on the west by Columbia and Colville rivers, and on the south by the Columbia Lava plateau and on the north by Pend Oreille River, may be designated as the Pend Oreille Mountains.

The mountains lying between Colville River on the east, Columbia River on the west, and the Columbia Lava plateau on the south constitute a definite topographic unit known as the Huckleberry Mountains.

Of the minor topographic divisions of the Selkirk and Columbia systems, Stevens County includes all of the Huckleberry Mountains, a small portion of the Columbia Lava plateau in the southern part of the county, and considerable portions of the Pend Oreille and Rossland Mountains.

RELIEF.

For the purposes of description, the topography of Stevens County may be grouped into seven divisions: (1) The Pend Oreille Mountains, (2) The Spokane Plateau, (3) The Huckleberry Mountain range, (4) The Columbia-Kettle River valley, (5) The Colville-Chamokane valley, (6) The Spokane River valley, and (7) The Rossland Mountains.

PEND OREILLE MOUNTAINS.

These mountains lie between Clark Fork on the east and the Colville-Chamokane and upper Columbia valleys on the west. They trend in a southerly direction from the forty-ninth parallel to the southern third of the county where they merge into the Spokane Plateau, which is a local northern extension of the Columbia Lava plateau. The crest or divide of this mountain range lies approximately along the eastern boundary of the county, but crosses back and forth several times into Pend Oreille County. The average elevation along the summit varies from 5,000 to 5,500 feet. The most prominent elevations on this divide are Chewelah Mountain, which has an elevation of 5,743 feet, and Calispell Peak, which is 6,905 feet high. Almost the entire western slope of these mountains, which are rugged and heavily timbered, lies within Stevens County. They are traversed by several westerly-flowing streams which have carved out deep

narrow valleys, but which during the Quaternary epoch were partly filled with deposits of glacial drift. North of the junction of Stevens, Spokane and Pend Oreille counties the crest of the Pend Oreille Mountains divides and one arm swings to the southwest past Deer Lake and Loon Lake and crosses the Colville-Chamokane erosional trough and forms the divide between the heads of these streams. From this locality it extends westerly and merges into a southeastern extension of the Huckleberry Mountains. This spur attains an elevation of 4,000 feet, but at Loon Lake a pass at an elevation of 2,400 feet separates it from the main divide.

SPOKANE PLATEAU.

This plateau is a portion of the northern extension of the Columbia Lava plateau. It possesses a level to undulating surface and has an average elevation of 2,000 feet. The areal extent of this plateau is approximately coextensive with the northern distribution of the so-called Columbia River basalts. The basaltic flows are nearly horizontal and deeply covered with glacial gravel and sand. Where the streams have cut down through these rock formations there are perpendicular bluffs of lava. The Spokane Plateau occupies portions of the southern fifth of the county in the form of tongues extending northerly across Spokane River. One of these areas lies in the southeastern corner of the county and is bounded by Spokane River on the south, the Spokane-Stevens county line on the east, the western spur from the Pend Oreille Mountains on the north and a subordinate spur of this same range on the west. A second area occupies the eastern portion of the Spokane Indian Reservation. It has as its eastern limit the Chamokane Valley, its southern, Spokane River, its western the southern extension of the Huckleberry Mountains and its northern the spur extending from the Pend Oreille Mountains westerly to the Huckleberry Mountains. Remnants of

this plateau occur farther north on the east and west sides of Colville Valley as far as the town of Valley.

HUCKELBERRY MOUNTAINS.

These mountains constitute a very important topographic feature of the western portion of the county. They are bounded on the west by Columbia River valley, on the east by the Colville-Chamokane Valley, on the north by the lower portion of Colville Valley, and on the south by Spokane River and the Spokane Plateau. The mountains average ten to twenty miles in width and have a prevailing north and south trend for a distance of approximately 55 miles. They are steep and rugged with sharp ridges and are usually heavily timbered. The average elevation of the crest of the range is about 4,500 feet. The highest point within the range is Stensgar Peak at an elevation of 6,200 feet. Dunn Mountain in the north central portion of the range has an elevation of 5,200 feet and Rice Mountain an elevation of 5,494 feet. The summit of the range is crossed by several passes varying in elevation from 3,200 feet to 4,200 feet. The eastern slopes of the mountains, toward the Colville-Chamokane Valley, are nearly twice as long as those on the western side of the summit toward Columbia River. The elevations along Columbia River valley average 500 feet lower than in the Colville-Chamokane Valley and the grades of the westerly flowing streams are accordingly much steeper.

ROSSLAND MOUNTAINS.

Within the state of Washington the Rossland Mountains form a triangular-shaped area limited on the south and east by Columbia River, on the west by Kettle River and on the north by the forty-ninth parallel. In the vicinity of the international boundary they are rugged and attain an elevation of about 5,000 feet. This elevation gradually decreases toward the south and at the

Topography along Columbia River near Bissell.

junction of the Kettle with Columbia River it is only 1,260 feet. The area has been deeply dissected by several streams which have excavated narrow and deep valleys with steep grades. The outer borders of these mountains along Columbia and Kettle rivers are marked with terraces representing former stages of elevation of the two rivers.

COLUMBIA-KETTLE VALLEY.

Columbia River lies in the Selkirk Valley trench which has been described as separating the Selkirk system of mountains from the Columbia system. This valley is conspicuously narrow for the size of the stream which is draining it. Columbia River crosses the middle portion of the northern boundary of the county from British Columbia and extends in a southwesterly direction across the northern part of the county to the junction with Kettle River. From this place it flows southerly to its junction with Spokane River and forms the western boundary of the county. The valley is narrow and in many places along the river there are steep cliffs partly formed in

View near Rock Cut, looking across Kettle River.

glacial drift and partly in the igneous and metamorphic rock formations. Bordering the river and extending up into the foothills of the western slopes of the Huckleberry Mountains are a series of terraces somewhat discontinuous and varying in width from one-half to over four miles. The surfaces of the terraces possess a very gentle slope and are covered with alluvium. Projecting upward above the floors of the terraces are ridges and knolls which were a part of the uneven topography upon which the glacial and valley alluvial materials were deposited. Numerous westerly trending valleys lie on the western slope of the Huckleberry Mountains and some of the higher alluvial terraces extend into these valleys for considerable distances.

The total length of Columbia Valley within the county is over 100 miles. Its elevation at the forty-ninth parallel is approximately 1,354 feet and at the junction with Spokane River about 1,050 feet. The floor of the valley over which the river flows is partly composed of sand and gravel and partly of the older igneous and metamor-

phic rocks. Where the river encounters the latter there is often a series of rapids.

From Marcus northerly the valley in which Kettle River lies forms the western boundary of the county. This valley is narrow and semi-arid. The elevation of Kettle River at Laurier, at the forty-ninth parallel, is about 1,644 feet, while 27 miles to the south, at the junction of this stream with the Columbia, the elevation is 1,260 feet. Kettle River is rather swift and the mountains on either side rise rather rapidly to elevations varying between 4,000 and 5,000 feet. Alluvial terraces occur at several elevations bordering the river but they are usually narrow and do not attain a width of over one and one-half miles.

COLVILLE-CHAMOKANE VALLEY.

The Colville and Chamokane rivers lie in a well defined erosional trough trending approximately north and south in a slightly sinuous course through the central portion of the county. The southern end of this trough merges into the Columbia Lava plateau near the junction of the Chamokane and Spokane rivers. About two miles north of Colville the trough divides. One branch in which a portion of the present Colville River lies, trends westerly to the Columbia River. The other branch extends nearly due north and joins the Columbia River valley near the town of Evans.

The floor of this trough varies from one to four miles in width, is nearly flat, and is filled with deposits of glacial drift and alluvium. Its width and size are out of all proportion to the size of the present rivers which drain it. The elevation of the floor of this trough at Long Lake on Spokane River is approximately 1,700 feet. It gradually increases northerly to within two miles of Springdale, where at an elevation of about 2,100 feet, it forms the divide for the drainage southward through Chamokane River and northward through Colville River.

The elevation of the floor of that portion of the trough occupied by Colville River gradually decreases until at Colville it is about 1,579 feet and at Kettle Falls, where it joins the Columbia, about 1,170 feet.

The sides of the valley are in places bordered by steep vertical cliffs, as in the case of the quartzite bluffs near Addy and Chewelah. Usually, however, there is a gradual upward slope dissected by lateral valleys of considerable size. Such lateral valleys are much narrower than the main north and south trough, but are usually deeply filled with glacial drift and alluvium. Their approximate level and often terraced floors are accordant with that of the Colville-Chamokane Valley.

The area lying to the west of the Colville Valley, north of Deer Mountain and east of the Huckleberry Range, is known as the north and south basin. These basins are deeply filled with glacial drift which extends even to the crest of Huckleberry Mountains. Within this area are several prominent rock hills projecting through the enormous deposits of glacial material which constitute the surface rock over the greater part of the basin.

The branch of the trough extending from Colville north to Evans is of the same character as the Colville Valley. At the present time it is occupied for a portion of its course by Clugston Creek.

DRAINAGE.

The entire drainage of Stevens County is ultimately into Columbia River. The more important streams through which this drainage is effected are the Colville, Kettle, Chamokane, Spokane and Little Pend Oreille rivers; Deep, Mill, Chewelah, and Clugston creeks and the Columbia River itself.

The eastern and southern slopes of the Rossland Mountains are drained directly to the Columbia River through Sheep, Nigger, Rattlesnake, Crown, Flat, and

Fifteen-Mile creeks. The drainage of the western slope of these mountains passes through Deep, Sand and Toulon creeks into Kettle River and thence into the Columbia River. These creeks all flow through narrow valleys and in most cases with relatively steep gradients.

The northeastern portion of the county is drained through Deep and Onion creeks directly into the Columbia River, and through Fish and Russian creeks indirectly to Clark Fork through British Columbia and thence to the Columbia. Deep Creek makes a big loop so that its head is within only a few miles of the Columbia.

The central and eastern portions of the county are drained to Colville River and thence to the Columbia. The streams effecting this drainage on the eastern side of the Colville River are Clugston Creek, the North, South and Middle forks of Mill Creek, the North and South forks of Chewelah Creek, the Little Pend Oreille River and several small streams southeast of Chewelah. Colville River also receives the drainage from the northern and eastern slopes of the Huckleberry Mountains, through Heller, Stranger, Deer, Smiths and Sherwood creeks. The Little Pend Oreille River is over 30 miles in length. The other tributaries vary from 8 to 25 miles in length, and flow through narrow valleys with moderate grades.

Chamokane River, which lies in the southern continuation of the erosional trough in which Colville River flows, receives the drainage of the south central part of the county and delivers it to Spokane River and thence to the Columbia. Its headwaters, consisting of several tributaries, rise in the higher portions of the eastern slopes of the Huckleberry Mountains. The stream flows eastward through Camas Prairie and upon reaching the main Colville-Chamokane trough, turns abruptly to the south about two miles south of the big bend in Colville River.

Lake at Bissell occupying glacial cirque basin.

The drainage on the western slopes of Huckleberry Mountains reaches Columbia River directly through Rickey, Quillascut, McGees, Stranger, Lake, Harvey, Hunters, Alder and Cottonwood creeks. These streams average from four to ten miles in length and descend with rather steep gradients through narrow valleys from the higher portions of Huckleberry Mountains.

The entire southern part of the county is drained into Spokane River. The more important streams which collect this drainage are the Chamokane, the Little Chamokane, Sand, and Blue creeks. The Little Spokane River, a tributary of the Spokane, receives the drainage from the southeastern corner of the county.

LAKES.

Lakes of any magnitude are strikingly absent within the county. Small lakes, of glacial origin, which are often too small to represent upon the map, are common in the more highly elevated portions of the county. Some of them, such as the Black Lakes east of Old Dominion

Mountain, occupy former glacial amphitheatres. Other lakes have been formed as the result of the damming of streams by deposits of glacial drift. Among the more important of these lakes are Deer, Loon, Pend Oreille, Pierre, Waits, Cedar and Turtle lakes. The largest of these do not exceed two square miles in area and for the most part owe their origin to the damming of glacial streams.

CLIMATE.

The low rainfall, characteristic of Washington east of the Cascades, stands in marked contrast with that on the western side. This is to be accounted for by the fact that the westerly winds from the Pacific Ocean are heavily laden with moisture and as they pass over the summit of the Cascade Mountains a large part of the moisture is precipitated upon the western slopes. These same winds which have been deprived of a considerable portion of their moisture are warmed as they pass over the Columbia Lava plateau which increases their capacity for absorbing moisture. As a result the precipitation in the eastern portion of the state is notably decreased. As these winds approach the mountains of the Columbia and Selkirk systems and the mountains of Idaho they are forced to rise, causing an increase in the humidity. As a result the precipitation in the mountains of Stevens County is greater than that characteristic of the Columbia Lava plateau, but not nearly so great as that west of the Cascade Mountains. As the winds are gradually forced over the Huckleberry and Pend Oreille mountains there is a gradual increase in precipitation which is represented by irregular belts trending north and south.

The total annual rainfall as measured at Colville ranges from 16 to 20 inches, and about two-thirds of this falls during the winter season. The average annual snowfall at Colville is about 40 inches, at Northport about

58 inches, and at Spokane 37.5 inches. A factor of note is the large number of clear days during the year.

The average temperature for the coldest months of the year at Colville is 21.9° and at Spokane 26.7°. That for the warmest month is 68.1° at Colville and 68.8° at Spokane. The highest temperature recorded at Colville is 103° and the lowest —29°. These extremes are uncommon.

The following table records the climatic data for some of the more important stations within the county:

Station	Elevation	Snowfall in Inches	Days With Rain of .01 in. or Over	Cloudy Days	Partly Cloudy Days	Clear Days	Average July Temperature	Average January Temperature	Average Last Killing Frost	Average First Killing Frost	Days Without Frost
Colville	1,579	40.4	91	138	64	164	68.1	21.9	June 3	Sep. 7	94
Northport ...	1,333	58.0	117	120	107	138	67.5	21.2	June 11	Sep. 9	90
Laurier	1,644	62.0	.....	185	68	112	.....	.....	May 4	Sep. 11	130

INHABITANTS AND INDUSTRIES.

The larger part of the population of the county is dependent upon agriculture and mining. The earliest settlements within the county were made by the Hudson Bay Company near Marcus in 1825. Until 1855 their interests were largely as hunters and trappers. Shortly after the discovery of gold in California prospectors extended their explorations far and wide and soon spread over portions of Stevens County. In 1859 Fort Colville, situated about three miles northeast of Colville, was built for protection to the settlers of the region from the Indians. Later on, home seekers came into this region and settled in the larger valleys. The most active settlement began after the opening of the reservation.

The present population of the county is approximately 25,279. It is scattered but for the most part confined to

the larger and more accessible valleys such as Colville and Columbia. The more inaccessible districts within the mountainous areas are sparsely settled.

The central portion of the county is connected with Spokane by the Spokane Falls and Northern Railway, a branch of the Great Northern Railroad, which enters the county from the south at Clayton and follows Colville Valley to Marcus where it branches. One branch follows Kettle River northward into Canada and back to Republic and the other continues up the Columbia River to Northport and thence on to Nelson, in British Columbia. No railroads at present exist along the Columbia River valley from Marcus southward to Lincoln County. This valley is served by long established mail and passenger stage lines which run from Myers Falls on the north to Davenport in Lincoln County on the south. At both terminals they connect with the railroads. Three well constructed state roads cross the Huckleberry Mountains and connect the towns along the Columbia River valley with the railroad along Colville Valley.

Among the more important towns is Colville, the county seat, with a population of 1,800. It is situated in the central portion of the county in Colville Valley. Northport, with a population of 2,000, is situated on the eastern side of Columbia River about seven miles south of the international boundary. The Northport smelter is located in this town and employed during the year of 1917 about 400 men. It is also a central point for the distribution of supplies to the surrounding mining camps and farming districts. Chewelah, with a population of 1,600, is the third largest town in the county and is situated in Colville Valley, about 22 miles south of Colville. It is also a base of supplies for several near-by mines as well as a large agricultural district. The town of Marcus is situated at the junction of Kettle and Columbia rivers and has a population of about 500. It is the junction of

Characteristic Topography along Columbia River between Daisy and Kettle Falls.

the Republic and Nelson branches of the Spokane Falls and Northern Railway.

Other smaller towns of considerable importance are Addy, Blue Creek, Myers Falls, Valley, Springdale and Loon Lake, all of which are situated along the line of the Spokane Falls and Northern Railway in Colville Valley. At Clayton, at the southeastern boundary of the county, there is an important brick and terra-cotta plant.

Orient, situated in the Kettle River valley, is a distribution point for the surrounding mining and farming district. Kettle Falls, Daisy, Gifford, Hunters and Fruitland are the more important towns along the Columbia River valley.

DESCRIPTIVE GEOLOGY.

GENERAL STATEMENT.

The rocks of Stevens County for purposes of description may be divided into five main groups. They consist of a very thick series of apparently conformable metamorphosed sedimentary rocks whose geologic age cannot be definitely determined because of total lack of fossil evidence. There are very large areas of batholithic igneous rocks of acidic and intermediate composition. A third group consists of a thick series of lavas, tuffs and interbedded sediments of Mesozoic and Tertiary ages. The fourth division is composed of acidic and basic intrusive dikes of probable Tertiary age. The fifth group consists of horizontally-bedded Quaternary deposits of poorly consolidated sands, gravels, clays and silts of glacial and fluviatile origin. All of these have been subdivided into 38 separate units for purposes of description and mapping. The boundaries of these units as represented upon the areal geological map accompanying this report are in many places very indefinite. The data upon which the contacts have been arbitrarily drawn is open to varying interpretations and future field studies may result in modifications not only in the locations of the contacts but also in the grouping of the several divisions of the metamorphic series.

SEDIMENTARY ROCKS.

Approximately three-fifths of the area of Stevens County is composed of metamorphosed sedimentary rocks. These have been invaded and in many places greatly disturbed by batholithic masses of granite, syenite and granodiorite. The metamorphosed sedimentary rocks consist of quartzite, argillite, calcareous argillite, slate, limestone, dolomitic limestone, and schist. These types often show great variations within themselves and they occur as rock outcrops in those areas of both low

and high relief although they are more common in the rugged mountainous districts. This is largely due to the fact that they have resisted erosional agencies much more efficiently than the granite masses. Large areas of the county are heavily covered with thick deposits of glacial drift and deep layers of soil so that wide stretches of the metamorphic rocks are concealed. Throughout the larger part of the county the metamorphic sedimentary rocks have a prevailing strike which ranges from a northerly to a northeasterly direction. The usual dip is persistently to the west and northwest and averages greater than 45°. The lithologic differences in the several units of this metamorphic series are usually not sufficient to render their distinction easy over wide distances. No fossils of either animals or plants have been collected from any of the metamorphic rocks within the county although fragments of such have been reported from a single locality. Neither erosional nor angular unconformities have been definitely determined at any place within the county. The total absence of fossils, unconformities, and lithologic characteristics of a definite nature anywhere within this thick series of metamorphosed sediments renders its separation into formations of definite geologic age almost impossible.

For purposes of description in this report the writer has been compelled to rely upon the evidence obtained by mapping the several lithologic units and an attempted interpretation of the geologic structure for subdividing this enormous thickness of sediments. The thickness which would result from the assumption that these metamorphic rocks consisted of a conformable monoclinal series of persistently westerly dipping strata occupying an area as wide as the county would be abnormal and even impossible. The explanation must be sought in terms of approximate strike faulting or in a series of parallel overturned folds. The possibilities for interpre-

tation under these conditions will be discussed in the following pages.

Considerable evidence exists for believing that the metamorphosed sedimentary rocks of Stevens County belong to a group and lie in a series of north to northeasterly trending overturned folds which have been deeply truncated by erosion. The axes of some of the folds are believed to be plunging and the structure as a whole is complicated by obscure faulting.

For purposes of description and mapping the metamorphosed sedimentary rocks of the county have been divided into 21 separate members. Eleven of these members, viz., the Deer Lake argillite, the Eagle Mountain quartzite, the Stensgar dolomite, the Deer Trail argillite, the Addy quartzite, the Chewelah argillite, the Old Dominion limestone, the Colville quartzite, the Clugston limestone, the Mission argillite and the Northport limestone, are believed to constitute a stratigraphic series in sequence from base to top as listed. The remaining ten members, viz., the Deep Lake argillite, the Republican Creek limestone, the Lead Point argillite, the Red Top limestone, the Fish Creek argillite, the Cedar Creek argillite, the Boundary argillite, the undifferentiated quartzite, the undifferentiated limestone and the undifferentiated argillite, have been distinguished solely for description and mapping. Their correlation with the other eleven members is very indefinite although they presumably correspond to the upper portion of that series.

METAMORPHIC SEDIMENTARY FORMATIONS IN BRITISH COLUMBIA AND IDAHO.

Investigations of considerable extent have been made by several writers on the geology of adjacent areas in British Columbia, Idaho and Montana. The problems which they have been compelled to consider are in many respects similar to those encountered in Stevens County. The rock masses have been divided into several groups

or formations and tentative correlation tables have been constructed. These writers frankly state that before any definite agreement can be reached as to the exact interpretation or correlation of these rocks much more stratigraphic work will be required and if possible some definite paleontologic knowledge must be obtained. Insomuch as the key to the definite solution of these problems does not apparently exist in the area under investigation it becomes necessary to draw upon the results which have been obtained from studies in other nearby areas and utilize such suggestions as they may offer on the problems at hand.

Dr. R. A. Daly[4] in his report on the geology along the forty-ninth parallel has summarized the work of earlier writers as well as his own and has constructed a rather comprehensive correlation table of the formations in the Cordillera. This includes not only the formations encountered along the international boundary but also those at some distance to the north in British Columbia and to the south in Washington, Idaho and Montana.

The oldest formation recognized in the boundary area has been designated as the Priest River terrane. It is a group of highly metamorphosed sedimentary rocks in which fossils are entirely absent. The series is exposed on the forty-ninth parallel in northern Idaho and western Montana. The estimate of the thickness of this series is rather uncertain but it is believed to be at least 18,000 feet. Farther to the west along the northern boundary of Idaho and Pend Oreille County in Washington is a very thick series of quartzite, phyllites and conglomerates which have been named the Summit series. This series possesses a total thickness of over 32,000 feet and its base rests unconformably upon the older rocks of the Priest River terrane.

(4) Daly, R. A., Geology of the North American Cordillera at the Forty-ninth Parallel. Department of Mines, Geological Survey of Canada, Memoir No. 38, p. 179, 1912.

The several members of the Summit series stand nearly vertical and have a northerly strike. A portion of the series crosses into the eastern part of Pend Oreille County, on the eastern side of Clark Fork.

To the west of the Summit series, as exposed along the forty-ninth parallel, is a group of quartzites, amphibolites, argillites, and marbles which have been designated as the Pend Oreille group. Field studies show no apparent unconformity between the base of this group and the top of the Summit series but rather a possible gradation from one to the other. The Summit series apparently dips down to the west beneath the overlying Pend Oreille group. The rocks of the latter group occur along the forty-ninth parallel as far west as a point four miles west of the Columbia River. From the international boundary they cross into Stevens County. No fossils of any type have as yet been found within the rocks of this group. They lie in a zone of intense deformation and crushing and are in many ways difficult to distinguish from the older Summit series. Because of their lithologic similarity to the Cache Creek group of British Columbia which upon paleontological evidence is of Carboniferous age, the rocks of the Pend Oreille group are tentatively correlated with the Pennsylvanian division of the Carboniferous. It is suggested, however, that the lower schists may include sediments of any age from the Carboniferous to the Silurian inclusive.

On the western side of the Columbia River the strata of the Pend Oreille group pass beneath the voluminous series of lavas and tuffs which have been named the Rossland Volcanic series. This series of volcanics extends along the international boundary for a distance of one-half of the width of Stevens County. This series has been referred in age to the Triassic and Jurassic but may include also lavas of Tertiary age.

The Priest River terrane, the Summit series, the Pend Oreille group and the Rossland Volcanic series have all been cut by dikes and batholithic masses of granite, syenite, granodiorite, diorite and gabbro. These will be discussed later in connection with the igneous rocks.

STEVENS SERIES.

Distribution.

The formations which have been mapped by Daly along the forty-ninth parallel and which have been designated as the Priest River terrane and the Summit series do not extend as far west as the northeastern corner of Stevens County. They strike approximately north and pass from British Columbia into Idaho and the eastern portion of Pend Oreille County. It is possible that certain members of the Summit series may some distance south of the international boundary swing around in a more southwesterly direction and enter the east side of Stevens County. If they did so at one time they have since been cut off by large areas of batholithic granite which constitute the prevailing formation along the eastern portion of the county.

The rocks of the Pend Oreille group extend from British Columbia into the northeastern part of Stevens County where they constitute the upper portion of the extensive belt of metamorphic sedimentary rocks which are shown upon the areal geologic map accompanying this report. The lower portion of the great series of metamorphic rocks exposed in the county may be older than the oldest of the Pend Oreille group as described in British Columbia. If so, there is no evidence at present available to determine just which members in Stevens County may be the equivalent of the basal beds in British Columbia. Under these conditions an attempt to correlate the entire series of metamorphic rocks in the county with the type Pend Oreille group of British Columbia

would be misleading. There appears to be no evidence which would warrant regarding the rocks of the Summit series as the equivalent of any portion of the metamorphic series in Stevens County. Until more definite evidence is secured it would seem the wisest policy to map and describe the several lithologic units which can be distinctly recognized within Stevens County under separate names. Later when more information is available it may be possible to place each of these members in its place in the column as already established in British Columbia. In this report the entire series of metamorphosed sedimentary rocks which are exposed within the county are tentatively grouped under the name "Stevens Series." The upper members of this series are the equivalent of the Pend Oreille group of British Columbia, and possibly of upper Paleozoic age. The middle and lower members may represent the middle and lower portion of the Paleozoic.

The rocks of the Stevens Series extend from the northeastern limits of the county at the forty-ninth parallel as a broad belt in a southwesterly direction and comprise the larger part of the western two-thirds of the county. In the northwestern corner of the county they pass beneath the lavas and tuffs of the Rossland Volcanic series. In the southern and southwestern parts of the county they also pass beneath the Tertiary lavas and tuffs which are a northern extension of the great volcanic series of the Columbia Lava plateau. In the eastern third of the county they have been invaded by a very extensive granite batholith and have long since been removed by erosion. They are absent also in the north central portion of the county just south of Columbia River where they have been eroded from a large underlying mass of granite. In many places the series has been intruded by small masses of deep-seated rock as well as

by dike rocks having a wide range in chemical and mineral composition.

Lithology.

The rocks composing the Stevens group consist of quartzites, argillites, phyllites, schists and dolomitic limestones. The quartzites vary in color from pure white to yellowish-brown, grayish-brown, dark gray to black. They range in texture from a white quartzose and vitreous texture to a medium-grained and even conglomeratic condition. Often they pass into a schistose phase where they may be classed as a quartz-mica schist. As a rule the larger belts of quartzite are rather persistent in character for considerable distances along their strike. Many times, however, they gradually grade over into a schistose phase or split into alternating belts of quartzite and schist.

The argillites occur as narrow bands interstratified with the quartzites, schists and limestones or as well defined belts of great thickness and persistency. They vary greatly in their physical appearance in different parts of the county and range in color from a light gray to a dark gray or from a greenish-gray to a black. In composition they are often rich in calcium carbonate so that they may be designated as a calcareous argillite. Other phases of the argillite are fine-grained and resemble slate, but in some cases pass into black carbonaceous shales or slates. Some types grade into a quartz-mica schist and are locally referred to as "silver shale." Some of the phases are typical phyllites and become highly schistose and crumpled.

The limestones range from pure white massive rocks to light and dark bluish, and from reddish-gray to black. They vary in composition from pure limestone to argillaceous limestone and to calcareous argillites dependent

upon the ratio of the lime components to the argillaceous content. In texture they vary from a massive crystalline condition to a banded and even schistose phase. Many of the limestones contain varying amounts of magnesium carbonate and even pass into true dolomites. As a result of more or less intense metamorphism they are crystalline and even in some cases pass into marble.

The several divisions or stratigraphic members which have been grouped under the Stevens Series are entirely nonfossiliferous. The presence of extensive belts of dolomitic limestone interbedded with the argillites and quartzites indicates the probable deposition of sediments in an extensive arm of the ocean which covered this part of Washington and parts of British Columbia during the later Paleozoic. The alternation in character of the sediments from the coarse sandstones to the fine shales and limestones suggests probable deposition upon a sea floor which was undergoing some oscillation but which was predominantly shallow.

Structure.

Wherever the several members of the Stevens Series are exposed within the county they possess a nearly uniform north or northeast strike. The dip is prevailingly to the west or northwest. At first glance the structure would seem to indicate the existence of an enormous anticlinal fold made up of a group of conformable stratigraphic units with the members of the Stevens Series comprising the northwest limb of the arch. Considering the width of the belt occupied by the Stevens Series it would be necessary to assume a thickness of over 20 miles for these sedimentary beds. The quartzite formations as a rule constitute very definite stratigraphic units. An examination of the areal distribution of the quartzite belts shows them to curve and in some instances to form horseshoe bends. The argillite and limestone belts conform very closely to the curving of the quartzite belts.

Three possible suggestions may be offered as an explanation of the structure and areal distribution of these belts: (1) They may be involved in an extensive monoclinal fold in which the entire series of strata are dipping to the west; (2) The several stratigraphic units may represent a repetition of the same beds due to strike faulting; (3) All of the stratigraphic members of the series may be involved in a number of overturned and pitching anticlinal and synclinal folds.

The enormous thickness of over 20 miles which would have to be assumed on the basis of a great monoclinal fold would render this explanation impossible. Further it would not account for the reverse curving of the stratigraphic belts. If the strike faulting were offered as an explanation the continuity of the horseshoe curves of the belts would not be as complete as it appears upon the map. The curved relations of the belts at once suggests pitching anticlines and synclines whereby the strike of the beds curves at the nose of the folds. The persistent westerly dip of the beds indicates that the folds have been overturned. The amount of overturning varies greatly and as a rule the strata of both limbs assume an angle of about 45° or less. In some places the dip of both limbs is vertical. Beginning with the top, the stratigraphic divisions of the Stevens Series, with the approximate thickness of each formation, is as follows:

	Feet
Northport limestone	3,000
Mission argillite	12,000
Clugston limestone	1,200
Colville quartzite	5,000
Old Dominion limestone	1,500
Chewelah argillite	4,000
Addy quartzite	8,000
Deer Trail argillite	3,000
Eagle Mountain quartzite	1,200
Deer Lake argillite	4,000
Total	42,900

The stratigraphic positions of the following members of the Stevens Series are uncertain:

	Feet
Deep Lake argillite	2,500
Boundary argillite	4,000
Fish Creek argillite	1,500
Lead Point argillite	2,200
Republican Creek limestone	1,200
Cedar Creek argillite	2,500
Red Top limestone	1,000

Deer Lake Argillite.

Distribution. The Deer Lake argillite occupies a belt in the east central part of the county varying from two and one-half to three miles in width, with a northerly trend for a distance of 22 miles. The southern end of this belt terminates about one mile south of Deer Lake in T. 30 N., R. 41 E. Its northern limits are in the north part of T. 33 N., R. 41 E. Its eastern limits are determined by the contact of the Loon Lake granite. On the west it lies in contact with the Eagle Mountain quartzite. The rocks of this formation occupy an approximate area of 48 square miles. The argillaceous quartzites outcropping upon Grouse Mountain in the central part of T. 30 N., R. 42 E., are probably a part of this formation.

Lithology. The rocks which have been designated as the Deer Lake argillite, in reality comprise interbedded quartz-mica schists, dark gray and grayish-brown quartzites as well as argillaceous slates. The latter phase prevails. The subordinate quartzites and schists occur in bands varying in width or thickness from two or three feet to over 100 feet.

Excellent exposures of these rocks occur along the north shores of Deep Lake. To the east of the lake in sec. 10, T. 30 N., R. 41 E., the rock is prevailingly a massive medium-grained argillaceous quartzite which forms bold outcrops and which upon close examination exhibits a well-defined banding which often is schistose. The rock grades from a typical dark gray quartzite to a light gray,

slaty or schistose quartzite. Along the shores of Deer Lake the rock is a banded, indurated sandstone interbedded with thinly bedded argillaceous shales and slates which show some silicification. The quartzite phases of the formation are much fractured and often filled with minute intersecting stringers of quartz.

Structure. The several members of the Deer Lake argillite have a prevailing north to northwest strike and a west to southwest dip. While the belt as a whole assumes this structure, yet, there are examples of minor local buckling and twisting which are entirely subordinate to the predominant structure. About three miles east of Jump-Off-Joe Lake in sec. 33, T. 31 N., R. 41 E., at the western edge of the argillite belt the local strike is N. 20° E., and the dip 55° N. W. Near the west end of Deer Lake the strike averages N. 5° E. and the dip 38° N. W. At the eastern end of the lake near the granite contact the strike is N. 45° W. and the dip 45° to the southwest. The average strike for the rocks of this belt is approximately the same as the strike of the area of the belt itself, that is, about N. 15° W. The average dip for the belt is about 35° to the west. In a few places the strata are standing nearly vertical.

The eastern portion of this belt lies along an intrusive contact with the Loon Lake granite. Apophyses and dikes from the granite extend into the argillites, but as a rule the contact relations are obscure or more often covered with glacial drift. The western portion of the belt lies with apparent conformity beneath the Eagle Mountain quartzite. It is possible that the Deer Lake argillites in reality, stratigraphically, are above the Eagle Mountain quartzite and lie in their present position as a result of a pronounced overturned fold which has been eroded to its very core. The argillite belt may be a greatly compressed overturned synclinal fold. No evidence was obtained by the writer in the rather hurried reconnaissance

of the region which would throw any definite light upon this subject.

Eagle Mountain Quartzite.

Distribution. The Eagle Mountain quartzite is named from its occurrence on Eagle Mountain about five miles northeast of Chewelah. This quartzite occupies a belt on the eastern side of Colville Valley and trends nearly north for a distance of about 34 miles. On the north it is cut off by the Loon Lake granite in the northern part of T. 33 N., R. 41 E. It extends southerly through Old Eagle Mountain persistently to a point two miles east of Jump-Off-Joe Lake in sec. 32, T. 31 N., R. 41 E. To the south of this locality it has been dissected by the Loon Lake granite and appears only in residual exposures projecting through the Quaternary glacial drift. The most southerly recognized exposure of this quartzite is about two miles south of Springdale. The width of the belt varies from 1,500 feet to about one mile. Its outcrops embrace an area of about 10 square miles.

Lithology. The outcrops of this quartzite constitute exceedingly bold and rugged topographic features. The rock is typically a hard massive crystalline to vitreous quartzite which breaks with an angular to conchoidal fracture and develops extensive talus slopes along the slopes of the mountains. In places, finely divided white mica has been developed in the rock so that locally it becomes schistose. The color is prevailingly a grayish-white which grades into a grayish-yellow and yellowish-brown. The belt is sufficiently homogeneous to constitute a definite lithologic unit but of a character very difficult to distinguish from the Addy or Colville quartzites.

Structure. Original bedding planes are sometimes fairly defined so that the strike of the formation can be ascertained. Commonly, however, it is too massive to make a definite determination. The strikes observed are parallel to the trend of the belt which is almost due north.

The dip appears to be vertical but at many places as on Eagle Mountain it dips to the west at an angle of approximately 40°. It is probable that the true average dip of the formation is less than 40° although locally it stands vertical. The westerly dip may be the result of complete overturning. It lies in apparent conformity beneath the Chewelah argillites. It may be the eastern limb of the Colville Valley syncline and constitutes the eastern extension of the Addy quartzite. If so, the Addy quartzite has greatly decreased to the east.

Stensgar Dolomite.

Distribution. The Stensgar dolomitic limestone occupies a rather persistent narrow belt not over 1200 feet in width and trending in a northeast direction for about 21 from its occurrence on Eagle Mountain about five miles northeast of Chewelah. This quartzite occupies a belt trends approximately S. 33° W. and terminates on the western side of the crest of the Huckleberry Mountains about three miles south of Turk in sec. 14, T. 29 N., R. 37 E. The belt lies parallel to the trend of the Huckleberry Mountains and upon their eastern slope near the crest.

Lithology. This belt varies greatly in appearance and composition along its strike. Typically it is a slightly banded to massive grayish-white to pure white crystalline limestone which upon analysis contains large and varying quantities of magnesium carbonate. In some places the magnesium carbonate content increases to such an extent that the rock becomes an impure magnesite and as such is commercially mined or quarried. The dolomitic phases of the rock are usually fine-grained and crystalline. They vary in color from a pinkish to bluish and reddish-gray dependent upon the relative amounts of such impurities as iron which are present. Intersecting joint seams are common and often along

these there has been secondary leaching. In several localities the dolomite locally grades into magnesite of varying degrees of purity. It is often impossible to distinguish between the commercial magnesite and the impure or dolomitic phases of it by an examination with the eye. A chemical analysis is required to separate these varieties.

The magnesite varies greatly in physical appearance. Some varieties are very coarsely crystalline and are composed of aggregates of crystals whose diameter is as great as one-fourth of an inch. They grade from this condition down to those varieties where the crystals are extremely minute. Many times the fine-grained massive dolomites are minutely fractured and along the fracture planes there are belts of magnesite ranging from a fraction of an inch to over one inch in width. Other specimens show individual crystals of magnesite spotted at random through the matrix of dolomite. This latter condition often shows an increase in the proportion of magnesite crystals until the bulk of the rock is entirely made up of magnesite.

In those localities where magnesite is entirely absent the dolomite sometimes grades over into a calcite containing only a small per cent of magnesium carbonate. There is a complete gradation from theoretically pure dolomite to pure limestone or calcite.

In some localities the limestones have been locally silicified so that it becomes difficult to distinguish between them and the massive quartzites.

Structure. The Stensgar dolomite lies with apparent conformity upon the Deer Trail argillite. Also overlying it with apparent conformity are argillites and quartz-mica schists as well as calcareous argillites which are grouped with the Deer Trail argillite formation. The Stensgar dolomite member thus becomes a well defined stratigraphic unit interbedded with the Deer Trail argil-

lite. It, along with the argillites, possesses a predominant dip to the northwest at an average angle of 35°. Locally, it may stand nearly vertical as well as lie nearly flat. It is buckled in places and locally deformed so that the structure is difficult to solve, but the predominant structure conforms to a general northeast strike with a westerly dip which averages 35°. It may lie in the western limb of an overturned anticline.

Deer Trail Argillite.

Distribution. The area which has been mapped as the Deer Trail argillite lies in the central portion of Stevens County and occupies a broad belt having an average width of three miles and trending in a northeasterly direction for a distance of about 20 miles. It passes diagonally through Tps. 29, 30 and 31 N. and Rs. 37, 38, 39 and 40 E., and embraces an area of approximately 60 square miles. It lies along the eastern slopes of the Huckleberry Mountains and reaches the summit to the south in the region of Cedar Canyon.

Lithology. This group of metamorphosed, sedimentary rocks which has been designated as the Deer Trail argillite embraces argillites, calcareous argillites, phyllites, quartz-mica schists, narrow bands of limestone and small discontinuous bands of quartzite. Argillites and quartz-mica schists are the most abundant. They commonly show good bedding planes and the planes of schistosity when developed are nearly always parallel to the bedding planes. Where the strata show considerable buckling and twisting the schistosity planes are diagonal or even at right angles to the bedding. The quartz-mica schists range in color from a light to dark gray and are thinly laminated. The argillites vary in color from very dark gray to a brownish-gray. Seldom do they appear to be distinctly carbonaceous. They are, however, often calcareous and locally grade over into limestones or dolo-

mitic limestones. The quartzite bands which are interbedded with the argillites are seldom over 20 feet in thickness and apparently are not continuous for great distances. They are not the massive white types such as the Addy and Eagle Mountain quartzites but rather have a dark gray color and are somewhat schistose or slightly argillaceous.

Structure. Much of the area involving the Deer Trail argillite is covered with deposits of glacial drift. Sufficient exposures are available to definitely determine the prevailing strike and dip of the formation over the entire belt in which it occurs. The strike of the formation averages N. 33° E. with a dip ranging from 20° to 88° to the northwest. Probably the average dip is about 40°. Locally the strata have undergone considerable buckling and distortion so that in places the strike is nearly east. Although the belt of this formation is nearly three miles in width yet the dip is prevailingly to the west and northwest. It is believed that these strata are involved in a sharply compressed overturned anticline. The quartzites exposed on the eastern side of this belt on Empey Mountain lie apparently unconformable beneath the argillites, and the Addy quartzites on the western side of the belt rest in apparent conformity above them. It is probable that both of these quartzite belts are the Addy quartzite and represent the two limbs of the overturned anticline. The axis of the fold has thus been deeply cut into by erosion so that the older Deer Trail argillites are now exposed. At the north end of the argillite belt, to the north of Brown's Lake, the quartzite of the west side of the belt appears to swing around and connect directly with that on the eastern side. The region in the vicinity of Brown's Lake is apparently the nose of a northeasterly pitching overturned anticline. In the southern portion of the belt the planes of schistosity in the more heavily metamorphosed argillites are approximately parallel to the

bedding planes. To the north in the vicinity of Brown's Lake near the nose of the anticline they are transverse and even at right angles to the bedding planes. To the north of Brown's Lake the bedding planes are more nearly east and west with a northerly dip. Farther south, the planes of schistosity are parallel to the prevailing strike.

To the northwest of Brown's Lake basic igneous intrusions have disturbed the strata and some rather complex faulting on a minor scale seems to exist. In tracing the areal extent of the formations in this region there has been more or less generalization.

Addy Quartzite.

Distribution. The Addy quartzite is one of the most extensively developed formations within the county. It constitutes the crest of the main portion of the Huckleberry Mountains. It crosses Colville Valley north of Chewelah and forms the high rugged mountains south of Little Pend Oreille River. Its southern limits are about three miles south of Turk at the south end of the Huckleberry Mountains where it forms a narrow belt about two-thirds of a mile in width. It has been cut off by a large intrusive area of granite. To the north it gradually widens and in T. 32 N., R. 39 E., it is more than six miles wide. Here it forks and the western branch trends about N. 10° W. where it forms the main part of Dunn Mountain. The eastern branch crosses Colville Valley between Chewelah and Addy where it forms an area over seven miles wide. In the southern parts of T. 34 N., Rs. 40 and 41 E., it is terminated by an extensive batholithic intrusion of the Loon Lake granite. About six miles west of Chewelah an arm of the mass turns and extends southerly as far as Empey Mountain in T. 30 N., R. 39 E. To the south and east of Empey Mountain it passes beneath extensive flows of the Camas basalt. The Addy quartzite embraces an area of approximately 150 square miles.

Lithology. The Addy quartzite consists predominantly of massive, hard, crystalline, light-colored quartzite. Associated with it in subordinate amounts are belts of quartz-mica schist, highly metamorphosed banded slates and well banded quartzites with much white mica developed. The pure white quartzites are composed almost entirely of quartz grains which are cemented together by crystalline intergrowth. These rocks are exceedingly hard and constitute rugged topographic features. When impurities such as iron oxide are present the rock becomes yellowish-gray and sometimes grayish-brown. Sometimes the quartzite is dark gray or nearly black in color and shows excellent bedding planes. In the vicinity of Addy the hard massive phase grades over into interbedded quartzites and argillites alternating in sequence. The alternating bands vary from a few inches to several feet in thickness.

Structure. The quartzite exposed along the southern portion of the Huckleberry Mountains is believed to constitute the western arm of an overturned anticline. The quartzites southwest of Chewelah and on Empey Mountain presumably form the eastern limb of the anticline. The quartzite has been removed from the axis of the fold so that the underlying Deer Trail argillites are exposed. This anticline appears to be pitching to the northeast and north of Brown's Lake plunges so that the axis has been preserved from erosion. To the north of Chewelah and to the northeast of Blue Creek the anticline forms a high mountainous area but is finally truncated by the large mass of granite which lies in the valley of Bear Creek. The western branch which trends northerly and forms Dunn Mountain appears to be a northerly plunging, overturned anticline. At the north end of Dunn Mountain it disappears as it passes beneath the overlying Chewelah argillite and Old Dominion limestone. Between Dunn Mountain and Colville Valley there is a synclinal trough

which noses out to the south in T. 32 N., R. 39 E. This syncline appears to plunge to the north. It is occupied by the Chewelah argillite. The quartzite exposed on the eastern side of Dunn Mountain presumably passes beneath the floor of Colville Valley and reappears in the hills east of Blue Creek and Addy. Strikes and dips are often difficult to determine in the quartzite belt and the structure is commonly obscured by minor faulting and local buckling.

Chewelah Argillite.

Distribution. The Chewelah argillite is widely distributed in the county. It forms a belt on the western side of the Huckleberry Mountains which lies between the Addy quartzite and the Colville quartzite and averages about four miles in width. Its southern limits are near the headwaters of Harvey Creek. Some of the areas of schist and argillite exposed to the south in the valley of Hunters Creek and near Spokane River may be a part of this belt. There appears to be no easy way to distinguish them from the Mission argillites and they have been mapped as undifferentiated argillites.

The Chewelah argillite belt extends nearly due north and swings around the north end of Dunn Mountain, where it divides. One portion passes northeasterly across Colville Valley and up the valleys of the North, Middle and South forks of Mill Creek to the Pend Oreille County line. On the summit of the Pend Oreille Mountains, at the headwaters of Mill Creek, this belt of the Chewelah argillite is over six miles in width. The area between Dunn Mountain and Colville Valley as far south as the east middle portion of T. 32 N., R. 39 E., is occupied by this argillite.

A second area of the argillite lies along the eastern side of Colville Valley. On the north it lies between the North and South forks of Chewelah Creek. It extends southerly past Chewelah and into the hills east of Valley.

To the south of Valley it is exposed at intervals where it projects upward through the overlying Camas basalt or the thick deposits of glacial drift. To the south of Springdale it is cut off by the Loon Lake granite. The Chewelah argillite occupies a total area of approximately 190 square miles.

Lithology. The rocks which have been grouped under the Chewelah argillites consist of interbedded quartz-mica schists, phyllites, argillites, calcareous argillites, dolomitic limestones, argillaceous limestones and narrow bands of quartzite. The quartz-mica schists are more abundant in the Chewelah argillite formation than in any of the units of the Stevens Series. They range in color from a silver-white to shades of red and gray. They are fine-grained and exhibit a lustrous surface along the cleavage planes. They vary greatly in hardness, dependent upon the relative amounts of quartz and white mica present. These types pass by degrees into the argillaceous phases. The argillites range in color from carbonaceous, black varieties to light gray, dark gray and grayish-brown. They vary in texture from a medium-grained thickly bedded phase to fine-grained, thinly laminated types. They differ greatly in the lime content and pass from argillaceous limestones to pure dolomitic limestones. Such limestone belts are in the form of lenses and are not very persistent so that they could be mapped as stratigraphic units. Bands of quartzite occur occasionally but are not important as constituents of the formation.

Structure. The Chewelah argillites, which are exposed on the western side of the Huckleberry Mountains and Dunn Mountain, rest in apparent conformity upon the Addy quartzite. Exposures of the argillite are rather limited because of the heavy covering of glacial drift, but wherever observations were made there was recorded a prevailing northeast or north strike with a westerly dip ranging from vertical to very low angles. It is over-

laid on the west by the Colville quartzite with apparent conformity. It is possible that a fault exists along the western side of Dunn Mountain and that the argillites have been dropped downward to the west. To the north of Dunn Mountain in T. 35 N., R. 38 E., the formation plunges to the north around the nose of an anticline and conceals the Addy quartzite. On the eastern side of Dunn Mountain the argillites are exposed in places from beneath the heavy covering of glacial drift. They have a prevailing westerly dip except in secs. 25 and 26, T. 32 N., R. 39 E., where they strike nearly east and west. Here they lie in the nose of a northerly pitching syncline and rest upon the Addy quartzite. In this region they have been greatly disturbed and show the effects of local minor faulting and buckling. The planes of schistosity trend diagonally to the bedding in a northeast direction. To the northeast of Dunn Mountain and south of Colville a large mass of the Loon Lake granite has been intruded into the argillites and diagonally sliced off a large portion of these strata. The normal bending of the strata around the nose of the anticline has been greatly disturbed because of this intrusion. On the eastern side of Colville Valley, in the basin of the three forks of Mill Creek, the argillites still maintain a predominant northwesterly dip, although in places there is considerable buckling and local deformation. On the south this belt has been intruded by the granite and on the north it lies beneath the Old Dominion limestone and the Colville quartzite.

The argillite exposures between the north and south forks of Chewelah Creek and on the western side of Old Eagle Mountain also have a strike slightly east of north and a westerly dip. To the south of Chewelah and east of Valley the strike becomes more nearly north but the westerly dip prevails with local buckling. These argillites rest with apparent conformity upon the Eagle quartzite and beneath the Addy quartzite on the western

side of Colville Valley. Their normal position should be above the Addy quartzite. It is probable that the Chewelah argillites to the north and south of Chewelah are involved in an overturned syncline so that the Addy quartzite appears to rest upon them.

It is believed that the argillites on the western side of the Huckleberry Mountains and Dunn Mountain constitute the western arm of an anticlinal fold. The eastern arm is probably buried beneath the thick layers of the Camas basalt in the southern part of the county. In T. 32 N., R. 39 E., a subordinate anticlinal fold branches off to the north and has as its axis the crest of Dunn Mountain. The main fold continues northeasterly across Colville Valley and enters the high mountains between the North Fork of Chewelah Creek and Colville Valley. This area is occupied by the Addy quartzite. The Chewelah argillites which formerly arched over it have been removed by erosion. The argillites to the north and south of Chewelah form the eastern limb. The western limb lies in the synclinal trough between Addy and Dunn Mountain. The argillites along the western side of this synclinal fold constitute the truncated remains of the eastern arm of the Dunn Mountain anticline.

Old Dominion Limestone.

Distribution. The Old Dominion limestone lies in the central part of the county. It forms a belt varying in width from one to two miles and extends along the northwestern side of the valley of the North Fork of Mill Creek. It terminates to the northeast, in the valley of Deep Creek north of Aladdin in T. 38 N., R. 41 E. To the southwest as it approaches Colville Valley it appears only in residual patches projecting through the deep covering of glacial drift. Southwest of Colville Valley and north of Dunn Mountain it forms small areas surrounded by glacial drift. From Orin Station, about five miles south

of Colville, it extends northeasterly as a belt about two-thirds of a mile in width as far as Old Dominion Mountain, where it appears to be cut off by a fault. This last named belt is parallel to that along the northwestern side of the valley of Mill Creek.

Lithology. This lithologic unit which has been termed the Old Dominion limestone varies greatly in physical character and color. The exposures along the northwestern side of the North Fork of Mill Creek are in reality very low grade limestones. In places they are only calcareous argillites. They commonly have a banded or shaly appearance and vary in color from a pure white to a black. Prevailingly, they are a light to dark gray with occasionally a bluish tint.

At the south end of Old Dominion Mountain the limestone is nearly a pure white color, has a uniform texture, and is highly crystalline. It varies greatly in the magnesian content and some varieties become true dolomites. In places it is largely replaced by silica especially in the near vicinity of the intrusive granite batholith. This belt of limestone can be traced as far to the southwest as Orin Station. The pure white phase grades over into fine and coarsely crystalline types which are interbedded and which are in places very decidedly dolomitic. Near Orin Station the rock becomes more argillaceous and shows greater variations in texture. On the north side of Dunn Mountain the Old Dominion limestone forms two parallel disconnected belts separated by a belt of the Chewelah argillite. They are apparently the two arms of the Dunn Mountain anticline. The axis has been so deeply eroded that the limestone roof has been removed. The limestone varies in both of these areas but is predominantly argillaceous. It possesses a bluish-gray to brownish-gray color and usually has good bedding planes. In places it grades into argillite so that mapping becomes difficult. In sec. 34, T. 34 N., R. 38 E., a quarry

has been opened in this rock. The rock in this quarry varies from a pure white, finely crystalline marble to a bluish-gray, coarsely crystalline type. In places it is greatly squeezed and contorted. Numerous joint planes pass through the mass so that it is not homogeneous.

Structure. The long narrow belt of limestone existing along the northwestern side of the North Fork of Mill Creek possesses an average dip of about 35° to the northwest although it locally stands vertically. It lies beneath the Colville quartzite and upon the Chewelah argillite. The parallel belt of limestone extending from Old Dominion Mountain to Orin Station has nearly the same structure. It is believed that these two belts of limestone constitute the northwest and southeast limbs of a sharply compressed and overturned anticline, the axis of which has been deeply eroded so that the underlying Chewelah argillites are exposed. This anticline appears to be the northeasterly continuation of the Dunn Mountain anticline. On the southwestern side of Colville Valley these two belts of limestone continue and pass around to the west and east sides of the Addy quartzite of Dunn Mountain. They are greatly disturbed by faulting of an obscure character as well as by the intrusions of the Loon Lake granite. The limestone on the eastern limb has in places been completely removed by the granite intrusions.

Colville Quartzite.

Distribution. The Colville quartzite extends diagonally across the county from the northeast to the southwest. It trends on the northeast from the southwestern corner of T. 38 N., R. 41 E., southeasterly into T. 31 N., R. 37 E. The northeastern end of the belt averages three miles in width. In the vicinity of Colville, the belt for a distance of eight miles trends nearly east and then turns almost due south and passes along the crest of the Huckleberry Mountains, where its width decreases to about one

Quartzite at Kettle Falls, with characteristic dip.

mile. Approximately parallel to the Columbia River and about two miles west of the belt which lies along the Huckleberry Mountains is a second belt of the same quartzite ranging from two-thirds of a mile to over two miles in width. Between these two quartzite belts is a long narrow belt of the Mission argillite. Roughly the Colville quartzite involves about 110 square miles of the county.

Lithology. The Colville quartzite as a unit is more homogeneous than the Addy quartzite. It ranges in physical character from a pure, light colored, massive rock composed almost entirely of quartz grains to a fine-grained pebbly or conglomerate quartzite. The pebbles are usually less than one-eighth of an inch in diameter. The conglomeratic phases are very common in the exposures along the western side of the Huckleberry Mountains. The grains are composed of rounded fragments of older quartzites, quartz, and slate. Locally, these belts become schistose and even argillaceous so that their mapping is difficult. To the south of Kettle Falls along

the Columbia River they grade over into schists and argillites and are difficult to distinguish from the overlying Mission argillites. The exposures in the mountains six miles southwest of Colville exhibit marked banding and considerable white mica has been developed throughout the mass.

On the eastern side of Colville Valley on Old Douglas Mountain, the quartzite splits up into alternating bands of quartzite, schist and argillite. The thickness of these bands varies from a few feet to over one hundred feet. As a rule, however, they are not persistent in character for great distances and are really local variations of the quartzite belt and have not been separated from it in mapping.

Structure. The quartzite and the interbedded sedimentary strata to the northeast of Colville Valley have a prevailing northwesterly dip although many local bucklings were noted. It is probable that small anticlinal and synclinal folds have been developed which will account for the lesser thickness of the belt when compared to its great areal width. It rests with apparent conformity upon the Old Dominion limestones and lies beneath the Mission argillites, and the Clugston limestones. Southwest of Colville it flattens so that in places the dip is not more than 15° to the north and northwest and it strikes nearly east as it passes around the plunging Dunn Mountain anticline. From the north end of T. 35 N., R. 38 E., the belt trends nearly due south and observations taken on the bedding planes show a similar strike, with a steep dip to the west. While the belt in this vicinity is much narrower than on Douglas Mountain, it is probable that the actual thickness is approximately the same.

The belt lying two miles west and parallel to the first shows a prevailing dip to the east although the angles are usually greater than 70°. In places the strata are locally overturned so as to dip steeply to the west. It is

believed that the two belts just mentioned trending north and south constitute the east and west limbs of a syncline whose axis trends approximately north and south and which has not been completely overturned.

Clugston Limestone.

Distribution. The Clugston limestone forms an irregular shaped area lying for the most part in T. 37 N., Rs. 39 and 40 E. It extends from Deep Creek four miles north of Aladdin in a southwesterly direction to the headwaters of Clugston and Onion creeks where because of squeezing and deformation it widens to more than two miles. It trends due south and terminates in sec. 10, T. 36 N., R. 39 E. It embraces an area of about ten square miles.

Lithology. The Clugston limestone varies from a pure white, dense, fine-grained, massive crystalline rock to a bluish-gray and dark gray, banded limestone which becomes somewhat argillaceous. The pure white varieties often show well defined banding or stratification. In some cases the purer types are interstratified with the less pure phases and in other cases they gradually grade over into the other impurer types. The medium-grained bluish-gray to very light gray tints prevail. The rock is commonly shattered and squeezed and the seams are often filled with secondary calcite which has filled the openings. Silicification has acted upon the rock in some instances although as a rule the per cent of silica present is not high. Lead and zinc carbonates have been precipitated in the fracture zones and are in places widely disseminated in small amounts through the rock.

Structure. The Clugston limestone lies upon the Colville quartzite and beneath the Mission argillite. At the north for a distance of over eight miles the limestone lies along an intrusive contact with the granite. The effect of the intrusion has been to squeeze the belt up into a

pod-like mass so as to suggest a greatly exaggerated thickness. Accompanying this squeezing there appears to have been fracturing and along these fracture zones silica-bearing solutions traveled and partially replaced the lime. In places the silica solutions brought in lead and zinc sulphides as well as small amounts of iron, copper and silver. These solutions and their mineral content were probably derived from the underlying granitic magmas. The lead and zinc ores are scattered in irregular shaped masses of small size through the fracture zones of the limestone. They occur in disseminations rather than in distinct fissure veins.

Mission Argillite.

Distribution. The Mission argillite is one of the most widely distributed formations in the county. It lies on both sides of the Columbia River and extends from the international boundary southwesterly to Ferry County where it turns south and passes as a long narrow belt about two miles in width between the two areas of the Colville quartzite. At the international boundary it is at least four miles wide on the west side of Columbia River and probably includes a large part of the argillites on the eastern side of the river which have been mapped as the Boundary argillite of uncertain correlation. Between Douglas Mountain and Kettle River the belt has an areal width of at least 17 miles. The larger part of the triangular shaped area between Kettle and Columbia rivers and south of the lavas of the Rossland Volcanic series is composed of schist and argillite intruded by granites and diorites. These metamorphosed sedimentary rocks have been grouped under the Mission argillite formation. A portion of the argillites and schists occurring in the southwestern portion of the county may be a part of this formation although there did not seem to be sufficient evidence to warrant mapping it as such.

Lithology. It is possible that the stratigraphic divisions which have been grouped under the term Mission argillite may constitute several formations. For purposes of mapping this would be difficult to do, as many of the stratigraphic divisions are not persistent for any great distances. The formation comprises banded and massive argillites, calcareous argillites, quartz-mica schists, and narrow intercalated bands of quartzite and limestone. Argillites and quartz-mica schists predominate as constituents of the formation. In places the argillites are only very slightly metamorphosed and are in composition not far removed from indurated clay-shales. They grade into as well as alternate with black, slaty, carbonaceous argillites. In some places they become very calcareous and approach in composition argillaceous limestones. Bands of pure white limestone varying in thickness from two to over one hundred feet occur interbedded with the argillites. In places these limestone bands are so persistent that they can be traced for several miles and have been mapped as undifferentiated limestones but are to be regarded as constituent parts of the Mission argillite formation. Distinctly banded quartz-mica schists are present in many places and form belts several hundred feet in thickness. They are interbedded with calcareous argillites and carbonaceous phyllites and form rather conspicuous outcrops in the hills west of Clugston Creek and east of Columbia River. The quartzite belts are interbedded and usually of the dark gray massive and slightly banded types.

In the vicinity of the international boundary these argillites have been intricately cut by dikes of granite, diorite, aplite, and rocks which belong to the lamprophyre group.

Structure. The Mission argillite as exposed in the southwestern portion of the county lying between the two belts of the Colville quartzite is involved in a closely

folded syncline which has not been overturned. To the north of the lower portion of Colville River the formation opens into a broad open geosynclinal fold which plunges northerly. In the area between the Columbia River and Clugston Creek the structure of the formation is difficult to interpret. The strikes are prevailingly north or northeast. The dips are mostly to the northwest and west at low angles, although sometimes the strata are standing nearly vertical. Local folds can be worked out but the exposures are so poor that they cannot be traced for any great distance. It is probable that the strata in this area are in small plunging folds which have been overturned to the east and then further complicated by minor faulting. These minor folds appear to be part of a geosynclinal trough.

The exposures of the argillites on the western side of the Columbia River from the international boundary to Kettle River have a strike approximately parallel to Columbia River and a prevailing constant dip to the northwest. The strike on the southeastern side of the Columbia River is also nearly parallel to the course of the river but the dip is almost always to the southeast. Along the river the rock exposures are largely of the Northport limestone. It is believed that the course of the Columbia River from the international boundary southwesterly to Kettle River is along an anticline which has suffered deep erosion so that the overlying Mission argillites have been stripped off and the core of the underlying Northport limestone brought to view. Proceeding northwesterly from the Columbia River toward Orient the Mission argillites appear to lie in a synclinal fold which is pitching northeasterly. The nose of this syncline lies in the northwest corner of T. 38 N., R. 37 E. From Barstow northward to Orient the argillites have been greatly disturbed as the result of igneous intrusions but the prevailing strike is nearly north with an easterly dip. North of

Kettle Falls on Columbia River.

Barstow the interbedded limestone belts can be traced around the nose of the fold and have been so mapped. To the west of Orient and in the vicinity of the headwaters of Fifteen Mile, Flat, Crown and Squaw creeks the argillites have been greatly disturbed by igneous intrusions and for the larger part disappear beneath the younger lava flows of the Rossland volcanic series.

Northport Limestone.

Distribution. The Northport limestone occupies a belt extending along the greater part of the Columbia River valley from a short distance south of the international boundary, southwesterly, nearly to the junction of Kettle River. The belt averages two and one-half miles in width. The exposures occur in rugged bluffs and ridges, which, from a distance give the appearance of snow covered mountains. The areas of limestone as mapped are rather discontinuous, nearly one-half of the belt being deeply buried beneath deposits of glacial drift and river wash. The largest areas occur on the west and east sides of the

Columbia River for a distance of about six miles south of Northport. Between Bossburg and Marble the limestone is largely on the west side of the river and forms important outcrops. To the west of Bossburg it is cut off by a large mass of intrusive granite.

Lithology. The Northport limestone is in reality interbedded with the Mission argillites but as a stratigraphic unit it is so distinct that it has been mapped as a separate formation. It varies greatly in character. Prevailingly, it is a massive, fine-grained, white limestone which in places is dolomitic. South of Northport, on both sides of the Columbia River, the rock forms large areas of the surface geology and is typically massive and possesses a pure white color which sometimes passes to a light gray. It is usually finely crystalline but occasionally becomes rather coarse and shows stratification planes.

From Marble southward to Bossburg the limestone is still predominantly light colored and massive but there is a tendency for it to become banded and to be interstratified with bands of quartz-mica schist and argillite. On the whole the limestone becomes more argillaceous than does that at Northport.

Structure. In the vicinity of Bossburg and Williams the limestone possesses a very low dip and in places is nearly horizontal. It forms a very shallow anticline from the axis of which the overlying Mission argillites have been removed by erosion. The belt so well exposed on the western side of Columbia River is abruptly terminated along the canyon which comes down to the river opposite Bossburg. On the southwest side of this canyon the mountains are composed of large masses of intrusive granite. The actual contact could not be determined but nearby the overlying Mission argillites are intruded by the granites and presumably the contact concealed beneath the covering of glacial drift is also of an intrusive

character. It is possible, however, that the canyon lies along a fault contact whereby the limestones have been dropped down against the granite. To the northeast of Marble the dips on either limb of the anticline become much steeper and the limestone appears to plunge beneath the overlying Mission argillites, and the argillites and schists of uncertain age which have been designated as the Boundary argillites. North of Northport in the lower valley of Deep Creek the rock formation is very heavily covered with deposits of glacial drift so that it becomes difficult to connect the different patches of slate and limestone stratigraphically one with another.

UNDIFFERENTIATED STEVENS SERIES.

General Statement.

In the northeastern corner of the county several belts of schist, argillite and limestone occur which can be separated as distinct stratigraphic units but which cannot be correlated with any of the other formations of the Stevens Series already described. They have a prevailing northeast and southwest trend and in part extend to the international boundary where they connect with the rocks which have been designated by Daly as the Pend Oreille group. The lithologic unit which in this report is designated as the Mission argillite also extends to the boundary and becomes a part of the Pend Oreille series. It is probable that some of the stratigraphic members in the northeast corner of the county are a part of the Mission argillite but no evidence was obtained to show definitely just how they should be correlated. More detailed field evidence may disclose these relations and permit of more definite correlation. For the purposes of this report it has seemed wiser to designate each stratigraphic unit as an independent member and map and describe it accordingly. The following units or members have been recognized: The Deep Lake argillite; the Republican Creek limestone; the Lead Point argillite; the Red Top lime-

stone; the Cedar Creek argillite; the Boundary argillite; and the Fish Creek argillite.

At several isolated localities within the county there are exposures of limestone, argillite, schist and quartzite. It has not always been possible to decide to which stratigraphic units they belong and accordingly they have been mapped separately and described as undifferentiated quartzites, undifferentiated limestones and undifferentiated argillites.

Deep Lake Argillite.

The exposures of the Deep Lake argillite occur in the southern part of T. 39 N., R. 41 E., along the wagon road on the eastern shores of Deep Lake. West of the lake the formation is diagonally sliced off by the intrusive granites. East of the lake the formation extends up into the steep mountain slopes where it is heavily covered with glacial material. The rock as exposed along the road is prevailingly a dark to light colored calcareous argillite. Interbedded with it are bluish-gray fine and coarse bands of argillaceous limestone showing well defined stratification. The formation as a whole is so calcareous as to render it difficult whether to map the unit as a limestone or argillite. The strike of the formation is approximately N. 60° E. and the dip 60° S. E.

Republican Creek Limestone.

The Republican Creek limestone is roughly a little over one mile in width, and trends in a southwesterly direction from the head of Republican Creek and Silver Creek past the north end of Deep Lake. It crosses to the lower valley of Deep Creek about six miles southeast of Northport where it is cut off by a large mass of granite. Typical exposures of this rock may be observed along the wagon road in secs. 24 and 25, T. 29 N., R. 41 E. The rock has been quarried and prospected and is composed of a prevailing massive white to light bluish-gray fine-

grained limestone. In places it shows banding and stratification. Locally it is coarse-grained and slightly argillaceous. The latter condition begins to develop as the belt is traced easterly toward Republican Creek. In the region of the Electric Point Mine in the east central part of T. 39 N., R. 41 E., the limestone alternates with argillaceous limestones of a medium bluish-gray tint. The strike of the strata on the lower part of Republican Creek is about N. 65° E. with a dip to the southeast ranging from 30° to 60°. Farther east near the Electric Point Mine in sec. 18, T. 39 N., R. 42 E., the strike changes to N. 45° W. and the dip varies from 10° to 35° to the southwest. There appears to be a local synclinal fold at this locality. On lower Deep Creek in secs. 24 and 25, T. 39 N., R. 40 E., the strike is constantly N. 40° E. with a dip to the northwest at the south end of the belt, and at the north side of the belt to the southeast. It is possible that this belt lies in a rather sharp syncline. If so, the dip of both limbs in this locality is 57°.

Lead Point Argillite.

The Lead Point argillite forms a belt about one and one-half miles in width and lies parallel to and just north of the Republican Creek limestone. Excellent exposures of the formation occur in the valley of Deep Creek near the place where Silver Creek enters it. A wide wagon road has recently been constructed up to the head of Silver Creek and across to the head of Republican Creek. Continuous exposures of the argillites occur along this highway. The rock is prevailingly a well-bedded argillaceous slate with minor bands of quartz-mica schist and limestone. It varies in color from a medium to a dark gray and is usually fine-grained and distinctly argillaceous. The strike of the strata is approximately N. 65° E. with a dip to the southeast of 45°. Local variations of greater and less values occur.

Red Top Limestone.

The Red Top limestone extends from Deep Creek in the southeastern corner of T. 40 N., R 41 E., northeast erly to Fish Creek where it terminates along a fault against the Fish Creek argillite. The belt averages about one mile in width. Exposures of the formation are well developed on Red Top Mountain and also in the road cuts along the valley of Fish Creek leading to the Frisco-Standard Mine. The rock varies in character but is typically an argillaceous, bluish-gray limestone exhibiting good bedding planes. In places it appears schistose and becomes a quartz-mica schist. On Red Top Mountain it becomes a white, fine-grained, banded marble interbedded with the bluish-gray argillaceous limestone. The strike of the formation as exposed upon Red Top Mountain is about N. 35° E. with a dip varying from 38° to 60° to the northwest. Along the wagon road on Fish Creek the strike is N. 43° E. and the dip 25° to the southeast.

Cedar Creek Argillite.

The Cedar Creek argillite is exposed along the wagon road extending from Cedar Lake northward to the international boundary. Exposures of it occur along the wagon road extending up Cedar Creek to the Frisco-Standard Mine and on the north slopes of Red Top Mountain. The rock is a medium to dark gray argillite which grades alternately into a calcareous argillite, a carbonaceous argillite and into a quartz-mica schist. The dark gray argillite which is most common is fine-grained and finely laminated or bedded. Just north of Cedar Lake these strata have a strike of N. 74° E. and a dip of 60° S. E. The area occupied by these rocks is largely covered with glacial drift and a dense growth of vegetation rendering the determination of the structure very difficult. Surface exposures have been greatly disturbed so that varying observations can be secured in a very small

area. The formation extends to the international boundary and is a part of the Pend Oreille group of British Columbia.

Boundary Argillite.

The mountainous area lying between Columbia River and Cedar Creek, in T. 40 N., R. 41 E., is extremely difficult of access. No roads extend into this area. It is rugged and covered with the most dense growth of underbrush of any part of the county. Even the higher parts of the area are covered with a glacial drift. With the exception of the northern part of the area rock exposures are mostly concealed. On the western slopes of the mountain argillites prevail. In secs. 29 and 30, T. 40 N., R. 41 E., black carbonaceous argillites and quartz-mica schists are interbedded with the true argillites. In places the latter becomes calcareous. In the vicinity of the international boundary the schists and argillites are intruded by a complex of fine-grained granite dikes together with diabase and lamprophyre dikes. So numerous are these that nearly one-half of the area is composed of this igneous complex. The metamorphic sedimentary rocks have been intensely disturbed so that the structure cannot be determined. This area between Columbia River and Cedar Creek has been mapped as the Boundary argillite insomuch as argillites prevail, yet the limestones and carbonaceous argillites which are interbedded may in reality be distinct stratigraphic units. It is probable that the Boundary argillites are in part at least the equivalent of the Mission argillites. Since no direct correlation can be made they are mapped and described separately.

Fish Creek Argillite.

The Fish Creek argillite occupies an area of about two square miles in the extreme northeastern corner of the county. It extends over into British Columbia and is a part of the Pend Oreille group. It is separated

from the Red Top limestone and the Lead Point argillites by a fault which follows along the course of Fish Creek. The strike of the Red Top limestone on the west side of the fault is N. 43° E. The Fish Creek argillite on the east side of the fault has a strike of about N. 15° E. to N. 20° E. and a dip ranging from 40° to 58° to the southeast. The exposures are definite and there is no question concerning the fault. The rock formation is composed chiefly of black carbonaceous argillites and interbedded bands of argillaceous argillites and dark colored quartzites. The argillites are greatly crumpled and show considerable variations in strike and dip. The prevailing strike ranges from due east and west to N. 70° W., and the dip from 10° to 35° to the southwest. The formation is intruded by a large mass of dark gray diorite which occupies an area of about one and one-half square miles.

Undifferentiated Quartzite.

At intervals throughout the county are residual masses of quartzite which cannot be correlated with any of those just described. One large area of four square miles is situated in the northeastern part of the county in the southeastern corner of T. 40 N., R. 42 E. It forms a large part of Old Baldy Mountain whose elevation is over 7,000 feet above sea level. The rock is a light-colored, more or less pure massive quartzite which in places passes into a micaceous phase. On the south it lies in contact with a mass of intrusive granite. On the northwest it is apparently faulted against the Deep Lake argillite, the Republican Creek limestone and the Lead Point argillite.

A second prominent area of quartzite lies in the central part of the county where it constitutes the main part of Old Dominion Mountain. It forms an area of about four square miles, and because of its great hardness and resistance to erosion it still retains an elevation of nearly

6,000 feet above sea level. The rock varies from a pure white massive quartzite to a banded and distinctly bedded dark gray, medium-grained quartzite. On the southeast it has been intruded by the Loon Lake granite and on the northwest it lies against the Chewelah argillite along a fault plane. Other small areas of very limited extent are scattered through the county. In places where they might be regarded as constituent parts of other formations they have not been separately mapped.

Undifferentiated Limestone.

Numerous areas of limestone in the county are disconnected from any of the definitely known belts. They exhibit all degrees of variation in composition. The majority of these areas are situated on the western side of the Huckleberry Mountains and as a rule constitute only a fraction of a square mile in extent. Among the more important of these are areas near the headwaters of Harvey and Hunters creeks. The limestone is usually of a bluish-gray color and more or less argillaceous with intercalated bands of nearly pure white limestone.

East of Chewelah, on the western side of Eagle Mountain, there are belts of pure white, bluish-white, and yellowish-white coarsely crystalline limestone in bands ranging from 50 to over 100 feet in thickness. They are interbedded with the Chewelah argillites and are a constituent part of that formation. These bands cannot be recognized as stratigraphic units for very great distances. Because of their prominence they have been separately mapped from the argillites. Interbedded argillites and quartz-mica schists have been grouped with the limestones in this region as it would be impossible to separate the individual bands on the scale of the map accompanying this report.

Other areas of importance occur intercalated with the argillites and schists of the Mission argillites. These

bands are several miles in extent but they usually taper out as shown upon the map.

Undifferentiated Argillite.

In the southwestern part of the county important areas of schists and argillite occur which may be in part the equivalent of the Mission and Chewelah argillites. The Colville quartzite becomes very schistose as it extends southward and the undifferentiated argillites may in part represent these quartzites. They exhibit all the variations so common to all the other argillite formations just described. East of Rock Cut in the triangle between Kettle and Columbia rivers and the international boundary there are exposures of schist, argillite and calcareous argillites which are often badly crumpled and distorted. These have been mapped as undifferentiated argillites. They probably represent a part of the Mission argillites but insomuch as they project from beneath an eroded covering of the Rossland Volcanics their correlation is very uncertain.

IGNEOUS ROCKS.

General Statement.

Upon the basis of origin, all of the broad groups into which igneous rocks are usually divided are present in Stevens County. Approximately two-fifths of the area of the county is composed of igneous rocks. The volcanic rocks of surface flows are largely confined to the northern and southern parts of the county. Almost the entire eastern portion is composed of batholithic masses of granite. The central and some of the eastern portions are largely composed of metamorphic sedimentaries underlaid with granites which at intervals penetrate the schists and quartzites and form exposed areas of intrusive rock, varying in size from a fraction of a mile to several square miles in extent.

The igneous formations which have been mapped show considerable variation. It has not always been possible to separate these different types and as a rule the prevailing phase or variety has been used for describing and naming the unit. The volcanic rocks consist of intercalated flows of lava and beds of tuff of varying thickness and lithologic character. It is usually impossible to separate these divisions for purposes of mapping, and accordingly they have been grouped as a unit. In the case of the Rossland Volcanic series, in the northern part of the county, there is an assemblage of probable contemporaneous intrusive dikes, intricately associated with the lavas. No attempt has been made to map these separately, as well as the dikes of later age. Throughout the county numerous dikes of aplite, diabase and lamprophyre occur in the older formations. The majority of these are only a few feet in width and have not been mapped. They are described, where important, in various parts of the report.

The several igneous formations in the county range in age from possible Pre-Cambrian to late Tertiary. The older masses show the effects of intrusive dynamometamorphism. The younger flows are comparatively unaltered, except for local surface weathering. Many of the basic dikes have been converted into a mass of biotite and chlorite. The subdivisions noted below have been recognized among the igneous masses of the county. It is possible that they may be in fact contemporaneous, but where there did not seem to be sufficient evidence for direct correlation they have been mapped and described under separate names.

Orient Gneiss.

The surface exposures of the Orient gneiss are confined to the northwestern corner of the county. They constitute a belt about one mile in width which trends nearly north for a distance of ten miles along the east

Glacier carved valley wall of Orient gneiss. View taken near Laurier.

side of Kettle River. This same formation extends at least eight miles west of Kettle River, where it constitutes the rock formation of the high, mountainous area of northeastern Ferry County. For a distance of ten miles south of the international boundary Kettle River has excavated its valley in this gneiss. South of Rock Cut it is partly covered with river terrace gravel, sand and deposits of glacial drift.

Excellent exposures of the Orient gneiss occur at the Galena Hill Mine near Rock Cut, in the railway cuts at the town of Orient, and along the wagon road northward to Laurier. The formation consists prevailingly of gneissoid and sheared granite and diorite. In places interlaminated with these are coarsely crystalline, light to medium-colored limestones and highly foliated schists. Associated with these are masses of slightly altered granites and diorites of apparent intrusive origin and of later age. It is probable that the typically gneissoid rocks were originally granites and diorites which were intrusive into a sedimentary series, and that later both

the igneous intrusives and the sedimentaries were subjected to intense dynamic metamorphism. The older series is cut by aplitic and lamprophyric dikes of much later age. The gneissoid and schistose bands have a prevailing northerly strike with an average dip of about 20° to the east, although in several instances low westerly dips were observed.

The gneiss typically exhibits a banded structure in which the dark basic minerals such as hornblende and biotite are segregated into bands ranging in thickness from a fraction of an inch to over four feet, while the lighter colored alternating bands are composed of quartz, orthoclase and labradorite feldspar. Interlaminated with these bands are occasional conformable belts of granite in which the banding or gneissic character is nearly absent. Possibly the zones where the gneissic phase predominates are the zones of most intense shearing and recrystallization. Of seventy representative specimens taken from the exposures of the Orient gneiss and examined, there appears to be a ratio of hornblende to biotite as 60 to 40. Usually plagioclase feldspar of the labradorite variety prevails over orthoclase. Accordingly the original intrusive rock must have approximated in composition a quartz-diorite or monzonite. In some places, however, granite prevails.

The age of this formation cannot be determined with certainty. It is older than the Stevens metamorphic series and may be of Pre-Cambrian age.

Loon Lake Granite.

The entire eastern portion of the county, from T. 39 N., R. 42 E., south to T. 30 N., R. 42 E., is composed of a large mass of batholithic granite. This belt varies from 6 to 18 miles in width. It is clearly intrusive in the Stevens metamorphic series. The formation extends to the south and southwest of Loon Lake where it occurs

Serpentine.

Exposures of serpentine occupying an area of about one square mile occur in the extreme northwestern corner of the county, approximately one mile east of Kettle River, at the town of Laurier. This mass of rock forms the hills which rise in elevation above the floor of Kettle River valley from 200 to over 1,000 feet. The exposures cross the international boundary into British Columbia. On the west and south the serpentine is intrusive into the Orient gneiss and the Rossland Volcanic group and on the northeast into an outlying patch of the Orient gneiss.

The original unaltered rock appears to have been a variety of peridotite which has been nearly everywhere almost completely changed to serpentine. At several localities within the mass partially unaltered specimens show the presence of cleavage faces of enstatite and altered crystals of olivine. The entire mass has been greatly sheared and the rock along the sheared zones has been completely altered to serpentine.

Macroscopically the rock varies in color from a dark green to a light bluish-green and a yellowish-green. It exhibits the characteristic slickensided structure of serpentines and in places has developed thin plates of white asbestos along the intersecting fractures. The more unaltered phases of the peridotite rock show phenocrysts of enstatite and olivine but they are usually obscured by serpentization.

Under the microscope the rock is seen to be composed of numerous, somewhat rounded crystals of olivine and a few crystals of enstatite. They are surrounded by a matrix of fibrous serpentine. In the slides examined nearly sixty per cent of the rock has been serpentized and the porphyry-like crystals of olivine in the serpentine are the residuals of a holocrystalline peridotite composed of olivine and enstatite. Magnesite occurs sparingly.

Other secondary alteration minerals are dolomite and talc.

Greenstone.

Very small areas of greenstone are commonly associated with the older metamorphic sedimentary formations. In most cases they are too small to be represented upon the areal map. One area involving about four-fifths of a square mile is composed of a large number of closely associated basic dikes which appear to have been contemporaneous with the sedimentary rocks and to have been metamorphosed with them. These rocks have been converted into a typical greenstone. The greenstones are exposed about two miles west of Blue Creek, in secs. 26 and 35, T. 33 N., R. 39 E.

In thin sections these rocks are shown to be composed of plagioclase, hornblende, augite and a little secondary quartz. The plagioclase is altered to sericite, but occasional crystals are sufficiently fresh to indicate a probable composition of basic labradorite. The hornblende is altered to chlorite as well as the augite, which still occasionally preserves its original crystalline outline.

Sheep Creek Conglomerate.

There are three areas of conglomerate in the northwestern portion of the county which are associated with the Rossland Volcanic series. The largest of these, occupying about one and one-half square miles, lies on the east side of Sheep Creek near the international boundary, in secs. 1 and 6, T. 40 N., Rs. 38 and 39 E. The second area lies on the summit of the divide between Sheep Creek and Columbia River, in sec. 30, T. 40 N., R. 39 E. The third area is situated about two miles southeast of Orient, on the slope of Toulon Mountain, in secs. 19 and 30, T. 39 N., R. 37 E.

The conglomerate exposed on Sheep Creek at the international boundary outcrops at an elevation of ap-

lies entirely in the triangle between Kettle and Columbia rivers and the boundary. Its areal continuity is in places broken due to the intrusion of masses of granite and diorite and to the exposure as the result of erosion of large areas of the older metamorphic formations which lie beneath.

The Rossland Volcanic group consists of a heterogeneous series of lava flows, tuffs, breccias and interbedded sediments whose geologic age cannot with certainty be determined. The older flows and tuffs have been subjected to more or less dynamic metamorphism while the younger members are comparatively fresh. They have been intruded by numerous dikes and stocks of granite as well as basic igneous rocks which have locally produced contact metamorphism. The older members of the group as exposed in British Columbia are reported by Daly to be obscurely involved with the metamorphic rocks of supposed Carboniferous age. On the south side of the international boundary the contact relations between the basal beds of the Rossland Volcanic group and the metamorphic members of the Stevens group are usually concealed beneath a covering of glacial drift. Wherever the contact relations could be partially made out the basal beds appeared to lie unconformably upon the eroded and upturned edges of the older argillites. The younger members as exposed upon First Thought Mountain contain interbedded shales with fragments of leaves and stems which suggest the Tertiary age. It is possible that the members of the Rossland Volcanic group may range in age from early Mesozoic to late Tertiary.

Near the south margin of this volcanic belt the several members are dipping at low angles to the north except where they have been greatly disturbed by igneous intrusions. Farther north, in the vicinity of the international boundary, these rocks are much more disturbed and in places are standing nearly vertical. The

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The conglomerate exposed on Sheep Creek at the international boundary outcrops at an elevation of ap-

proximately 3,800 feet above sea level. The eastern slope of Sheep Creek valley near the boundary is deep and the conglomerates are fairly well exposed. A short distance south of the boundary they are mostly covered with deposits of glacial drift and exposures of rock occur at only isolated intervals. The best exposures are to be found in the cuts along the Velvet Mine road and on the slopes of the hill above the road. The conglomerates are composed of pebbles ranging in size from one-tenth of an inch to over four inches in diameter. Prevailingly they are less than one inch. The pebbles are usually waterworn and rounded and are made of chert, quartz, quartzite, argillite and andesite. They are cemented by an argillaceous sandstone. The conglomerate grades into hardened shale and sandy shale which are always dark gray in color. The shales are somewhat massive although in places, poorly defined bedding planes can be recognized. The planes in this vicinity strike approximately N. 40° E. and dip to the southeast at an angle of 65°. The gradation from the shale to the conglomerate can be clearly seen. Lava flows are interbedded with the conglomerate as may be seen on the hill slopes above the wagon road. The total thickness of the conglomerate is difficult to determine as it has been considerably disturbed by faulting and folding. It is probably at least 500 feet thick and consists of a series of beds of varying extent which were forming contemporaneously with the outpouring of the Rossland volcanic flows.

The second area of conglomerate occurring on the divide between Sheep Creek and Columbia River is intricately mixed with tuff and a flow-breccia which are both component parts of the Rossland Volcanic series.

The third area on Toulon Mountain consists of a belt of conglomerate resting unconformably upon the older Stevens series and the intrusive granite dikes. The beds are nearly 100 feet thick and dip at a low angle of 20°

to the north. Resting upon the conglomerate are andesitic lava flows which continue to the summit of Toulon Mountain. The conglomerate is made of pebbles of quartz, quartzite, slate, and pebbles of acidic and basic intrusive rocks. The pebbles are water worn and less than one inch in diameter. The matrix is partly sand but occasionally a tuffaceous matrix is present. The conglomerate represents the base of the volcanic section in this locality and may correspond to the upper part of the section as exposed farther north on Sheep Creek.

On First Thought Mountain, east of Orient, a belt of soft shale containing fragments of stems and leaves occurs interbedded with the lavas and tuffs. Exposures occur on the property of the First Thought Mine and have been opened in their surface excavations. These may be contemporaneous with the conglomerate belts just described. They possibly record former small bodies of fresh water which were receiving sediments while the conglomerates were deposited along the courses of streams which were draining the region during this period of volcanic activity.

No fossils were collected by the writer but impressions of leaves collected by the Canadian Geological Survey from the same conglomerates just north of the boundary and determined by Professor Penhallow indicate the Tertiary age.

Rossland Volcanic Group.

The Rossland Volcanic group covers an extensive area in British Columbia, north of the international boundary. It crosses the boundary into Washington, where it has an area of nearly 100 square miles. It is possible that those areas which have been mapped as the Jumbo Volcanics and the Phalen Lake Volcanics are in part correlative with the Rossland Volcanic group. That portion of the Rossland Volcanics which is the southern extension of that described by Daly along the international border

lies entirely in the triangle between Kettle and Columbia rivers and the boundary. Its areal continuity is in places broken due to the intrusion of masses of granite and diorite and to the exposure as the result of erosion of large areas of the older metamorphic formations which lie beneath.

The Rossland Volcanic group consists of a heterogeneous series of lava flows, tuffs, breccias and interbedded sediments whose geologic age cannot with certainty be determined. The older flows and tuffs have been subjected to more or less dynamic metamorphism while the younger members are comparatively fresh. They have been intruded by numerous dikes and stocks of granite as well as basic igneous rocks which have locally produced contact metamorphism. The older members of the group as exposed in British Columbia are reported by Daly to be obscurely involved with the metamorphic rocks of supposed Carboniferous age. On the south side of the international boundary the contact relations between the basal beds of the Rossland Volcanic group and the metamorphic members of the Stevens group are usually concealed beneath a covering of glacial drift. Wherever the contact relations could be partially made out the basal beds appeared to lie unconformably upon the eroded and upturned edges of the older argillites. The younger members as exposed upon First Thought Mountain contain interbedded shales with fragments of leaves and stems which suggest the Tertiary age. It is possible that the members of the Rossland Volcanic group may range in age from early Mesozoic to late Tertiary.

Near the south margin of this volcanic belt the several members are dipping at low angles to the north except where they have been greatly disturbed by igneous intrusions. Farther north, in the vicinity of the international boundary, these rocks are much more disturbed and in places are standing nearly vertical. The

structural details could not be worked out within the time available but it is believed that in the near vicinity of the boundary the prevailing structure is simple and that only locally has the disturbance been very great.

The lavas of this group show a great variation in the petrographical character of the rock. Augite and augite-biotite latite are the most abundant types represented. Subordinate to these are quartz latite and augite andesite. Occasional belts of rhyolite were noted.

The quartz latite in this section is typically composed of a fine-grained aphanitic groundmass made up of microlites of labradorite with interstitial grains of augite in a matrix of iron stained glass. The phenocrysts consist of labradorite, biotite, hornblende, quartz and orthoclase. The hornblende and biotite are largely altered to chlorite.

The augite latite is composed of phenocrysts of labradorite feldspar and augite embedded in a groundmass of plagioclase and augite with glass. The groundmass has been greatly altered and consists of a mixture of calcite, quartz, epidote and chlorite. The augite of the groundmass is largely altered to uralite. Magnetite and apatite are accessory minerals. In some of the flows biotite is an essential constituent along with the other minerals just mentioned. This type may be described as an augite-biotite latite.

Many of the lavas occurring on Sheep Creek are typical augite andesites. In thin section they are seen to be composed of augite and labradorite embedded in a groundmass of plagioclase and augite with glass.

Jumbo Volcanics.

At the headwaters of Fifteen Mile Creek, at the eastern end of Jumbo Mountain, there are some greatly altered and metamorphosed lavas and intrusive igneous rocks of apparent andesitic composition. They occupy an area of approximately eleven square miles, in T. 39 N., Rs. 37 and 38 E.

The region in which these lavas are found is heavily covered with deposits of glacial drift and rock exposures are not always continuous. The lavas lie on the south border of the Rossland Volcanics. The Jumbo Volcanics appear to rest unconformably upon the Mission argillites and the Northport limestones. On the northwest they have been cut by a stock of granite. On the northeast they seem to pass beneath the lower members of the Rossland Volcanic group although the exact relations could not be made out definitely. It is possible that a fault contact separates them. Numerous basic dikes cut the Jumbo Volcanics as well as a few dikes of granite and diorite which are too small in size to be represented upon the geologic map.

Examinations made of thin sections of several representative specimens from the lavas of this group show a considerable uniformity in mineral composition. As a rule the rocks are much more greatly altered than the lavas of the Rossland group. The phenocrysts are predominantly labradorite-feldspar and augite with accessories of magnetite and enstatite. The feldspars are largely altered to sericite while the augite and occasional hornblende crystals are altered to chlorite and uralite.

Diorite.

The diorite masses are difficult to separate from the granite because of the gradation of one type into the other. At several places they occur as apophyses or dikes cutting the metamorphic formations. Exposures of diorite and granodiorite may be seen on the road along the Middle Fork of Mill Creek, a short distance east of the junction of the North and Middle forks of Mill Creek. Other exposures occur along the Columbia Valley south of Kettle Falls and in the hills east of Rock Cut. The rock is typically a light to dark gray fine to medium-grained holocrystalline rock, composed of feldspar and either biotite or hornblende and occasionally quartz.

Under the microscope many variations are noted in the mineral composition. The most abundant type is composed of labradorite-plagioclase with augite, and sometimes hornblende and biotite. In the more acidic varieties orthoclase and quartz enter as essential constituents. Magnetite and titanite usually are present as accessories. While diorite is the prevailing type, yet granodiorites, monzonites and quartz monzonites form gradational phases. In the more porphyritic phases phenocrysts of feldspar and augite stand out prominently in the finer-grained groundmass of feldspar and pyroxene.

Diabase.

Dikes of diabase occur in several scattered areas through the county. Many of these dikes are too small to be represented upon the geologic map. Others attain a width of 300 feet or more. They occur on a scale of sufficient importance to map in the areas west of Chewelah and north of Myers Falls.

The rock is typically a medium to fine-grained, rather dense, medium to dark gray rock. Upon alteration it assumes a dark greenish tint. In thin sections it is found to be composed of basic labradorite laths and interstitial augite together with minor amounts of enstatite and olivine. Magnetite is a common constituent. The feldspar crystals exhibit the typical ophitic arrangement, with the augite grains between. Commonly the diabase is greatly altered and the hornblende and augite which are present in varying amounts are partly changed to chlorite. The feldspars are usually partly changed to sericite. The crystals vary greatly in size but are commonly small and lie in a residuum of brownish glass.

Sheppard Granite.

The Sheppard granite has been described by Daly in his boundary report. One prominent area lies north of the international boundary about five miles west of Col-

umbia River. This mass extends south of the boundary and occupies an area of about five square miles in the northwestern part of T. 40 N., R. 40 E. It forms the mountains between the headwaters of little Sheep Creek and Nigger Creek.

The Sheppard granite is intrusive into both the older Mission argillites and also the eastern extension of the Rossland Volcanic group. The contact relations are difficult to decipher in most places as the covering of glacial drift is well distributed and conceals most of the exposures.

The Sheppard granite is typically aplitic in appearance. It is fine-grained and noticeably crystalline with a prevailing pinkish to pinkish-gray color. The dark ferromagnesian minerals are conspicuously absent. When examined under the microscope it is found to be composed of an aggregate of orthoclase, quartz, and albite-oligoclase with very subordinate amounts of biotite which have been largely altered to chlorite. The accessory minerals noted were rutile, zircon, titanite and magnetite.

Gerome Andesite.

The Gerome andesite is confined to the southwestern corner of the county above the junction of Columbia and Spokane rivers. It appears to be a northern extension of larger areas farther south in the Columbia Lava plateaus. Two tongues extend northward into Stevens County. One of these is nearly four miles in width and nine miles in length and extends in a north and south direction from Detillion Bridge on Spokane River to Fruitland. The second area, involving about two square miles, lies to the west near Columbia River in the north corner of T. 29 N., R. 35 E. This corner of the county is thickly covered with glacial deposits and wash material from both Columbia and Spokane rivers and presumably large areas of the andesite are concealed beneath this mantle.

The Gerome andesite consists of lava flows, tuffs, breccias and intercalated beds of shale and sandstone containing impure carbonaceous seams of varying thickness. The total thickness of these igneous and sedimentary members is at least 700 feet. They lie in a north and south depression which has been carved into the older formations. The older formations consist of the matamorphic rocks of the Stevens series and the granite intrusives which are everywhere unconformable beneath the volcanics. Usually the lava beds are only 10° or 15° from the horizontal but near the margins of the belt they sometimes increase to 30° and 50°. Lava flows predominate, but tuffs, breccias and sediments compose possibly 20 per cent of the whole.

The andesite when unaltered varies from a medium to dark gray color. Usually phenocrysts of columnar hornblende and occasional biotite crystals are conspicuous in a fine-grained, rather dense groundmass. When examined in thin sections the rock is seen to consist of phenocrysts of hornblende, augite, biotite and labradorite-feldspar. These crystals are embedded in a groundmass composed of labradorite-microlites and grains of augite scattered through a matrix of iron-stained glass. The hornblende is oftentimes unaltered except for limonite around the margins. The common alteration products of both the hornblende and augite are chlorite and uralitic aggregates. The feldspars exhibit varying degrees of alteration to sericite and kaolin. In some of the sections phenocrysts of plagioclase are entirely absent although it is abundant in the groundmass. Hornblende is the most abundant constitutent of the rock while biotite ranges from three to eight per cent.

Camas Basalt.

The great basaltic lava flows, so extensively developed south of Columbia and Spokane rivers, extend northerly into the southern portion of Stevens County as long ir-

regular shaped tongues. They fill the older Tertiary depressions and in many places the granites and metamorphic rocks project up through the surrounding areas of basalt in monadnock-like fashion.

A large part of the area between the Huckleberry Mountains and the Chamokane Valley as far north as the town of Valley is composed of flows of the Camas basalt. In places isolated areas of the older formations project through it and at other localities the basalt occurs only as residual patches resting upon the older rocks. The larger part of the Spokane Indian Reservation is covered with deposits of glacial drift so that the areal extent of the underlying formations cannot be absolutely determined. They appear mostly in small exposures and the distribution of the basalt has been somewhat generalized upon the areal map. On the western side of the Huckleberry Range areas of basalt occur but they are also mostly disconnected. The most northerly occurrence of basalt which can be referred to this formation is situated four miles southwest of Chewelah in sec. 34, T. 32 N., R. 40 E. It lies on the western side of Colville Valley and has an area of about two-thirds of a square mile.

The general lithologic appearance of the basalt does not vary greatly in any of the exposures in the southern part of the county. Lava flows predominate. Tuffs and breccias occur in places but are not characteristic. The thickness of the flows varies in the many exposures. In some localities erosion has removed the greater portion of the flows leaving only residual masses. In other areas, as along the south side of Camas Prairie, in T. 29 N., R. 39 E., the thickness is approximately 500 feet. Everywhere the lava rests unconformably upon the older formations including the Gerome andesite in the southwestern part of the county. In almost every instance the lava flows of basalt have a nearly horizontal position and

no dips were observed where the angle was greater than 20°. No sedimentary intercalations were seen in the basaltic flows and consequently no information is available within the county which will show the exact age of the flows except that they are later than the Gerome andesite.

The basalt occurring in the southern part of the county is typically fine-grained, dense, and almost black in color. Crystals of dark glassy plagioclase and greenish olivine are readily discernible. Under the microscope, in thin section, the phenocrysts are found to be basic labradorite, often exhibiting zonal structure, well developed crystals of olivine, and minor amounts of augite and sometimes enstatite. The phenocrysts are embedded in a very fine-grained groundmass composed of microlites of plagioclase and olivine in a glassy matrix of iron-stained glass. Flow structure is commonly exhibited in many of the thin sections. The plagioclase phenocrysts are usually somewhat altered to sericite and kaolin. The olivine is characterized by roughened cracks which are in some cases filled with short fibres of serpentine and magnetite. Magnetite also occurs as an accessory mineral constitutent of the groundmass.

Phalen Lake Volcanics.

The lavas which have been mapped as the Phalen Lake Volcanics occur in the north central part of the county, in the eastern portion of T. 38 N., R. 38 E., on the south side of the valley of the Columbia River. They embrace an area of about 11 square miles and form hills attaining an elevation of 4,200 feet. They lie on the divide between the Columbia River and Bruce Creek, and form a steep escarpment overlooking the western side of Phalen Lake.

The Phalen Lake Volcanics constitute a series of lavas, tuffs, and breccias resting unconformably upon the upturned and eroded edges of the Mission argillite and the

Northport limestone. These volcanics have a thickness of over 1,000 feet. They have low dips of less than 20° on the margins of the area and lie in a shallow synclinal fold with a north and south axis. The lavas are situated seven miles south of the Rossland Volcanics, and in appearance they do not resemble the latter. They have not undergone metamorphism and except for surficial alteration appear relatively fresh. The basal beds are composed of whitish, hardened tuffs and above these are dark gray lavas. The upper portion of the series is a mixture of tuff and lava, with a preponderance of breccia.

The lava phase of this volcanic formation varies from fine to medium-grained and averages a medium gray color. In thin sections it is found to be composed of good-sized phenocrysts of labradorite, badly altered hornblende showing marked pleochroism, and minor quantities of augite. Quartz is usually present in small amounts. Magnetite is rather abundant as an accessory constituent of the groundmass. The groundmass is composed of plagioclase microlites and augite in a glassy matrix. The feldspars show the usual alteration products of sericite and kaolin. Fresher specimens cut parallel to the 010 face give average extinction angles of 27°.

The tuffaceous phases of the rock are light colored and have a grayish-white tint. They are fine-grained and greatly indurated. In thin sections they are seen to be composed of broken fragments of quartz, plagioclase and pyroxene crystals. All of these are embedded in a glassy matrix. The majority of the crystals are composed of plagioclase of the acidic labradorite variety and commonly show zonal structure. Crystals of quartz are abundant and show inclusions of both the gaseous and fluid types. Minor amounts of augite, titanite, apatite and magnetite were noted. The rock appears to be of the dacite variety.

Palmer Volcanics.

The Palmer Volcanics constitute a small area of about five square miles on the south side of the lower portion of Colville Valley, in the northern part of T. 35 N. and the southern part of T. 36 N., R. 38 E. Much of the area mapped as a part of this formation is covered with glacial drift so that the areal boundaries have been only approximately determined. The southern contact with the Colville quartzite is very indefinite.

The formation consists of tuffs, lavas, breccias and intercalated bands of gravels the pebbles of which attain a diameter of nearly 12 inches. Tuffs and breccias predominate as the component parts of the formation. They rest unconformably upon the Colville quartzite and dip at a small angle to the north and northeast. They form only a residual patch and have not been observed at any other locality. They may be in part the equivalent of the Phalen Lake Volcanics but since this cannot be definitely determined they have been mapped separately.

QUATERNARY DEPOSITS.

In Stevens County, as in the case of a large part of Washington, deposits of Quaternary age of varying thickness conceal many of the older formations. These deposits are composed of glacial drift and sand and gravel laid down by the action of streams. Some of the deposits accumulated in comparatively quiet bodies of water such as glacial lakes. All of Stevens County has been glaciated and the deposits covering the older formations are largely moraines. Along the valley of Columbia and Kettle rivers there are terrace deposits largely built up by the action of glacial streams.

Studies by Dawson and Daly in Western Canada show that the middle portion of the Cordillera was almost completely covered by an extensive ice cap over 300 miles in width. This ice cap occupied the area between the

Rocky Mountain system on the east and the Cascade Mountain system on the west. Within the mountains on either side were large valley glaciers which descended and joined the interior ice cap between. The average thickness of the ice in the international boundary belt in British Columbia is estimated to have been at least 2,500 feet. Its thickness in the Columbia River valley is thought to have been at least 5,200 feet and over Salmon River about 4,000 feet. In Kettle River valley and in the valley of Sheep Creek it is believed to have been 4,500 feet in thickness.

South of the international boundary the front margin of the ice divided into lobes which extended southward and followed the trend of the larger valleys. These lobes extended out onto the Columbia Lava plateau. As a result the entire preglacial drainage lines were choked and shifted so that in only a few cases do the streams occupy their former sites. Time did not suffice for a detailed study of the glacial problem of Stevens County but from such examination as was made, there appeared no indication of more than one glaciation during the Pleistocene. The materials composing the drift are universally fresh. The same deposits examined by Daly north of the international boundary are believed to be of the late Wisconsin epoch of the eastern glaciation.

One of the large lobes of ice extending southward from the ice front south of the international boundary followed down Columbia River valley to and beyond its junction with Spokane River where it deployed out onto the lava plateau of Lincoln County. A second tongue came down Kettle River and joined the Columbia lobe at the junction of the two streams. A tongue of ice from the Columbia lobe branched off near Williams and passed southward east of Bossburg and down lower Clugston Creek valley into the Colville valley. This Colville tongue extended southward to Loon Lake. An ex-

One of Little Pend Oreille Lakes at the headwaters of Little Pend Oreille River, near the eastern border of Stevens County.

tensive arm branched off from the Colville tongue and moved eastward along the broad valley of the Little Pend Oreille River at least as far as the Pend Oreille County line. One tongue from the Columbia lobe crossed the Huckleberry Range at the low gap near the headwaters of Dunn Creek and south of Dunn Mountain in T. 32 N., Rs. 38 and 39 E., and joined the Colville Valley tongue. The glaciers moved up onto the mountains to elevations of over 5,000 feet. The higher portions of the summits of the Huckleberry Mountains and such other mountains as Old Dominion projected as nunataks above the ice cap.

The paths of these tongues and lobes are now occupied with moraines consisting of the varying types of drift. Since the retreat of the ice stream, erosion has been very active and deep canyons have been excavated into the morainic material, and along the courses of the larger streams terraces have been formed. Spokane River has cut down through the drift so that in places along its north side the cliffs are from 500 to 600 feet above the

bed of the stream. They have been extensively terraced for at least ten miles north of the river. The terraces have been greatly modified by erosion.

Along the valleys of the larger rivers there are broad alluvial flats. All the smaller valleys usually have alluvial flats of varying width along their courses. These become much broader where the smaller streams join the larger ones. Wherever the alluvium can be definitely established over considerable areas and especially in the larger valleys it has been so mapped. This is especially true in the Colville Valley. There are many other areas in the county where the alluvium is more or less confused with the glacial sands and their separation is rather difficult. Such deposits have been mapped as a part of the glacial drift. No attempt has been made to separate the different kinds of drift either according to their lithologic composition or to their mode of origin. All the Quaternary deposits in the county except certain accumulations of alluvium have been mapped as glacial drift. In those areas where the drift is thin and where the general character of the underlying rock formations is fairly certain the latter have been given the preference in mapping.

STRUCTURE AND GEOLOGIC HISTORY.

STRUCTURE.

GENERAL STATEMENT.

A very definite statement concerning the structure of the formations of the county is almost impossible with the present fund of geologic knowledge. The older rocks belonging to the Stevens Series were folded, in part at least, prior to the intrusion of the Loon Lake granite. The several members of the Stevens Series have a predominant northeast and southwest strike and a dip to the west and northwest. A study of the relations of the outcropping bands of the several formations, in connection with the strikes and dips of the strata, indicate very strongly that the entire sequence of the Stevens Series has been thrown into a number of closely appressed and overturned folds as well as simple open folds. These have been intruded by masses of batholithic granite which have produced intense local disturbances as well as faulting. The folds have suffered intense erosion so that many thousands of feet of strata have been removed and the cores in some instances uncovered.

FOLDS.

A study of the areal geologic map shows that the majority of the folds trend diagonally across the county. In the east central part of the county their continuity has been terminated by the intrusion of large masses of granite. The more important of the folds will be described as the Dunn Mountain anticline and its continuation into the Mill Creek anticline, the Columbia Valley syncline, the Deer Trail anticline and its continuation into the Blue Creek anticline, the Chewelah syncline, the Addy syncline, the Toulon syncline, the Northport anticline, the Bruce Creek syncline and the Deep Creek syncline.

A prominent structural feature along the eastern side of the Columbia River valley is a synclinal fold trending

nearly north and south from Harvey Creek to the junction of the Columbia and Kettle rivers. An examination of the plotted strikes and dips expresses a closely folded syncline which in places is slightly overturned. The folds on the western limb are nearly vertical while on the eastern limb they average 70°. The two limbs can be traced by the prominence of the outcropping belts of the Colville quartzite and the intervening belt of the Mission argillite. From the areal mapping the fold would appear to end at Harvey Creek. The formation south of Harvey Creek is complicated but it is probable that the trough extends as far south as Fruitland where the formation has been greatly disturbed by igneous intrusions.

A prominent anticline, trending about N. 20° E., lies three miles east of the summit of the Huckleberry Range. The Deer Trail argillite below and the Addy quartzite above are involved in this fold, which has been closely appressed and overturned. The axis of the fold has been deeply carved by erosion so that for a distance of 15 miles the overlying Addy quartzite has been removed, and a belt three miles in width, of the Deer Trail argillite exposed. The truncated edges of the Addy quartzite, which constitutes the east and west limbs of the fold, form two broad parallel belts. The latter are on the south terminated by intrusive granite and disappear beneath a covering of Tertiary lavas. In the middle portion of T. 32 N., R. 40 E., the two belts join as the anticline pitches to the northeast beneath Colville Valley and beyond. The dips of the strata in this fold vary greatly but have a predominant slope to the northwest. This fold is designated as the Deer Trail anticline.

The Deer Trail anticline crosses Colville Valley between Addy and Chewelah and continues northeasterly for a distance of about nine miles where it is terminated by the batholithic intrusion of the Loon Lake granite. The continuation of the fold northeast of Blue Creek is

referred to as the Blue Creek anticline. In the vicinity of Blue Creek this fold has been greatly appressed and overturned so that the strata dip to the northwest at angles as low as 30°. The axis still pitches to the northeast at an angle of possibly 4°. At no point do the underlying Deer Trail argillites appear at the surface. The northwestern limb of the fold has been invaded by masses of granite.

In the southern part of T. 32 N., R. 39 E., the nose of a synclinal fold has been developed in the western limb of the Deer Trail anticline. The two limbs of the fold are composed of the Addy quartzite. The formation in the central part is the Chewelah argillite. The axis of the fold trends nearly north and south for a distance of about ten miles where it terminates against a mass of intrusive granite. All of the strata in both limbs are dipping to the west, indicating a closely appressed and overturned fold. This fold is named the Addy syncline.

Just west of the nose of the Addy syncline, in the same township and range, an anticlinal fold has been developed, the axis of which plunges to the north. The core of the fold is composed of the Addy quartzite. Flanking it on the east and west sides are the Chewelah argillites. At the north end of Dunn Mountain in T. 34 N., R. 38 E., the Addy quartzite passes beneath the overlying Chewelah argillites and does not again reappear within the county. Both the quartzites and argillites in both limbs of the fold have persistent dips to the west and afford another illustration of an overturned fold. At the north end of Dunn Mountain the eastern limb of the fold has been thrust in a reverse direction to the southwest so that the overlying argillites partially override the quartzites. Obscure faulting also complicates the structure in this region. This fold is referred to as the Dunn Mountain anticline.

The Dunn Mountain anticline continues northeasterly to Colville Valley and extends up the valley of Mill Creek to the Pend Oreille County line. That portion of the fold northeast of Colville Valley will be designated as the Mill Creek anticline. The axis of the fold pitches to such an extent that the Colville quartzite outcrops prominently as one of the limbs of the fold. The belt involved in this fold is nearly ten miles in width and the dips are prevailingly to the northwest although there are many exceptions to this condition. The region is thickly covered with deposits of glacial drift and outcrops are not everywhere exposed. It is probable that several folds complicated by faulting are involved in this area.

An important closely appressed and overturned syncline, trending slightly east to north, lies along the eastern side of Colville Valley between Chewelah and Springdale. The western limb is composed of the Addy quartzite and the eastern limb of the Eagle Mountain quartzite, which may be the equivalent of the former. The central portion of the fold is occupied by the Chewelah argillite. These strata extend eight miles northeast of the town of Chewelah where they are terminated by the intrusive granites. Although the strata are in places covered with glacial drift yet on the whole they are exceptionally well exposed. They dip universally to the west and northwest at steep angles. Locally there is some crumpling. The fold is slightly overturned and has been deeply truncated by erosion. It will be designated as the Chewelah syncline.

Between the valley of Mill Creek and Columbia River there is a broad area of the Mission argillite which appears to lie in a series of folds or possibly a geosyncline whose major axis trends N. 35° E., at the headwaters of Bruce and Onion creeks. The prevailing strike of the strata is in a northeast and southwest direction although there are many local variations. The dip is usually at

low angles to the northwest. This fold may be designated as the Bruce Creek syncline.

A synclinal fold has been formed in the area southeast of Toulon Mountain, in T. 39 N., R. 37 E. The axis of the fold trends approximately N. 30° E. and the nose is situated in sec. 6, T. 38 N., R. 37 E. The strata of the western limb pass beneath the Rossland Volcanics of Toulon Mountain. The eastern limb is well exposed on the divide between Toulon Creek and Columbia River. The dips are usually less than 40° and in many places not over 10°. Locally where there have been disturbances or where intrusions have buckled the strata they stand nearly vertical. The eastern limb in part extends as far to the northeast as Sheep Creek but the greater portion of it passes beneath the Rossland Volcanics. This fold may be partly in the nature of a geosyncline as several minor bucklings were noted. It has been deeply eroded and may be termed the Toulon syncline.

The Northport limestones and the Mission argillites exposed along the valley of Columbia River form an anticline whose axis trends approximately parallel to the general course of the river. On the northwestern side of the river the dip is prevailingly to the northwest except where there have been local disturbances. On the eastern side of the river the dip is usually to the southeast but in places it is nearly flat. Apparently the fold is a very shallow anticline which has been so deeply eroded that the argillites overlying the Northport limestones have been removed. Faults whose positions have not been determined seem to obscure the general structure. This fold is referred to in this report as the Northport anticline.

In other portions of the county there are folds more or less complicated by faulting or badly cut into by igneous intrusions whose extent and character are difficult to determine. Folds of this type occur in the north-

eastern corner of the county but the mantle of glacial drift is so thick that only a few observations on the strikes could be determined.

FAULTS.

Faulting on a minor scale throughout all parts of the county is exceedingly common. Presumably several faults of great extent are also present but it has not been possible to definitely establish their position or relations. Colville Valley, from Blue Creek to Colville, may lie along a line of major faulting. The Old Dominion limestone belts on the northeast side of Colville Valley appear to have been displaced on the southwest side of the valley. This may in part be due to obscure thrusting accompanying the intrusion of the Loon Lake granite. Similar faulting is probably in part responsible for the abrupt termination of the Addy quartzite at the north end of Dunn Mountain. Complex faulting has greatly disturbed the strata at the south end of the Blue Creek syncline, west of Chewelah.

IGNEOUS INTRUSIONS.

The intrusions of batholithic granite and diorite have had a very pronounced effect upon the structure in Stevens County. The Loon Lake granite was intruded probably shortly after the folding of the strata of the Stevens series. The northeasterly trending folds of this series are obliquely cut off along the entire eastern border of the county by a vast intrusive mass of granite. While the western two-thirds of the county are largely composed of metamorphic formations and lava flows, it is presumably underlaid by this extensive granite batholith. In numerous localities apophyses from this underlying batholith project through the quartzites, argillites and lavas in the form of stocks and dikes. In those areas where the intrusives are common the metamorphic formations have been greatly disturbed and local deformation is very complex.

GEOLOGIC HISTORY.

PRE-CAMBRIAN.

With the exception of the Orient gneiss, rocks of Pre-Cambrian age are not known to exist in Stevens County. Farther east, in Idaho, Montana and British Columbia, formations of Pre-Cambrian age have been described, and they have been designated as the Priest River terrane and a part of the Summit series. Directly west of the point where British Columbia, Idaho and Washington meet, these older formations pass to the west beneath the Pend Oreille group which is regarded as being of Paleozoic age. It is probable that the Pre-Cambrian formations underlie a large part of Stevens County but have been largely absorbed by the underlying magmas. They presumably formed the floor upon which the formations of the Stevens series were laid down. The Orient gneiss may represent a part of this floor which has undergone the most intense metamorphism, together with the intrusive granites which have also suffered intense dynamometamorphism.

PALEOZOIC.

At some time during the early or middle Paleozoic there began the development of an extensive geosyncline having an approximate north and south trend and lying between the Rocky Mountain area and the Cascade land mass. During the progress of Paleozoic time this downfold widened and deepened and became the basin of deposition for an extensive series of sands, muds, limestones, sandy shales and shaly sandstones. Contemporaneous with the deposition of these sediments there were outpourings of lava but not on a very extensive scale as compared with later Tertiary times. By the close of the Carboniferous these sediments had attained a maximum thickness of possibly 43,000 feet.

MESOZOIC.

No marine sediments of definite Mesozoic time have been recognized in the county although it is possible that the upper part of the Stevens series may have been formed during this time. During the Triassic and Jurassic periods it is probable that the sediments deposited in this great Paleozoic trough were being elevated and folded and that by the close of the Jurassic they had been uplifted above sea level, folded and overturned. To the west and southwest heavy sedimentation, accompanied by vulcanism, was taking place during the Triassic and Jurassic. It is possible that the formations of the Stevens series as they arose above sea level may have been brought into the zone of weathering and erosion, and have contributed some sediment to the Triassic marine basins occurring to the southwest and west. Following the Cordilleran evolution at the close of the Jurassic which brought the older rocks above sea level and folded them, great batholiths of granite and other allied rocks were intruded into the Stevens series and aided in their metamorphism. During the Cretaceous, the entire area of Stevens County, as well as most of Idaho and Montana, were highly elevated land areas, and were undergoing vigorous erosion. A large part of the sediment derived from these rocks in Stevens County may have been transported westward to an extensive Cretaceous marine embayment located at the international boundary, near the present divide of the Cascade Mountains.

After the invasion of the Stevens series by the great batholithic masses of granite and during the consolidation of these magmas there was rupturing and fracturing of the roof, composed largely of quartzites, argillites and limestones. Magmatic waters emanating from these slowly cooling magmas acted as mineral bearing solutions which traveled upward through all the fracture zones and ultimately precipitated their mineral content

as ore and gangue matter. The dolomites and limestones were greatly shattered and offered less resistance to the passage of the solutions and as a result suffered considerable impregnation. In the argillites and schists the solutions tended to travel along the bedding planes although in places they filled fractures which cross both the bedding and schistosity planes.

It is possible that the lower portion of the Rossland Volcanic series may have formed during the latter part of the Mesozoic era although the evidence is not conclusive.

TERTIARY.

During the Tertiary epoch all of eastern Washington underwent vigorous erosion. Local fresh water basins were formed from time to time in which sediments accumulated. Along with the sediments were deposits of volcanic ash and lava flows. No large fresh water basins have been discovered in Stevens County although small local basins apparently existed. In these muds, sands and ash were deposited. Flows of lava were being poured out over the surface in the northern and southern portions of the county. In the southern third of the county flows of andesite, followed by basalt, covered large areas of the region. These flows were the northern extension of the great lava fields of the Great Basin south of Columbia River. Those in the northern part of the county constitute a separate volcanic province. They accumulated to a great thickness and form a large part of the surface geology of the Rossland Mountains. By the close of the Tertiary a large part of Stevens County appears to have been reduced to a plain of low relief.

QUATERNARY.

Early in the Quaternary epoch Stevens County, along with other parts of the state, suffered deformation. Following these earth movements the northern Cordilleran region was covered with continental glaciers. Between

the Rocky and Cascade mountains there was a belt at least 300 miles in width and trending north and south which was almost completely filled with ice, the latter possessing an average thickness of at least 3,500 feet. In the Columbia River valley it had a thickness of over 5,500 feet. South of the international boundary the ice cap broke up into a number of lobes which traveled southward along the larger valleys and in Stevens County deployed out onto the great lava plateau south of Spokane River. Enormous quantities of sand and gravel were transported by the glaciers and upon their retreat this material was dropped and in many places filled the former drainage channels. The country as a result is heavily veneered with deposits of glacial drift. Since the retreat of the glaciers there has been a continuous attempt at a readjustment of the drainage lines as well as erosion of the glacial deposits.

ECONOMIC GEOLOGY.

INTRODUCTION.

Stevens County affords an excellent field for the study and investigation of a large number of different types of ore deposits and the relations of these deposits to the geologic formations in which they occur. During recent years a large amount of attention has been given by geologists to a scientific study of ore deposits in all parts of the world. Attempts have been made to determine under what physical and chemical conditions the different kinds of mineral deposits have come into existence, and what influence the different rock formations of the earth's crust have had upon the distribution, size, form, mineral content and richness of such deposits. As a result it has been possible to develop a generalized classification of ore deposits. It has been found that the different kinds of deposits have been formed under varying geologic conditions at different times in the earth's history and that many of them have undergone subsequent alteration so that the resulting minerals are entirely different from those first formed. In many instances the minerals first formed are of such low grade that they are not of economic importance while those which have been altered from the low grade types may be exceedingly rich.

In this report an attempt has been made to determine what formations occur within the county and to designate their areal distribution as well as their structural relations below the surface. A study has been made of the larger number of mines and prospects within the county with an attempt to determine the position, extent and mineral content of each deposit and its relation to the geologic formations containing it. The large number

of prospects and the extent of territory covered in the relatively small amount of time available for examination have rendered it impossible to give the detail desirable to each property, and to warrant a definite conclusion concerning its merit.

The metals of greatest importance occurring in Stevens County are copper, lead, silver, gold, and zinc. Ores of tungsten, molybdenum and manganese occur and are mined to a small extent. Among the non-metaliferous products of importance are magnesite, limestone, marble, dolomite, clay, shale, sand, gravel and road metal. Altogether there are more than 300 mining properties in the county of which about 100 have mined and shipped ore. Many of the mining properties have been developed only on a small scale and are to be considered as prospects. Many of these prospects are at present far removed from transportation and ore shipments are impossible because of heavy transportation rates. At the present time the copper and lead-silver ores are furnishing the bulk of the metaliferous wealth of the county although in the past there has been a considerable production of gold.

GEOGRAPHIC DISTRIBUTION.

Metaliferous deposits of both commercial and non-commercial importance occur scattered throughout the county. The majority of them are grouped into several areas which are referred to as mining districts although several properties of considerable economic importance are isolated and cannot be considered as belonging to any particular district. The more important districts into which the mining properties are grouped are: Chewelah, West Chewelah, Valley, Deer Trail, Springdale, Kettle Falls, Myers Falls, Clugston Creek, Colville, Fifteen Mile Creek, Orient, and Northport. The description

of the individual mines and prospects will be considered under each of these districts as a unit.

GEOLOGIC DISTRIBUTION.

The physical and chemical character of the different formations in the county have had a direct influence upon the formation of the ore bodies. In most cases the veins and ore deposits have been precipitated from solutions traveling along the zones of fracturing and faulting as well as along the planes of bedding or contacts between igneous and sedimentary rocks. In certain kinds of rock formations, such as quartzite or granite, the walls of the fractures or faults lie firmly in contact and the opportunities for the easy passage of mineral-bearing solutions is somewhat difficult. Such solutions as do pass through cannot as a rule readily attack and replace the wall rock adjacent to the fractures or fault planes unless the zone of fracturing is of some width. Granitic rocks are as a rule more easily acted upon than quartzites. Limestones are usually most easily fractured and mineral bearing solutions arising through such fracture zones dissolve a part of the lime and effect a direct replacement with sulphides of the various metals. The fracture zones, parallel with and diagonal to the bedding planes, in the argillites and calcareous argillites, have also afforded avenues for mineral deposition. The high-temperature minerals such as ores of tungsten and molybdenum are associated with granites.

Conforming to these generalizations the limestone and argillite formations of the Stevens group contain a large proportion of the ore deposits of the county. In the Orient district, the ores, in nearly every case, lie in zones of fracturing in the Rossland Volcanics or the monzonite dikes intruded into the volcanics. The tungsten and molybdenum minerals occur in the Loon Lake granite. The quartzites of the Stevens group are almost always barren of ore deposits.

CHARACTER OF OUTCROPS.

The outcrops of the ore bodies are in many cases concealed beneath deposits of glacial gravels and sands. As a rule even in those areas where the bed rock is exposed the surface exposures of the veins are very indefinite. Where oxidization has been unusual the carbonates or oxides of lead, iron and copper appear uniformly at the surface. In some cases well-defined ledges of quartz or calcite can be traced for short distances. Where indications of mineral deposits or veins occur there are usually numerous shallow trenches and open pits which have been made in the course of prospecting. Nearly all the veins in the county occur on the slopes of the mountains or in the gulches. The valleys are commonly filled with gravel or alluvium and surface deposits of minerals are conspicuous by their absence although in many cases commercial ores which have not been discovered may lie beneath.

CLASSIFICATION OF ORE DEPOSITS.

The following classification, based upon the form and occurence of the deposits, embraces most of the ore bodies of the county:

Veins filling fissures, shear zones, and joint planes:
- Veins in volcanic rocks.
- Veins in diabase.
- Veins in dolomite and limestone.
- Veins in argillite and schist.
- Veins in granite.

Replacement deposits:
- Irregular disseminated replacements in dolomite and limestone.
- Impregnations and replacements in amphibolite.
- Irregular replacements along shear zones and fault planes in dolomite and limestone.
- Replacements along intersecting fracture zones.

Veins along lamination planes in the schist and argillite.
Contact metamorphic deposits.
Contact deposits.
Veins along contacts of intrusive dikes.
Deposits of sedimentary origin.
Deposits of secondary enrichment.

VEINS FILLING FISSURES, SHEAR ZONES AND JOINT PLANES.

This class of ore deposits includes the majority of those occurring in the Orient and Fifteen Mile Creek districts, as well as many of those in the Chewelah, Myers Falls and Springdale districts. The lava flows of the Orient district have been fractured by numerous major and minor faults as well as insignificant joint planes. Mineral bearing solutions have arisen through these passage ways and have precipitated the metalic salts in solution and also the silica. As a rule the veins are narrow with well-defined walls. Occasionally mineralization extends into the wall rock especially when the wall rock has been greatly brecciated and crushed. The small lateral joints often contain minute seams of quartz carrying traces of pyrite, chalcopyrite or galena.

The diabase dikes in the Fifteen Mile Creek district and those west of Chewelah and Blue Creek have been fissured and mineralized in a similar manner. Usually the fractures are of small extent and the veins are as a result not very persistent. The walls are sharply defined and the wall rock shows very little alteration and mineralization. A similar condition usually prevails where mineralization has taken place in the granite. The tungsten and molybdenum veins in the granite are sharply defined quartz fillings of fissures although occasionally there has been some mineralization in the more easily altered femic minerals of the granite.

In the argillites and schists the veins commonly lie along the bedding planes. Often such zones are the re-

sult of replacements in the particular beds which have been most susceptible to alteration although the fracturing may have opened up an avenue for the circulating solutions. In the argillites many of the quartz veins lie in well-defined fissures in which no replacement has taken place. Such veins may well follow the strike of the formation for a time and then cross it diagonally. Examples of this type may be seen in the Frisco-Standard and Liberty Copper mines.

REPLACEMENT DEPOSITS.

The ore deposits occurring in the limestones are typically replacement deposits. Where the limestone areas have been subjected to great crushing movements fracture zones of small size have been developed at random throughout the mass. Sometimes these are of considerable extent and at other times they are merely seams or gashes. They have afforded avenues for circulating mineral bearing solutions to pass through all parts of the formation and to precipitate their mineral content with uneven distribution. Deposits formed in this manner are usually of small size and of irregular shape. Under such conditions of deposition the problems of mining consist of searching for pockets of ore rich enough to mine and the development of such a property cannot usually be carried out on a very systematic plan, as in the case of a well defined vein. In some areas as at the Napoleon mine or the Big Iron mine, large masses of amphibolite have been fractured so as to form wide zones of considerable extent. These have been invaded by mineral bearing solutions which have not only filled the fracture zone but have also to some extent replaced a part of the rock itself with gangue or ore minerals.

Wherever major fracture zones in limestone intersect minor fractures or joints the circulating solutions have been very active in precipitating their metallic content and replacement has been so strong as to develop roughly,

chimney-like ore bodies with their long axes parallel to the line of intersection of the two fractures. Deposits of this type are often very rich and have afforded some of the largest and richest ores of the county. Examples of this type are the ore bodies in the Electric Point, Gladstone and Cleveland mines.

In the Chewelah district, the Chewelah argillite contains, interbedded with it, narrow bands of limestones and calcareous argillite. These bands have yielded to deformational stresses and have been fractured and acted as zones for circulating solutions containing copper salts. Zones of mineral replacement have formed along original fracture planes which conform to the strike and dip of the argillites. Similar conditions of deposition obtain in many of the properties in the Northport district.

CONTACT METAMORPHIC DEPOSITS.

In the Clugston Creek district zones of mineral deposition occur in the limestone parallel to and within a few feet of the granite contact. Well-defined fissures do not appear to exist. The limestone has been partly replaced by silica and fine disseminations of galena, sphalerite and chalcopyrite. This condition extends to the granite contact although the granite has escaped mineralization. Examples of this condition may be observed on the A and C property near the divide between Clugston and Bruce creeks. The molybdenum northeast of Phalen Lake occurs in quartz veins lying parallel to and within 10 feet of the granite contact, but within the granite formation.

CONTACT DEPOSITS.

In the Orient, Fifteen Mile Creek and western Northport districts the contacts between intrusive dikes and the limestone, latite or argillite formations have served as avenues for the mineral bearing solutions to arise and precipitate some of their mineral content. Occasion-

A view of one of the working faces in the Finch Quarry of the Northwest Magnesite Company.

ally mineralization extends into the surrounding wall rock but as a rule the veins are rather distinct and usually narrow. Quartz is usually present as the gangue mineral in these types of deposits.

DEPOSITS OF SEDIMENTARY ORIGIN.

Along the eastern side of Huckleberry Mountains a well-defined belt of dolomitic limestone is interbedded with the Deer Trail argillite. It has been mapped and designated as the Stensgar dolomite. It trends northeasterly, has a prevailing dip to the northwest and extends from the Deer Trail mining district northeasterly to a point a few miles west of Chewelah. At intervals within this belt the dolomite passes over into magnesite. These bodies of magnesite vary greatly in their chemical character and appear to be a replacement of the dolomite. The dolomites are believed to have been deposited on the sea floor at the time the argillites were accumulating as a result of the precipitation of calcium and magnesium

carbonates. Later, enrichment of the dolomites in magnesium due to the extraction of calcium carbonate, resulted in the formation of magnesite.

LIST OF MINERALS IN STEVENS COUNTY.

A large variety of minerals occur associated with the rocks and ores of Stevens County. Many of these are quite common in any district where a considerable number of different types of rocks are present. Many of the intrusive igneous rocks have been injected into the limestone formations as well as the calcareous argillites and a large variety of metamorphic minerals has resulted. Several high-temperature minerals have been formed in the granitic masses. Minerals which are usually associated with saline lakes are typically absent, although they occur elsewhere in the Okanogan Highlands and on the basaltic plains east of the Columbia. The more prominent minerals are noted below:

Apatite. This is a common accessory constituent of the granite and diorite of the county.

Argentite. This mineral occurs in the lead-silver ores of several mines in the district, the most noteworthy of which is the Old Dominion. It is probably a secondary mineral.

Arsenopyrite. This mineral occurs in very small amounts in an open cut in the Chewelah Consolidated Mine in a quartz gangue, and also in the Germania Tungsten Mine.

Augite. Augite is abundant in the Gerome andesite, the Camas basalt and the diorite and lamprophyre dikes.

Azurite. This mineral occurs in the oxidized zone of some of the copper deposits in the form of a thin coating on the quartz and calcite gangue minerals, but is less common than the malachite.

Barite. Barium sulphate occurs as veins in the calcareous argillites in the Chamokane district near the

headwaters of Chamokane Creek. It is white in color and characterized by its high specific gravity.

Biotite. This is one of the most abundant constituents of the Loon Lake granite, as well as the monzonite. It forms the essential mineral of many of the lamprophyre dikes so abundant in the county.

Bornite. Small amounts of bornite occur associated with the deposits of chalcopyrite, but usually as a secondary mineralization forming a coating on the chalcopyrite and in the upper zones.

Brucite. This mineral occurs in a mass of considerable size in a deposit of magnesite, which in turn lies in a belt of dolomite west of Valley.

Calcite. Large bedded deposits of calcite occur in thick bands, interbedded with argillites and quartzites of the Stevens Group. Often it is pure, but more commonly grades into dolomite of varying purity. Calcite also occurs in secondary mineral fissures.

Cerussite. The carbonate of lead, cerussite, occurs in many of the lead deposits in the oxidized zone as an alteration product from the galena. It is the predominant ore mineral in the Electric Point Mine, one of the most active mineral producers in the county.

Chalcedony. This mineral has been noted as an amygdaloidal filling of the vesicles in many of the Tertiary and other lavas of the county.

Chalcocite. In the majority of the copper properties of the county, this is a rather common mineral, although it is not an abundant mineral, except in the United Copper Mine, where it constitutes a large part of the ore deposit.

Chalcopyrite. This is the most widely distributed of all the copper bearing minerals in the county. It occurs as a fissure vein filling, as in the Loon Lake and the Copper King mines. Commonly it is associated in a com-

plex manner with galena and sphalerite, as in the Cleveland Mine. In the Orient district it is finely disseminated in the pyrite and pyrrhotite.

Chrysocolla. The hydrated silicate of copper occurs sparingly in the oxidized zones of copper deposits along with malachite and azurite. It is less common than either of the latter minerals.

Copper. A few small flakes of native copper were seen in the joints of the Rossland Volcanics, where it is of non-commercial importance. Native copper is rare in the county and was not seen elsewhere.

Cosalite. This mineral is a lead-bismuth sulphide, occurring in needle-like crystals in the quartz in association with the wolframite in the Germania Mine. Analyses which have been made of the mineral show it to contain one ounce of silver and 0.02 ounces of gold to the ton.

Cuprite. The red oxide of copper, cuprite, is common as a minor alteration mineral in many of the copper deposits of the county.

Diopside. This variety of monoclinic pyroxene occurs occasionally in the basic diorites and intrusive gabbros.

Dolomite. This occurs both as a gangue mineral in several deposits and also as a constituent of certain members of the Stevens Group. It varies greatly in the ratio of calcium to magnesium, so that there are complete gradations from calcite to dolomite and in places to magnesite.

Epidote. This mineral has been developed in the calcareous argillites along fracture zones which have been mineralized. Yellowish-green epidote occurs as a gangue mineral in the gneissic granites just west of Laurier in Ferry County. It has also been formed as a secondary constituent in the alteration of many of the basic igneous dikes.

Fluorite. This mineral is rather uncommon but occurs in association with the quartz gangue at the Germania Tungsten Mine and with the molybdenum deposit near Phalen Lake. It occurs as an accessory constituent of the granite and especially near the contact with the schists and quartzites.

Galena. This is one of the most abundant and widely distributed minerals in Stevens County. It occurs both in the finely crystalline massive condition and also in large crystals. As a rule it is more abundant in the veins occurring in limestone than in other rocks. In many cases it carries considerable values in silver.

Garnet. Garnet of a reddish-brown color has been found as a common mineral in the Orient gneiss and occurs in the limestones near the contact with intrusive igneous masses.

Gold. Native gold is said to have been found in the oxidized zones of many of the mines of the Orient district and especially in the Beecher. The pyrite and pyrrhotite deposits of the Orient and Fifteen Mile Creek districts carry varying amounts of gold.

Hematite. Small quantities of hematite occur in the surface oxidized portions of the pyrite and pyrrhotite ores, such as the Scotia and Napoleon deposits. It may be in part a form of turgite.

Hornblende. This common variety of the monoclinic amphiboles is an abundant constituent of many of the volcanic and intrusive igneous rocks of the county.

Hübnerite. This tungsten mineral which contains 23.9 per cent of MnO, occurs in masses over an inch in thickness, scattered through the quartz in the Tungsten King Mine.

Hypersthene. The orthorhombic pyroxenes occur rather sparingly in the Camas basalt, the Gerome andesites and in some of the intrusive diorites.

Ilmenite. As an accessory mineral, ilmenite occurs in small amounts in the Loon Lake granites and in the quartz monzonite, as well as in the alluvial sands along Columbia River.

Kaolinite. This mineral occurs abundantly as an alteration product from the feldspars of the granite and diorite. In an impure form it has accumulated in beds as the result of deposition in pools of water and is a source of clay deposits.

Limonite. This mineral is a common surface alteration product from the oxidation of pyrite, pyrrhotite and chalcopyrite deposits, where it forms a gossan. It also forms in the decay of sedimentary rocks containing varying amounts of ferruginous carbonates. Considerable quantities occur in a clay at the contact between limestones and basaltic lavas.

Magnesite. This mineral as known in most western areas occurs as vein fillings in serpentine and peridotite. In Stevens County it occurs as a replacement in dolomite rocks of sedimentary origin. It continuously varies in composition from the theoretical composition and exhibits all possible gradations into dolomite. In color it ranges from white to gray, bluish-gray, reddish-gray, red and dark gray, and in texture from very fine-grained to coarsely crystalline.

Magnetite. As an accessory mineral small grains of magnetite were noted in the granites, diorites and the Camas basalt. Small irregular patches of it occur in the serpentine east of Laurier.

Malachite. The hydrated carbonate of copper, malachite, is common and occurs in small amounts in the oxidized zone of nearly all the copper deposits.

Molybdenite. Molybdenite occurs in a quartz vein in granite northeast of Phalen Lake and close to the roof of the granite batholith. It occurs also in association

with chalcopyrite in a fissure contact vein in the Juno-Echo Mine at Chewelah. In small amounts it is common as a high-temperature mineral in several parts of the county.

Muscovite. Muscovite constitutes a rather abundant accessory constituent of some of the intrusive granite, but is common in the quartz-mica schist of the Stevens metamorphic group.

Olivine. This mineral occurs as a constituent of the peridotites east of Laurier and also in certain of the diabase dikes and in the Camas basalt.

Opal. Small quantities of opal occur in the tuffs intercalated with the Tertiary Camas basalts in the southwestern portion of the county.

Orpiment. In association with realgar this mineral occurs at the Chewelah Consolidated Mine. Only one small specimen was noted.

Orthoclase. The monoclinic potash feldspar, orthoclase, is an abundant constituent of the Loon Lake granite and the monzonite porphyries. In some localities the crystals attain a length of four inches and compose 80 per cent of the rock mass.

Plagioclase. The triclinic sodium calcium feldspars are the most common constituents of the diorite and andesite and the basic lavas. They occur as accessory minerals in the granite and acidic lavas.

Pyrite. This is the most common ore mineral in Stevens County. It is present in varying amounts in nearly all the mines and prospects. In the Orient district it is the usual mineral in the fracture zones in the latite areas, as in the First Thought Mine, and carries the gold content. In such mines as the Big Iron, Scotia and Napoleon it forms large masses.

Pyromorphite. This is a secondary mineral occuring in the oxidized zone of some of the lead deposits. It has

been recognized in the Eagle Mine at Chewelah and in the Cleveland Mine west of Springdale.

Pyrrhotite. This mineral is abundant in the replacement zones in the schists of the Orient district and as a fissure filling in the lavas of the Fifteen Mile Creek district, where it commonly carries some finely disseminated chalcopyrite and low values in gold.

Quartz. This is the prevailing constituent of the quartzites. It occurs in all the granites and aplites and forms the gangue of many of the ore bodies of the county.

Realgar. This mineral has been found only at the Chewelah Consolidated Mine in one of the small surface cuts in a quartz vein. It is extremely rare, being present only in the minutest quantities.

Rutile. As an accessory mineral rutile occurs in the granites and diorites of the county, as well as in dust-like aggregates in some of the quartzites.

Scheelite. Scheelite, the tungstate of calcium, is intimately associated with the wolframite in the Germania Mine, where it occurs as a pure white mineral resembling quartz, but with a much higher specific gravity.

Serpentine. This mineral occurs as an alteration product of the ferro-magnesian minerals of the basic igneous rocks. East of Laurier it forms an area of considerable size from the alteration of peridotite. Serpentine has been developed in connection with the magnesite deposits at the U. S. Marble quarry west of Valley.

Siderite. This forms an important gangue mineral for the chalcopyrite ores in several mines in the Chewelah district. It occurs in bands ranging from a few inches to over 40 feet in thickness and lying within and conforming to the bedding planes of the schist.

Silver. Native silver is reported to occur in small amounts in several of the lead-silver deposits, but only in the upper oxidized zones.

Sphalerite. Commonly known as zinc blend, sphalerite is widely distributed in all the mining districts of the county. It is more commonly associated with the lead ores and sometimes occurs in considerable quantities, especially in the limestone formations. It occurs both massive and in finely disseminated crystals. It is often a replacement mineral and is distinctly banded.

Spinel. This mineral was noted in the granite near Old Dominion Mountain as an accessory rock constituent and also in the sands along the Columbia.

Stibnite. The sulphide of antimony, stibnite, is rare as a mineral in the county. It occurs rather prominently in the ore at the Wells-Fargo Mine, where it is associated with a quartz gangue. It usually occurs in small vug-like masses irregularly scattered through the gangue. Small values of silver are said to occur in it.

Talc. Talc occurs in the serpentine mass east of Laurier as an abundant alteration product of the ferromagnesian pyroxenes occurring in the basic diorites.

Tetrahedrite. In nearly all the districts of the county, tetrahedrite occurs in small amounts. It usually carries varying amounts of silver. It is a common mineral in the High Grade Mine at Chewelah and the Silver Queen Mine south of Kettle Falls, as well as in many others.

Titanite. Titanite occurs as an accessory mineral in the granite and diorite and is usually present in the alluvial sands along Columbia River.

Tourmaline. Small radiating crystals of tourmaline occur in the quartz of the granite in the Germania Tungsten Mine.

Tremolite. This variety of the monoclinic amphiboles occurs in some of the limestones and calcareous argillite formations of the Deer Trail and Orient districts and occasionally in other places.

Wolframite. This mineral is a brownish-black tungstate of iron and manganese, and occurs in a quartz gangue, filling fissures in the granite at the Germania Mine, and also in the deposits on Grouse Mountain east of Loon Lake.

Wollastonite. Specimens of wollastonite were noted in the limestone belts in the altered zones adjacent to intrusive igneous masses.

Zircon. Zircon occurs as an accessory constituent of the granite and also occurs in the sands exposed along Columbia River.

GENESIS AND AGE OF THE ORE BODIES.

The entire series of argillites, limestones and quartzites of the Stevens group was uplifted and folded before the intrusion of the Loon Lake granite. The complete area of the county is presumably underlain by this granitic mass which at one time, while in a liquid condition, was injected into the overlying sedimentary rocks. It is probable that this batholithic intrusion occurred near the close of the Jurassic epoch and was contemporaneous with, or followed close upon, the deformational movements which produced the folding of the rocks. Without doubt the stresses set up in the rocks at this time developed zones of fracturing and faulting, together with minor slip and joint planes, and these became avenues for the greatly heated ascending mineral bearing solutions derived from the granitic magma below. The force of crystallization may have exerted pressures which aided in the opening of the zones of weakness and gave direction to the more important avenues of circulation. As these solutions traveled upwards through the fracture zones in the limestones and argillites, silica, calcite and the sulphides of the metals precipitated out in the narrow, and probably in most cases closed, fissures but reacted with the adjacent wall rock and after partially dissolv-

ing it replaced it with the mineral content from solution. It is probable that the greater part of the mineral deposition in the county occurred shortly after the granitic intrusions. In the Orient, and in the Fifteen Mile Creek districts, the country rock is a part of the Rossland Volcanic formations. These were fractured and are filled with silica and metallic minerals. The lavas are in part of Tertiary age and it is probable that the time of mineralization was much later than that of the central and southern part of the county. It may have taken place following the Tertiary intrusions which are well known just north of the international boundary, and which in the Orient district are represented by the numerous monzonite and granitic dikes. Although there is no definite evidence available, it is probable that the ore deposits of Stevens County came into existence at two different time intervals. One of these may have been at or near the close of the Jurassic and the other possibly during the Miocene or Pliocene. Both of these epochs of mineral deposition probably followed an epoch of uplift, folding, fracturing and batholithic intrusion. The assumed age of mineralization is dependent upon the age of intrusion.

HISTORY OF MINING DEVELOPMENT AND PRODUCTION.

The first mineral discoveries in northeastern Washington are reported to have been made in 1865. The early mining activity was almost confined to the search for placer gold. The first discoveries in Stevens County were made in the Colville district in 1883. In 1885 the Old Dominion claims were located. Shortly afterward mineral locations were made in the Chewelah and Deer Trail districts. In 1896 the Colville Reservation was thrown open to mineral entry and a large number of prospectors came into the region. The larger number of mining properties in the county were located in the few years following this opening. Roads were built into many localities and many shipments of high-grade ore

were made. In many cases the ore was packed out long distances on horseback. After much of the high-grade surface oxidized ores were mined lower grade ores were encountered. Many of the properties which started development were unable to find ore of sufficiently high-grade to warrant shipment for any considerable distance. The fluctuation in the prices of silver and copper acted somewhat as a barrier to extensive mining development.

During the past two years there has been a revival of mining activity due to the demand for certain ores for war purposes and also the rapid rise in the prices of silver and copper. Several properties which have been more or less inactive for some years are being opened up and unwatered. One of the difficulties encountered in mining operations has been the complex character of the ores. Methods of treatment for the successful extraction of the metals have not been developed on a commercial scale. It is probable that many properties which are now inactive will at some future time produce considerable amounts of ore provided means can be found to effectively and commercially treat these ores.

A line of railroad traverses the county from north to south and many shipping points are available. Moderate to poor roads connect the mines and prospects with the shipping points on the railroad. In some cases at present, ores can be commercially hauled by team or auto-truck for distances of over 20 miles to the railroad. The smelters in British Columbia, as well as those at Northport and at Tacoma, receive the greater portion of the ores produced at the present time.

NON-METALLIC DEPOSITS.

Among the more important non-metallic substances of commercial importance are magnesite, limestone, dolomite, and clay. Basalt, quartzite and silicified argillites are abundant and constitute an available source of road

metal. The glacial deposits of the county furnish ample supplies of gravel and sand.

The magnesite deposits, as at present known, are mostly confined to a long narrow belt of dolomite trending along the eastern flanks of the Huckleberry Range from Deer Trail on the south to a point west of Chewelah on the north. It is possible that some of the other dolomite formations in the county may contain replacement deposits of commercial magnesite but up to the present they have not been discovered.

Dolomite is extensively represented throughout the county. It varies greatly in chemical composition, and grades by degrees into pure limestone. About four miles east of Colville a dolomitic deposit is being developed and a large calcining plant established. The material is to be shipped to the paper mills of Oregon and Washington in place of the magnesite from California. It is used in the manufacture of paper.

The limestone varies greatly in the ratio of calcium oxide to magnesium oxide. That in which the magnesium content is very low or absent is of value and is being used in the manufacture of lime and also in the manufacture of Portland cement. The rock from one quarry is being mined and used as a flux in the Northport smelter.

DESCRIPTION OF MINING DISTRICTS.

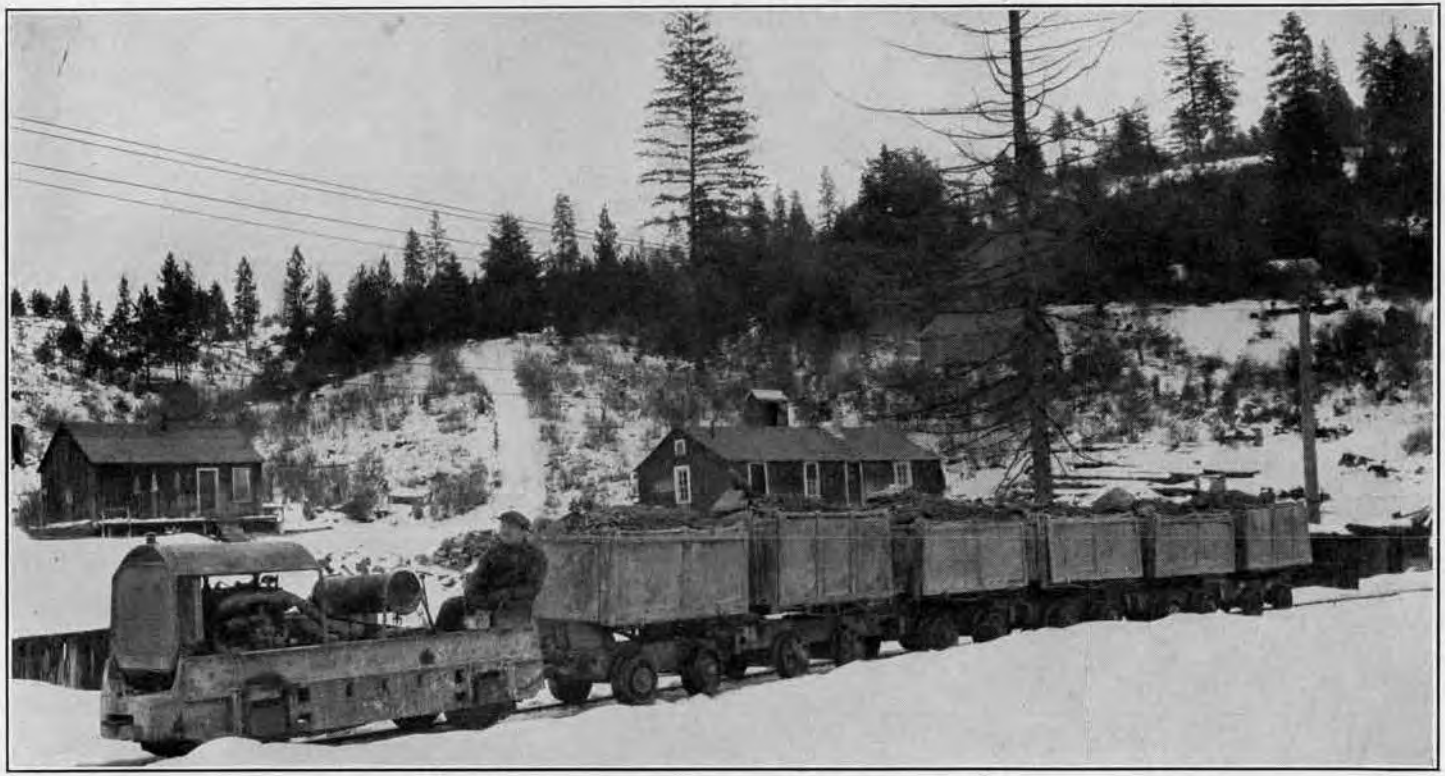
CHEWELAH DISTRICT.

GENERAL STATEMENT.

This district lies in the central part of Stevens County, on the east and west sides of Colville Valley. Altogether about 450 square miles of territory are involved. The area naturally is divided into two divisions, one of which lies on the west side of Colville Valley and the other on the east side. The principal town and shipping point in the district is Chewelah, a town of 1,600 population and situated on the Great Northern Railroad. Other towns of importance are Blue Creek and Addy.

The first locations in the district were made shortly after the Reservation was thrown open in 1896. The Eagle mine was the first to be developed and this was followed by others on the southern and western slopes of Eagle Mountain. The United Copper Mine is now leading all others in activity. Several mines are producing on a small scale but the majority are doing only the annual assessment work. Good roads extend to most of the properties and in many of them a large amount of development has been done. Considerable equipment has been installed in the form of mills, machinery, and camp buildings.

The formations exposed in the district consist mainly of argillite, limestones and quartzites of the Stevens group. These are cut by masses of granite and lamprophyre dikes. The ore bodies consist largely of fissure and replacement deposits in zones of fracturing and fissuring and lie parallel to the bedding planes of the limestone and argillite. They are most conspicuous in the near vicinity of the granitic intrusive rocks. On the west side of Colville Valley the veins consist of slightly mineralized fissure zones in diabase and amphibolite as well as in the argillite. Copper, lead and silver consti-



Gasoline locomotive hauling train of ore from main adit of United Copper Mine.

tute the chief values of the ores, although copper leads in production. Chalcopyrite, bornite, chalcocite and galena are the most important ore minerals.

UNITED COPPER.

This property comprises seven claims and five fractions which were incorporated as the United Copper Mining Company in 1906, with head offices in Spokane. The claims are situated about five miles northeast of Chewelah which is the nearest railway point. Chewelah is reached by a wagon road of easy grades and fair construction. The ore and supplies are hauled by both teams and trucks.

The mine is developed by a main tunnel, at an elevation of 2,300 feet, with a direction nearly due east. The tunnel has been driven 4,220 feet to the point where it intersects the vein about 1,000 feet below the outcrop. Drifts aggregating 1,460 feet have been made north and south from the main crosscut and about 700 feet each way. At intervals of 25 to 35 feet ore chutes leading into the stopes, have been installed. In the hanging-wall of the vein, near the intersection of the crosscut and drift tunnels, a two-compartment shaft is being sunk which at the time of examination was 175 to 180 feet in depth. At 120 feet below the collar a station has been cut and drifting north and south on the vein is in progress. The drift extends 75 feet south of the shaft where a fault has been encountered which throws the vein about four feet to the west. The north drift extends 100 feet to the north and shows good ore in the face. The face of the north drift on the tunnel level is in a hard basic dike resembling diorite. Besides the workings from the main tunnel there is an upper tunnel about 600 feet above from which a large amount of drifting, raising and stoping has been done. It is about 400 feet from the upper tunnel to the outcrop of the vein.

The rocks of this immediate vicinity consist of alternating bands of argillite, calcareous argillite, quartz-

Drifting on the United Copper Vein, 1200-foot level.

mica schist, and quartzite, all of which have a prevailing strike of N. 20° E. and a dip of 70° to 75° to the southeast. They all belong to the Chewelah argillite. On the east of the argillite lies the Eagle Mountain quartzite. These strata have been subjected to intense fracturing and faulting, and they have been cut by numerous narrow lamprophyre dikes. The ore deposits occur in a zone of fracturing paralleling the bedding planes of the argillite. The ore is chiefly chalcopyrite and smaller amounts of gray copper, together with iron pyrites in a gangue of quartz. The mineralized zone is from 5 to 20 feet in width with an average of perhaps eight feet. The ore above the 1,000-foot level is being mined by the shrinkage stope method, but this is not altogether satisfactory on account of the blocky nature of the ground. It is estimated that from 200 to 250 tons of rock are being sent to the mill each day, of which 10 per cent to 20 per cent is being sorted out as waste.

The new mill has a rated capacity of 150 tons and is now treating about 125 tons. It was built to re-treat the accumulated tailings from an old mill; which are estimated to be about 100,000 tons. The older mill unit is still used. Here the ore is crushed down to table-feed size and concentrates made on Deister-Overstrom tables. The table tails are flumed to the new mill, where they are reground for flotation treatment.

The new unit contains a 4x5-foot ball mill rated at 150 tons capacity per 24 hours of the old dump tailings. The tailings are sent to small storage tanks and then to 45-inch cone-classifiers. The overflow passes from the classifiers to 8x14 inch elevators. The sands pass from the classifier to the ball mill, which grinds in closed-circuit with an Aikens classifier. The overflow from both the cone and Aikens classifier is delivered to the flotation cells.

COPPER KING.

This property is situated northeast of Chewelah, from whence it is reached over a fairly good wagon road, with a down grade from the mine to the railroad. The formation is a part of the Chewelah argillite and has a prevailing strike of N. 22° E., with a steep dip to the southeast and sometimes to the northwest. The prevailing rocks exposed are quartz-mica schists, argillites and calcareous argillites. The strata are cut by faults, one set of which strikes N. 85° E. with a steep angle of dip to the north, and the other with a strike of N. 45° W. The ore deposits are fissure veins lying parallel to the bedding planes of the formation. They vary greatly in thickness when followed along their strike so as to give the appearance of pods or lens-like bodies. The gangue material consists of quartz, calcite and siderite in varying amounts. The ore minerals are chalcopyrite, pyrite and tetrahedrite which in the upper workings have been somewhat altered to azurite, malachite and limonite. The ore bodies lie on the north side of the canyon from the United Copper property and are apparently a northerly continuation of certain veins encountered in the underground workings of the United Copper Mine.

The property is developed by a main lower working tunnel whose portal is at an elevation of 2,850 feet. The length of this tunnel through the Amazon ground to the west side line of the Copper King claim is 950 feet. From this point up to where the tunnel cuts the ledge is 192 feet. From the ledge the tunnel is continued 375 feet easterly. There are three drifts to the south, each of which is about 200 feet in length and two drifts to the north one of which is 200 feet in length and the other 65 feet. The direction of the main tunnel to where it intersects the Copper King west side line is N. 73° E. and beyond this point S. 84° E. From the lower tunnel it is reported that over 6,000 tons of copper ore have

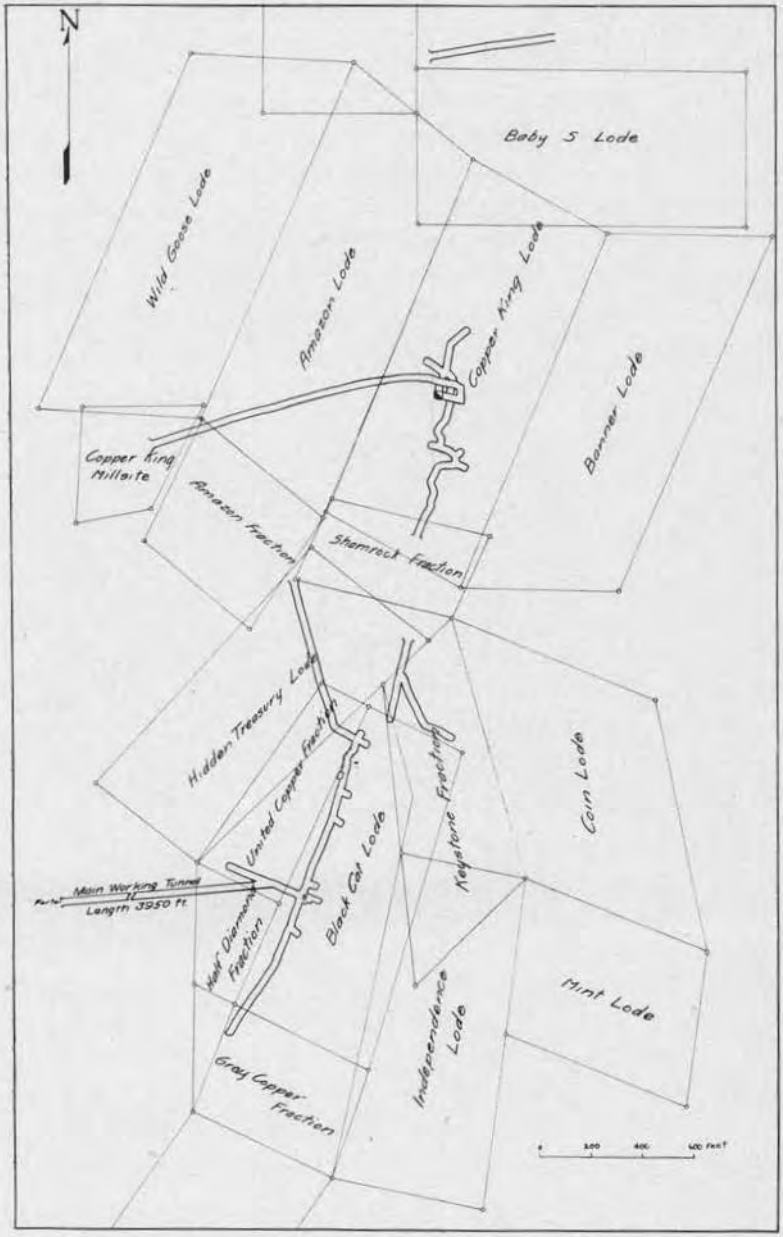


FIG. 3. Map showing location of claims and plan view of workings of both the United Copper and Copper King mines.

been shipped. One large stope in the lower tunnel which is about 100 feet in length and from 8 to 20 feet in width is said to have yielded over 4,000 tons of ore which averaged copper 2½ per cent, silver 3 ounces, and gold $1.00.

An upper tunnel has been driven, in which there are over 1,000 feet of tunnel work as well as stopes extending nearly to the surface. From this a considerable amount of ore has been shipped.

COPPER QUEEN.

This mine is situated in sec. 29, T. 33 N., R. 41 E., north of the Copper King Mine. The development work involves a long crosscut tunnel driven to the east through the strata of the Chewelah argillite formation which strikes N. 20° E., with a dip of 70° to the southeast. About 600 feet from the portal of the tunnel a four-foot vein of siderite and quartz parallel to the bedding planes was encountered. It carries chalcopyrite as the ore mineral. Several lamprophyre dikes were cut as the tunnel was being driven. Two other crosscut tunnels have been driven on the property making over 1,200 feet of tunnel work altogether.

HIGH GRADE.

This property, formerly known as the Delmonico, is situated in sec. 31, T. 33 N., R. 41 E., at an elevation of 2,515 feet, and about four miles northeast of Chewelah. The formation exposed is a buff-colored limestone interbedded with the Chewelah argillites, all of which strike N. 8° E., with a vertical dip. The property is developed by a shaft which at the time of examination had been sunk to a depth of 125 feet. The limestone in the vicinity of the shaft is intersected by a network of narrow quartz stringers. Within the limestone there is a belt nearly 200 feet wide with a north and south trend containing large quantities of siderite. The shaft has been sunk on some east and west stringers of quartz carrying chalco-

cite, tetrahedrite, and galena and which are said to also carry high values in silver.

JIM DANDY.

This prospect is situated in the northeast quarter of sec. 32, T. 33 N., R. 41 E. The rock formation exposed consists of alternating bands of argillite, limestone, calcareous argillite and quartz-mica schist, all of which have a general strike of N. 16° E. and a nearly vertical dip. The development work consists of a main tunnel whose portal is on the Sunset claim and which has been driven S. 79° E. for 325 feet as a crosscut. Near the face a drift has been driven N. 25° E. for 158 feet and from it another crosscut to the east for a distance of over 300 feet. A small amount of chalcopyrite was observed in a drift near the face. Several other short tunnels and open cuts have been made upon the surface.

On the Express Fraction claim a short tunnel a little over 200 feet in length has been driven in the Chewelah argillites and the overburden of glacial drift. A part of the tunnel follows the contact between the bedrock and the overlying glacial material.

INDEPENDENT KEYSTONE.

This group consists of four claims and a fraction located in sec. 32, T. 33 N., R. 41 E. The formation consists of interbedded argillite, calcareous argillite and quartz-mica schist belonging to the Chewelah argillite formation. The strata have a prevailing strike of N. 16° E. and a dip of 80° to the southeast. The property is developed by a tunnel driven along the bedding planes of the formation, on a vein of quartz and gouge containing some chalcopyrite. Some distance from the portal a lamprophyre dike was encountered, having a strike of N. 20° E. and a dip of 75° to the northwest.

BELCHER.

This property consists of a group of nine claims situated on a western spur of Old Eagle Mountain. The country rock consists of the several members of the Chewelah argillite formation, all of which have a prevailing strike of N. 30° E., with a dip of 80° to the northwest. There are many variations in the dip however. The development work consists of tunnels, shallow shafts and open cuts.

At an elevation of 2,900 feet a tunnel is being driven from near the center of the Exchange claim S. 60° E. to cut a quartz vein exposed on the Dickson claim. At the time of examination it extended 420 feet to the face. The rock encountered is a white, silicified limestone and a schistose argillite. About 50 feet from the face a vein of quartz six feet in width occurs carrying some galena. About 50 feet from the portal an oxidized zone crosses the tunnel carrying small amounts of limonite and a little chalcopyrite. At the discovery shaft on the Dickson claim a 4-foot vein of quartz, having a strike of N. 20° E., with a vertical dip, occurs, cutting the quartz-mica schist. The shaft has been sunk to a depth of 12 feet, exposing chalcopyrite and a little chalcocite. This is thought, possibly, to be the continuation of the United Copper vein. Thirty feet east of the shaft is a second 6-inch vein and 50 feet farther east a 30-foot ledge of siderite. Shallow shafts have been opened upon these veins.

On the Lookout claim a tunnel has been driven southeasterly to cut the southerly extension of the United Copper vein. This tunnel extends into the Widow's Mite claim. From the Widow's Mite claim a tunnel has been driven northwesterly past the face of the tunnel just mentioned, with the object of cutting the United Copper vein. Both of these tunnels are entirely in argillite and quartz-mica schist. It is probable that the vein lies some-

where on the western portion of the Lookout claim and west of the portal of the tunnel. Where the shaft intersects the upper United Copper tunnel the argillite has a strike of N. 26° E., with a vertical dip. At the face of the same tunnel the strike of the formation is N. 34° E., with a dip of 86° to the southeast. The strata and the vein which is in conformity swings more to the southwest as it approaches the southern end of the White Cat claim. On the White Cat claim a shaft has been sunk to a depth of 135 feet on a pitch of 83° to the southeast on a quartz vein said to vary in width from three inches to three feet. This is thought to be on the United Copper vein.

REDWOOD.

The Redwood claim is situated in sec. 5, T. 32 N., R. 41 E., about five miles east of Chewelah. It lies to the southeast of Eagle Mountain, on the western flanks of the Pend Oreille Mountains. The formation exposed consists of limestone and quartzite which have been cut by masses of granite on the south. The development consists of a crosscut tunnel driven easterly for a distance of 400 feet through white, marbleized limestone and bluish-gray limestone. A short distance back from the face a vertical shaft has been sunk which at the time of examination was filled with water. A raise has also been extended to the surface on bodies of ore occurring as a replacement in the limestone along zones of fracturing and brecciation. Galena is the principal metallic mineral.

IMPERIAL COPPER.

This property lies in the bottom of a canyon along the western flank of Old Eagle Mountain, at an elevation of 2,800 feet, in sec. 6, T. 32 N., R. 41 E. The formation consists of a white limestone belt lying on the western side of an argillite and quartz-mica schist belt. A shaft has been sunk in the limestone, close to the schist contact, to a depth of 106 feet. At the 106-foot level a crosscut tunnel

has been driven to the west for a distance of 450 feet. At the time of examination the shaft was filled with water. Near the collar of the shaft a tunnel has been driven to the northeast, where a 4-foot vein of quartz was cut.

BLUE STAR.

This property is one of the oldest in the Chewelah District and was formerly known as the Eagle Mine. It is situated in sec. 5, T. 32 N., R. 41 E., and sec. 32, T. 33 N., R. 41 E., about 3½ miles northeast of Chewelah. The

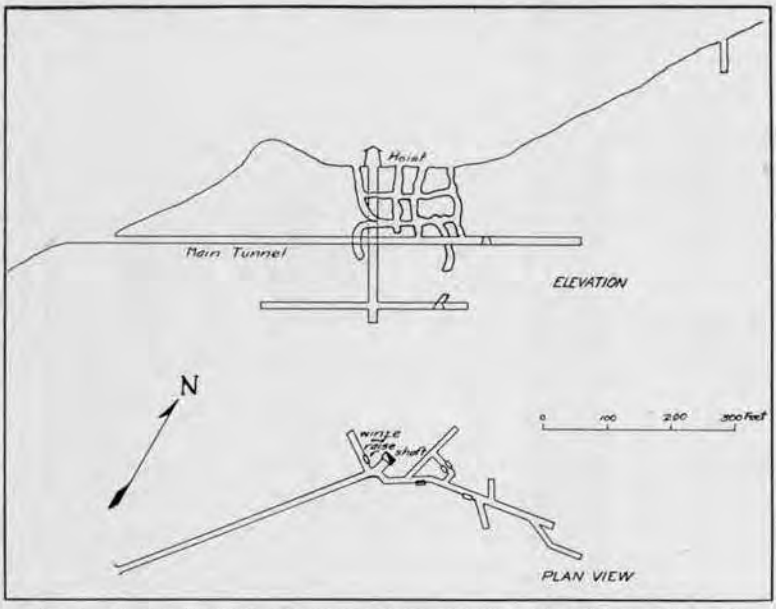


FIG. 4. Longitudinal and plan views of Blue Star Mine, Chewelah District.

property comprises three claims which have been grouped and incorporated as the Blue Star Mining Company, with head offices in Chewelah. This property was located in 1886, and at various times considerable development work has been done upon it.

The mine lies near the south end of Eagle Mountain. The rock formations consist of limestone, dolomitic limestone, siliceous limestone and quartzite, which have

been cut by a large mass of granite situated on the south side of the ore bodies.

The property has been developed by a vertical shaft which has been sunk to a depth of 219 feet. The elevation of the collar of the shaft is 2,925 feet. A tunnel has been driven in a direction N. 40° E. for a distance of 500 feet, where it intersects the shaft 117 feet below the collar. Beyond the intersection with the shaft the tunnel has been continued for a distance of 600 feet in a direction N. 85° E. Seventy-five feet west of the main shaft a winze has been sunk 135 feet deeper.

The rock formations encountered in the underground workings are the southern extension of those which outcrop on the west side of Eagle Mountain. Near the portal of the tunnel the rock is a part of the granite exposed prominently in the region. The succession to the northeast, in passing through the tunnel, is on the northeast side of the granite intrusive contact, hard fine-grained bluish limestone for a distance of 300 feet, a white massive crystalline limestone of a blocky nature due to jointing and fracture planes extending for 200 feet to the mineralized zone at the shaft. This rock continues for a distance of 200 feet beyond the shaft, along the continuation of the main tunnel. East of the white limestone there are 200 feet of calcareous argillites which continuously become more siliceous and finally merge into a quartzite. Beyond these beds for a distance of 200 feet to the face of the tunnel there are light-colored and rather fine-grained quartzites.

The ore minerals are galena and lead carbonate carrying silver. The ore bodies occur in the form of chimneys and irregular shaped chambers in fracture zones through the white limestone. These ores have been derived presumably from solutions accompanying the intrusive granites.

AMAZON.

This property is situated in secs. 29 and 32, T. 33 N., R. 41 E., about five miles northeast of the town of Chewelah. It consists of three claims known as the Amazon, Amazon Fraction and the Wild Goose, which were located in 1898 by T. C. Meader, M. McCrea, Edward Burr and Joshua Story. They are now owned by J. Oppenheimer of Chewelah.

The geology of the property involves the eastern portion of the Chewelah argillite belt, a short distance west of its contact with the Eagle Mountain quartzite. The rocks exposed are mostly quartz-mica schist and argillite. These rocks have been intruded by lamprophyre dikes. The Amazon vein lies along the bedding planes with quartz-mica schist for both hanging and foot walls. It varies in width from 2 to 16 feet and has a strike of N. 23° E., with a dip to the northwest of 70°. The ore-bearing minerals are chalcopyrite, which near the surface has been altered to azurite, and a rusty gossan of honeycombed quartz stained with limonite. These minerals carry silver and gold. The values in the ores are said to be copper 2½ per cent, silver 2 to 37 ounces, and gold 50 to 60 cents per ton.

The property has been developed by open cuts, shallow shafts, prospect tunnels and winzes, involving about 650 feet of tunnel work and 310 feet of drifting. The main workings are on the Amazon Fraction claim and consist of a tunnel driven upon the vein in a direction N. 23° E. A crosscut has been driven from this vein to the east where a second similar vein was encountered which also lies parallel to the bedding planes of the schists. A lower tunnel has been driven giving a depth of 325 feet on the ore body which is composed of gray copper. A total of 550 tons of ore are said to have been mined. This was treated at the smelters at Trail and Grand Forks, B. C. The total value of the ore shipped

from this property since its discovery is reported to be $6,212.00. A shipment of two cars of oxide ore to the Granby smelter yielded $841.00 in copper and $125.00 in silver.

The rock formation and the manner of origin and deposition of the ores in this mine are similar to those in the United Copper property. It is probable that the character of the ore in depth will be of the same nature.

JAY GOULD.

The Jay Gould Mine is situated about three and one-half miles east of Chewelah in the northeast corner of sec. 8, T. 32 N., R. 41 E., at an elevation of about 2,650 feet. The veins on this property were first located about 1880 and development work was done at various times. At the present time there are four claims belonging to this group known as the Red Jack, McAdoo, North Pole, North Pole Extension and Jay Gould. The property was incorporated in 1914 as the New Currency Mining Company, with the head office in Chewelah.

The formation exposed in the vicinity of the workings are largely interbedded quartz-mica schist, argillite and quartzite, which have been intruded by granitic and basic dikes associated with the main granite mass to the west. The metamorphic sediments are a part of the Deer Lake argillite of the Stevens series, but on this property they have been greatly disturbed by the igneous intrusions and show a wide variation in strike and dip. Isolated belts of limestone occur in the granite as a result of the displacement. The main vein on the Jay Gould claim strikes N. 45° W. and dips to the southwest at an angle of 45°. The gangue is quartz containing galena, pyrite, sphalerite and chalcopyrite. It has a width of about five feet.

An inclined shaft has been sunk on the vein to a depth of 195 feet and from this several hundred feet of drift have been driven from both the 100 and 150-foot levels.

At the time this property was visited it was idle and the lower workings inaccessible. It is reported by the officers of the company that a fault was encountered and the ore body has not as yet been located. Other improvements consist of a 100-foot tunnel and several open cuts.

A large part of the development upon this property was done during the years 1890 to 1903. Four cars of ore

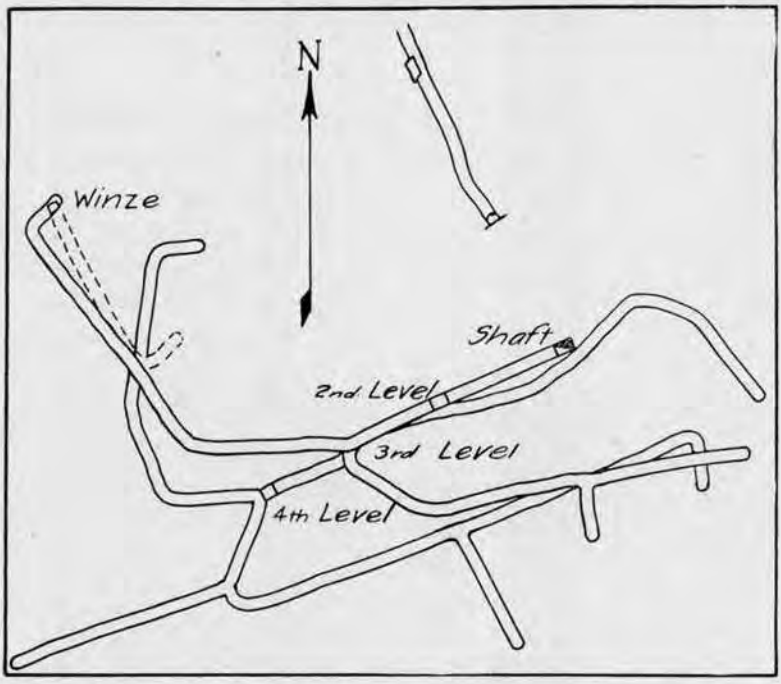


FIG. 5. Plan view of principal workings, Jay Gould Mine, Chewelah District.

are said to have been taken out and shipped to the Tacoma smelter in 1903 which averaged $14.00 in gold and $10.00 in silver. In 1915, 40 tons of ore were mined but not shipped. Because of the impossibility of examining the ore bodies in the underground workings, no suggestions can be made concerning the possible positions of the faulted portion of the vein or conclusions concerning the character of the ore bodies.

JUNO-ECHO.

The Juno-Echo Mine is located in sec. 7, T. 32 N., R. 41 E., about two miles northeast of Chewelah. The property comprises three claims known as the Juno, Echo, and the Tacoma. The last two are located on the vein and the first is a side claim.

The geological formations involved are the Chewelah argillite and intrusive granite. The bed-rocks consist of dolomitic limestone and quartz-mica schist on the west and granite on the east. The schists and limestones have a prevailing strike of N. 23° E. and a dip of about 70° to the northwest. Basic igneous dikes ranging from one foot to 12 feet in width, having the mineral composition of lamprophyres, cut these formations but have no prevailing strike and dip. One of these near the mouth of the main shaft is from 12 to 14 inches wide and has a strike of N. 15° W. and a dip of 80° to the northeast.

The ore bodies occur in a fissure vein near the contact of the limestone and granite. The strike of the main vein varies from N. 25° to N. 30° E. and the dip averages 80° to the southeast. The ore minerals are chalcopyrite and molybdenite in a quartz gangue. The mineralization frequently extends into the wall rock. The vein averages about 2½ feet in width. The polished surface observed upon many of the ore specimens indicates extensive wall movements after the deposition of the ores. While the ore occurs in a fissure vein it is primarily a contact deposit between the limestone and the intrusive granite and the minerals are characteristic of high-temperature deposits.

The mine has been developed by a main vertical shaft which has been sunk to a depth of 255 feet. At a depth of 128 feet a station has been cut and a drift run for a distance of about 75 feet to the northeast. There is also a crosscut to the west of about 40 feet. On the 230-foot level there has been done about 250 feet of development

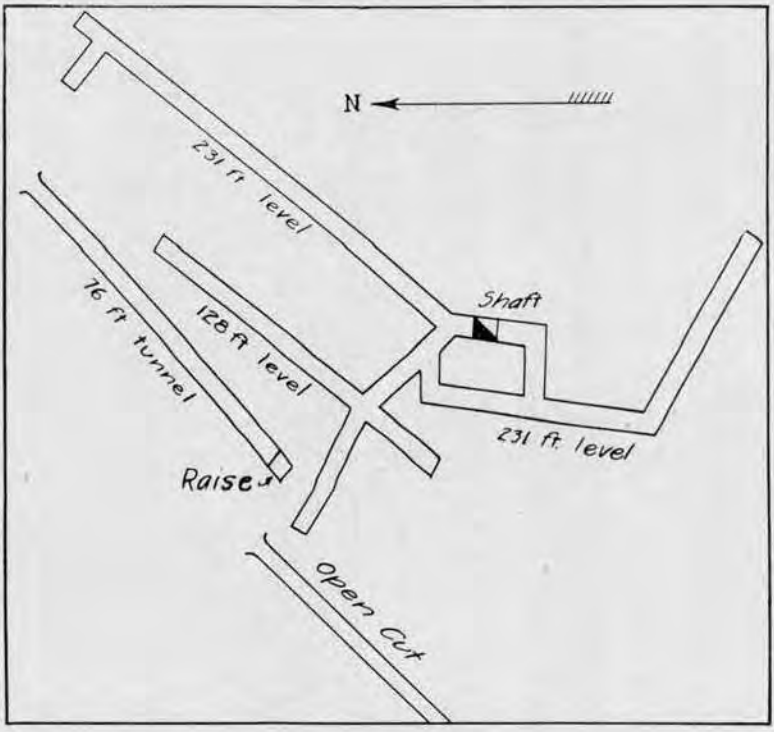


FIG. 6. Plan of the Juno-Echo Mine, Chewelah District.

work. The elevation at the collar of the shaft is about 2,100 feet above sea level. During the year 1917 three carloads of copper ore were shipped.

SECURITY COPPER.

The Security Copper Mine is situated about one and one-half miles east of the town of Chewelah in secs. 6 and 7, T. 32 N., R. 41 E. Locations were first made about 1900 by A. V. Shepler, S. Weese and E. A. Van Slyke. In 1913 this property was incorporated as the Security Copper Company with offices in Spokane. The following claims are included within the group: Last Chance, Lolo Morton, Copper Jack, Matterhorn, None Such, None Such Fraction, None Such Fraction No. 2, Leland M., and Triangle A. In addition there are 80 acres of land under a state lease.

The formations identified with this property are the Chewelah argillite and a stock from the Loon Lake granite intrusive into the argillites. The Chewelah argillite as exposed in the workings and open cuts on these claims is composed of interbedded argillite, quartz-mica schist and dolomitic limestone. All these strata have a prevailing strike of N. 30° E., and a dip averaging 70° to the northwest. The claims have been located upon six parallel veins which have been numbered one to six respectively. Nos. 1, 2 and 3 veins are on the Lolo Morton claim. No. 4 vein is on the Matterhorn claim, and Nos. 5 and 6 veins on the None Such and None Such Fraction claims.

The principal development work has been done upon the Matterhorn claim and on No. 1 vein. A vertical shaft whose collar is at an elevation of 2,220 feet has been sunk to a depth of 552 feet. At 500 feet below the collar a station has been cut in the west side from which a crosscut tunnel has been driven easterly for a distance of 150 feet and westerly for 250 feet. The west crosscut intersects what is called No. 4 vein, which is said to be 105 feet in width. A drift has been made to the north for a distance of 235 feet. The vein filling is decomposed argillite containing stringers of quartz that are sometimes mineralized with chalcopyrite and pyrite and their oxidized products. The formation is a part of the Chewelah argillite.

No. 1 vein lies farthest east, near the contact between granite and calcareous argillite. It is a zone in the argillite rock about 10 feet in width which has been somewhat mineralized. No. 2 vein lies west of No. 1 vein and between argillite and limestone. Some mineralization shows for a width of 60 feet in the argillite. No. 3 vein is 130 feet west of No. 2 vein and is a zone of argillite 63 feet in width and showing some mineralization. No. 4 vein is 180 feet west of No. 3 and represents mineralized

country rock along the contact between limestone and argillite. No. 5 vein is 295 feet west of No. 4 vein and is a similar zone of country rock, showing some mineralization for a width of 160 feet. No. 6 vein is 440 feet west of No. 5 vein and shows some mineralization occurring in limestone and argillite for a width of 128 feet. These are all prospected with open cuts, shallow shafts and trenches.

CHEWELAH STANDARD.

This mine is situated about one and one-half miles east of the town of Chewelah, in the northern part of sec. 7, T. 32 N., R. 41 E. The property consists of five claims, the Jungle, Single Standard, Double Standard, N. I. T. and Standard Fraction, which were formerly known as the Nellie S. group, but which are now known as the Chewelah Standard group. The claims are said to have been located first about 1900. The property is now incorporated as the Chewelah Standard Mining Company, with headquarters in Spokane.

The formation exposed on this property consists of argillite, limestone and quartz-mica schist, which have been intruded by the Loon Lake granite. The ore deposits consist of quartz veins in the granite but not far from the contact with the schists. The minerals composing the ore are chalcopyrite and molybdenite. The granite is cut by intersecting fine-grained pegmatite dikes and crystals of both molybdenite and chalcopyrite are impregnated through the pegmatite as well as the quartz veins which cut the granite. On the Jungle claim a quartz vein follows the contact between the schist on the west and the granite on the east and a tunnel has been driven along it in a direction N. 30° E. The vein dips 70° to the northwest. This vein is believed to be the same as vein No. 2 of the Security Copper Company's property. About 150 feet east on the same claim is a second parallel quartz vein containing chalcopyrite and molybde-

nite. This vein is entirely within the granite and a shaft has been sunk upon it to a depth of at least 30 feet, and from the bottom a drift has been run to the southwest for a distance of 75 feet. It is probably the equivalent of vein No. 1 of the Security Copper property.

Approximately 225 feet east of the vein last described is a third vein on the Single Standard claim upon which a shaft has been sunk to a depth of 60 feet. The formation is entirely composed of a fine-grained granite. The quartz vein cutting this granite strikes about N. 45° E. and pitches to the northwest at an angle of 70°. It is composed of white milky quartz having a width of about two feet. The walls are usually sharp but in places side stringers extend out into the granite wall rock. The ore-bearing minerals are chalcopyrite and molybdenite, which have formed not only in the quartz but to a smaller extent in the granite wall rocks. This vein may be the same as the main vein on the Juno-Echo property to the south but if so has made a decided swing in its strike.

At the time of examination it was impossible to study the ore deposits in the underground workings as the shaft was filled with water. It is reported that in the lower part of the shaft the vein varies from 5 to 12 feet in width and lies along a contact between limestone and granite. One carload of ore is said to have been shipped to the Granby smelter in 1915 which yielded returns of $6.00 per ton in copper and silver.

DIAMOND C.

This claim is located in the southwest quarter of sec. 7, T. 32 N., R. 41 E., about two miles east of Chewelah, at an elevation of 2,540 feet. The formation exposed is calcareous argillite cut by granite dikes. Deposits of glacial drift conceal much of the bedrock. An inclined shaft has been sunk to a depth of 39 feet on a granite dike about eight feet in width with a strike of N. 30° E.

and a dip of 70° to the northwest. The dike carries stringers of quartz with some pyrite and chalcopyrite.

WINSLOW.

This property is situated in sec. 26, T. 33 N., R. 41 E. It has been incorporated as the Silver Queen Mining Company. The formation exposed consists of quartzite with interbedded slate and chert. A main crosscut tunnel has been driven N. 65° W. for 230 feet. About 145 feet from the portal a vein of quartz has been cut having a strike of N. 25° E. and a dip of 75° to the northwest. The vein consists of quartz and intermingled country rock which has been somewhat mineralized with galena, chalcopyrite and pyrite. It is said to assay $8.00 in gold. Up the hillside above the tunnel at an elevation of 3,900 feet, a shaft has been sunk to a depth of 27 feet on the vein. The minerals seen are galena and sphalerite in honeycombed quartz, with some calcite.

MONTGOMERY.

This group of claims lies in secs. 17 and 20, T. 32 N., R. 41 E., on the high ridge along the eastern side of Colville Valley, at an elevation of 2,840 feet. The formations exposed are quartzite and interbedded schist. A vein of quartz three feet in width outcrops with a strike of nearly north and south and a dip of 45° to the east. The ore minerals are chalcopyrite, galena and hematite in a gangue of siderite and quartz. A short tunnel has been driven on this vein nearly due south. Nearby a shaft has been sunk 15 feet on a quartz vein carrying some galena and chalcopyrite. Twenty feet below the shaft a tunnel has been driven S. 20° E. for 30 feet through schist, where it cuts a quartz vein which has been greatly disturbed. On the Monarch claim a tunnel said to be 400 feet in length cuts slate and limestone, and on the Fairview a shaft has been sunk to a depth of 140 feet with a 150-foot tunnel, all in schist and argillite.

MAYFLOWER.

This group consists of four claims situated in the west part of sec. 28, T. 32 N., R. 41 E. The formation exposed consists of quartz-mica schist, argillite and interbedded quartzites, all of which are cut by dikes of granite. Near the north center end of the Crown claim a quartz vein is exposed having a strike of N. 20° W., with a dip of 45° to the northeast. The walls are calcareous argillite and the ore mineral chiefly galena. A series of open cuts, shallow shafts and trenches have been made along the hillside. A main shaft has been sunk to an unknown depth and at the time of examination was filled with water. A quartz-mica schist which is more or less calcareous is the prevailing formation. Some of the ore shows azurite, malachite, cuprite and a little chalcopyrite.

NABOB.

This claim lies south of the Fred B., in sec 9, T. 32 N., R. 41 E. A vein of quartz about one foot in thickness, and having a strike of east and west with a dip of 30° to the north, cuts the formation composed of quartzite. The ore minerals are pyrite, pyrrhotite and a small amount of chalcopyrite, which carry small values in gold. The prospect is developed by an inclined shaft to a shallow depth.

FRED B.

This prospect is located in sec. 9, T. 32 N., R. 41 E., about four miles northeast of Chewelah. The formation exposed in the vicinity is a massive quartzite cut by diorite and granite dikes. A vein of quartz about one foot in width, with a strike of N. 45° W. and a dip of 70° to the southwest, is exposed on the property. A shaft has been sunk upon this to a depth of 12 feet. A short distance to the east an open cut has been made upon the same vein which carries some galena and pyrite. The country rock is mineralized to a minor extent for four feet on each side of the vein.