WASHINGTON

GEOLOGICAL SURVEY.

HENRY LANDES, STATE GEOLOGIST.

VOLUME I.

ANNUAL REPORT FOR 1901.

OLYMPIA, WASH.:
GWIN HICKS, . . . STATE PRINTER,
1902.

BOARD OF GEOLOGICAL SURVEY.

HENRY MCBRIDE, ... *President.*
Governor of Washington.

C. W. MAYNARD, ... *Secretary.*
Treasurer of Washington.

F. P. GRAVES, ... ———
President of the University of Washington.

E. A. BRYAN, ... ———
President of the Washington Agricultural College and School of Science.

STAFF OF GEOLOGICAL SURVEY.

HENRY LANDES, ... *State Geologist.*
Professor of Geology, University of Washington.

SOLON SHEDD, ... *Geologist.*
Professor of Geology, Washington Agricultural College and School of Science.

W. S. THYNG, ... *Geologist.*
Professor of Mining Engineering, Washington Agricultural College and School of Science.

D. A. LYON, ... *Geologist.*
Late Professor of Mining Engineering and Metallurgy, University of Washington.

LETTER OF TRANSMITTAL.

To His Excellency, HENRY MCBRIDE, *Governor of the State of Washington and President of the Board of Geological Survey:*

SIR—I have the honor to present herewith the annual report of the State Geological Survey for the year 1901. It embraces a preliminary account of the geology and mineral resources of the state, to which is added a bibliography of the literature referring to Washington geology. It is hoped that this report, while very general in its nature, may serve as a basis for more elaborate and detailed reports in future years.

Very respectfully,

HENRY LANDES, *State Geologist.*

UNIVERSITY OF WASHINGTON,
SEATTLE, March, 1902.

CONTENTS.

PART I.

PAGE.

CREATION OF A STATE GEOLOGICAL SURVEY, BY HENRY LANDES, 3
Introduction 3
The Law Establishing the Survey 4
Organization of the Board of Geological Survey 5
Field Work of 1901 6
Office Work 8
Expenses of the Geological Survey 9

AN OUTLINE OF THE GEOLOGY OF WASHINGTON, BY HENRY LANDES 11
Topography 11
Olympic Mountains 12
Puget Sound Basin 13
Cascade Mountains 14
Okanogan Highlands 15
Columbia Plain 15
Blue Mountains 16
Geological Formations 17
Metamorphic Rocks 17
Gneiss 18
Schist 18
Crystalline Limestone 20
Quartzite 21
Igneous Rocks 21
Granite 22
Basalt 24
Andesite 27
Serpentine 27
Sedimentary Rocks 28
Pre-Cretaceous Period 29
Cretaceous Period 30
Tertiary Period 30
Eocene Epoch 31
Miocene Epoch 33
Pliocene Epoch 34
Quaternary Period 34
Pleistocene Epoch 34

PART II.

PAGE.

THE METALLIFEROUS RESOURCES OF WASHINGTON EXCEPT IRON, BY HENRY LANDES, WM. S. THYNG, D. A. LYON AND MILNOR ROBERTS 39

Introduction 39
Stevens County 42
Northport District 43
Myers Falls District 44
Flat Creek District 44
Colville District 45
Chewelah District 45
Springdale District 46
Cedar Canyon District 46
Ferry County 50
Republic District 52
Lincoln County 60
Okanogan County 61
Wauconda District 62
Myers Creek District 64
Palmer Mountain District 66
Conconully District 70
Moses District 72
Upper Methow District 73
Twisp District 74
Squaw Creek District 75
Whatcom County 78
Mount Baker District 79
Slate Creek District 83
Skagit County 88
Thunder Creek District 89
Bald Mountain District 90
Chelan County 90
Horseshoe Basin District 91
Bridge Creek District 92
Railroad Creek District 92
Peshastin District 94
Snohomish County 98
Darrington District 99
Stilaguamish District 101
Monte Cristo District 108
Silver Creek District 111
Index District 114
King County 120
Kittitas County 125
Swauk District 125

Metalliferous Resources—*Continued:* PAGE.
Pierce County.. 127
Carbon River District..... 127
Lewis and Skamania Counties..... 131
St. Helens District..... 131

REDUCTION PLANTS IN WASHINGTON..... 136
Smelting Works 136
Chlorination and Cyanidation Plants..... 147
Stamp Mills (Amalgamation)..... 150
Arrastras 152
Concentrators and Combination Plants..... 154

PART III.

THE NON-METALLIFEROUS RESOURCES OF WASHINGTON, EXCEPT COAL, BY HENRY LANDES..... 161
Building and Ornamental Stones..... 161
Introduction 161
Granite Quarries..... 164
Index 164
Spokane 165
Medical Lake 165
Snake River 165
Sandstone Quarries 166
Chuckanut..... 166
Sucia Island 167
Tenino..... 167
Wilkeson 170
Serpentine Quarries 170
Valley 170
Marble Quarries 172
Stevens County 172
Clay Materials..... 173
Introduction 173
Denny Clay Company 174
Little Falls Fire Clay Company 178
Washington Brick, Lime and Manufacturing Company..... 182
Limestone 184
Introduction 184
San Juan Islands..... 184
Granite Falls 187
Springdale..... 188
Republic..... 188

Non-Metalliferous Resources—*Continued:* PAGE.
Soils 190
General Statement 190
Origin of Soils 190
Disintegration of Rocks by Mechanical Agents 191
Disintegration of Rocks by Chemical Agents 192
Fertility of Soils 193
Chemical Composition 193
Physical Condition 194
Climate 194
Washington Soils 195
Soils of Western Washington 195
Soils of Eastern Washington 197
Road-Making Materials 201
General Statement 201
The Construction and Care of Roads 201
Materials for Road-Making 202
Road-Making Materials of Washington 203
Petroleum 207
General Statement 207
Conditions of Occurrence 207
Origin of Petroleum 208
Petroleum in Washington 209

PART IV.

THE IRON ORES OF WASHINGTON, BY S. SHEDD 217
Distribution and Combinations in which Iron Occurs 217
General Statement 217
The Ores of Iron 218
Production of Iron Ores in the United States, by Classes 220
The Relative Values of Iron Ores 220
History of Iron Mining and Manufacture in Washington 221
Distribution of Iron Ores in Washington 224
Analyses of Washington Iron Ores 225
The Character and Commercial Value of the Iron Ores of Washington 227
Varieties of Ores 227
Commercial Values 227
Summary 229
Analyses of Iron Ores of Various Mines in the United States and Cuba 230

Iron Ores of Washington—*Continued:* PAGE.
The Iron Mining Possibilities of Washington 232
Conditions Necessary for Profitable Iron Mining 232
Conditions in Skagit County 232
Conditions in Kittitas County 232
Conditions in King County 233
Conditions in Stevens County 233
Conditions in Mason County 234
Lake Cushman District 234
Analyses of Iron Ores from Lake Cushman 234
Black Hills 235
Analyses of Iron Ores from the Black Hills, Chehalis County 235
Hamilton District 235
Analyses of Iron Ores from the Hamilton District, Skagit County 235
Location and Mode of Occurrence of the Ore 235
Extent of Iron Deposits 236
Character and Composition of the Hamilton Ores 237
Snoqualmie Pass District 241
Analyses of Iron Ores from Snoqualmie Pass, King County, 241
Mode of Occurrence of the Snoqualmie Pass Ores 241
Character and Composition of the Snoqualmie Pass Ores .. 242
Clealum District 243
Analyses of Iron Ores from the Clealum District, Kittitas County 243
Mode of Occurrence of the Clealum Ores 243
Character and Composition of the Clealum Ores 244
Geology of the Clealum Iron District 245
Pre-Eocene Rocks 245
Eocene and Post-Eocene Rocks 245
Genesis of the Ores 249
Source of the Iron 249
Conditions of Deposition 250
Chemical Relations 251
Colville and Valley District 252
Analyses of Iron Ores from Stevens County 252
The Mode of Occurrence of the Ores 252
Character and Composition of the Stevens County Ores 253
Clugston Creek District 253
Conclusions 255

THE COAL DEPOSITS OF WASHINGTON, BY HENRY LANDES 257
Introduction 257
Geology of the Coal Measures 259
Varieties and Uses of the Coal 262
Whatcom County 263
Blue Canyon District 265

Coal Deposits of Washington—*Continued:* PAGE.
Skagit County 265
Cokedale District 266
Hamilton District 266
King County 267
Newcastle-Issaquah District 267
Renton-Cedar River District 269
Green River District 270
Pierce County 272
Wilkeson-Carbonado District 272
Kittitas County 275
Roslyn-Clealum District 275
Thurston County 277
Bucoda-Tenino District 277
Lewis County 278
Chehalis-Centralia District 278
Cowlitz County 279
Kelso-Castle Rock District 279

PART V.

THE WATER RESOURCES OF WASHINGTON 285
Potable and Mineral Water, by H. G. Byers 285
City Water Supplies 285
Mineral Springs 291
Alkali Lakes 293
Artesian Water, by C. A. Ruddy 296
Introduction 296
Yakima Valley 300
Kittitas Valley 305
Whitman County 305
Water Power, by R. E. Heine 308
Introduction 308
Snoqualmie Falls 310
Spokane Falls 311
Mill Creek, near Walla Walla 313
Prosser Falls, Yakima River 314
Chelan Falls 315
Puritan Mines, near Loomis 316
Whatcom Falls 316
Nooksack Falls 317
Tumwater Falls, near Olympia 318
Carbon River and Evans Creek, Fairfax 319

PART VI.

BIBLIOGRAPHY OF THE LITERATURE REFERRING TO THE GEOLOGY OF WASHINGTON, BY RALPH ARNOLD 323

ILLUSTRATIONS.

FACING PAGE.

Topographical Map 11
Geological Map 17
Yakima Canyon 21
Mount St. Helens 25
Lake of the Mountains, near Cascade Pass, Cascade Mountains 29
Map of the Mining Districts 39
Outcrop of Independence Ledge, Monte Cristo 108
The Everett Smelter, owned by the Puget Sound Reduction Company 136
The Republic Mill, owned by the Republic Reduction Company 147
The State Capitol, constructed of Chuckanut and Tenino Sandstone. 161
Tenino Sandstone Quarry 167
Mill for Sawing Stone, Tenino Sandstone Quarry 167
Quarry of U. S. Marble Company, Valley 170
New Quarry Level, U. S. Marble Company, Valley 172
Quarry of U. S. Marble Company, Valley 172
Denny Clay Works, Seattle 176
Plant of the Washington Brick, Lime and Manufacturing Company, at Clayton 182
Roche Harbor Lime Works 186
Quarry of the Valley-Brook Lime Works, Springdale 188
Lime Kilns, Valley-Brook Lime Works, Springdale 188
Plant of Pacific Steel Company, Irondale 217
Furnace, Pacific Steel Company, Irondale 221
Charcoal Kilns, Pacific Steel Company, Irondale 221
Iron Mountain, near Hamilton 236
Inaugural Iron Mine, near Hamilton 236
Clealum Mountain 244
Guye Iron Mine, near Snoqualmie Pass 244
A Map of the Known Coal Fields of Washington 257
Coal Bunkers, Seattle 268
No. 4 Opening and Electric Lighting Plant at Roslyn Coal Mines 276
Sections of Coal Seams, with Coal Analyses 282
Sections of Coal Seams, with Coal Analyses 282
Sections of Coal Seams, with Coal Analyses 282
Lake Whatcom 285
Blue Lake, near Oroville 285
Falls of the Spokane River, Spokane 292
Falls of the Yakima River, Prosser 292
Falls of the Spokane River, Spokane 300
Head-Works of Snoqualmie Falls Power Company 308
Interior of Snoqualmie Falls Power Station 316

PREFACE.

In the CREATION OF A STATE GEOLOGICAL SURVEY, which constitutes the first chapter of Part I of this report, after some mention is made of the causes leading up to the inauguration of a Survey, a copy of the law is then given. This law is modeled after that of older states where geological surveys have been in progress, and emphasizes the economic rather than any other side of geology. Some mention is also made of the organization of the Board of Geological Survey and the selection of a survey staff to whom the actual work of the Survey is entrusted. An account of the field work of the first season is included, together with some statements concerning the office work of the State Geologist, and a word in regard to the expenses of the Survey.

In AN OUTLINE OF THE GEOLOGY OF WASHINGTON, or the concluding chapter of Part I, a resume is given of the present knowledge of the geology of the state. It is planned to afford a sort of bird's-eye view of the topography and the geological formations, in order that the detailed work of the future may be planned with intelligence. It is thought worth the while to include a map upon which an attempt has been made to outline the larger geological formations. The boundaries of the different formations have, as a rule, been accurately determined only in a few places, and between these points the lines of separation are mainly conjectural. Nevertheless it is believed that the geological map will prove of help to all those whose work brings them in contact with the state's geology.

In the article on the METALLIFEROUS RESOURCES OF WASHINGTON, EXCEPT IRON, which comprises Part II of this volume, only an outline or sketch of the subject is attempted, preparatory to detailed descriptions of the various mining districts that will be given in later reports. Some of the representative or typical metalliferous deposits are described, selected here and there from the large area in which the metallic minerals are known to occur. No attempt is made to classify the ore deposits according to their mineral contents, but the usual products such as gold, silver, copper, lead, etc., are all described together. This is done because of the peculiar intimate association of these minerals, one with another, in the veins of ore.

The geographical classification of the metalliferous deposits is that by counties, districts and mines. The district boundaries as given in this report are largely those of convenience, and they may vary considerably from those established by law or custom. The proper outlines of the districts will be given when these are later described in detail. In this article the name of the writer of each section is placed at the beginning of it, except that the State Geologist has been responsible for the preparation of the article as a whole, and all unsigned sections have been written by him. The names of the persons who have given the information contained in the minor parts are placed in brackets at the end of the paragraph.

The NON-METALLIFEROUS RESOURCES OF WASHINGTON, EXCEPT COAL, or Part III, contains a brief discussion of six mineral products, viz.: building and ornamental stones, clay materials, limestone, soils, road-making materials, and petroleum.

In the few pages devoted to building and ornamental stones, some reference is made to the geographical distribution of these products, and the best developed quarries are hastily described. While the building and ornamental stones of the state are of great importance, but scant attention is given them in this report because it is planned that they shall be the subject of an extended and exhaustive article in the report for 1902.

While clay is an important resource, the matter pertaining to it is chiefly limited to descriptions of a few of the leading plants concerned in the manufacture of clay products. As in the case of building stone a complete account of the clay resources of the state will be given in the next annual report.

Limestone for lime-making is one of the state's leading mineral resources. Large deposits of excellent limestone occur at many places in Washington. The lime-burning industry is already well developed, and at the present time large quantities of lime are exported from Washington to all the neighboring states, to California and to Hawaii.

Soils come under the head of non-metalliferous, or mineral resources, because they are derived directly from rocks. In this article soils are treated from the geological standpoint, and the close connections between the rock formations and the different varieties of soils is shown.

Road-making materials are valuable resources wherever they occur, and Washington is fortunate in possessing throughout the state road metals of superior quality. Road construction on the most scientific basis is receiving a great deal of attention now-a-days in the older states, and Washington with her splendid materials should be a leader in the grand movement toward good roads.

Petroleum, at the present time, is not one of the state's determined mineral resources. The subject receives some consideration in this report because of the wide-spread interest in oil prospecting, and because of the many inquiries as to whether or not there is any possibility of oil being found in different parts of the state. There are some parts of Washington where the correspondence in age, composition and structure between the rocks here and those of the oil-bearing districts of California is very striking. In such localities of the state, especially where there are good surface indications, prospecting for oil may be looked upon as well worth the while.

In the IRON ORES OF WASHINGTON, by S. Shedd, which embraces the first chapter of Part IV, the subject is treated more exhaustively than is the case with any other part of this report. A description is given of all the known occurrences of iron in the state, together with complete analyses and comparisons with ores found elsewhere. In the field work necessary to the preparation of the article on iron ores, two seasons were occupied by Professor Shedd and his assistants. The field work was all done prior to the inauguration of the State Geological Survey, and the entire expense of it was borne by the State Agricltuural College and School of Science.

The article on the COAL DEPOSITS OF WASHINGTON, by Henry Landes, which concludes Part IV, is a brief description of the coal fields and coal mines of the state. While the general geology of the subject is touched upon, along with the extent of the coal areas, etc., the commercial phase of the subject receives the most emphasis. At the present time coal constitutes by far the most important mineral resource of the state, and the treatment accorded it in this report is regarded as wholly inadequate. The present article is but a temporary treatment which it is planned to replace by a thorough and extended one a little later.

The WATER RESOURCES OF WASHINGTON, or Part V of this report, deals with the potable and mineral waters, artesian waters and the water power of the state.

In POTABLE AND MINERAL WATER, by H. G. Byers, some statements are made concerning drinking water in general, followed by a discussion and the analyses of the drinking water of the various cities of the state. Comparisons are made with certain potable waters found elsewhere. Descriptions are given of the principal mineral springs, including analyses of their waters, temperature, etc. At the time this article was written some of the mineral springs were inaccessible, and hence cannot be described until a later report. A partial study was made of the alkali lakes in the hope that the water might be sufficiently con-

centrated to be of economic value. From the analyses such does not appear to be the case.

In ARTESIAN WATER, by C. A. Ruddy, after some general statements concerning artesian basins, the leading artesian districts of eastern Washington are described. In any arid district the possibility of artesian water is a matter of great interest because of the necessity of water for irrigating purposes. It is hoped that there will be an opportunity for investigations throughout the arid and semi-arid portions of central Washington, so that all the artesian basins may be discovered and described, in order that their storehouses of water may be unlocked.

In WATER-POWER, by R. E. Heine, after some introductory statements concerning the latent water-power of the state, brief descriptions are given of the best known water-power plants. All of these plants have been only lately put in operation, and it is thought that they but mark the beginning of a development which will prove a tremendous factor in the commercial advancement of the state.

The BIBLIOGRAPHY OF THE LITERATURE REFERRING TO THE GEOLOGY OF WASHINGTON, which comprises Part VI of this report, was written chiefly by Mr. Ralph Arnold, of Stanford University. After the manuscript was received from Mr. Arnold, a number of references were added by Professor Milnor Roberts. This bibliograpy has been prepared with great thoroughness and care, and it is believed to be practically complete. While many of the articles are out of print, or else are to be found only in the larger libraries, it will be noticed that the most important papers mentioned are of a late date and as a rule easily procured. Professor Roberts has prepared brief notes upon some of the articles, stating the substance of their contents, where they may be secured, cost, etc. It is hoped that this bibliography of Washington geology, the first to be prepared, may be found useful to all students of the subject.

PART I.

CREATION OF A STATE GEOLOGICAL SURVEY.

AND

AN OUTLINE OF THE GEOLOGY OF WASHINGTON.

BY

HENRY LANDES.

CREATION OF A STATE GEOLOGICAL SURVEY.

INTRODUCTION.

In her gifts to the State of Washington, Nature has been exceedingly generous. She has endowed the young commonwealth with resources many and varied, and already our citizens are coming to a realization of the material wealth which surrounds them. The fertile soil with which a large portion of the state is blessed is leading to a great development along agricultural lines; the extensive and magnificent forests of evergreens are conducive to lumbering and manufacturing on a large scale; the many fine harbors, advantageously located, point to a large and increasing commerce; the waters teeming with fish hold within their depths great riches; while the large mountainous area in which useful and precious metals abound contains in itself enough to make Washington a wealthy state, if correct and accurate knowledge of its mineral resources is made accessible to the public. In order that these resources lying hidden in the earth may be made known to our own citizens, and to any others who may wish to take a part in the building up of the state, it is necessary that a careful and systematic study should be made of our economic minerals. Thus it came about that, in response to a general demand of those interested in the development of the mineral resources of the state, the Legislature of 1901 passed a law providing for a Geological Survey of Washington, and appropriated money for the carrying on of the same. Following the plans of some of the older states in which geological surveys have been of great utility and benefit it was provided that the work of the survey for the present at least should be as practical as possible; that the economic minerals should be studied first of all; and that the results of the survey work should be embodied in reports and bulletins from time to time and disseminated among the people.

THE LAW ESTABLISHING THE SURVEY.

Be it enacted by the Legislature of the State of Washington:

SECTION 1. There is hereby established a State Geological Survey of the State of Washington, which shall be under the direction of the Board of Geological Survey of the State of Washington, which is hereby established, composed of the Governor, the Lieutenant Governor, the State Treasurer, the President of the University of Washington, and the President of the Washington Agricultural College and School of Science, who shall serve without compensation, but shall be reimbursed for actual expenses incurred in the performance of their official duties, and the said board shall have general charge of the survey, and shall appoint as superintendent of the survey a geologist of established reputation, to be known as the State Geologist, and upon his nomination such assistants and employes as the said board may deem necessary, and the said board shall also determine the compensation of all persons employed by the survey, and may remove them at will.

SEC. 2. The said survey shall have for its object:

(1) An examination of the economic products of the state, viz., the gold, silver, copper, lead, and iron ores, as well as building stones, clays, coal and all mineral substances of value.

(2) An examination and classification of the soils, and the study of their adaptability to particular crops.

(3) The investigation and report upon water supplies, artesian wells, the water power of the state, gauging the streams, etc., with reference to their application for irrigation and other purposes.

(4) An examination and report upon the occurrence of different road building material.

(5) An examination of the physical features of the state with reference to their practical bearing upon the occupations of the people.

(6) The preparation of special geological and economic maps to illustrate the resources of the state.

(7) The preparation of special reports with necessary illustrations and maps, which shall embrace both the general and detailed description of the geology and natural resources of the state.

(8) The consideration of such other kindred scientific and economic questions as in the judgment of the board shall be deemed of value to the people of the state.

SEC. 3. The board shall cause to be prepared a report to the Legislature before each regular meeting of the same, showing the progress and condition of the survey, together with such other information as they may deem necessary and useful or as the Legislature may require.

SEC. 4. The regular and special reports of the survey, with proper illustrations and maps, shall be printed as the board may direct, and the reports shall be distributed or sold by the said board as the interests of the state and of science demand; and all money obtained by the sale of the reports shall be paid into the state treasury.

SEC. 5. All materials collected, after having served the purpose of the survey, shall be distributed by the board to the University of Washington, the Washington Agricultural College and School of Science, the normal schools, and the leading high schools of the state in such a manner as to be of the greatest advantage to the educational interests of the state.

SEC. 6. The Board of Geological Survey shall meet for organization within thirty days after the passage of this act. The regular meetings of the board shall be held on the first Wednesday in April and the first Wednesday in November of each year.

SEC. 7. The sum of five thousand dollars ($5,000) annually, or so much thereof as may be necessary, is hereby appropriated out of any funds out of the treasury not otherwise appropriated for the purpose of carrying out the provisions of this act.

SEC. 8. "An act to create a mining bureau, and to define its powers and duties, and declaring an emergency," approved February 25, 1890; also "An act to create the office of a State Geologist, prescribing his duties and compensation, and making an appropriation for the same, and declaring an emergency," approved February 28, 1890, are hereby repealed.

ORGANIZATION OF THE BOARD OF GEOLOGICAL SURVEY.

In accordance with the law, and at the call of the Governor, the following gentlemen: Governor Rogers, Lieutenant Governor McBride, State Treasurer Maynard, President Graves of the University of Washington, and President Bryan of the

Agricultural College and School of Science, met upon June 5, 1901, at Tacoma, and organized the Board of Geological Survey of the State of Washington. Permanent organization was effected by electing Governor Rogers as president of the Board, and State Treasurer Maynard as its secretary.

The first important business of the board was the selection of the survey staff. Professor Henry Landes, of the University of Washington, was chosen State Geologist, with Professors Solon Shedd and W. S. Thyng, of the Agricultural College and School of Science, and D. A. Lyon of the University of Washington, as geologists. Charles E. Gaches, George W. Evans, Louis Pohle and Lewis D. Ryan were appointed field assistants for the season of 1901.

The board voted that members of the survey staff should receive no salaries other than a small *per diem* allowance for time actually spent in the field work of the survey. The president and the secretary of the board were authorized to pass upon the accounts of the State Geologist and to draw upon the State Auditor for the payment of the bills approved by them.

FIELD WORK OF 1901.

In order that the citizens of the state may be informed as to what the survey attempted to do in its first field season, the general scheme of the summer's work is here set forth and somewhat elaborated. It was thought advisable to do first of all such field work as would be required in order to prepare a general statement of the mineral resources of the state. With this end in view, the major part of the season was spent in reconnaissance work, studying the geological formations, examing the mines of gold, silver and copper, making maps and sections of the coal fields, examining with care the building and ornamental stones, and collecting other data for the first report, which should be devoted chiefly to a description of the state's mineral resources. It was also planned to gather such data during the first season as would be needed in the preparation of some special bulletins on the coal fields, building and ornamental stones, clay materials, and on one or two of the most prominent mining districts of the state. In order to carry on the plans outlined above, three parties were placed in the field. These were equipped so that they might move with as great

rapidity as possible and thus be able to cover a large part of the state in the time at their disposal. Necessarily the work was of a reconnaissance order, and only a little attention could be given to details. The personnel and scope of work of the three parties will now be mentioned.

The first party was composed of the State Geologist, D. A. Lyon, C. E. Gilman, Lewis Ryan, Charles Landes and J. W. P. Dunlap. About July 1st, after having provided themselves with the necessary horses and camp equipment, they began work at Republic. Here they remained about ten days, studying the mining geology of the district. The party then proceeded north to Curlew, visiting several properties on the way. The next move was to the Myers creek district and thence to Oroville and Loomis. At the latter place some time was spent visiting and studying the best developed mines in the Palmer mountain district. From this point the party proceeded to the Methow by way of Conconully. From the Methow they moved up the Twisp river, over Twisp pass to Bridge creek, and down the Stehekin to the head of Lake Chelan. From this point the mines on Railroad creek were visited. From Lake Chelan the party passed to the Horseshoe basin, thence over Cascade pass and down the Skagit to Marblemount. Barron was next visited and an examination was made of the mines on Slate and Thunder creeks and thereabouts. Returning down the Skagit to Hamilton, some time was spent in studying the coal field of that region. The boundaries of this field were approximately determined, as were those of the Cokedale field as well. Blue Canyon was next visited, and here some time was spent in determining the boundaries of that large coal field, and in studying the outcrops of coal which occur at several places northward and eastward of Lake Whatcom. While the party were camped at Keese a detachment under the leadership of D. A. Lyon visited the principal mines of the Mount Baker district. The last move of the party was to LaConner where the horses were to winter, and here the work of the party closed for the season.

The second party, consisting of Professor Solon Shedd as geologist and George Evans and Louis Pohle as field assistants, spent the season mainly in an examination of the building and ornamental stones of the state, paying some attention to the clay materials as well. They began work at Spokane in the last

days of June by making an examination of the granite quarries about Spokane and Medical Lake. Then came an investigation of the marble and serpentine which is found at Valley station and elsewhere in Stevens county. Finishing their work here, they then moved to Western Washington, where the remainder of the summer was spent in a study of the building stones and clays of that region. Tenino, Wilkinson, Index, Chuckanut and Sucia Island were visited, as well as many other places where stone of desirable character for building purposes was known to exist.

Professor W. S. Thyng, who made studies upon several mining districts during the summer, began his work upon the mines in the districts about Silverton, Monte Cristo, Goat lake, Silver creek and Index. From Index he went to the Carbon river district to examine the copper mines located there. He finished his work by an examination of the Cedar canyon district in Stevens county.

OFFICE WORK.

It is a fact acknowledged by every one who has had any experience in the matter that the hardest and most exacting work of a Geological Survey is that of the office. It is here that the field notes must be most carefully elaborated, the minerals and rocks collected during the summer must be identified and described, and numerous analyses made of the same; maps and sections must be prepared for illustrating the subject matter of the bulletins and reports; and great care must be exercised in every direction in order that the reports may be complete and accurate in every respect.

Since the inauguration of the survey, a considerable portion of the time of the State Geologist has been taken in making replies to inquiries from our own citizens and from many outside the state, who desire information concerning our mineral resources. It is of course necessary that these replies be carefully prepared, so that the demands of our citizens and of outside capitalists may be fully met. While the correspondence has already reached large proportions, it will doubtless reach a greater volume when the fact that Washington has a Geological Survey becomes better known.

One important part of the work of the Geological Survey is the identification of minerals and rocks sent in by prospectors

and mining men. Such specimens will be examined and promptly reported upon if the following rules are observed: 1st. A specimen should weigh not less than one-half pound and should be taken from as great a depth as possible. 2d. Each specimen must be accompanied by a statement of the exact location where it is found, and a description of the mass as a whole from which it came. 3d. The specimen must be sent prepaid, with the name of the sender plainly written upon the package, and addressed to the State Geologist, University Station, Seattle, Washington.

It must be patent to every citizen that no assays or chemical analyses can be expected from the office of the State Geologist. In the first place no provision is made for any such work in the law creating the Geological Survey. In the second place the sampling or selection of ores for assays or analyses is of the greatest importance, and usually an average sample is not taken, so that the assay or analysis indicates very little as to the real value of the mineral deposit. In the third place the cost of making such assays or analyses by the survey would be so very great that its resources would be largely consumed in this work alone, and the sender only would be benefited and not the state.

EXPENSES OF THE GEOLOGICAL SURVEY.

The amount appropriated by the Legislature of 1901 for the carrying on of the work of the Geological Survey was five thousand dollars per annum. For all moneys paid out in the prosecution of the work of the survey vouchers are taken in duplicate. These vouchers pass through the hands of a committee of the Board of Geological Survey, and upon their approval one set passes to the State Auditor, while the duplicate set is retained by the board. The appropriation above mentioned must provide for the entire expenses of the survey, not only for the field work but for the printing of all reports and the mailing of the same.

The cost of doing field work in Washington is probably fully as great, if not greater, than that of any other state in the Union, because of the extreme ruggedness of large parts of the state and the difficulties in the way of transportation. It is, therefore, only by practicing the most rigid economy and by getting a large amount of work done without any attendant compensation that it is possible to attain even moderate results.

RELIEF MAP OF WASHINGTON, BY SOLON SHEDD.

AN OUTLINE OF THE GEOLOGY OF WASHINGTON.

The following brief account of the geology of Washington must be regarded as general and at the same time provisional. It is thought desirable at this time to make some preliminary statements concerning the state as a whole, in order to pave the way for the detailed work of the future. Up to the present time it is only at a few points, often widely separated, that the geology of the state has been studied with thoroughness and with an attention to details. Not until all parts of the state have become readily accessible, and especially not until complete topographic maps have been made, will it be possible to carry on all of the investigations necessary to formulate a complete and detailed account of Washington geology.

The most important work on the geology of Washington has been done by the United States Geological Survey, mainly by Messrs. Bailey Willis, I. C. Russell, and George Otis Smith. In the Bibliography of Washington Geology, comprising part 6 of this volume, will be found a list of the contributions to the geology of the state that have been made by the above mentioned geologists and others. In the preparation of this article all printed reports on the geology of Washington that were accessible have been freely drawn upon, and an attempt has been made to give full credit in every case. The writer has been engaged for several seasons in geological field work in various parts of Washington, and much of the result of his work on the general geology of the state is embodied herein.

TOPOGRAPHY.

Before an intelligent discussion of the geology of Washington can be had, it is necessary that some statements concerning the topographic features of the state should be made. In time to

come, when the geology is better known than it is now, the topographic features as a result will be much better understood; and consequently, when topographic maps shall have been made of the entire state, the details of its geology will be made out with much greater ease than is possible at the present time.

A visitor to Washington cannot but be immediately impressed by the very great diversity of physical features which the state possesses. From the low plains which are found along the 3,000 miles or more of coast line it is possible within a short space of time to ascend to heights on which the snow remains throughout the year. The far reaching influence of such great differences in the topography of the state are readily observable. Not only is a varied scenery produced, but of necessity there follows a great variation in the climate, rainfall, soil, vegetation, and occupations of the people in the different topographic provinces of the state.

A study of the relief map which accompanies this report will make it clear that the physical features of the state may be divided into six provinces. Passing from the Pacific ocean inland these divisions are: Olympic Mountains, Puget Sound Basin, Cascade Mountains, Okanogan Highlands, Columbia Plain, and Blue Mountains. It must be understood, of course, that no hard and fast lines separate these provinces. The border line is always arbitrary and difficult of exact location. Another fact to be noted is that without exception these provinces extend beyond the boundaries of the state, overlapping into the adjoining states. The provinces already noted are capable of subdivision into smaller and yet smaller areas which can receive but scant attention in these pages.

OLYMPIC MOUNTAINS.

These mountains should be regarded as merely a segment of the general coastal range which extends northward and southward beyond the confines of the state. They reach their greatest development in Washington in the triangular shaped area bordered by the ocean, the Straits of Fuca and the arms of Puget sound. Their highest peak is Olympus, which has an elevation of about 8,000 feet, and is the first point of land to be recognized by navigators when approaching the coast of Washington from the westward. The Olympics when seen from any point of view exhibit a labyrinth of serrated ridges and sharp

peaks. Standing as they do in the path of the moist westerly winds, and rising to a considerable height above the sea, these mountains are visited by an excessive precipitation.

The Olympics have been but little explored and reliable information concerning them is very meager. It is known, however, that they are well nigh impassable because of their extremely broken and dissected character. The divides are exceedingly sharp and difficult to follow. The rivers flow in deep canyons with walls which in many instances can not be scaled. On the whole the streams of these mountains seem to be approaching the stage of maturity in their development.

The southern extension of the Olympics consists merely of hills or ridges rising as a rule not more than 1,500 feet above the sea. In fact so inconspicuous are they in the topography of the southwestern part of the state that the term mountains is not usually applied to them. They have been cut in two by the Chehalis and Columbia rivers.

PUGET SOUND BASIN.

The Puget Sound basin lies between the Olympic and Cascade mountains, its longer axis having a north and south direction. It has the form of a broad trough, its large central area being less than 100 feet above sea level, while its eastern and western sides rise gradually until they coalesce with the mountains.

The basin for the most part has a foundation of sedimentary rocks which have been thrown into folds. The inequalities produced by the folding of the strata have been largely reduced by erosion, so that the basin at the present time is a plain of low relief.

A late episode in the history of the basin was a subsidence of sufficient extent to cause the wide valleys of the northern portion to sink below sea level, whereby the rivers became "drowned" and Puget sound was produced. A still later episode was the advent of great glaciers from the mountains to the northward, eastward, and westward, whereby the northern part of the basin was overwhelmed and its rock foundation almost wholly hidden by a mantle of glacial sediments varying in thickness from 500 to 1,000 feet. The glacial sediments consist for the most part of plains of till, with local deposits of stratified clay, sand and gravel. About the southern end of Puget sound

there are many level, barren plains of coarse sand and gravel, which were formed by the great streams of water which the melting glaciers produced. The southern part of the basin has a somewhat more hilly or broken character than the northern part, because of an absence of plains of glacial materials.

CASCADE MOUNTAINS.

On the southern border of Washington where the Cascade mountains enter the state they have a breadth of about fifty miles, which increases to 100 miles at the British Columbia line. The general height of the mountains is about 8,000 feet above the sea, although there are some peaks, usually old volcanoes, which rise to much greater heights. Only one of the volcanoes that are well known stands on the axis of the range, viz., Glacier Peak. The remaining volcanoes, Baker, Rainier, and St. Helens, stand on the western flank of the mountains, and Adams on the eastern side.

The northern half of the Cascades in Washington differs much in character from the southern half. In the southern portion igneous activity has been very great and much of the topography is due to the presence of volcanoes with their attendant lava flows. In the northern Cascades there is such a marked uniformity in the heights of the loftier peaks and ridges as to suggest very strongly that they are the remnants of a plateau. In other words, the northern Cascades have seemingly been carved out of a great plateau which was the result of the uplifting of a peneplain. The ruggedness of the topography, therefore, is not due primarily to the folding of the rocks, but to erosion. The streams have been, and are yet, large and well fed, so that the old plateau is now well dissected and transformed into mountains of extreme ruggedness. The main streams which flow out from the Cascades all have valleys noted for their depths, so that the flanking mountains stand alongside in great boldness. In ascending the principal mountain valleys, especially those on the western side of the Cascades, one notices that the grade is gentle, even into the heart of the mountains, and the ascent is nearly all made in the last few miles before the summit is attained.

Very many glaciers, some of large size, occur in the higher portions of the Cascade mountains. They once filled the larger

mountain valleys and eroded and modified these very materially. Amphitheatres or cirques are found at the heads of many streams, and as these basins usually contain small lakes and parks, they afford some of the most beautiful scenery that the mountains possess.

OKANOGAN HIGHLANDS.

The Okanogan highlands occupy that portion of the state lying north of the Columbia and Spokane rivers and east of the Cascades. On their western border they merge insensibly into the latter mountains, and on the east they join the mountains of Idaho. In their geological characteristics they closely resemble the northern Cascades, but in their topographical aspects they are quite different. Instead of ruggedness they are characterized largely by beautiful rolling surfaces, with long gentle slopes leading down from the watersheds to the wide stream basins. The hills are low and broad and of a slope so slight that they are covered with a deep soil. The divides between the larger streams, although they reach heights of 5,000 or 6,000 feet above the sea, are gently rounding and not sharp or abrupt. The larger valleys were filled with glaciers at one time, and characteristic terraces or moraines are now found along the valley sides. Throughout the Okanogan highlands there is a close and easily observed relationship between the vegetation and the amount of rainfall. On the higher hills and ridges where the rainfall is greatest forests grow everywhere. On the lower hills and in the higher valleys the rainfall will not support a forest growth, but bunch grass grows luxuriantly. In the lower valleys of the larger streams, where the rainfall is least, bunch grass disappears and sage brush takes its place. The forests have an open character with practically no underbrush, the number of streams is large and the water excellent, so that the highlands have a remarkable park-like character.

COLUMBIA PLAIN.

With the exception of the Blue mountains, described below, virtually all of that part of the state south of the Okanogan highlands and east of the Cascade mountains is embraced in the Columbia plain. From the Columbia river at a height of 500 or 600 feet above the sea, the plain rises rather rapidly to the westward until it merges into the piedmont plateau which bor-

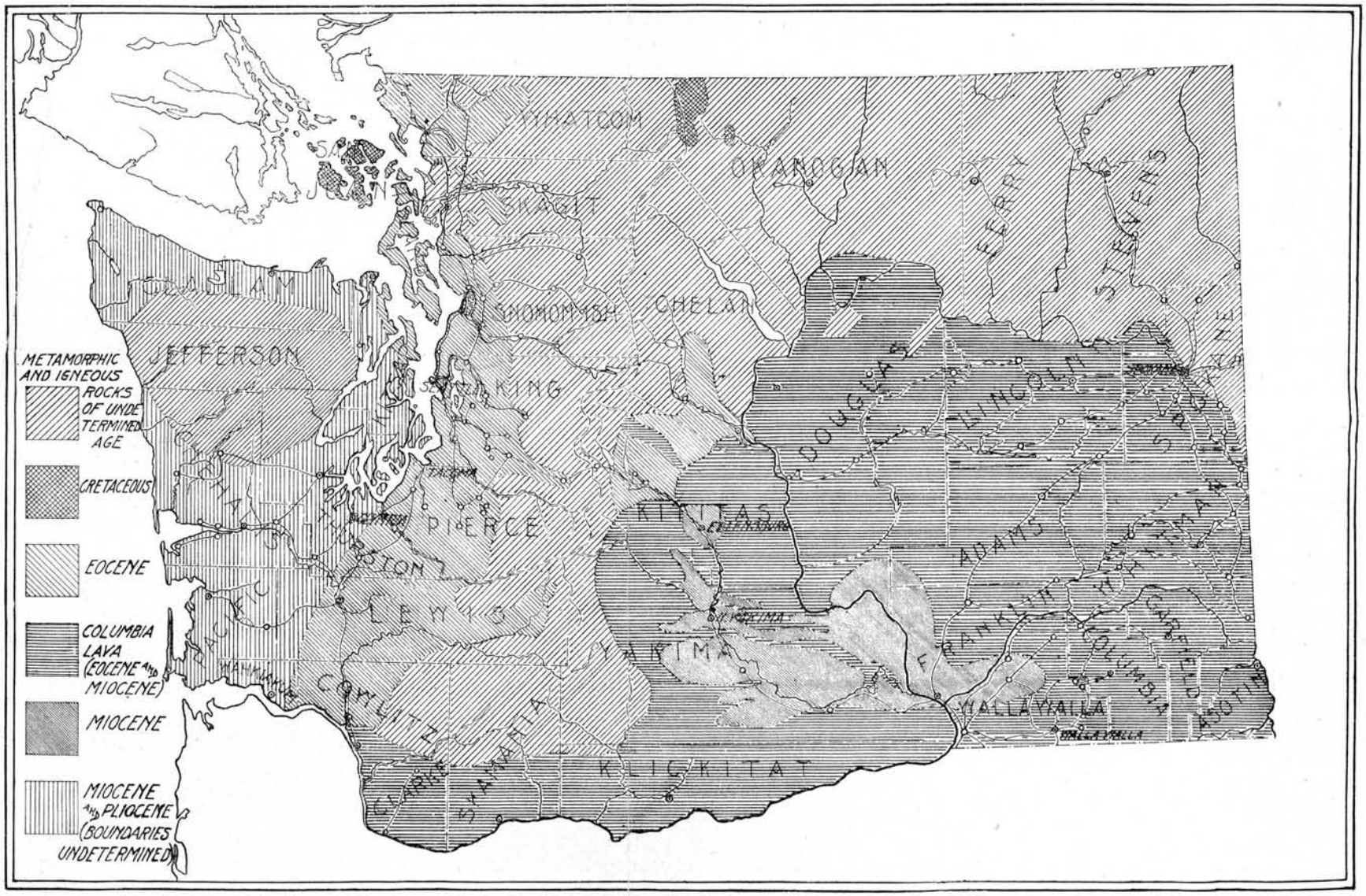
ders the Cascades. To the eastward the plain rises slowly and does not reach an altitude of 2,000 feet until near the Idaho line. The area under discussion is really composed of a number of plains and plateaus which can not be differentiated with accuracy at this time.

While the Columbia plain as a whole is quite level and monotonous, there are some local irregularities which tend to give the plain a diversified appearance. In the region about North Yakima there are a number of sharp east and west ridges of a semi-mountainous character, which represent anticlines or arches in the sheets of lava. These ridges have occasionally risen athwart the stream courses, and some rivers, such as the Yakima, have cut deep gaps across them. In some parts of the plain, notably within the great bend of the Columbia river, the country is much cut up by old river courses, now wholly abandoned by streams, and known locally as coulees. Of these, Moses and Grand coulees are good types. The coulees are often 500 or 600 feet in depth, with precipitous walls, and represent the courses of streams which have now sought other channels, or which have withered away because of a decrease in the amount of rainfall. Each coulee now has within it usually a chain of small alkali lakes.

In the region drained by the Snake river and its tributaries deep canyons have been cut in the plain. From the Snake river northward toward Spokane, in what is known as the Palouse country, the plain (or more properly called here a plateau) is covered with hills having altitudes of from 400 to 600 feet, which possess the character of sand dunes. They are hills of æolian origin, made up of deposits of fine soil which was carried to its present position by the prevailing winds of the southwest. These wind-blown hills have long, gentle southwesterly slopes, with northeasterly ones that are somewhat abrupt. They must have been formed at a time when there was less precipitation than now and when the surface of the country had no vegetation upon it. Since the time when the hills were fashioned out of the wind-blown soil the streams have accomplished considerable erosion, and now have their drainage lines well established.

BLUE MOUNTAINS.

These mountains, situated on the border line between Washington and Oregon, represent merely a local uplift of promi-



A PRELIMINARY GEOLOGICAL MAP OF WASHINGTON.

nence in the great lava plain. A broad, dome-shaped area of lava was elevated here, rising about 7,000 feet above the sea, and about 5,000 feet above the surrounding plain. While the streams have cut deep canyons in the mountains, as a whole they still retain their even-topped appearance. The mountains are high enough to have sufficient precipitation to support a moderate forest growth, and in this way they afford a contrast to the surrounding prairies.

GEOLOGICAL FORMATIONS.

METAMORPHIC ROCKS.

Metamorphic rocks are those which have been acted upon by heat and pressure for the most part and as a result they have undergone certain changes from their original conditions. These changes are so great that the rocks are greatly altered in their structure, mineral composition, and physical aspects. Some common examples of metamorphism are the changes of ordinary limestone into marble, sandstone into quartzite, and clay-rock into slate.

It is generally believed that the metamorphic rocks are the oldest as far as known in Washington, while at the same time all efforts to determine their geological age have so far been unsuccessful. From their marked physical resemblance to Archæan rocks found in other parts of the United States some have been inclined to designate the metamorphic rocks of Washington as Archæan, but this cannot be done with assurance until further evidence is obtained. In many places it has been observed that the metamorphic rocks have sedimentaries lying unconformably upon them, and in fact it has been largely from the erosion of the former that the latter have been made.

It is known that metamorphic rocks occupy a large portion of the state, being very frequently met with throughout the Cascades, from Stampede pass northward to the British Columbia boundary, and from near Puget Sound eastward across the Cascade mountains and Okanogan highlands to the Idaho line. The ordinary varieties of metamorphic rocks in Washington are gneiss, schist, marble, slate, and quartzite. The most important of these are described below.

Gneiss.

Gneiss is a rock composed essentially of the same minerals as granite, and as a consequence is often mistaken for the latter. While a hand specimen of gneiss usually resembles closely a hand specimen of granite, in a ledge of gneiss a banded or stratified appearance is always displayed. Gneiss in general is a good building stone, and in Washington it oftentimes has within it mineral veins of economic importance.

The gneiss of Washington is generally associated with granite and schist, usually lying above the former and below the latter. The most important areas of gneiss observed by the writer are the following: A wide belt, having a north and south course, which is crossed by the road from Myers Falls to Republic; along the Kettle river, between Curlew and Midway, where many veins of pegmatite occur in the gneiss; along the Okanogan river between Johnson creek and Oroville; at several points along the Methow river, between its mouth and the Twisp river, notably near the mouth of Gold creek; along Bridge creek and the Stehekin river, from Twisp pass to Lake Chelan; and on the Columbia river between Chelan Falls and Wenatche.

Schist.

Schists are metamorphic rocks, possessing a cleavage which causes them to break into thin laminæ or folia. The parting along the cleavage planes is almost always wavy, although occasionally it is smooth. When derived from a sedimentary rock the cleavage of schist is at right angles to the original stratification, although all semblance of the latter has usually been wholly destroyed by metamorphism. Schists are recognized by their cleavage habit and by the greasy feel which they usually possess.

Schists are of various kinds and are usually classified according to the prominent minerals found within them. Mica is usually the most abundant mineral and mica schists are therefore of the most frequent occurrence. Chlorite, hornblende, and staurolite, with some others, also occur occasionally and give rise to chlorite schist, hornblende schist, etc., etc.

Russell * mentions a number of localities herein given where schists occur. A great escarpment occurs on the south side of Yakima valley two miles southwest of Clealum. The schists

* Russell: 20th Ann. Rep. U. S. Geol. Survey, Part II, pp. 102-3-4, 1900.

may be traced westward from this point for ten or twelve miles, with an increasing thickness exposed. Similar schistose rocks outcrop about the base of the Wenatche mountains, at various localities at the head of the Teanaway and on Nigger creek, and thence northward to beyond Leavenworth on the Great Northern Railway.

The mountains west of the Columbia and on the north side of the Wenatche valley, known as the Entiat range, are composed largely of mica and hornblende schist. Here the schist is cut by dikes of basalt and acid dikes as well and in some places quartz veins are found containing free gold. Another exposure of schist, thought by Russell to be a continuation of the last mentioned area, occurs in the mountains to the northward of Lake Wenatche between Chiwahwah and White creeks. Hornblende schist also occurs in the vicinity of Dirty Run peak, near the western end of Lake Wenatche, and along the crest of the ridge which extends northwest from it for about ten miles. This same rock forms the south wall of the valley of the west fork of White creek, and extends to the main Cascade divide near Glacier peak. The valley of Indian creek is almost surrounded by schists, which also crown Indian pass and cover most of the country from the region along the Sauk river to the mouth of Whitechuck creek. Schist is found in the region around Cascade pass and along Cascade creek for nearly its entire length. The most northern area of schist recorded by Russell occurs on the Skagit, extending from the mouth of Skaadle to beyond the mouth of Beaver creek. On the east side of the valley of the Skagit the same schist outcrops from Thunder creek to a point five miles up Ruby creek. Russell * also mentions schist as occurring under the lava in the Snake river canyon between Grande Ronde river and Wild Goose creek, and in the mountains along the western base of which runs the Washington-Idaho line. On the Snake river, at Buffalo rock, fifteen miles above Asotin another outcrop of schist occurs.

Other considerable areas of schist have been observed by the writer, usually associated with gneiss. Schist occurs commonly along the Methow between its mouth and that of Twisp river. Schist with gneiss occurs on Bridge creek and on the Stehekin between Twisp pass and the head of Lake Chelan. It occurs

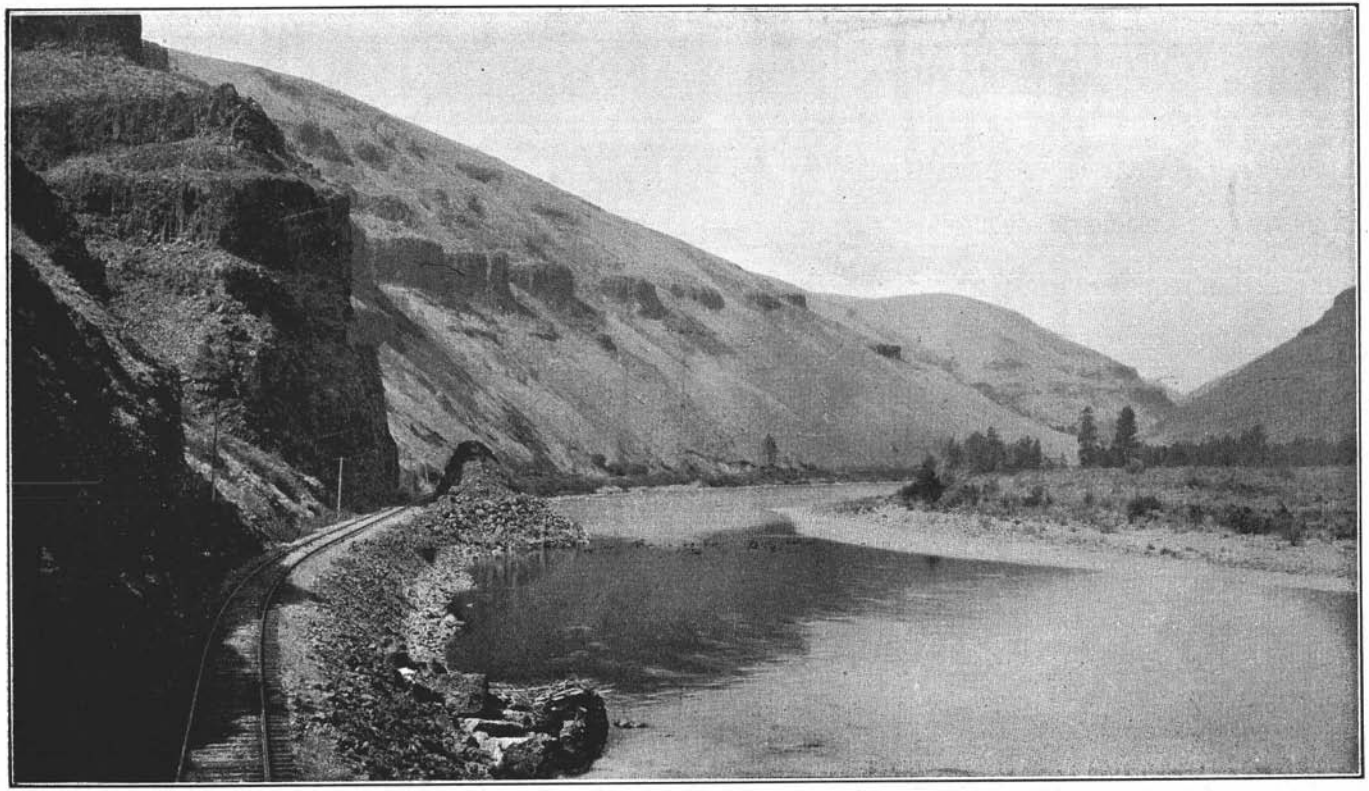
* Russell: Water Supply and Irrigation Papers, U. S. Geol. Survey, No. 4, p. 36, 1897

occasionally on the borders of Lake Chelan and between the mouth of Chelan river and Wenatche. Large areas of schist occur on the Skagit from near Marblemount to Cokedale.

Near Hamilton the schist contains some important veins of magnetic iron. West of Hamilton and about Cokedale are two areas where schist is the enclosing rock of some coal basins to be described later on. Upon the eastern and southern boundaries of the large Blue Canyon coal field mica schist constitutes the rim rock. Schist is found in isolated outcrops about La Conner. It also occurs on the Great Northern Railway near Madison, and for a number of miles from Berne to the eastward. Four miles east of Cheney along the Northern Pacific Railway there are several outcrops of mica schist where the overlying basalt, thin at this place, has been wholly removed.

Crystalline Limestone.

In the metamorphic area above described, crystalline limestone occurs in a large number of localities. Originally a common limestone, it has become crystalline or marbleized through the influence of heat and pressure which was at some time exerted upon it. From an economic standpoint the best crystalline limestone, as far as now known, occurs in Stevens county where commercial marble is found at several places and is extensively quarried. A long, narrow belt of limestone extends north and south across Ferry county, lying at the western foot of the granite divide which separates the Columbia and Kettle rivers from the streams to the westward. Near the head of Lambert creek and in the vicinity of the town of Curlew the limestone forms hills which show quite prominently because of their white color. Crystalline limestone occurs midway between Republic and Wauconda. It also occurs near Johnson creek on the Okanogan river and on the eastern slope of Palmer mountain. On the western slope of the Cascade mountains crystalline limestone occurs at many places from Snoqualmie Pass northward, notably near the Denny iron mines, along the Stillaguamish river near Granite Falls, along the Skagit river between Baker and Marblemount, and near Kendall in Whatcom county. Important areas of the same rock occur on the San Juan islands, where the limestone is intimately associated with some basic eruptive rocks. It occurs here in isolated masses varying in



YAKIMA CANYON, BETWEEN NORTH YAKIMA AND ELLLENSBURG.

size from a few feet in diameter to one-fourth of a mile or so. This limestone doubtless belonged to some sedimentary beds from which fragments were torn by the eruptive rocks in their ascent from their former position below the surface.

Quartzite.

Quartzite is a metamorphic rock which has been derived from sandstone by the cementing of the sand grains by silica. It is practically, therefore, entirely composed of silica, and is of course very hard and resistant.

In a country where gneiss, schist, and crystalline limestone occur it would be very exceptional if quartzite did not occur also. In Washington, however, as far as the metamorphic area has been studied, quartzite has been noted in only a few places. It has been observed by the writer on the Similkameen river, a few miles directly north of Loomis. It is here interstratified with beds of gneiss. Russell* mentions quartzite as occuring at several places north of the Snake river and near the Idaho line, where islands of quartzite appear in the sea of lava. Kamiack and Steptoe Buttes in Whitman county are two very prominent examples of quartzite. The first of these rises over 500 feet, and the second over 1,000 feet, above the surface of the surrounding basalt plateau.

IGNEOUS ROCKS.

The igneous or heat rocks are those which have solidified from a fused condition. An igneous rock may be formed by the fusion of a sedimentary rock, or it may represent merely the final stage in metamorphism. Two kinds of igneous rocks may be noted — the plutonic and the volcanic. The plutonic or deep seated rocks are those which, cooling at a distance beneath the surface and under great pressure, solidify slowly, attaining a coarse granular structure, except near their borders where they come in contact with the cooler rocks. In Washington the plutonic rocks are well represented by granite, syenite, diorite, etc., but as detailed studies have not been made in regard to the particular areas where these different varieties occur, it will be convenient to group them all under the head of granite.

Volcanic rocks are those which are brought to the surface or

*Russell: Water Supply and Irrigation Papers, U. S. Geol. Survey, No. 4, pp. 37-38, 1897.

near to the surface by volcanic action and are either spread out in layers, intruded into fissures as dikes, or accumulated as fragments of lava. On account of their sudden cooling, many volcanic rocks are glassy or only partly crystalline. Others are wholly crystalline, the crystals generally, but not always, being of a small size. Examples of volcanic rocks are to be found throughout Washington, notably the great lava plains of southeastern Washington, and within and about the great volcanoes of the Cascade mountains.

Granite.

Granite occurs at very many places and in very large quantities in Washington. Throughout the metamorphic area of the state above described granite is perhaps the most common rock. It is the belief of the writer that further study will make it clear that there are in the state two kinds of granite—one representing a final stage in metamorphism, or in other words, a metamorphic granite—the other variety an intrusive granite which was forced into the rocks above it. It is possible that these varieties are both shown along the line of the Great Northern Railway in the Cascade mountains. At Index a light colored granite occurs composed mainly of feldspar and quartz, with comparatively small amounts of mica and hornblende. Although the writer has observed this granite over a considerable area about Index, at no place has any evidence of intrusion been noted. At the point where the railway crosses the mountain summit there is another large area of granite, composed mainly of mica and hornblende with a proportionally small amount of quartz and feldspar. This granite is very plainly intrusive, for it shows within it embedded masses of mica schist which it broke off in its ascent.

Granite occurs about Spokane and Medical Lake, where important quarries have been developed. In Ferry county a long narrow belt of granite is found on the summit of the divide between the streams flowing east into the Kettle and Columbia rivers, and those flowing west into Curlew creek and the San Poil river. A similar belt running north and south is crossed on the road from Republic to Wauconda.

Mount Bonaparte, in Okanogan county, stands at the center of a large granite area. It is probable that this area continues southward along the summit between the streams flowing east-

ward into the San Poil river and those flowing westward to join the Okanogan. There is a granite area of unknown width, extending southward from Loomis by way of Conconully and Ruby to the Columbia river. The central portion of this area extends in an east and west direction virtually from the Okanogan river to the Methow, making it one of the largest granite areas of the state. Near Ruby and elsewhere the granite contains a pinkish feldspar, which gives it a beautiful appearance. Granite occurs for two miles east and about eight miles west of Twisp pass, and it is not improbable that this granite continues northwest and southeast forming the divide between the drainage of the Methow and Lake Chelan. Granite occurs along the whole course of Railroad creek, which heads on the summit of the Cascades and which empties into Lake Chelan near its northern end.

Russell* gives several localities in the Cascades where granite and related rocks occur. There is a very large area of granite around Mount Stewart, known as the Mount Stewart granite. All of the high peaks of the Wenatche mountains are composed of this rock, and an area of granite extends from a point about five miles northwest of Blewett to beyond the summit of the Cascades at the point crossed by the Great Northern Railway. Ingall creek, for its whole length to within four miles of its junction with the Peshastin, forms a border of this area. Here the boundary turns and runs nearly due north to seven or eight miles beyond Leavenworth, where it again turns and goes toward the west.

The drainage basin of the north fork of White creek is nearly all in granite, and this area probably connects with that of Cascade pass. Similar granite is found along Indian creek and on Glacier peak. Between the two latter localities a part of the granite branches off from the main mass and in the form of dikes is intruded into the schists to the south. Granite has also been noted along the Sauk river, where schistose rocks are the prevailing type. Another granite area, noted by both Willis† and Russell‡, occurs along the Skagit river from Marblemount to Thunder creek.

---

*Russell: 20th Ann. Rep. U. S. Geol. Survey, Part II, pp. 105-108, 1900.

†Willis: 10th Census U. S., Vol. XV, p. 761, 1886.

‡Russell: 20th Ann. Rep. U. S. Geol. Survey, Part II, p. 107, 1900.

Little is known of the granite in the southern part of the Cascades. According to Smith*, granite forms an elevated platform on which stands the volcanic cone of Mount Rainier. Granite has been observed by the writer at the foot of Silver Star mountain, fifteen miles northeast of Washougal on the Columbia river. It is very probable that granite occurs at intervals along the axis of the Cascade mountains from the British Columbia line to a point within a few miles of the Columbia river. Mr. Charles A. Ruddy has informed the writer that a few miles from the mouth of the Dosewallips river on Hood's Canal large boulders of granite are found, which have beyond any doubt been brought from the Olympic mountains adjoining.

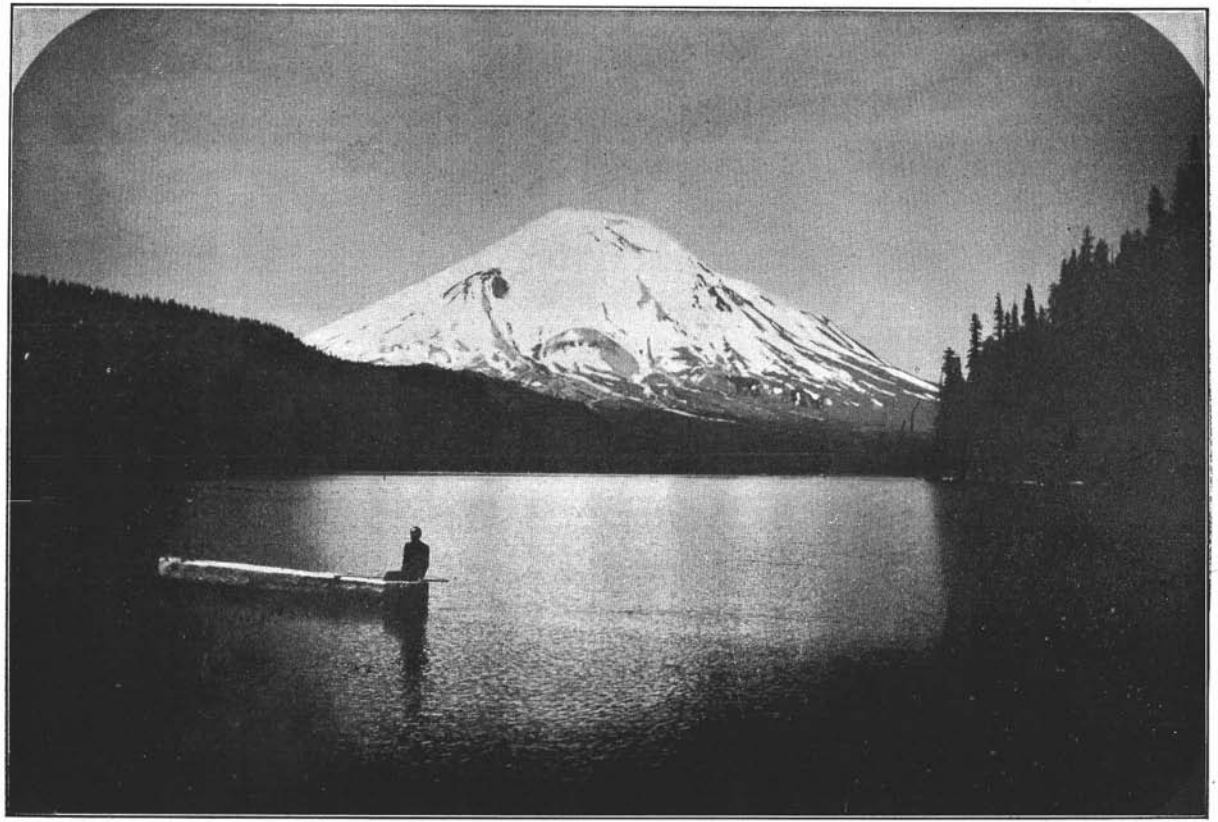
Basalt.

The most important volcanic rock of the state is represented by the series of basaltic outflows known as the Columbia lava.† The Columbia lava not only extends over a good portion of Washington, but covers all of Southern Idaho, Eastern Oregon, and extends into California as well. It is doubtless the largest lava flow in the world, covering nearly 250,000 square miles and displaying a thickness in some places in excess of 4,000 feet. Along the margin of the basaltic flow the lava becomes comparatively thin, as is shown near the big bend of the Columbia river, where the granite beneath the lava shows in canyons at depths of 300 or 400 feet. It is generally conceded that the basalt came to the surface through great fissures of considerable linear extent rather than through the usual volcanic vents. In other words the basalt is of a composition which is characterized by a low melting point, and consequently the molten lava would flow for long distances before cooling. Throughout the Columbia lava plain there are no indications of true volcanoes, as far as observed.

The floor upon which the Columbia lava was outpoured was quite uneven. It was a floor composed as far as known of granite, schist, gneiss, and other metamorphic rocks not dissimilar in character, perhaps, from the Okanogan highlands which lie

*Smith: 18th Ann. Rep. U. S. Geol. Survey, Part II, p. 423, 1898.

†This formation is discussed in the papers by Russell, Smith, LeConte, Gibbs, Richthofen, and Symons, which are mentioned in the Bibliography of Washington Geology at the close of this volume.



Photograph by Dr. U. M. Lauman.

MOUNT ST. HELENS AND SPIRIT LAKE.

to the north, or the mountains along the Idaho-Washington line. Some of the bolder hills of the former floor were never covered, as in the case of Kamiack and Steptoe Buttes and others. Other hills, although finally covered by lava, are yet known to have reached heights of 2,500 feet above the surrounding valleys. Such instances are to be seen in the canyon of Snake river.

Wherever the rivers, such as the Snake, have cut deeply into the basalt, the individual lava flows may be readily made out. The number of lava flows presumably varies in different parts of the lava field. According to Russell,* in the canyon of Snake river, where perhaps there is the greatest exposure of lava, eight distinct lava sheets may be seen. Smith † says that ten or more separate flows can be counted in the canyon of Yakima river, and that individual flows may be traced for great distances. The surface of the basalt in some places is yet characterized by the ropy appearance which is always observed upon recent unweathered lava flows. In appearance the basalt is usually black in color, but various tints of brown, red, gray, and green may easily be found. It is observed that the lava varies somewhat in character in the successive flows, and that from the surface of a flow toward the center some differences may be noted. In some of the flows the basalt is very compact and heavy, while in other cases it presents rough and scoriaceous surfaces, caused by the small cellular cavities which were produced by the steam when the rock was molten. In some instances where the molten rock cooled with great rapidity the minerals did not have time to form and the basalt is therefore glassy, but in the central part of the thicker flows where cooling took place with great slowness the rock is crystalline in structure and the crystals can readily be seen by the naked eye. The composition of the basalt from a mineralogical standpoint is that of plagioclase feldspar, augite, olivine, and magnetite, in a glassy ground mass composed of silicates of alumina, magnesia, soda, potash, lime, iron, etc. According to Russell, "chemical analyses of basalt show that in general it contains from 46 to 47 per cent. of silica and from 11 to 22 per cent. of alumina, together with lime, magnesia, potash, etc., in proportions varying from a small fraction of one per cent. to over ten per cent. It is the presence of

*Russell: Water Supply and Irrigation Papers, U. S. Geol. Survey, No. 4, p. 48, 1898.

†Smith: Water Supply and Irrigation Papers, U. S. Geol. Survey, No. 55, p. 15, 1901.

lime, potash and phosphoric acid in basalt that gives the soils formed from its decay much of their richness for agricultural purposes."

Everywhere that the basalt is seen in a vertical section the columnar structure is very apparent. By the columnar structure is meant the parting of the lava into long colonnades or prismatic columns. These columns vary greatly in thickness and height; in the latter dimension they often reach thirty feet or more and in breadth they may be from three to four feet. In cross section the columns are usually hexagonal, although sometimes very irregular, with sides ranging in number from three to eight. As a rule the smaller columns are more perfect than the larger ones, and it is also noted that in the smaller lava flows the columns may be limited to the central portions of the sheet. A rock such as basalt necessarily shrinks a great deal upon cooling. When the shrinkage is quite regular, symmetrical breaks in the rocks are found which are known as joints. It is because of the great network of joints which extend through the mass of rock that origin is given to the basaltic columns.

When the basalt was outpoured in the form of fiery inundations, it of course filled the valleys first of all, and rose by successive additions to greater and greater heights. It is known that in some cases there was considerable time intervening between successive flows, for extensive layers of gravel and the charred remnants of forest growth often occur between the lava beds.

At the time of its eruption the lava must have assumed a position practically flat or horizontal. That position continues to the present time in some parts of the lava field. In other places, however, the lava beds have suffered great deformation in the way of faulting and folding, and we now find these beds tilted at various angles. The Blue mountains represent a moderate arching of the lava so that here a broad dome has been produced, which rises four or five thousand feet above the surrounding plain. The Badger mountains, located in the great bend of the Columbia, probably had a similar origin. In the western portion of the lava field, as the Cascade mountains are approached, the structure of the lava and of the mountains is closely identical. In other words the basalt has been folded into arches and troughs, or anticlines and synclines, which are plainly

evident to anyone passing through that region. The larger streams, such as the Yakima, have held tenaciously to their courses, even though the arches of lava have arisen across them and deep canyons, such as the striking Yakima canyon, have been produced.

In age the Columbia lava belongs chiefly to the Eocene Tertiary, but the final flows did not cease until Miocene Tertiary time.

Andesite.

Andesite is a volcanic rock composed essentially of plagioclase feldspar and one or more of the following: hornblende, augite, and biotite. It resembles basalt in some respects, but fuses with more difficulty, and is generally of a lighter color. It occurs commonly in Washington, both as intrusive sheets, or dikes, and as extrusive sheets in the form of flows from volcanoes.

The rocks of Mount Rainier have been studied by Smith,* who reports the cone as being composed for the most part of flows of andesite, with occasional layers of basalt. Russell† mentions andesite as forming the summit of Glacier peak, and also dikes or old lava flows that radiate from it in different directions.

Andesite rocks are also said to form the summit of Goat mountain‡, west of the Clealum river, and to be immediately associated with the formations in the region drained by the headwaters of the Yakima river.

Serpentine.

Serpentine is not an unusual rock in Washington, especially in the central and northern Cascades, and its presence has been noted by several observers. In composition serpentine closely resembles talc, both being hydrous silicates of magnesium. Serpentine is generally a soft mineral or rock, some shade of green in color, usually massive in form, although occasionally very fibrous. It is always formed by the metamorphism of some other rock, and hence is secondary. The peridotites, rocks composed essentially of olivine and pyroxene, are particularly liable to alteration whereby serpentines are the result.

---

*Smith: 18th Ann. Rep. U. S. Geol. Survey, Part II, p. 416-23, 1898.

†Russell: 20th Ann. Rep. U. S. Geol. Survey, Part II, p. 134, 1900.

‡Willis and Smith: Clealum Iron Ores, Trans. Am. Inst. Min. Eng., February, 1900

The best known serpentine area in the state is that which encircles the Mt. Stuart granite and which has been described by Russell*. Here the serpentine occurs at many places, notably on the headwaters of the south fork of Icicle creek, on Fortune creek, middle and north forks of the Teanaway river, south of Ingall creek, throughout the drainage basin of Nigger creek, on the ridges to the east of Fish lake and the upper waters of the Clealum river, and in the region around Blewett. In all of these cases the serpentine seems to have been derived from peridotite, and the degree of alteration varies in different portions of the field. Mineral veins are a common accompaniment of the serpentine, and in the region about Blewett, Fish lake, and other localities within the serpentine belt, valuable ores of copper, silver, and gold are found.

In Stevens county several areas of serpentine have been discovered, the best known probably being the one at Valley, on the Spokane Falls and Northern Railway. The serpentine here is a valuable ornamental stone, and the quarrying of it has become an important industry. It has a pleasing color, may be obtained in large masses, and possesses other desirable qualities.

SEDIMENTARY ROCKS.

Sedimentary or stratified rocks are those which are made from the sediments or fragments derived from older rocks. These fragments may be produced along the sea shore by the work of the waves, or they may be produced upon the land by the forces of air and water. Sediments are transported usually by water and deposited upon the ocean floor, in estuaries, or in lakes. Thus we have rocks of marine, brackish water, and fresh water origin. Rocks are also divided according to composition or the kind of sediment which has entered into them, so that we have limestones, clay rocks, sandstones, etc. Another classification that may be made of sedimentary rocks is one according to the geological age in which they were made.

The sedimentary rocks of Washington cover a large portion of the state and are of great importance. At the present stage of knowledge concerning Washington geology the sedimentary rocks are better known than are the other divisions. From their irregular line of contact with the metamorphic and volcanic

*Russell: 20th Ann. Rep. U. S. Geol. Survey, Part II, page 109, *et seq.*, 1900.

LAKE OF THE MOUNTAINS, NEAR CASCADE PASS, CASCADE MOUNTAINS.

rocks on the western flank of the Cascades, the sedimentary rocks extend continuously to the coast with the exception of the higher central portion of the Olympics. In the northern Cascades and over the Okanogan highlands, sedimentary formations occur at many places, usually in comparatively small isolated areas. They represent of course the remnants of previous areas of larger size which in the course of time have been greatly reduced by erosion. Many of the areas now separated were at one time connected. These isolated areas are often found where least expected, and so small are they that a great amount of detailed work will be necessary before they are all made known. On the eastern slope of the Cascades in the central part of the range there are some fields of sedimentary rocks of considerable extent. Some outlying areas, disconnected by erosion, reach down to the Columbia river and a little way beyond. The only part of Washington which seems to be quite free from sedimentary rocks is that part of the state which lies to the eastward of the Columbia river and to the southward of the Columbia and Spokane rivers. In the following discussion the different formations will be taken up in the order of their supposed geological position, or geological age, beginning with the oldest.

PRE-CRETACEOUS PERIOD.

A limestone which bears fossils that are supposed to be the remains of crinoid stems lies beneath the iron-bearing schists along Skagit river. Upon evidence offered by these fossils, Willis* ventures the opinion that the limestones are of Carboniferous age. If so, they are the oldest rocks so far identified in the state. In this same article Willis mentions black slates, conglomerates, and limestones from the Monte Cristo district which he thinks may be of Mesozoic age.

Russell† describes a series of sandstones, shales and conglomerates, of a distinct reddish-brown color which outcrop in the mountains bordering Methow river near the old mining camp of Ventura. He calls the series the Ventura formation, and suggests that it may be of Pre-Cretaceous age. He bases his correlation on the stratigraphic relationship of this formation with the two Cretaceous formations that adjoin it—the Similkameen

*Willis: 17th Ann. Rep. U. S. Geol. Survey, Part I, p. 55, 1896.

† Russell: 20th Ann. Rep. U. S. Geol. Survey, Part II, p. 193, 1900.

sandstone on the north and west, and the Winthrop sandstone on the east.

CRETACEOUS PERIOD.

As far as known, the Cretaceous age is but little represented among the sedimentary rocks of the state. The oldest and probably the best known locality is that of Sucia Island and a few other small adjoining islands of the San Juan group, lying between the island of Vancouver and the mainland. These rocks have been designated the Vancouver formation because of their splendid development upon the large island of that name. Sucia Island has yielded about fifty species that are common to the Chico group of California, which is of upper Cretaceous origin.

Another locality, widely separated from this, is on the Snoqualmie river about three miles below Snoqualmie Falls, where from an outcrop of rocks characteristic marine fossils have been obtained.*

A third area yet further separated from the other two, located upon the headwaters of the Similkameen and Methow rivers, is described by Russell.† The Similkameen formation consists chiefly of sandstone, shale, and limestone with smaller quantities of conglomerate, quartzite, and breccia, the whole forming a series which is 4,000 or 5,000 feet thick. The mollusks obtained from the limestone, and the well-preserved ferns found in the blue sandstone at the base of Gold Ridge, establish the Cretaceous age of this formation.

To the southeastward of the area just described, on the Methow river near Winthrop there is to be found a series of coarse sandstones and light grey sandy shales having a thickness of about 2,000 feet. From the abundant plant remains found in the shaly layers the Cretaceous age was cleary established. This group of rocks has been termed by Russell the Winthrop sandstone.

TERTIARY PERIOD.

The Tertiary rocks have been studied for a number of years, and beyond a doubt are the best known rocks of the state. They are of great economic importance because they contain within them large deposits of coal and valuable ledges of building stone.

---

*Kimball: Am. Geol., Vol. XIX, p. 305, 1897.

†Russell: 20th Ann. Rep. U. S. Geol. Survey, Part II, p. 114, *et seq.*, 1900.

As was the case in other parts of the United States, Tertiary time in Washington was characterized by the presence of many lakes, in which sediments of great thickness were deposited. In the early part of Tertiary time, or during the Eocene epoch, vegetation grew with great luxuriance about the lake shores, and upon the lake floors vegetal matter was deposited in thick beds between the layers of sand and clay. After an average accumulation in these lakes of several thousand feet of mechanical sediments and vegetal matter, the strata were elevated, folded, and sometimes faulted, the vegetal accumulations were compressed and metamorphosed and converted into coal seams. The lakes above mentioned were located along the eastern and western borders of the Cascade mountains, and in the northeastern part of the state, in what is now Okanogan, Ferry and Stevens counties. They had their best development west of the Cascades, along the eastern side of the present Puget Sound basin, but in this region the Tertiary sedimentary rocks have been largely covered by lava flows from the mountains nearby, and by the sediments from the great glaciers which later passed over them.

A little way to the westward of the chain of lakes just described was the sea coast of that time which was somewhat parallel to the present ocean border. Upon the floor of the shallow ocean sediments accumulated, consisting mostly of clay, sand, and gravel, with thin layers of limestone. The marine deposits were made almost wholly in middle and later Tertiary; or in the Miocene and Pliocene epochs. As far as known there is no unconformity in the Tertiary period between any epoch and the one following. The Eocene rocks have received more study than those of the Miocene and Pliocene epochs because of their economic importance. The rocks of the latter epochs lie in the southwestern part of the state and have received practically no attention from geologists.

Eocene Epoch.

The Eocene rocks of Washington are nearly all coal-bearing and so a reference to the map of the coal fields, herein, will give one an idea of the approximate extent of the rocks of this period. In some instances the areas are very small and the thickness of the rocks not very great. In other cases, as in the Blue Canyon coal field, an area of more than 360 square miles is represented and the rocks are not less than 10,000 feet in thick-

ness. The geological characteristics of each Eocene area is described in more detail in the article on the coal fields of Washington, which is a part of this volume.

During the field season of 1901 the writer collected from a few new localities some plant remains which were submitted for examination to Professor F. H. Knowlton of the United States Geological Survey, and his report is here given:

PRELIMINARY REPORT ON FOSSIL PLANTS FROM THE STATE OF WASHINGTON, COLLECTED BY HENRY LANDES, 1901.

BY F. H. KNOWLTON.

This material consists of seven small lots of specimens, from as many separate localities, all, with a single exception, being in the northwestern part of the state. The species afforded by the various localities are as follows:

Day creek, near Hamilton, Skagit county, Wash.:

Quercus banksiæfolia Newberry.
Quercus sp.

Coal creek, near Hamilton, Skagit county, Wash.:

Quercus banksiæfolia Newberry.
Quercus coriacea Newberry.
Thuja interrupta Newberry.
Glyptostrobus Europæus (Brongn.) Heer.

Cokedale, Skagit county, Wash.:

Quercus banksiæfolia Newberry.
Nyssa ? cuneata ? Newberry.
Cinnamomum n. sp.?

These three localities, being evidently of the same horizon, are best considered together. The most abundant and unmistakable species is *Quercus banksiæfolia* of Newberry. It occurs at all the localities and is a very beautiful species. It was originally described by Newberry,* from Chuckanut, near Bellingham bay, and so far as I now know has been found but once since, namely, by myself at the coal mines at Blue Canyon on the east side of Lake Whatcom. The history of *Quercus coriacea* and *Nyssa ? cuneata* is the same, and the conifer identified as *Glyptostrobus Europæus* was found at the same place.

Thuja interrupta was described originally from the Fort Union group near old Fort Union, North Dakota. I found it also on Blue Canyon, and it is present in the material from Coal creek.

The locality at Chuckanut was referred by Newberry to the Cretaceous, and this was nearly fifty years ago when much less was known of the geology of this region than now, and I do not think it should be so

* Bost. Jour. Nat. Hist., Vol. VII, p. 522, 1863; Extinct Floras of North America, p. 69, pl. xviii, figs. 2-5, 1898.

regarded. From the general appearance of the plants alone I should incline to place the age as somewhere near the Middle Tertiary, certainly younger than beds at Carbonado, etc. In any case these three localities represent an age similar to that of the beds at Blue Canyon.

Coal Creek, near Keese, Whatcom county, Wash,:

Sequoia Langsdorfii (Brongn.) Heer.
Sabal similar to *Sabal* n. sp., from Liberty, Wash.
Cinnamomum n. sp. of vein XII, Franklin, Wash.
Cinnamomum sp.
Pipu n. sp.
Phyllites n. sp. of vein XII, Franklin, Wash.
Populus n. sp. of vein XII, Franklin, Wash.

This collection contains beautifully preserved and very interesting material, some of which is undoubtedly new, and much of which is identical with, or similar to, forms from vein XII at Franklin, Wash. On this ground I should regard the age as similar to that at Franklin. I have not given the names of the new species in advance of their publication in my proposed monograph.

Skykomish, Snohomish county, Wash.:

Anemia n. sp., as found at Carbonado.
Glyptostrobus sp., as found at Roslyn.
Ficus n. sp., as found at Carbonado.
Ficus n. sp., as found at Liberty.
Celastrus n. sp., as found at Carbonado.

The age of this locality would seem to be the same as that at Carbonado and Roslyn, the beds at Liberty being a little lower. In any case it is probably not greatly different from the age at Carbonado.

Black River Junction, King county, Wash.:

Acer n. sp.
Cinnamomum n. sp.
Ficus ? n. sp.

This material is the same as that obtained at Steel's Crossing and, judging from the matrix as well as the plant impressions, came from the identical beds. There is no evidence tending to change my opinions on the age.

Republic, Ferry county, Wash.:

Thuja interrupta Newberry.
Sequoia Langsdorfii ? (Brongn.) Heer.
Cinnamomum sp.

There is too little of this material to base a very definite conclusion on, but it would seem to be similar or identical with the beds in Skagit county.

Miocene Epoch.

Marine Miocene strata which have been correlated with the Astoria beds, outcrop along the shore from Port Blakely to

Pleasant Beach, on Puget Sound. The formation at this locality consists of several thousand feet of sandstone, shale, and conglomerate, all tilted at a high angle. Dall* mentions rocks of this age as occurring at Shoalwater Bay (Willapa Harbor), Bruceport, and Bellingham Bay. Willis† mentions a fresh water formation in the southeastern portion of the New Castle hills which he correlates with the Miocene.

The Ellensburg sandstone, as described by Russell‡, is the largest fresh water deposit of known Miocene age yet discovered in Washington. The formation is well exposed along the Yakima river between Dudley and Ellensburg, and consists of strata of sandstone, volcanic dust, and conglomerates, both consolidated and unconsolidated. This formation lies immediately above the Columbia basalt, and reaches a thickness of about 1,500 feet in the North Yakima area.§ The Ellensburg formation was deposited in a large lake which covered much of central Washington, the exact boundaries of the lake being as yet unknown. The lacustrine sediments, being as a rule quite incoherent, have been largely removed by erosion.

Pliocene Epoch.

It is not improbable that future study will disclose rocks of this age among the sedimentary formations which make up the southwestern part of the state. Dall‖ mentions the occurrence of a "mytilus bed" at Bruceport which he thinks is of Pliocene age.

QUATERNARY PERIOD.

Pleistocene Epoch.

Marine Pleistocene deposits within the state are confined chiefly to raised beaches. Dall¶ writes of the occurrence of beds 30 to 40 feet thick which lie uncomformably upon the Pliocene at Bruceport. Raised beaches of Pleistocene age occur at Alki and Restoration Points and elsewhere about Puget Sound wherever the beach is made up of bed rock. Pleistocene sediments in the nature of glacial deposits occupy a large portion of

* Dall: Bull. 84 U. S. Geol. Survey, p. 228, 1892.

† Willis: 18th Ann. Rep. U. S. Geol. Survey, Part III, p. 414, 1898.

‡ Russell: 20th Ann. Rep. U. S. Geol. Survey, Part II, p. 127, 1900.

§ Smith: Water Supply and Irrigation Papers, No. 55, p. 17, U. S. Geol. Survey, 1901.

‖ Dall: Bull. 84, U. S. Geol. Survey, p. 228, 1892.

¶ Dall: Bull. 84, U. S. Geol. Survey, p. 227, 1892.

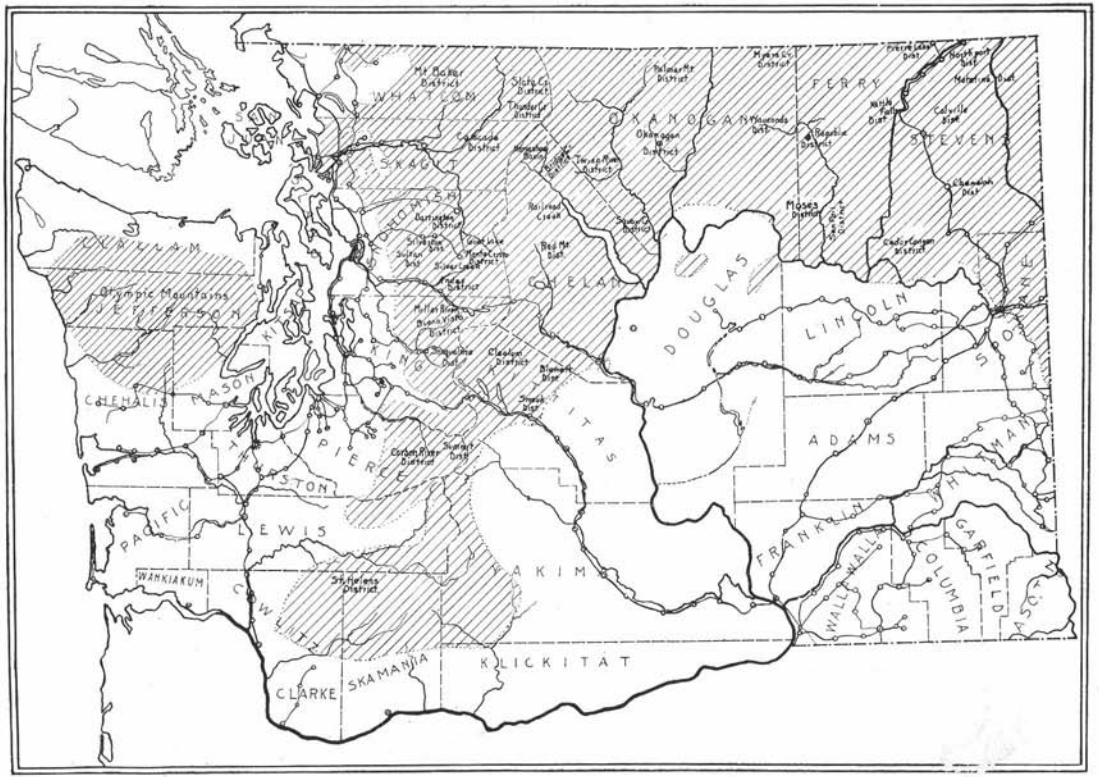
the state. In all of the mountain districts, except in the Blue mountains, glaciers once covered the mountain tops and filled the valleys, and the latter are now partially occupied by terraces, boulders, and moraines. The region about Puget Sound was occupied by great ice masses which came from British Columbia, the Cascades, and the Olympics. The sediments left by these glaciers consist of till, with stratified sand, clay, and gravel, in all averaging in thickness not less than five hundred feet.

PART II.

THE METALLIFEROUS RESOURCES OF WASHINGTON, EXCEPT IRON.

BY

HENRY LANDES, WM. S. THYNG, D. A. LYON,
MILNOR ROBERTS.



A map indicating the locations of the principal mining districts, and the approximate boundaries of the region in which metalliferous deposits occur.

THE METALLIFEROUS RESOURCES OF WASHINGTON.

INTRODUCTION.

In at least thirteen of the counties of Washington metalliferous deposits are known to occur, and in all of these counties from one to several mining districts have been organized. The metallic minerals are practically limited to that area on the geological map which is designated as the region of metamorphic and igneous rocks of unknown age. Veins of ore therefore occur at many points throughout northern Washington from the neighborhood of Mount Baker eastward to the Idaho line, and from the international boundary southward along the length of the Cascades to within a few miles of the Columbia river. The Olympic mountains presumably contain rocks analagous to those of the Cascades, but it has not yet been demonstrated that valuable metalliferous deposits occur within the Olympics.

In this brief description of the metalliferous resources of the state it is not feasible to separate the metallic minerals one from another and give an account of the occurrences of each. In most cases these minerals occur together, oftentimes in the same vein, and generally in the same district. Of the various classes of ores the sulphide ores are by far the greatest in abundance. Along with the sulphides, arsenides and antimonides are very common. Oxides and carbonates do not commonly occur, and native minerals are conspicuously rare.

Gold is found in all of the mining districts, and even in all veins. It occurs most frequently associated with iron pyrite, arsenopyrite, chalcopyrite, sphalerite and galena. In a few districts, as Mount Baker and Squaw creek, gold occurs with tellurium as a telluride. It does not commonly occur in quartz in a free-milling condition, at least very far below the surface.

Many stamp mills have been erected which treated gold-bearing quartz successfully when the ore was taken from the surface, but this process had to be abandoned when depth was attained where the ore became base. Comparatively little gold is obtained in the state from placer diggings. Placer deposits do not seem to have been formed to any large extent, presumably because of an absence of quartz ledges which carry free gold.

Silver is as widespread in its occurrence as gold, and practically none of the ledges are free from it. It occurs most commonly as a sulphide, in close association with other sulphide minerals, notably galena. In some of the districts silver-lead ore is the chief product. In other districts, as Cedar canyon, silver is practically the entire product, occurring in the native form as well as a sulphide. In other instances, as about Republic, silver occurs in small quantities, especially in comparison with the gold values.

The copper minerals are widespread in occurrence, there being very few metalliferous deposits of any kind which do not contain some copper. It is not uncommon to find gold, silver and copper in about equal amounts as regards value. In some districts, as that of Republic, copper minerals, if present at all, occur in exceedingly small quantities. On the other hand there are some districts, as Index and Carbon river, where practically all of the values in the ledges come from the copper minerals alone. The most abundant copper mineral is chalcopyrite, with bornite as a natural though minor associate. Tetrahedrite or gray copper is not uncommon, and chalcocite is found in some veins. Native copper has been found at several places, as at Eatonville and on the Quilcene river near its mouth, but it is comparatively rare. The oxides and carbonates scarcely occur at all west of the summit of the Cascades ; they occur in small quantities at many places in eastern Washington where weathering has not been followed so closely by erosion, as in the humid region nearer the coast.

About the only lead mineral found is galena, which occurs abundantly in association with the other sulphides. While it is very rare at times, it is yet a common mineral in a large majority of the mining districts of the state. In some districts, as Colville, Horseshoe basin and others, galena constitutes the chief metallic mineral of the ore veins.

Zinc, in the form of sphalerite, or zinc blende, is also of widespread occurrence, although the amount found in any one vein is never large. It occurs in intimate association with the other sulphides, especially with galena.

Arsenic occurs very commonly in the ore veins, usually in the form of arsenopyrite. This mineral is always gold-bearing and for that reason its presence is looked upon as desirable. In some cases, as in the Monte Cristo mine, arsenopyrite occurs in such large quantities that the arsenic constitutes an important commercial product. Native arsenic, realgar and orpiment also occur, notably about Monte Cristo and Goat lake.

Antimony, sometimes in the metallic form, sometimes as stibnite or tetrahedrate, occurs in more or less abundance in many districts. In a few instances, as at the Happy Thought mine, on Miller river, King county, the quantity is sufficient to make it of commercial importance.

Molybdenum, in the form of the sulphide, molybdenite, frequently occurs in the ore veins, generally in very small quantities. In the Crown Point ledge, on Railroad creek, it occurs in sufficient amount to make it worth the while to work the mine for this one product alone.

The total value of the metalliferous products of Washington for the past twenty years, as given by the Director of the Mint, has been about $10,000,000. The output of 1901 is estimated at $1,072,680. The metalliferous deposits of the state, because of their isolation and generally refractory character of the ores, are necessarily of slow development. With the building of railways into the mining districts, and with improved facilities for ore treatment, a great development of the mining industry in Washington is sure to follow.

In the following description of the metalliferous deposits of the state a classification is made according to counties, districts, and mines. A beginning is made on the eastern border of the state, and the counties are then taken in turn to the westward and southward. The mining districts are not all represented by any means, only representative ones being described. Similarly in each district considered only a few of the mining properties, as a rule, are mentioned. Those selected are so chosen because they are typical of the district, or because being more accessible they could be more readily visited in the hasty field work. The

properties herein described therefore represent but a fraction of the very large number found throughout the mining regions of the state.

STEVENS COUNTY.

Stevens county lies in the extreme northeastern corner of Washington, extending in an east and west direction from Idaho to the Columbia and Kettle rivers, and from Spokane and Lincoln counties on the south to the state boundary on the north.

In its topography, Stevens county is characterized by three prominent ridges, and three prominent valleys, all having a north and south course. Near the Washington-Idaho line a mountain ridge having a general height of about 5,000 feet, extends from the Pend d'Oreille river at Newport to British Columbia. Parallel to this chain a second one lies between the Pend d'Oreille river on one side, and the Colville on the other, and has an altitude of about 4,500 feet. To the westward, situated between the Colville and Columbia rivers, is the third chain, somewhat lower than the others, its highest point extending to about 4,000 feet above the sea. The larger streams have completely severed the ridges in several instances, and the smaller streams have produced many prominent passes and gaps. Of the conspicuous north and south valleys of the county, the Pend d'Oreille is comparatively narrow, and has the canyon aspect strongly developed. On the other hand the Colville is quite a broad valley in which the river lazily meanders across its long flood-plain. The valley farthest westward, that of the Columbia, is also broad, and has an elevation above the sea of about 1,100 feet at the point where it enters the county.

Stevens county, although lying in the great basin between the Cascades and the Rockies, is well watered, its elevation being such that the precipitation in the form of snow and rain amounts to over 25 inches per year. The rivers are large and give to the county an abundant water supply, while their falls and rapids will some day yield great power as well. The Columbia in Stevens county is a broad and deep stream, and yet is not navigable

because of its strong current and the rapids along its course. Clark's fork, or the Pend d'Oreille, is one of the largest tributaries of the Columbia, and is navigable for a part of its course in Stevens county. The Colville is a small river, draining a broad fertile valley, which was settled early in the history of Washington. The Spokane forms a part of the southern boundary, and the Kettle a part of the northwestern boundary. The more elevated parts of the county are covered with a strong forest growth of evergreens. The mountains along the eastern boundary are included within the Priest River Forest Reserve. Practically the entire county is forested, although when the lower valley levels are reached the timber becomes somewhat sparse.

Stevens county is largely a region of metamorphic and igneous rocks. The basalt of the Columbia plain reaches the Spokane river at the southern limits of the county. The north and south divides are composed mainly of granite, with gneiss, schist, crystalline limestone, and other metamorphic rocks. The crystalline limestone yields an excellent marble at several places, and it often has serpentine as an associate. At a few localities veins of coal are found, which are doubtless analagous in age and mode of origin to the Tertiary coals of the western part of the state. Metalliferous deposits have been found in many parts of Stevens county or wherever careful prospecting has been carried on. The ores occur for the most part in the higher hills which constitute the divides between the larger streams. Silver has been the most prominent metal mined, occurring in the forms of silver sulphides, native silver, and silver-lead. In some ledges gold is the most important metal, and in a number of others, copper in various mineral forms is the chief constituent.

NORTHPORT DISTRICT.

Bullion.—On Bullion mountain, near the Columbia river, there is a group of seven claims belonging to the Bullion Mining Company, of Spokane. The property is about eight miles west of Northport and three and one-half miles from the Spokane Falls & Northern Railway. There are two ledges on the property, one eighty feet and the other fifty feet in width. They both strike northeast and southwest, and dip to the northwest. On ledge No. 1 a shaft has been sunk a distance of 160 feet. At

the 50 foot level a drift has been run 80 feet, and at the 150 foot level another drift has been run 100 feet. On ledge No. 2 a shaft has been sunk 100 feet, and at the 100-foot level a drift 40 feet long has been driven. A number of open cuts have been made to show the width of the veins. A water-power plant has been installed on Crown creek which generates ample power for running a sawmill, drills, concentrator, etc. The company has already spent $15,000 in developing the property. No ore has yet been shipped, but there is now on the dump 50 tons of shipping ore and 100 tons of concentrating ore, all taken out in development work. The concentrates yield on an average, gold $2, silver 40 ounces, and lead 70 per cent. (H. J. Brown, secretary, Spokane.)

Silver King.—The Silver King Mining Company's property, consisting of four claims, is situated four and one-half miles southeast of Northport. It contains several veins composed largely of silver-lead ore. Some assays of solid ore have yielded silver 6 ounces and lead 77 per cent. Three shafts have been sunk, 30 feet, 28 feet, and 20 feet in depth, respectively, at a total cost of $1,000. (J. R. Fleming, secretary, Spokane.)

MYER'S FALLS DISTRICT.

Mint.—On Gold hill, near Myer's Falls, is located the Mint group of claims. There are three veins, varying in width from eight to twenty-five feet, with a northwest and southeast strike, and a dip to the southwest. A tunnel and shaft aggregating 200 feet have been driven, at a cost of $2,500. Assays on the ore have given gold $8, silver 5 ounces, and copper 8 per cent. (D. F. Strobeck, Spokane.)

St. Paul-Express.—These claims are located very near the Mint group, on Gold hill. Two veins are found here, from 12 to 35 feet wide, striking northwest and southeast and dipping to the southwest. A small amount of development work has been done, consisting chiefly of a tunnel and a shaft. Assays of the ore have been made which give gold $7.50, silver 5 ounces, and copper 9 per cent. (D. F. Strobeck, Spokane.)

FLAT CREEK DISTRICT.

Examiner.—The Examiner Mining Company's group of four claims is situated on Mineral hill in the Flat creek district.

Work was begun by the present company in January, 1899, and since then they have driven 450 feet of tunnels and shafts. Steam power is used for hoisting and pumping. The work done represents an expenditure of over $10,000. The vein is six feet wide and strikes northeast and southwest. The dip is to the northwest. Assays on the ore vary from $2 to $16 per ton in gold and silver. (W. Genge, secretary, Spokane.)

COLVILLE DISTRICT.

Bonanza.—The Bonanza mine is located four miles northeast of Bossburg. The property was originally located in 1885, and came into the hands of the present owners, the Deer Trail Consolidated Mining Company, in January, 1900. The vein has a width of about eleven feet. Since the present company obtained control of the property it has shipped about 1,500 tons of ore of an average value of $16 per ton, chiefly in lead and silver. The company has erected a shaft house, an ore house, bunk houses and boarding houses, and a blacksmith shop. A steam hoist is also installed. The total length of underground workings including shaft, levels, stopes, etc., amounts to about 2,500 feet. The total cost of all development work amounts to about $30,000. (W. W. Tolman, Spokane.)

CHEWELAH DISTRICT.

Minnehaha.—This property is located on the east fork of Chewelah creek, in section 36, T. 33, N. R. 40 E. The ledge varies in width from 8 to 30 feet, and strikes northwest and southeast, with a southwesterly dip. The average assay value is $7.50 in gold, 6.5 ounces in silver, and 6 per cent. copper. A tunnel 40 feet long has been driven, costing $500. (D. F. Strobeck, Spokane.)

Blue Creek.—The Blue Creek Copper Mining Company, of Spokane, has a group of three claims about a mile and a half from the Blue creek switch of the Spokane Falls & Northern Railway. The three claims join each other end to end, all being on the same ledge. The ledge averages about six feet wide and strikes northwest and southeast. Assays of $26.75 per ton in copper have been obtained. About 300 feet of underground development work has been done, at a cost of $3,000. (J. J. Brown, Spokane.)

SPRINGDALE DISTRICT.

Kemp-Komar.—The Kemp-Komar Copper Mining Company has two claims which are located about six miles north of Loon lake. There is one vein 12 feet wide which carries a paystreak varying in width from a few inches to 5 feet. It strikes northeast and southwest and dips about seventy degrees to the northwest. Four car loads of ore have been shipped which averaged 25.5 per cent. copper, while another car load gave 16 per cent. copper. The total values are in copper. A shaft has been sunk 200 feet and from the bottom a drift has been run 250 feet. In another part of the vein a shaft has been sunk a distance of 40 feet. One tunnel 60 feet long, another 90 feet, and a drift 20 feet long have also been driven to develop the ore body. Near the surface the ores are carbonates and oxides, except in the west workings, at the bottom of which the sulphides replace the surface ores. Occasional assays show a small value in gold and silver, the highest in gold being $2 per ton, and in silver 6 ounces per ton. (L. K. Armstrong, Spokane.)

Honest John.—The Honest John Mining Company's group of three claims is located about two miles northwest of Springdale, on the Spokane Falls & Northern Railway. The vein is five and a half feet wide and dips to the southeast, with a northeast and southwest strike. The values are mainly in silver and lead, and assay returns of $40 per ton have been received. In the development of the property a tunnel 120 feet in length has been driven, several small shafts have been sunk, and some open cuts made. (W. O. Applequist, secretary, Spokane.)

CEDAR CANYON DISTRICT.

BY WM. S. THYNG.

Cedar canyon district is located in the southwestern part of Stevens county, in an air line twenty miles west of Springdale, on the Spokane Falls and Northern Railroad, and thirty-five miles north of Davenport, on the Washington Central branch of the Northern Pacific. The district is reached from both of these places by wagon roads, the length of the road from Springdale being twenty-five miles, and of that from Davenport forty-two miles. While this district is perhaps not as well known as some in the state, it has nevertheless within the last few years produced a large amount of ore. The ore, until late

in the summer of 1901, was all shipped by way of Davenport, but since the shortening and improving of the road to Springdale, accomplished during the past season, probably most of the ore mined will be shipped from that point until the time comes when the district itself will be reached by a railroad. Throughout the district the ore is mined wholly for its silver contents, although in many cases lead is also saved in the smelting.

Deer Trail.— The Deer Trail properties, owned and operated by the Deer Trail Consolidated Mining Company, are and have been by far the largest producers and shippers of ore in the district. The president of the company is Mr. J. D. Chaplin, address, St. Catherine, Canada; Senator W. W. Tollman, Spokane, Washington, is vice-president and general manager. The headquarters of the operating department is in Spokane. The company owns the following claims in the district: Deer Trail, Deer Trail No. 2, Legal Tender, Victor Fraction, Elephant, and Baby Elephant.

There is but one ledge, which has an average width of four feet, a strike of south thirty degrees west, and an average dip of forty degrees to the southeast. This dip is found to be quite variable, ranging from ten to forty-five degrees. The country rock or formation is a stratified limestone, which runs northeast and dips between eighty and eighty-five degrees to the northwest. The vein matter is made up of quartz containing inclusions of country rock in places. The ore in the upper levels consists of highly oxidized sulphurets and chlorides, but it passes, however, in depth, to sulphides both of lead and silver. Galena, when found, generally averages between 10 and 15 per cent.; the silver found with the galena running from 50 to 500 ounces per ton of ore; gold, both in the upper and lower levels, is generally found to the amount of $1 to $2 per ton of ore; sphalerite (zinc blende) is always found accompanying the galena, and in amounts of about 8 per cent. to each 15 per cent. of the galena. A pay streak of ore, from three inches to four feet in width, with an average of twelve inches, is found, while in places the entire vein widens to 12 or 15 feet. The pay streak is generally very continuous and shows a good parting of gouge, which is almost pure talc. The average value of all ore taken out of the mine is about 100 ounces in silver per ton. The ore is hand picked on the surface, and part of it spalled; the average

value of all ore shipped is 200 ounces in silver and eight per cent. in lead. The mine was opened in 1895, and was acquired by the present company on the 25th day of January, 1900. The vein lies nearly parallel with the surface of the mountain and is reached at a number of points by short tunnels.

The total extent of underground development is about 2,000 feet, but the area of stoped ground could not be ascertained. The ore is mined entirely by hand, the universal method throughout the district. About $30,000 has been expended in development and in surface work and improvements, and the estimated value of the output to date is approximately $500,000; the exact amount of ore mined and sold to date could not be ascertained. The statistics of yield and value are from Senator W. W. Tolman, general manager of the mine.

Silver Queen.—This mine is owned and operated by the Silver Basin Mining Company, of which the president is Mr. W. O. Van Horn, and the general manager is Mr. L. E. Van Horn, both of Fruitland, Washington. This property lies about three-quarters of a mile southwest of the Deer Trail. The ledge strikes along the magnetic north and south line, with a dip that is usually about vertical, the deflection occasionally being to the east or to the west. The west wall is remarkably well defined. The ledge is in a contact between white and blue limestone, the white limestone lying to the east, where the parting between it and the country rock is not easily distinguished. The average width of the ledge is about six feet. The value of the ore is wholly in silver, which occurs largely as brittle silver, although recent developments during the past winter, have uncovered a considerable amount of native silver along parting planes. The lead contents of the vein are very low, but where galena is found, it generally runs high in silver, often containing from 500 to 600 ounces to the ton. The pay streak varies greatly in thickness, but appears to follow most closely the west wall. The gangue matter is chiefly dolomite.

Silver Seal Fraction.—Immediately south of the Silver Queen and located upon the same ledge, is the Silver Seal Fraction Mine, represented by Mr. F. M. Van Horn, of Fruitland, Washington. Upon this properry an adit tunnel 341 feet long has been run, cutting the ledge at a depth of about 80 feet. This

tunnel was driven and is controlled jointly by the Silver Queen and the Silver Seal companies. From this tunnel 204 feet of drift has been driven in the Silver Seal, and from this drift considerable stoping has been done, at one place to a height of 24 feet. From the point where this drift crosses the property line, or end line of the Silver Queen, it has been continued for 110 feet. Upon the Silver Seal property a shaft has been sunk 76 feet from the surface, which intersects the drift about 20 feet south of the tunnel head. This shaft is entirely in ore. Upon the Silver Queen a shaft has been sunk, which in September, 1901, was some 215 feet in depth. Since that time this shaft has been continued and connection has also been made with the Silver Seal drift. The plan of both companies is to work in the future, each from its own shaft, the Silver Queen being already equipped with a hoisting plant. The Silver Seal has shipped eleven carloads (about 220 tons) to the Northport Smelter, via Davenport, and in September, 1901, had about 700 tons of shipping ore upon the dump. The Silver Queen has shipped three carloads of ore and has at present something over 50 tons upon the dump.

Brooks.—This is another property of considerable importance in the district, and is owned by the Brooks Mining Company, of which the president is Mr. E. L. Spencer, of Davenport, Washington. This company owns three claims in the district, the Brooks, Success, and First Adventure, but at the present time is operating only the Brooks claim, which is located immediately north of the Silver Queen and is supposed to be upon the same ledge. The development to date consists of a shaft 75 feet in depth, from which 50 feet of drifting has been done, and a tunnel 265 feet in length, completed last season, and which taps the ledge at 90 feet depth. This tunnel is driven through a saccharoidal limestone. The ore is similar to that of the Silver Queen. Two car loads of the value of $3,000 have been shipped from the drift workings.

Orchid.—Four claims, the Orchid, Laura E., Cyclone, and Cornell are owned by the Orchid Mining Company, of which the president is Mr. G. W. Kipp, address, Cortez, Pennsylvania, and the general manager, Mr. C. L. Young, of Davenport, Washington. This property is located about three-quarters of a mile

Department
Southern Illinois University
Carbondale, Illinois 62901

almost due south of the Deer Trail. The claims cover two ledges, which have a north and south strike. The development work, consisting of tunneling, drifting, and a short shaft, aggregates 1,750 feet. Some little stoping has also been done. The company shipped three tons of high grade ore in August, 1900, to the Tacoma smelter. The ore as found so far consists of chlorides of silver and lead, in intimate association, with small amounts of brittle silver.

While the properties above mentioned are probably at the present time the largest and most important of the district, there are others upon which considerable development work has been done and which would seem well worthy of mention. These include the Silver Basin, Moonshine, Jolly Boy, Emerald, Hoodoo, Hoodoo Extension, Saturday Night, Sunday Morning, Plata Rica, and others.

The district is highly mineralized and many of the ledges yield exceptionally good values in silver. As is the case with so many of the mining districts in this state, the vexed question is that of transportation. With a railroad directly into the district a number of properties, now standing idle on account of lack of shipping facilities, would at once be placed upon a firm paying basis.

FERRY COUNTY.

Ferry county lies between the counties of Stevens on the east and Okanogan on the west, and embraces a part of the large tract that has been commonly known for so many years as the "Reservation." Until the present time Ferry county has suffered because of its isolation, but accessibility to it will be largely increased by the two railways which are now being constructed into the heart of the county, the local terminal point of each being Republic.

In its topography Ferry county is interesting although simple. The county has on its southern border the winding valley of the Columbia, and on its eastern border the valleys of the Columbia

and the Kettle. A broad continuous valley extends north and south through the central part of the county, made by the San Poil river and Curlew creek, both heading near together in the neighborhood of Republic, but flowing in opposite directions. Between the valley just mentioned and that part of the Columbia-Kettle is a north-south ridge or watershed rising about 4000 feet above the main valleys. To the westward of the San Poil-Curlew valley the surface rises gradually to the western border of the county, and beyond it until the Okanogan divide is attained. On the whole the topography of the county is characterized by broad valleys and rounded hills, rather than by canyons and mountains; it is an old topography rather than a new one. The grades are so moderate that roads are easy of construction in practically all parts of the county. Along the sides of the larger valleys terraces rise one above another, the uppermost one being often 600 feet above the stream below. Across the valleys in occasional instances the moraines inherited from glaciers have formed slight dams, producing small shallow lakes.

Although Ferry county has an average rainfall of but fifteen inches per year, still all the higher parts of the county are covered by a good forest growth. In the northeastern part of the county, on the higher divides adjacent to the Columbia and the Kettle rivers the groves of pine, tamarack, and other evergreens are very fine and assume considerable commercial importance. In the valleys, and on the lower hills, the decreased rainfall does not admit of the growth of trees, but a luxuriant bunch-grass growth is found instead. The drainage of the county is altogether into the Columbia, the two chief tributaries of that stream being the Kettle and the San Poil. The small streams of the county head for the most part among the granite and crystalline rocks, and are conspicuous for their purity and freshness.

As to the geological features of the county it may be noted in a general way that granite, gneiss, schist, and crystalline limestone are the prevailing formations, with some intrusive and extrusive rocks of a late age. A broad belt of granite, flanked by gneiss, schist and crystalline limestone, lies immediately to the westward of the Columbia and Kettle rivers, and extends from the southern to the northern limits of the county. A parallel belt of similar rocks is found along the western side of the county. About Republic there is an area limited to a few square miles

where conglomerates, sandstones, and shales of Eocene age occur. In several parts of the county extensive sheets of lava, chiefly basalt, are found, which are of late origin; in some instances dikes of intrusive matter are prominent, and many of the veins of ore have some connection with these.

At many places in Ferry county metalliferous deposits occur, and there is no part of the county but what could be termed good prospecting ground. Wherever the base ores occur development work has not progressed very rapidly because of the difficulties encountered in removing the ores to points of treatment; on the other hand wherever ledges of quartz are found, especially those which hold out promises of being free-milling, development work has proceeded more rapidly. The large quartz edges about Republic, from which some high assays were had of the surface croppings, have attracted a great deal of attention from the date of their discovery. About Curlew, Empire and Belcher mountain, in the northern part of the county, and in the vicinity of Keller, in the southern portion of the county, a large amount of development work has been done on the ore deposits found thereabouts.

REPUBLIC DISTRICT.

The Republic district is located toward the western side of Ferry county, and a little to the northward of the north-south midway point. The district has an approximate length and width of eight miles each and lies immediately about the confluence of Granite creek [illegible] an Poil. The town of Republic lies at the center o[illegible] district, and is easily reached by good roads from the north, east, south and west. The regular stages connect daily with the Spokane Falls & Northern trains at Myer's Falls, and with the Canadian Pacific trains at Grand Forks, each of these points being approximately 42 miles from Republic. Two railways are now building to Republic, both coming from the northward via the Kettle river and Curlew creek. These roads will be in operation by the spring of 1902.

The region immediately about Republic is one of comparatively low relief, the hills possessing rounded forms and gentle slopes. The soil has accumulated to a considerable thickness, almost completely hiding the bed rock except along the stream courses and on an occasional steep hill slope. Some of the hill

slopes are bare of trees, but the most of them are forest covered. The snowfall is not heavy, so that the precipitation, which amounts to about 15 inches per year, occurs chiefly in the form of rain.

The oldest rock formations represented about Republic are certain schists, gneisses and crystalline limestones, into which large masses of granite have been thrust. After the intrusion of the granite there was a long period of erosion, followed by the formation of lake basins, one of which existed in and about the Republic district. In this lake deposits of clay, sand and conglomerate were made, which in time were hardened into rock. By the fossil leaves found in the sediments the lake beds are known to be of early Tertiary (Eocene) age. After the deposition of a considerable thickness of these sedimentary beds they were greatly disturbed and tilted at various angles by intrusions of porphyritic andesite. Since the dislocation of the stratified rocks they have been largely removed by erosion, but in the town of Republic and at several points to the northward remnants of them may be easily found. The andesite mentioned above is of a dark gray color, somewhat soft, and easily disintegrated. It is the most frequent rock met with immediately about Republic, and the principal quartz ledges are found within it.

The general course of the veins of ore is north and south. Occasionally there is some modification in direction, as along the northern border of the district where the ledges run more to the northeastward and southwestward. As a rule the ledges are unusually wide, with great persistency in length, and as far as the eye can see are composed wholly of quartz, with a very little calcite. The quartz is nearly pure white, with occasionally some very narrow black bands within it. It is very tough, hard to break, and posses a well-marked conchoidal fracture. It appears to be wholly devoid of the sulphide minerals, and even in the richest ore the free gold is rarely or never seen even with a strong magnifier.

Various plans of treating the Republic ores have been tried, but the only very satisfactory results have been those obtained by smelting, and it is not unlikely that this will be the method employed in the future. In the matter of the extraction of gold rom the ores of the district it is interesting to note that in a

paper read before the American Institute of Mining Engineers, at Washington, D. C., February, 1900, Messrs. T. M. Chatard and Cabell Whitehead state the results of experiments made in the chemical laboratory upon Republic ores. The object of their investigations was to explain the well known low percentage of gold-extraction by amalgamation. After making numerous tests of the ore, they finally arrived at the following method:

"A sample of the coarse ore was finely pulverized, and the metallic iron present removed by a magnet. Ten grams were then digested on the water-bath for one hour with hydrochloric acid, diluted with an equal bulk of water, and then filtered. The washed residue was then digested with a hot solution of sodium carbonate to extract any silica rendered soluble by the acid treatment, while the acid solution was evaporated to dryness to recover any dissolved silica. The solution was then analyzed by the usual methods, and the complete results were as follows.

Insoluble residue	97.11	Zinc	.025
Soluble silica	.31	Lime	.066
Alumina	.33	Magnesia	trace
Ferric oxide	.40	Sulphur	.060
Ferrous oxide	.29	Phosphoric acid	.018
Copper	.016	Water	1.530
Total			100.155

"This analysis indicates that the material which envelopes the gold and prevents its dissolving in the cyanide consists mainly of hydrated oxides of aluminum and iron, since the amount of 'soluble' silica is insufficient for any known combination with the bases, even if we suppose that all of it was originally so combined. * * *

"As a rule, the gold and silver in these ores are in the form of very minute particles, and these appear to be so enveloped in the slimy hydrates as to be floated off by the water when the ore is panned; the hydrates also forming a coating impervious to cyanide solutions. When the ore is treated with acid the hydrates are dissolved, and the gold, thus set free, is easily collected in the pan. The action of heat by driving off the water of hydrates, leaves the oxides in a brittle and porous condition, so that they either separate from the gold or permit the cyanide solution to reach and dissolve it. Calcium has, however, the reverse effect upon the silver, as the extraction of this metal was always less after the ore had been heated than before, due probably to the conversion of sulphide of silver into metallic silver, which is less easily soluble in cyanide than the sulphide."

Although a large amount of development work has been done upon very many properties in the district, lack of space forbids the description of all but a few of the more prominent mines.

Republic.—This mine, now owned by the Republic Consolidated Gold Mining company, is the best developed property in

the Republic district. It is located at the southern limits of the town of Republic, on the western side of Granite creek.

The ledge outcrops on the summit of a sharp ridge which rises about 700 feet above the bed of the stream. It has a north and south strike, with a dip to the eastward of about 80 degrees. The foot-wall is a porphyritic andesite, while the hanging wall is conglomerate, overlaid by sandstone. At the surface the vein varies in width from four to twenty-four feet.

In the development of the ledge three tunnels were driven from the eastern hill slope through the sandstone and conglomerate until the vein was reached and cross-cut. The lowest or mill tunnel has a length of 2,225 feet, and cuts the ore body 600 feet below its outcrop. This tunnel is on a level with the upper landing floor of the mill, and is the one now used altogether in the working of the mine. From the cross-cuts, or points where the tunnels penetrated the vein of ore, drifts have been made in both directions for considerable distances. From these drifts winzes and raises have been driven until the ore body has been thoroughly prospected. As a result of the underground work it has been found that within the vein there exists a well-defined ore shoot which extends downward from the widest point of outcrop to the lowest point reached, viz., the 600-foot level. This ore shoot is roughly lenticular in form, has a width of fully thirty feet at its center, gradually becoming narrower when followed either way along the strike of the vein. The ore shoot does not stand vertical, but dips to the southward at an angle of about 60 degrees.

The ore varies very greatly in value throughout the ledge. Large bodies of quartz have been found of a value too low to pay the cost of mining and reducing. On the other hand pay streaks of extraordinary richness have been discovered. Barren quartz and rich quartz all look so nearly alike that only by repeated assays can the miner know in what kind of ore he is working. The ore contains about 90 per cent. of silicia, with some alumina, iron oxide and lime. No traces of arsenic, antimony, copper or lead are found. The quartz is as a rule very white, although sometimes it is banded and somewhat resembles onyx or agate.

The best grade of ore which is taken from the mine is mostly shipped to the smelters at Everett and Tacoma. The ores of

lower grade are treated at the mill owned by the Republic Reduction Company, which is located at the mouth of the lowest tunnel, on the bank of Granite creek. This mill is described under the title of Reduction Plants. In two and one-half years the Republic mine has paid dividends to the amount of $382,500.

Mountain Lion.—This mine, next to the Republic, is the best developed property in the district. It is situated about two miles northwest of the town of Republic. On the property there are three parallel veins, with a north and south strike. The central one is the principal vein, and the one upon which the most development work has been done. It occupies a fissure in porphyritic andesite, and has a dip to the west of about 80 degrees.

The ledges have been developed by a long tunnel which cuts through the three veins at a depth of about 300 feet below the surface; by a double compartment shaft, 300 feet deep, which connects the end of the tunnel with the surface above, and by drifts, cross-cuts, winzes and raises which represent in totality several hundred feet.

In the main vein the development work disclosed the presence of an ore shoot 600 feet long, and of a depth not yet determined. At its widest point it measures 18 feet, occasionally being reduced to 10 or 12 feet. The vein filling is apparently all quartz, often resembling flint or hornstone, and usually very compact. Within it there are many small cavities lined with quartz crystals. At most places the walls of the vein are quite distinct, but sometimes the ore is frozen to the walls and does not break off readily. Gold constitutes the chief value in the ore, occurring free, but in an exceedingly fine state. Silver occurs sparingly, one or two ounces per ton being present. No leaching has taken place in the vein, the surface assays being as high as those at a depth The east vein has a width of seven feet, its depth and length as yet undetermined. Some sulphides are present in this ledge, At the 150-foot level the ore is much oxidized. This ledge has a dip of 60 to 70 degrees westward, and may come into the principal vein at depth. At the surface the two ledges are 160 feet apart.

The 100-ton mill which has been erected to treat the Mountain Lion ore is fully described under the heading Reduction Plants.

Tom Thumb.—The Tom Thumb mine is located one mile east of the Mountain Lion mine and more directly north of Republic. One vein of ore is being developed. It has a northeast and southwest strike with a dip of 45 degrees to the southeast. The ledge has walls of porphyritic andesite, and measures on an average eight feet from wall to wall. The vein filling is quartz, very closely resembling the Republic ore. Eight or nine ounces of silver are present with each ounce of gold.

The development work consists of a shaft, with many drifts, cross-cuts, and winzes, aggregating in all 1,500 feet, and having cost with the mine machinery about $80,000. The main shaft reached the ledge at a depth of 255 feet, the first 215 feet being in sandstone and shale, the last 40 feet in porphyry. The mine machinery consists of a 100 h. p. boiler, an 8-drill compressor, and a 45 h. p. hoisting engine.

Quilp.—This mine is located at the northern border of the older part of the town of Republic, or Eureka as it was once called. The Quilp is at the southern end of a prominent north and south ledge, lying parallel with, and on the east side of, Eureka gulch. This ledge is easily traced northward through six claims, or for a distance of about 9,000 feet. Throughout it has walls of porphyritic andesite.

At the Quilp mine the ledge has a dip to the eastward of about 45 degrees, and a width varying from 3½ to 5 feet. The development work consists of about 2,637 feet, represented by a shaft, with several drifts, cross-cuts, winzes, etc. Ore to the extent of 754 tons has been sold, for which $13,142 have been received. The values are altogether in gold and silver, the gold varying little in amount from the surface downward, while the siver values constantly increase. In the lower workings about 60 per cent. of the total value is in gold, and 40 per cent. in silver. The mine machinery consists of a 7-drill compressor, boiler, hoisting engines, pumps, etc. About $85,000 has been spent in developing the property.

Lone Pine-Surprise.—This mine is located on the same ledge as the Quilp and immediately to the northward. The strike of the vein continues northward and southward with a dip to the east. The width of the ore body varies from 2 to 16 feet. The ore is not dissimilar in appearance from that of the Republic mine. It contains about 5 ounces of silver to each ounce of gold.

Four hundred and twenty-three tons of ore have been sold for which $5,638 were received. The underground development work aggregates altogether 3,285 feet. Up to date the cost of all work done upon the property amounts to $81,125.

Black Tail.—This mine is located on a ledge parallel with and to the east of the Quilp-Surprise ledge, and distant from it about 400 feet. The Black Tail ledge varies in width from 3 to 8 feet. The dip is very irregular as descent is made. The walls are in the main distinct, but the quartz is often frozen to the walls. The quartz often extends as stringers into the adjoining andesite. The vein shows a banded structure that is more pronounced than usual. Thin seams of clay often occur in cracks in the quartz. At the southern end of the Black Tail claim the ledge splits into two parts, one part turning to the left very sharply, the other to the right less sharply. Five stringers come into the ledge from the east, the largest one having a maximum width of three feet.

Assays of the ore show that 10 ounces of silver are present for each ounce of gold. About 300 tons of ore have been sold, 200 tons at $13 per ton, and 100 tons at $20 per ton. About 2,000 feet of development work has been done. The estimated cost of all work done upon the property, outside and inside of the mine, is placed at $50,000.

San Poil.—The San Poil mine is located at the southern end of a ledge which is found on the west side of, and parallel to, Eureka gulch. This ledge has been traced northward for about a mile. On the San Poil property the ledge has a strike of north 30 degrees west, and a dip to the eastward of about 80 degrees. The ore occurs in distinct lenses or shoots, which reach a maximum thickness of 8 feet. While the vein filling is largely quartz, there is more calcite present than is usually found in the Republic veins. Within the ledge an occasional horse is encountered, and one small fault occurs. The walls are well defined, and very firm, so that only a small amount of timbering is required. About 2,200 feet of underground work has been done. Of ore 200 tons have been sold, for which $13 per ton were received.

Ben Hur.—This mine is located immediately to the northward of the San Poil, and on the same ledge. This ledge shows prominently at the surface, and is easily followed. The surface

ore is scarcely weathered and there has been but little leaching. On the Ben Hur the ore occurs in distinct shoots, with areas between of broken wall rock seamed in all directions with stringers of quartz. The ore shoots vary in size, averaging in width from 6 to 8 feet, and one of them was found to be 80 feet long. The ore is chiefly quartz, banded, and usually frozen to the walls. The gold and silver contents are found in the proportion of one ounce of the former to five ounces of the latter.

El Caliph.—This mine is located north of Granite creek, about one and one-half miles northwest of the town of Republic. The ledge has a strike of north 70 degrees east, and a dip to the southeastward at a very high angle. It is a quartz ledge between walls of porphyritic andesite, varying in thickness from one to eighteen inches, averaging about eight inches. The ore is much iron stained at the surface, and sulphides will no doubt be found beyond the zone of surface alteration. Free gold may often be seen in the surface specimens. Eighty-five tons of ore have been sold, yielding $9,000. Only a very small quantity of silver occurs in the ore. Very little development work has been done upon the property, about 450 feet in all, represented by a tunnel and a shaft.

Morning Glory.—This mine is located immediately to the westward of the El Caliph, and is presumably upon the same ledge. The vein has a northeast and southwest strike, and a dip of 45 degrees to the northwestward. The ore here is of a high grade, 55 tons having been sold for $13,807. Tellurium is found, indicating the presence of tellurides of gold and silver. About 1,700 feet of development work has been done, at an estimated cost of $39,000.

Princess Maud.—This mine is located on the mountain side west of the San Poil, and very near the Republic mine. The ledge has a north and south strike with an eastward dip of about 65 degrees. It varies in width from 2½ to 5 feet, with an average of about 4 feet. The walls are of porphyritic andesite, and very well defined. The values are in both silver and gold, the former being somewhat in excess. A pay streak at the 50-foot level is being developed which averages in value about $24 per ton. The development work to date consists of 488 feet of tunnel, a winze of 425 feet, and a drift 710 feet long. The greatest

depth reached is 625 feet. Steam power is employed, the equipment consisting of a Leyner two-drill compressor, Rand drills, boiler, etc. Up to date about $52,000 has been spent in developing the property.

Butte and Boston.—This property is located upon the same ledge as the Princess Maud. The ledge has here also a north-south strike and an eastward dip. The width of the vein averages 6 feet. The average assay value of the ore is about $16 per ton, $14 of which are in gold. About 1,060 feet of underground development work has been done, consisting of two shafts, one 265 and the other 75 feet; two tunnels, one 285 and the other 35 feet, and drifts aggregating 400 feet. About $30,000 have been spent upon the property to the present time.

LINCOLN COUNTY.

Lincoln county lies practically altogether within the domain of the Columbia basalt, a formation in which metalliferous veins do not occur. Along the northern boundary of the county, however, especially near the confluence of the Columbia and Spokane rivers, metamorphic rocks appear which were never covered by the lava, and in these veins of ore occur. A brief description of one of the mining properties of the district is here given.

Crystal.—In the spring of 1896 the Crystal Mining Company, of Spokane, began work upon two ledges located one and one-half miles to the eastward of the mouth of the Spokane river. One of these ledges is nine feet, and the other eight feet, in width. Each has a northeast and southwest strike. In the development of the property three shafts have been sunk having an aggregate depth of 425 feet; drifts have also been driven to the extent of 540 feet. The average assay value of the ore is about $40 per ton in silver and lead. About 500 tons of ore lie on the dump ready for shipment. The company has a 32 h. p. hoisting engine and a 50 h. p. boiler. The total cost of all development work is estimated at $28,000. (John Gray, manager, Spokane.)

OKANOGAN COUNTY.

Okanogan county lies north of Chelan and Douglas counties and west of Ferry. It is one of the largest counties in the state and the one farthest removed from railway facilities. It possesses no features, however, which would make railway construction impossible anywhere throughout the length and breadth of the county.

In its topographical aspects Okanogan county is characterized by considerable diversity. In a general way the southern and eastern parts of the county are regions of broad valleys, rolling hills and level plateaus; the northwestern portion of the county is a district of high mountains, being typical of the rugged parts of the Cascades. The Okanogan river is a very sluggish stream flowing in an old valley remarkable for its breadth. The Methow, especially in its lower reaches, also flows in a broad, fertile valley, and is bordered by rolling hills. Glaciers have passed down both the Methow and Okanogan valleys and have left traces of their former presence in the shape of terraces and moraines. The lower parts of Okanogan county along the Columbia, Okanogan, and lower Methow rivers, possess a rainfall which does not exceed ten inches per year, and as a consequence desert-like conditions prevail and agriculture may be carried on only by the aid of irrigation. In those parts of the county possessing a greater altitude, notably the northern and northwestern portions, the country is forest clad. The western portion of the county is very well forested and is included within the Washington forest reserve.

Okanogan county is largely a region of ancient metamorphic rocks, with large areas of granite. At several places in the county there are small areas of sedimentary rocks which represent the later geological times. These areas are small because they represent deposits made in former lakes. In both the older metamorphic rocks and the younger sedimentaries there have been many intrusions of igneous rock of various kinds which tend to complicate the geological structure.

In nearly all parts of Okanogan county veins of ore occur, many of which are of economic importance. Development work

upon the ore bodies has been in progress for several years, in most instances with gratifying results. The ore for the most part is such that requires smelting in order to extract the precious metals, although some free gold occurs. The absence of easy shipping facilities has militated against the rapid development of the mines. The principal mining districts in the county are those of Wauconda, Myers Creek, Palmer Mountain, Conconully, Moses, Upper Methow, Twisp, and Squaw Creek.

WAUCONDA DISTRICT.

This district is located near the eastern boundary of the county, about twenty miles south of the international boundary and twelve miles northwest of Republic. It is situated at the headwaters of Granite creek, a stream which unites with the San Poil at Republic. The district is practically upon the north-south divide which separates the eastward flowing streams from those whose courses are westward to the Okanogan. The topography of the district is not of the rugged type, the hills and ridges being low and as a rule possessing rounded forms. The yearly precipitation is low, but of a quantity to support a moderate forest growth. The trees are not large and do not stand very close together, yet the timber is in sufficient quantity to meet the requirements of large mining operations for many years.

The oldest rocks of the Wauconda district consist essentially of gneiss, schist, crystalline limestone, slate, and other metamorphics which have been greatly dislocated by intruded masses of granite. Both the metamorphic rocks and the granite often contain within and upon them intruded and extruded masses of porphyritic andesite, and basalt. Some of the hills are capped by horizontal layers of basalt, which seems to have been the last rock outpoured. Granite constitutes the axis of the divide above mentioned. Going eastward from the granite one passes over gneiss, schist, and slate, in beds dipping very steeply to the eastward. To the eastward of the metamorphics a small intrusion of granite is next encountered, followed by porphyry and basalt.

The ore bodies of the Wauconda district which occur for the most part as fissure veins in the metamorphic rocks, are characterized by their great size. The vein filling is quartz, with a little calcite, carrying free gold in a very fine state. In most respects the ore does not differ essentially from much of the ore found in

the Republic district. The Wauconda district takes its name from the mine of that name which was the first located, and is now much the best developed, in that locality.

Wauconda.—The Wauconda property consists of thirty-two claims, twenty-two of them in the main group near the town of Wauconda, and ten in another group about three miles distant. On the property there is a series of wide parallel veins, having a strike a little west of north, and traceable for considerable distances. The two main ledges are the Oregonian and the Wauconda. The main tunnel, No. 5, which runs almost due west, nearly at right angles to the vein, struck the former ledge about 700 feet from the mouth, and left it at 770 feet, while the face of the tunnel, at present 1,025 feet in, indicates that the Wauconda ledge is near at hand. These ledges or mineralized zones, present a very remarkable condition in the magnitude of the mineralized portion of the mountain. The veins run about 30 degrees west of north and dip about 60 degrees, the hanging wall being to the east. Where the main tunnel, which is about 500 feet below the apex of Wauconda mountain, cuts through the first mineralized zone the vein has a width of 152 feet. While most of this is very low grade ore, yet assays never fail to show some gold throughout its extent. One portion of this, of solid quartz from ten to fifteen feet in width that has been drifted upon both north and south, shows values of from $10 to $20 per ton.

The Oregonian ledge, the one which is at present best developed, is encountered in the tunnel at 570 feet and is not passed through until 770 feet is reached. The portion of this from 570 to 700 feet is low grade like the first ledge and is composed of mixed quartz and the slaty country rock. Solid quartz, however, commences at 700 feet and continues to the foot wall. The 40 feet of ore from 700 to 740 feet is the main ore body of the mine. This has been drifted upon to the northward and the southward from a chamber which has been cut at a distance of 726 feet from the tunnel mouth. The south drift has been extended 50 feet, and the north drift 80 feet, thus opening up the ledge for a length of 130 feet. The ore from this ledge has been very thoroughly sampled by small average assay samples, and again by 50 and 100 pound samples worked in the sampling mill. The values obtained varied from $5 to $50, but the greater number ranged from $10 to $20; a general average of

$12 for the part of this ore body already in sight is conservative. The different portions of the ledge opened up by the drifts show a fairly uniform quality and value of ore.

It is expected that the main tunnel will very soon reach the Wauconda ledge. This ledge is partially developed by tunnel No. 4 at about 250 feet below the top of the mountain. In this tunnel drifts have been made on the ledge aggregating 215 feet and two cross cuts have been driven, one westward to the foot wall, 28 feet, and eastward 56 feet toward, but not reaching, the hanging wall. The values encountered were very satisfactory, especially toward the hanging wall. Tunnel No. 1 developed the Oregonian ledge near the surface, as No. 4 did the Wauconda ledge, and as shown by these two tunnels the latter ledge is richer. Therefore it is expected that when the main tunnel encounters the Wauconda ledge it will prove to be another ledge of as great magnitude and value as the Oregonian ledge already described. Besides these ledges, three other large ones have been prospected on the property which the tunnel will eventually develop. The mill which has been erected to treat the ores from the Wauconda mine is described under the section headed Reduction Plants.

MYERS CREEK DISTRICT.

This district lies in the northeastern part of the county, in the drainage basin of Myers creek, and round about the small towns of Chesaw and Bolster. The surface of the country is that of a plateau, having a height of 3,000 to 4,000 feet above the sea, with low hills and ridges lying upon it. The slopes are so gentle that a deep soil has accumulated and outcrops of bed-rock are of rather uncommon occurrence. The soil is very fertile and supports a rich growth of bunch-grass, the precipitation not being large enough to induce forest growth except upon the higher hills.

The rock formation is chiefly granite, with different varieties of eruptive rocks. Some of the ore veins are associated with eruptive masses of serpentine. The ore bodies of the district are usually made up of the common sulphides, iron pyrite, chalcopyrite, galena and sphalerite, with quartz and calcite as the gangue minerals. The ore is of a character that requires smelter treatment in order to obtain the values, which consist of gold and silver with a little copper.

Monterey.—This property, belonging to the Monterey Gold Mining Company, is located three miles south of the international boundary line and four miles west of the Ferry county line. The ledge reaches a maximum width of 35 feet, and carries gold, silver, copper, and lead. The best ore yields assays varying from $50 to $85 per ton. The ore contains a considerable quantity of iron and lime, making it to a certain extent self-fluxing when smelted. A main tunnel 728 feet in length has been driven, striking the vein at a vertical depth of 300 feet. Several shafts have been sunk and a number of drifts made, bringing the total amount of development work up to 1,000 feet. (M. M. Walsh, superintendent, Oakesdale.)

Yakima.—This property is located near Chesaw and belongs to the Yakima Mining and Milling Company. The ore is found in serpentine, either disseminated through it or occurring in ledges. The ledges are several in number, with parallel courses, and as a rule are but a few inches in width. The largest vein varies from four to six feet in width, and contains bands of solid ore. The metallic minerals are chalcopyrite, galena, sphalerite, and iron pyrite, carrying gold and silver. The veins have an east and west strike with a southward dip of 25 degrees.

Review.—The Review Gold Mining Company, of Spokane, has two claims located near Bolster. The ore body lies between walls of granite and slate. The metallic minerals consist chiefly of chalcopyrite and iron pyrite, with quartz and calcite as gangue minerals. The development work consists chiefly of two tunnels which have been driven on the vein, one having a length of 360 feet, and the other a length of 813 feet. There is a large amount of ore on the dump. A smelter test of 50 tons taken from various places on the ledge is said to have given an average assay of $17.20 per ton, the principal value being in gold.

Mary Ann Creek Placers.—On Mary Ann creek, a small stream emptying into Myers creek near Chesaw, placer gold was discovered in 1888, and the placers have been worked in a small way ever since that date. Fourteen claims are located on the creek, nearly all of which are worked each season. The gold occurs from the grass roots downward through the washed gravel to bed rock. About four feet above bed rock a seven-inch seam of clay occurs, immediately above which the gravel is richer

than elsewhere. The gold is coarse, no mercury is used, and nearly all of the gold is caught in the first riffle. No trees or tree-roots are found upon the claims, and hence the ground is easily worked.

PALMER MOUNTAIN DISTRICT.

In this report Palmer mountain district is made to include that part of Okanogan county lying between Okanogan river and Gold hill, and from the international boundary to the vicinity of Loomis. This district came into prominence a number of years ago because of the large bodies of quartz which it contains, but development work has been hampered by the long haul from the railroad that is necessary in order to secure mining supplies and machinery. In spite of every obstacle, however, work on many properties has been steadily carried on, so that in the total amount of its development the district is exceeded by but one or two others in Washington.

Palmer mountain, having a height above the bordering valleys of about 4,000 feet, occupies the central part of the district. This mountain has a very broad base, and slopes so gentle that wagon roads are easily constructed upon all sides of it, except the west. Palmer mountain is surrounded by broad, low valleys, the Spectacle lake depression lying at the southern foot, the Wannicutt lake basin at the east, with Simlahekin creek and Palmer lake as the western boundaries, and the Similkameen river skirting the mountain on the north. To the west of Palmer mountain, and beyond the valley of the Simlahekin and Palmer lake, lies Gold hill and Mount Chapaca, two of the bolder outliers of the Cascades. The region under consideration has a rainfall of but ten to fifteen inches per year, and as a consequence the higher parts only are forested, the remaining areas being covered with bunch-grass and sage brush.

Palmer mountain district is a region of old metamorphic rocks, mainly schist, slate, gneiss, quartzite and crystalline limestone. These formations show conspicuously from about the middle of Palmer mountain eastward to the Okanogan river. At some places, notably at White Rock bluffs, unmetamorphosed sedimentary rocks occur, consisting of conglomerate, sandstone, slate and limestone. These beds are seemingly non-fossiliferous, but from their lithologic resemblance to rocks of determined age found to the east and to the west of them, they are doubtless

of early Tertiary age. Eruptive rocks are very common, mainly granite and diorite, with different kinds of porphyry. Gold hill is a mass of granite, with intrusions of porphyry. The western half of Palmer mountain to the metamorphic contact above noted, is made up of diorite, seamed with porphyry dikes.

The ore veins are essentially of two kinds, quartz veins, and those in which the sulphide minerals predominate. The quartz veins usually carry free gold at the surface, but this disappears with depth and sulphides make their appearance. In some cases enough quartz bearing free gold has been found to warrant the establishment of stamp mills, several of which are found in the district. The sulphide veins consist mainly of pyrrhotite, iron pyrite, sphalerite, and chalcopyrite, with calcite and quartz as gangue minerals. These veins carry both gold and silver, the former affording the larger amount.

In the Palmer mountain district the mining claims have been segregated into large groups, which are controlled and operated by different companies. This arrangement is made possible by the fact that parallel ledges often occur so near together that it is advantageous to develop them as a group.

Palmer Mountain.—The Palmer Mountain Gold Mining and Tunnel Company's group of fifty-six claims forms a compact body on the southwest slope of Palmer mountain, near Loomis, and extends from the base to the summit of the mountain. In the development of this property a main tunnel eight by nine feet in cross section, has been driven in from the base of the mountain, a distance of 4,000 feet. This tunnel is perfectly straight and with no more slope than is necessary to secure good drainage. At the end of the tunnel a vertical depth of 1,400 feet has been attained. The tunnel is all the way in diorite, except for the dikes which were passed through. In the 4,000 feet of tunnel twenty-eight veins of ore were cross-cut, a number of which are small and which do not appear on the surface. Parallel with the dikes, which are older than the veins, are certain shear zones where the rock is much broken and a schistosity is developed. The shear zones are mineralized, which probably took place at the time when the veins were formed.

The power plant of this company is located near the mouth of the tunnel, and consists of an Ingersoll-Sargeant air compressor, air receivers and pipes, three air drills, a 55 h. p. boiler, a

40-inch blower and exhauster driven by a 19 h. p. engine, with the necessary blacksmith and machine shops. On Toats Coulee creek, about a mile and a half from the mouth of the tunnel, the company owns a water power capable of developing 3,000 h. p.

Gold Hill.—This mine is located on Gold hill about three miles west of Loomis. The company owning this mine have altogether eighty-six claims, upon which a number of ledges are found. At the present time the development work is being done largely on one vein, which has an average width of about four feet. This vein has a northeast and southwest strike and a dip of 75 degrees to the northwest. It is a true fissure vein with walls of granite. The vein is filled with massive quartz, occasionally banded with iron pyrite, chalcopyrite, galena, sphalerite, and copper carbonate, carrying gold and silver. About 4,000 feet of underground development has been done, consisting of drifts and crosscuts. Water power is employed to run a 50 h. p. compressor and the saw mill. To secure the proper fall a flume four by four feet in cross section and one mile long has been constructed along the side of Toat's Coulee creek.

Golden Zone.—The Golden Zone mine is located on the Similkameen river, sixteen miles north of Loomis, and three miles from the British Columbia boundary. On the property there are three parallel ledges which outcrop on the face of a granite cliff, which fronts the valley. The one ledge which is being developed has a northeast and southwest strike, with a dip to the northwest varying from 45 degrees to 80 degrees. The vein when followed along its course widens and narrows, varying from a few inches to four feet in thickness. The ore body consists of quartz carrying chalcopyrite, galena, iron pyrite, molybdenite, and a little free gold. A large amount of ore has been removed from the mine and treated in the stamp mill at the foot of the mountain. Whatever free gold the ore contains is caught on the plates, while the cencentrates are shipped to Everett and Tacoma.

Bull Frog.—On the summit and west slope of Palmer mountain and the west slope of Little Mount Chapaca, there is a group of fifty-one claims belonging to the Bull Frog Gold Mining Company. Most of the claims were located about 1889, and active development has been carried on from 1893 to the

present time. Eight veins have had more or less done upon them. They vary in width from eighteen inches to twenty-five feet, and strike northwest and southeast. The total amount of underground work is represented by 1200 feet of tunnels, drifts, etc. There is now on the dump several thousand tons of ore. A test run of ten tons yielded $17 per ton, of which $12 was in gold and $5 in silver. The company has erected a cyanide mill of 60 tons daily capacity, run by steam. (Adelbert Hart, president, Oakland, California.)

Black Bear and War Eagle.—These mines lie adjacent one to another on the northwest slope of Palmer mountain, about four miles from Loomis. There are three veins on the Black Bear, two of which have been worked. On the War Eagle there is but one vein. The Black Bear veins are almost four feet wide; that of the War Eagle is five feet wide. They all strike northwest and southeast, and dip to the northeast. The ore is chiefly quartz, carrying free gold in the oxidized portion of the vein, with sulphides below. It averages in value about $18 in gold, silver and copper, chiefly in the first of these. In the Black Bear about 2500 feet of underground development work has been done, and on the War Eagle 500 feet. In Loomis there has been erected a plant to treat the ore, consisting of a five-stamp mill and a concentrator, all run by water power. The value of the ore mined and sold up to date amounts to $150,000. This sum also represents approximately the amount that has been expended in developing the two properties. (John Boyd, Loomis.)

Tribune.—This property is located on the east slope of Palmer mountain, and embraces three claims. On these claims there are four veins, having an average width of about five feet. They have a northwest and southeast strike with a dip to the southwest. The average assay value of the ore in gold and silver is about $12. About 1400 feet of underground development work has been done, and 40,000 tons of ore have been mined. A ten-stamp mill has been erected on the property. The power employed is a 65 h. p. boiler for the mill, two 15 h. p. boilers for the hoist, and 10 h. p. for running four Frue vanners. (John Boyd, Loomis.)

Whiskey Hill.—The Whiskey Hill group of twenty-one claims lies at the eastern foot of Palmer mountain, nine miles

from Loomis, near Wannicut lake. A shaft has been sunk a depth of 170 feet, and 730 feet of tunnel driven. There is a large amount of ore on the dump, being the contents of a tunnel seven by nine feet in cross-section and 650 feet long. The average assay value is $7.50 in gold. Thus far all the drilling has been done by hand. Work was begun on the property in April, 1897, and since that time $16,600 has been spent in development work. (William Lewis, Superintendent.)

CONCONULLY DISTRICT.

This district includes a large area about Conconully, chiefly within the drainage basin of Conconully creek, but extending as far northward as the Q. S. property. The district is chiefly one of rolling hills, being located on the borderland between the Okanogan valley and the Cascade mountains. The country is deeply soil-covered, the rainfall is light, the vegetation ranges from sage brush and bunch-grass to a heavy forest growth, depending upon the altitude and amount of precipitation.

The bed rock of the district consists chiefly of granite, schist and gneiss, with various intrusive rocks of later times. Both quartz and sulphide ledges are found, the latter predominating. The greatest amount of development work in the district has been done upon some silver-lead veins, located near the towns of Ruby and Conconully. These properties were worked very energetically previous to the decline in silver some years ago. The mines will doubtless become producers again whenever the building of a railway into the district makes it possible to ship the ore to a smelter. Meanwhile upon a number of the properties prospecting and development work is being steadily carried on.

Q. S.—Midway between Loomis and Conconully, and eleven miles from either point, there is a group of twenty-four claims belonging to the Q. S. Gold Mining and Smelting Company of Spokane. There are six veins in the property which can be traced on the surface for the full length of three claims. All of the veins have been worked to a limited extent. Their strike is northeast and southwest and the dip is to the southeast. The average assay value in gold and copper is $14 per ton. The claims were located in 1897, and work was begun upon them about that time. About 1,240 feet of underground development

work has been done, including shafts, crosscuts, etc. (S. E. Barron, president, Spokane.)

Blue Lake.—The Blue Lake Gold and Copper Mining, Smelting and Power Company owns a group of twenty claims on Goat mountain, midway between Loomis and Conconully, which they started to open up in the summer of 1901. They have drifted a few hundred feet on the principal vein and have taken out about 5,000 tons of ore, assaying from three to eleven dollars in gold, and from three to forty-nine per cent. in copper. There are six veins, from one to three feet wide, all standing nearly perpendicular. Hand work has so far been employed, but the company expects to utilize water power for drilling and other purposes. (C. T. McElroy, Milwaukee, Wisconsin.)

Tough Nut.—One mile north of Conconully on the east side of Salmon river, is the Tough Nut mine. The property consists of three claims belonging to the Salmon River Mining and Smelting Company. There are two veins, one of them fourteen inches wide and the other two feet. They stand almost perpendicular and strike north and south. Altogether about $5,000 has been expended in development work, including ore bins and ore chute, and 300 feet of shafts and tunnels. Five hundred tons of ore have been taken out, having an estimated total value of $9,000 in silver and lead. (J. W. Douglas, president; E. C. Gurnel, secretary.)

Homestake.—The same company which owns the Tough Nut also owns the Homestake mine, adjoining the Tough Nut on the south. On the Homestake about $4,000 have been spent in running a tunnel which is now 260 feet in length. The ledge is about twenty feet wide and carries silver-lead ore averaging about $15 per ton. Three claims have been staked upon the main ledge. It strikes northwest and southeast and dips to the southwest. Up to the present time 400 tons of ore have been mined. One hundred tons have been sold, for which $1,500 was received. (J. W. Douglas, president; E. C. Gurnel, secretary.)

Arlington.—This mine is located on Ruby mountain, five miles south of Conconully. There are two claims, the Arlington and the Pomeroy, both patented. The vein is large, averaging 28 feet in width at the 200-foot level. It has a north and south

strike, with a westward dip. The principal values are in silver, those of copper and gold being irregular. The underground development consists of about 2,800 feet of work, mainly represented by a 200-foot shaft with three drifts. About 1,000 tons of ore have been sold for which nearly $25,000 was received. (H. S. Stoolfire, owner, Spokane, Wash,)

MOSES DISTRICT.

This district is located in the southeastern corner of Okanogan county, in the region drained by the Nespelim river and its tributaries. It is one of the newest districts in the state, having been created since the Colville Indian reservation was thrown open to mineral entry in 1898. It is a region of low bunch-grass hills, where the rainfall is slight, and where trees grow sparingly.

Multnomah.— The Multnomah group of ten claims lies three and a half miles northwest of the Nespelim agency. There are ten veins varying from three to seventy-five feet in width. They all strike southwest and northeast and dip to the southeast. They vary in richness from $5 to $50 per ton in gold, silver, copper and lead. A number of small openings have been made, aggregating about 200 feet, and costing about $5,000. (Dr. F. O. Hudnut, manager, Spokane.)

Apache.— The Apache claim is located one mile west of the Nespelim agency. There is one vein on the claim, having a width of twelve feet. It stands nearly perpendicular and strikes east and west. A fifty-foot shaft has been sunk on the vein and a little drifting done, costing all told about $1,000. Five tons of ore have been mined and sold having a value of $700 per ton. Nearly all the values are in silver, but there is a little gold present. (Dr. F. O. Hudnut, Spokane.)

Great Western.— The Great Western group of three claims is situated four and a half miles west of the Nespelim agency and six miles from the Columbia river. About $1,000 has been spent in development work. There is now about 100 tons of ore on the dump assaying as high as $75 per ton in silver and lead. The ores are sulphides and carbonates. (Great Western Mining Company, Spokane.)

UPPER METHOW DISTRICT.

This district embraces the country drained by the Upper Methow, and is one possessing a rugged topography because of its nearness to the summit of the Cascades. The precipitation is sufficient to insure a fine forest growth, the whole district being included in the Washington Forest Reserve. The district is entered usually by way of the open valley of the lower Methow, along which good roads have been constructed.

The district is one of metamorphic rocks, gneiss and schist, with various eruptive masses, often of granite. Thick deposits of sedimentary rocks also occur, consisting mostly of sandstone and conglomerate.

Methow.—On the south fork of the Methow river the Methow Gold and Copper Mining Company has a group of seven claims located on McKinney mountain, upon which some development work has been done. The work has been done mostly upon one vein which is about eight feet wide and which carries a pay streak varying from two to four feet in width. The vein stands almost perpendicular and strikes northeast and southwest. The ore is largely chalcopyrite, and assays from 2.2 ounces to 20.2 ounces silver, and from 3.8 per cent. to 25.5 per cent. copper per ton. Tunnel No. 1 has been driven on the ledge a distance of about 120 feet, and from it a winze 50 feet deep has been sunk to ascertain the dip of the vein. Tunnel No. 2 is now being driven for a working tunnel, and will cut the ledge 300 feet below tunnel No. 1. This tunnel is now in a distance of 165 feet. The estimated cost of all development work, including tunnels, buildings, etc., is $5,000. (B. R. Ostrander, president, Spokane).

Oriental and Central.—These claims are located on a vein six feet wide carrying about $10 per ton in gold. The company has sunk one shaft 60 feet, another shaft 40 feet, and run an adit tunnel 270 feet. Work was begun in September, 1900, and since then $5,000 has been expended in development work. The claims belong to the Oriental Mining Company. (John R. Cassin, president, Spokane).

Goat Creek.—On Goat Creek there is a group of nine claims belonging to the Goat Creek Mining Company, of Spokane. All

the development work has been done upon one vein which is about five feet wide. The vein strikes north 30 degrees east, and dips southeast at an angle of from 60 degrees to 75 degrees. One shaft has been sunk 127 feet and another one 25 feet. An adit tunnel has been driven 350 feet and about 50 feet of drifting done. Up to the present time no ore has been sold. The average value of the ore is gold $2, silver 14 ounces, copper 16 per cent. Altogether about $9,000 has been spent in development work. (John R. Cassin, manager, Spokane).

TWISP DISTRICT.

This district is included within the drainage basin of the Twisp, a river of about thirty miles in length which enters the Methow from the westward. The Twisp rises among mountains varying in height from 6,000 to 8,000 feet, whose slopes are heavily forest-covered. Along the lower course of the stream the bordering mountains are low and rounded, and usually bared of forest but clothed with a luxuriant growth of grasses.

The rocks are in general of the metamorphic class, mainly schist and gneiss, through which project many outcrops of granite. Near the mouth of the Twisp there is a considerable area of sedimentary rocks, consisting for the most part of conglomerate, sandstone, and carbonaceous shale. The latter occurs quite conspicuously in a few places, and it has sometimes been mistaken for outcrops of coal.

Spokane.—This claim is located on the north side of the Twisp, about one and one-half miles from its mouth. The ledge is somewhat irregular and not very well defined, but has an apparent north and south strike, with a steep dip to the westward. It varies from a few inches to three feet in width. The mineral contents of the vein consists of sphalerite, arsenopyrite, chalcopyrite, and iron pyrite, with calcite and quartz. The ore occurs usually in pockets or bunches, occasionally in solid bands. The country rock adjacent to the vein is strongly mineralized, making the walls sometimes difficult to determine.

St. Lawrence.—The St. Lawrence group of four claims is situated at the head of North creek, a tributary of Twisp river. There are two veins upon which work has been done. One is seven and a half feet wide and the other thirty feet wide. They

both strike northeast and southwest and dip 45 degrees to the northwest. The ore averages about $20 per ton in gold, silver and copper. The development work consists chiefly of a shaft, a tunnel, and an incline, costing all told about $5,000. (W. R. Marvin, Spokane.)

SQUAW CREEK DISTRICT.

This district lies about Squaw creek, a small stream flowing from the westward into the Methow at a point about nine miles above the mouth of the latter river. Situated as it is in the valley of the Methow and near the Columbia, the district is one of low altitude, with a surface made up of rolling hills and gentle slopes. Only the higher parts are forest-covered, the evergreen growth being somewhat sparse, but sufficient for ordinary mining operations.

The prevailing country rock of the district is gneiss, with eruptive masses of the granite type. The veins of ore as a rule have been deposited in pronounced fissures, the walls of which are of sufficient prominence to be readily identified. The vein filling is usually composed of quartz and calcite as gangue minerals, with iron pyrite, chalcopyrite, galena, arsenopyrite, tetrahedrite and sphalerite. The principal values are in gold and silver, the gold occurring both free and as a telluride. As a rule the ore is not uniformly distributed throughout the veins, but occurs in well-defined chutes. The ledges of the district in general have an east and west strike, standing about perpendicular or dipping a few degrees to the northward.

Hidden Treasure.—The Hidden Treasure Mining and Mill ing Company has a group of six claims on the east slope of Johnson mountain, about one mile north of Squaw creek, and two miles west of the Methow. The Hidden Treasure vein has a strike of north 60 degrees west with a dip of 60 degrees to the northeast. It is a true fissure vein with walls of gneiss. It is from two to four feet in width, except where the ore chutes occur, when a width of eight to ten feet is noted.

The ore in the Hidden Treasure vein consists chiefly of chalcopyrite, galena, sphalerite, and iron pyrite, with quartz and calcite as the gangue minerals. The values are chiefly in gold and silver, with a small amount in copper. The gold occurs in

small amounts as free gold, and to a small extent in the form of sylvanite.

Development work on this property was begun in 1896. Two tunnels have been driven on the Hidden Treasure ledge, an upper one having a length of 200 feet, and a lower one with a length of 260 feet. From the second tunnel a winze has been sunk to a depth of 50 feet, and from the bottom of the winze drifts and crosscuts aggregating 80 feet in length have been driven. Some ore has been stoped out from one of the ore chutes, about 290 tons in all. Of this, 90 tons has been shipped to a smelter, for which $67 per ton was received.

Highland Light.— This mine, owned by the Highland Light Mining Company, is situated immediately west of the Hidden Treasure, and on the same ledge. The ledge has been developed by a shaft 170 feet deep, which cuts through an ore chute dipping eastward. The first 50 feet of the shaft is in ore. At the 25-foot level a drift 20 feet long was run and the ore stoped out; at the 50-foot level another drift 45 feet long was made, and some of the ore taken out from here assayed $90 per ton in all values; at the 100-foot level the vein showed two and one-half feet of good ore, and a drift was run 20 feet to the eastward. At the bottom of the shaft drifts were run in both directions. On this level the ledge averaged three feet in thickness, and the ore assayed from $40 to $50 per ton. (John D. Atkinson, Olympia.)

Standard and Louisa.— These claims adjoin the Hidden Treasure group. The ore vein varies from three and a half to five feet in width. It has an east and west strike and dips to the north. The ore that has been mined averages in value $24 per ton. Only a small amount of development work has been done on the ledge. (James West, president, Seattle.)

Henrietta.— On the south side of Johnson mountain is the Henrietta group of four claims. The vein of ore varies from three to five feet in width. It has an east and west strike, and dips to the northward. The ore assays on an average about $25 per ton in gold, silver and copper. In developing the property one tunnel of 120 feet has been driven, and a shaft has been sunk to a depth of 40 feet. (J. M. Woollery, Spokane.)

Hunter.— This property has a vein of ore which varies from three to nine feet in width. It has an east and west strike, and dips to the northward at an angle of 88 degrees. The average assay value of the ore is $32 per ton, in gold, copper and silver. The development work consists of open cuts, shafts, and tunnels, representing an outlay of $8,000. About 400 tons of ore are now ready for shipment. (James E. Blackwell, president, Hunter Mining Company).

Tom Hal.— This mine, the name of which has recently been changed from the Friday mine, is on a group of five claims. The ledge varies in width from four to ten feet, the richest ore having been encountered in the narrowest part. The ore consists chiefly of iron pyrite, chalcopyrite, and arsenopyrite. It is essentially a gold ore, but carries a little silver and a small percentage of copper. Ten tons of selected ore when shipped to the Everett Smelter yielded $70 per ton. In the underground work a tunnel 110 feet in length was driven, crossing the ledge at this point. A drift of 100 feet was next made, and from the end of this a winze of 100 feet was sunk. From the bottom of the winze drifts of about 70 feet were run in both directions. (John D. Atkinson, Olympia).

Bolinger.— This property, consisting of five claims, is situated on the south fork of Gold creek, two and one-half miles west of the Methow river. There are two parallel ledges on these claims two hundred feet apart and much alike in character. The larger or main ledge is four and a half feet wide on the surface and seven feet wide at the bottom of a ninety foot shaft. This is a true fissure vein, with walls of gneiss. The vein filling is arsenopyrite, galena, chalcopyrite, and iron pyrite, in a quartz gangue. The vein has a strike of N. 30 E., and a dip of 45 degrees to the southeast. In the development work of the property a tunnel four hundred and fifty feet in length has been driven which strikes the two parallel ledges at distances of 235 feet and 450 feet respectively from the mouth of the tunnel. The first ledge is tapped at a distance of 105 feet below the surface and assays from five dollars to fifty-four dollars in gold, and is eight feet in width. The second or main ledge, which is crosscut by the tunnel at a vertical depth of 225 feet, is ten feet wide and carries ore that averages by smelter tests twelve dollars per ton.

About thirty or forty per cent. of the values are in silver and the rest in gold.

Independence.—This property is located on the south fork of Gold creek, very near the Bolinger mentioned above. The ledge varies in width from four to eight feet, and may be easily traced on the surface for a distance of 800 feet. It is a fissure vein with walls of gneiss. The metallic minerals are iron pyrite, arsenopyrite, chalcopyrite, and molybdenite, in a quartz gangue. Occasionally the metallic minerals occur as solid bands which often reach a thickness of eighteen inches. The alteration in the vein due to weathering is slight, and the honeycombed quartz of the surface gives way to unchanged ore at a depth of a few feet. The strike of the vein is about north and south, with a dip of 45 degrees to the westward. The assays of the ore that have been made show values of from $5 to $10 per ton.

WHATCOM COUNTY.

Whatcom county lies in the northern tier of counties, and extends trom the summit of the Cascades westward to the Gulf of Georgia. The western and eastern parts of Whatcom county present marked contrasts in many ways. The western one-third of the county has but a slight elevation above the sea, is characterized by wide alluvial valleys and low hills, and is crossed in all directions by railways and wagon roads. On the other hand the eastern two-thirds of the county is a region of high mountains which possess an extremely rugged character, abounding in deep canyons and sharp divides, and into which trails and roads are built with difficulty.

In the mountainous part of Whatcom county many varieties of rocks are encountered. Gneiss, schist, slate, crystalline limestone and other metamorphics commonly occur. Associated with these are masses of igneous rocks of both intrusive and extrusive origin. In the western part of the mountainous district stands the bold cone of Mount Baker about which volcanic rocks abound.

Although metalliferous deposits have been found in many parts of the mountainous district of Whatcom county, the ledges which have received the most attention are those which are located to the northward of Mount Baker, in the Mount Baker district, and those which are located in the neighborhood of Barron in the Slate Creek district. A brief general description of these districts, with some statements regarding the chief mines and claims within them, will now be given.

MOUNT BAKER DISTRICT.

By D. A. Lyon.

The Mount Baker mining district is situated on the head waters of the north fork of the Nooksack, on the western slope of the Cascades, and includes all the territory which lies immediately north of Mount Baker. On account of the lateness of the season at which our party reached this district, in the early autumn of 1901, and having but a limited time at our disposal, it was found possible to visit only the most important camps. As a result this report is to be considered as wholly preliminary in its nature and will be enlarged upon as soon as more field work can be done.

The district is reached by Maple Falls, which is the present terminus of the Bellingham Bay & British Columbia Railroad. From Maple Falls there is a good wagon road to Shuksan, a distance of about 20 miles. From Shuksan, the Mount Baker Mining Company, owning the Post-Lambert group, has constructed a well built trail to its properties, and in doing so has made it easier to get to those prospects and mines lying to the northwest of Shuksan and in the vicinity of Twin lakes. Those properties which are located to the east and south of Shuksan are for the most part tributary to the state trail.

As may be inferred, nearly all of the prospects and mines of the Mount Baker district are located in the high Cascades, the Post-Lambert group, at an altitude of about 6,000 feet, being the highest of any of the developed mines. Here the snow comes early and stays late, and falls to a great depth. The water supply is plentiful all the year around, and in most cases is in such quantities and so located as to permit of its being utilized for power. In many cases there is an abundance of timber for mining purposes, although some of the mines are lo-

cated at altitudes where timber is scarce, or are above the timber line altogether.

Although over 3,000 quartz claims have been located in the Mount Baker mining district, yet only a few of these have been developed into mines. The principal ores of the district are gold and copper bearing. The gold is present as free gold, and occurs in white quartz, or is present as a telluride, while in other places it is found associated with gold bearing sulphides in veins of bluish grey ore which contains much lime. Again we find large bodies of slate with kidney quartz, which occur as masses, with no well defined hanging or foot wall.

Post-Lambert.— This is one of the best developed properties in the district. It includes a group of eight claims located on the southern slope of what is known as Bear mountain, and to the east and south of two small mountain lakes, known as Twin lakes, which are about twenty miles west and somewhat north of Mount Baker, and are about thirty-six miles southeast of Chilliwack, British Columbia. The property is owned by the Mount Baker Mining Company, the offices of which are in Portland, Oregon.

In developing the property most of the work has been done on the Lone Jack ledge, where a tunnel or inclined shaft has been driven on the outcrop and follows the ledge in for a distance of 140 feet. To the east of the outcrop on a level at a vertical distance of 100 feet below the opening of the inclined shaft, a crosscut is being driven, in order to intersect the vein, which will be done at a distance of about 475 feet. Open cuts have also been made on the Lone Jack ledge in several places, and all of these disclose a well defined vein, and show the presence of free gold and tellurides. The ledge has a north and south strike, with walls of slate. It outcrops for a distance of about 2,500 feet, and has been thoroughly sampled for a distance of 1,200 feet, the average width in this distance being two and one-half feet. From two hundred and eleven free milling tests which were made on this ore, the value in free gold was found to be on an average $28, while numerous fire assays made on the same show it to have a value of $32 per ton. This difference is due to the presence of tellurides, which, being base, are not amalgamable. These will be treated by some other process, preferably by smelting.

There is being constructed on the property a ten stamp mill for the purpose of treating the ore from the Lone Jack ledge. It is intended to carry the ore from the mine down to the mill-site by means of an aerial tramway, the materials for the construction of which are now on the ground. The mill-site is at an elevation of about 2,000 feet, while the mine is at an elevation of about 6,000 feet. It is intended to stamp the ore and remove as much of the gold as possible by amalgamation, and then treat the tailings by concentrating them, in order to recover the non-amalgamable tellurides.

Great Excelsior.—This property is located near the Nooksack, 14 miles from Maple Falls, on the road to the Post-Lambert properties mentioned above.

The Great Excelsior ledge, the exact width of which has not been determined, preserves its character for several hundred feet along its outcrop. It occurs apparently at the contact of slate and porphyry, the former being the hanging wall, and has a strike that is northeast and southwest. The ledge is composed chiefly of quartz and dolomite. Throughout this mass the metallic minerals occur in a finely disseminated state.

Very little development work in the way of prospecting shafts and tunnels has been done on this property, as it was hardly considered necessary, since large masses of ore are already exposed. In one place the hanging wall of slate has been eroded by the creek, leaving the ledge faced up to a considerable height. As to the value of the ore the writer was informed that in no place on the ledge had rock been found, although they had tried to do so, which assayed less than $1.50 per ton. The surface of the ore body is well oxidized, and the values are less than those which are obtained by going in on the same. From tunnels which penetrate the face of the ledge and which have been driven in to a distance of 15 to 30 feet, it is found that at this distance from the surface the mass is crossed in every direction by stringers of pyrites and white quartz, and that these stringers often carry very high values, in no instance assaying below $200 per ton, and often going as high as $500 or $600 per ton. At first sight the ore has the usual appearance of a quartz and sulphide ore, but on examination it is found to contain gold and silver which occur apparently as tellurides, but combining in a manner which is not yet understood, and so gives an uncommon

occurrence of these metals. No free metals are found, and the gold and silver values are about equal; that is, in dollars and cents.

On the strength of what seems to be so spendid a showing, the company owning this property has during the past year devoted all its energy to the work of installing the necessary machinery for the treatment of the ore. The method of getting out the ore will be by open cuts, it being proposed to drive a tunnel into the ore body, and on the floor of this tunnel to construct tramways. The ore will be quarried down from either side of the open cut, dumped into tram cars, and sent directly to the mill for treatment.

Nooksack.—This property was located in 1898. It is situated on a dike which is 315 feet wide, and it is said that the same has been traced for a distance of several miles. The ore is a gold bearing sulphide, and is of a low grade, assaying $3.50 per ton, but to all appearances there is a large amount of it.

The company owning this property have developed it to a considerable extent and now have in place a four-stamp mill and other necessary machinery, and would have begun active operations during the summer of 1901, but were delayed by the late arrival of some pipe from San Francisco, which will be used to conduct water to the mill for power purposes.

Terra Alta.—This property, which is owned by the Terra Alta Mining Company, of Whatcom, is situated on the south extension of the Post-Lambert group of claims on Bear mountain. More or less development work was done on this property during the summer of 1901. About 100 feet of tunneling was driven which opened up a 14-foot vein which is said to carry values in sulphides to the amount of $306 per ton, and another vein 12 feet wide which bears a close resemblance to the Lone Jack lead and is thought to be an extension of the same. It is said to be remarkably rich in gold, some of the values occuring as tellurides.

Trails have been built to the mine, and cabins erected, and during the summer of 1902 the company owning the property expect to install the necessary machinery for the proper exploiting of the mine and for the treatment of the ore.

Saginaw.—The Saginaw claims were located in the early part of 1901, and during that summer two tunnels were driven on the

property, one of 60 feet, cross-cutting a three and one-half-foot ledge, which is said to carry high values, and another tunnel of 37 feet. A shaft was also started and sunk to a depth of 12 feet. On the surface the vein outcrops as small stringers and has been traced for several hundred feet. The values are in copper and gold.

Pierce.—The Pierce group consits of ten claims which are situated on Silica creek and about five miles from the Post-Lambert property. These claims were located in 1889 and in the spring of 1901 active work was begun on their development. Two shafts were sunk, one of 40 feet in depth, another of 50, and about 60 feet of tunneling was driven. The vein has an average width of about three feet, and is said to have been traced for several thousand feet. The values at present are principally in free gold, and give an average assay of about $12. The company owning these claims expect to begin the work of installing mill machinery during the summer of 1902.

Lone Star.—These claims are located on Swamp creek. During the summer of 1901 two tunnels were driven on the property, one of 68 feet, and another of 20 feet. The ore body is a white quartz vein about 25 feet wide, and parallel with it is a grey quartz vein whose exact width has not been determined. The gold values occur as tellurides and sulphides.

SLATE CREEK DISTRICT.

BY D A LYON

This district is situated in the extreme eastern part of Whatcom county, in the territory drained by Slate, Mill and Boulder creeks. These streams are tributaries of Ruby creek, which in turn is a tributary of the Skagit river. The district is reached in two ways, either by way of the Columbia and Methow rivers to the headwaters of the latter and then over the summit of the Cascades, or else by following up the valleys of the Skagit river and Ruby creek.

Situated as it is in the very heart of the higher Cascades, Slate creek district possesses a very rugged topography. The snowfall is excessive and makes ingress and egress quite difficult or even impossible at times during the winter season. The numerous streams abound in waterfalls and latent water power occurs everywhere. The higher peaks and divides rise above

the timber line, but in the valleys there is ample timber for all the demands of the mining industry.

The ledges of the district occur in two distinct formations. One of them is a black slate, containing numerous quartz veins, usually very thin, which run parallel with the cleavage. This formation extends from the mouth of Slate creek almost to its head-waters, and forms the Slate creek range. The cleavage of the formation in this district is almost north and south, and is parallel to the stratified sandstones, shales and limestones to the east of this area. These last named form what Professor I. C. Russell * calls the Similkameen formation, which embraces an area about 15 miles east and west, extending northward beyond the international boundary line, and southward beyond Crater pass. This area is composed mainly of sandstones, shales and limestones, with quartzite and minor quantities of conglomerate and breccia near the bottom.

In structure the series of rocks lies in closely compressed folds, having a north and south trend, with dips inclined in places, while in others the beds stand nearly or quite vertical. On Gold ridge, which is to the north of Crater pass and immediately east of the summit, in Okanogan county, the rocks dip eastward in such a manner as to indicate that the folds have been overturned to the west. At this point the dip of the strata eastward is at an angle of about eight degrees, but to the north of this the dip increases and soon becomes vertical. The underlying member of the Similkameen series is a hard, nearly white quartzite, changing, as at the Eureka mine, to conglomerate and breccia. Above the quartzite come slates, sandstones, shales and limestones. At the base of Gold ridge is a thick bed of bluish sandstone. This has been penetrated by tunnels which the Gold Ridge Mining Company have driven in the St. Paul and Minneapolis claims.

In many places the Similkameen formation is cut by dikes which trend north and south. On the Minneapolis and St. Paul claims one of the dikes is exposed at the entrance to the tunnel on these claims. It is three to four feet thick, stands nearly vertical, and cuts the sandstones which dip eastward at an angle of about eight degrees. There are numerous other dikes of this kind in the district which have an approximately vertical posi-

* Russell: 20th Ann. Rep. U. S. Geol. Survey, Part II, p. 114, 1898-9.

tion, are light in color, of porphyritic structure and for the most part have a north and south trend. In the region of Gold hill, and also in the vicinity of Windy pass, at the head waters of the east fork of Slate creek, there are numerous east-west fissures which cut the rocks at right angles to the longer axes of the folds, and which have been filled with quartz containing free gold. It is on these veins that the Eureka, Mammoth, Tacoma, Gold Ridge, and many other mining properties are situated.

Eureka.—This mine, owned and operated by the Eureka Mining Company, is situated on the head waters of the east fork of Slate creek, immediately north of Barron, about fifteen miles south of the international boundary line, and about one mile west of the summit of the Cascade mountains. The ore is found in lenses, or pockets, and occurs as a conglomerate. It carries $8 to $10 per ton in gold values, part of which is free, while part is associated with sulphides. Streaks are found containing very rich sylvanite ore.

In order to reach the ore body a tunnel 240 feet in length was driven in on the ledge, and from the end of this a shaft was sunk 65 feet. The ore is hoisted up through this shaft, taken out through the tunnel, and then sent down to the mill by means of a gravity tramway. In the treatment of the ore it is fed into a ten-stamp mill where it is crushed to pass a 40 mesh screen. The stamps have a drop of seven inches, and fall at the rate of 104 drops per minute. The product of the stamps is then passed over amalgamated plates, and is concentrated by means of two Wilfley tables. From the Wilfley tables the tailings pass over canvas slime tables for the purpose of removing any valuable particles which may have escaped the concentrators. However, it is not possible to save all of the values, as about $1.60 per ton is lost in the tailings.

Mammoth.—The Mammoth mine is located at Barron, near the headwaters of the east fork of Slate creek, one-half mile west of the summit of the Cascades. The vein upon which the Mammoth is located is from two to four feet in width with a northward dip of 60 degrees, and a strike about east and west. The gold is found in a white quartz, and is partly free and partly in combination with sulphur and tellurium. The average assay value in gold is about $20 per ton. The mine has produced to date gold to the value of $25,000.

The ore body was opened up by driving a tunnel in on the vein, crosscutting the same, and then following the vein. Only one level has been driven, and this for a distance of about 1,800 feet. Air-driven drills are now used in taking out the ore. After the ore is taken from the mine it is sent to the mill by means of an aerial tramway, as the mill is quite a little lower than the mine. The former process used in treating the ore is that of crushing and then stamping in a five-stamp mill. The product of the stamp battery was then passed over amalgamated plates whereby the free gold was extracted by amalgamation, and the tailings were then concentrated for the non-amalgamable values. As a large amount of values were lost by this method of treatment, the mill and mine were closed during the summer of 1901, and arrangements were made for the installation of new mill machinery, the contract for which has been let and the same will be put in place during the summer of 1902.

So far the owners of the property have spent about $50,000 in developing the same. With better facilities for treating the ore, and with a mill that will save a reasonable percentage of the values, it may confidently be expected that the Mammoth will become a paying mine.

Tacoma.—This property, owned by the Gold Standard Mining Company, has approximately the same location as the Mammoth, being a little to the west and north of the latter. The strike of the vein which is being worked is almost east and west, and dips about 60 degrees to the north. As far as it has been exposed it has an average width of about two feet. About 100 feet to the north is another ledge which is parallel to the one which is being developed. The character of the ore is much the same as at the Mammoth, the values occuring in white quartz both as free gold and as tellurides.

Gold Ridge.—The claims of the Gold Ridge Mining Company are located practically on the summit of the Cascades, but mainly on the headwaters of the Methow river, about ten miles south of the international boundary line. Part of the claims lie in Whatcom county and part in Okanogan county. They were discovered in 1893, at the time of the discovery of the Eureka and the Mammoth, but work was not begun on them until 1897. On the property there are two distinct sets of parallel ledges.

One set of four has a north and south strike, which is parallel with the mountain, while the second set of three veins has an east and west strike with a northward dip. The average assay value of the ore is about $10 per ton, a part of which occurs as free gold and the remainder in combination. It resembles in general the other ores of the district. So far only prospecting work has been done on the claims. This consists of 830 feet of tunnels, shafts, raises, the estimated cost of which has been about $20,000.

Ninety-Nine.—This property, owned principally by Charles H. Ballard, of Barron, consists of 11 claims, located on Crater mountain. The ledge on which the group is located is about four feet in width, with a pay streak of about two feet. The ore has yielded some very high assays, the values being in free gold and tellurides. The ledge occurs between walls of slate and quartzite, and is well defined. So far only prospecting work has been done on the property, a cross-cut tunnel having first been driven to the ledge, a distance of 240 feet, and then drifts were made.

Anacortes.—This property consists of seven claims situated on the Cascade branch of West Canyon creek. Four of the claims are located upon one vein and three upon a parallel vein. So far only development work has been done upon the property, and this chiefly upon the Anacortes and Tip Top claims. At the time this group was visited by the writer, drifts had been run on three different levels. The lower tunnel was in a distance of 310 feet. One hundred feet above this another had been run 100 feet, and about twelve hundred feet above the middle drift, another drift had been started and was in 90 feet. The ore body shows up well in all of these drifts and the walls are quite sharply defined.

The principal ledge in the group is one of quartz carrying free gold, tellurides and sulphides. Its outcrops can be followed for a long distance, and can be seen on both sides of the mountain through which it cuts. Its average width is 2 feet, and the widest part uncovered is 13 feet. Its strike is about 10 degrees west of north and it has a dip of 70 degrees to the southwest. Its hanging and foot walls are both of slate, but in the upper tunnel about 14 inches of conglomerate occurs in the vein on the hanging wall

side. The assay value of the ore ranges from $8 to $300 per ton, and some very high assays have been received on picked specimens.

North American.—The North American Mining and Milling company owns a group of nine claims, situated between Boulder and Mill creeks, at an elevation of about 4,300 feet. These claims are located on lodes which show up remarkably well at the surface, and wherever drifted upon have given high values upon assaying. The values occur in a white quartz which is more or less oxidized at the surface, and it is presumed that the ore will become base at a depth. The strike of these veins is nearly east and west. At the time this property was visited by the writer, the development work which had been done consisted of three tunnels and five drifts. One of these tunnels was 100 feet in length, another 40 feet, and another 35 feet. One of them was being driven in a clayey formation which, when panned, showed the presence of an appreciable amount of free gold.

Monto Cristo.—This property consists of two claims on Canyon mountain, to the north of Canyon creek. The claims are located on two north and south ledges each of which has a width of about seven a half feet, and which yield an average assay of about $6.

SKAGIT COUNTY.

Skagit county lies between the counties of Whatcom on the north and Snohomish on the south, and extends from the summit of the Cascades westward to tidewater. As was the case with Whatcom county, the very mountainous character of the eastern part of Skagit county is in great contrast in every way with the alluvial plain of the western part. The low plain of the coast, however, is continued eastward in the wide alluvial valley of the Skagit, which extends to within a few miles of the extreme eastern limits of the county.

The mountainous area of Skagit county is largely one of metamorphic rocks, chiefly schist, gneiss, and crystalline limestone. Granite occurs, as well as many varieties of younger ex-

trusive and intrusive rocks. Prospecting for metallic minerals has been done over large portions of the mountainous section of the county and many ledges have been found. Data is at hand for reports upon but two districts of the county, Thunder creek and Bald mountain, and some brief statements about these will now be given.

THUNDER CREEK DISTRICT.

BY D. A. LYON.

This district is situated in the extreme northeastern corner of the county, adjacent to the summit of the mountains, and very near the Whatcom county line. It lies within and immediately about the basin of Thunder creek, a tributary of the Skagit which enters that river about twenty-five miles above Marblemount.

Ledges of ore were discovered in this district a number of years ago, but it is only recently that active development work has been undertaken. The country rock of the district is chiefly granite, with dykes of porphyry. The altitude is so great that the rocks are generally bare of vegetation and soil, so that veins of ore may be readily seen and traced.

Willis and Everett.—This property, consisting of nine claims, is owned by the Baker Mount Mining Company, of Seattle. It is located in Silver basin, on the south fork of Thunder creek. There are on the property three well defined veins, two of which are parallel and have a northwest and southeast strike. The third vein has a north and south course, and cuts the other two.

The values of the upper ledge, which is from eight to twelve feet thick, run very high. It is not unusual for an assay to yield $200 in silver and $9 in gold per ton. Picked samples have run as high as 3,600 ounces of silver per ton.

The lower ledge, four to ten feet in thickness, runs very high in silver, together with some gold. On this vein there is an open cut of 50 feet on the ore body. The foot wall is granite; the hanging wall porphyry. Below these veins are other ledges on which some work has been done.

Lakeside.—This property is located on the south side of Silver basin, on the south fork of Thunder creek. The ledge is about three and one-half feet wide, with both its hanging and foot walls of granite. Its strike is north 50 degrees east, with a

vertical dip. The average assay value per ton is about $36 in gold and about $20 in silver.

Great Northern.—This property is located immediately adjoining the Lakeside, described above. The ledge is 26 feet wide, with a strike of north 50 degrees east, and with a vertical dip. The vein carries gold, silver and zinc.

As these properties are all quite close to one another, it is proposed in the near future to build a concentrator, which will be so located that it can treat the ore from all the mines of the basin.

BALD MOUNTAIN DISTRICT.

Bald Mountain.—This mine is located fifteen miles southeast of Sedro-Woolley, near the summit of Bald mountain. It is easily reached by wagon road and trail from Clear Lake. The country rock is schist and slate, with a large dyke of diorite cutting these formations. The slate is massive and contains bands and irregular masses of lime-soda feldspar scattered through it. The mine itself is located in section 17, township 34, range 6 east, on both sides of the summit of the mountain. There are a number of veins all badly weathered at their outcrops. The strike of the main ledge is north twenty degrees east, and the dip is southeast fifty degrees. The hanging wall is schist, the foot wall has not yet been found. The ledge is supposed to be about sixteen feet wide. One assay of the ore gave thirty per cent. copper and three dollars in gold. The development work that has been done consists of two shafts, one 60 feet and the other 50 feet in depth, with a crosscut tunnel of 420 feet in length. The property belongs to the Bald Mountain Mining Company, of Clear Lake.

CHELAN COUNTY.

Chelan county lies between the Columbia river on the east and the summit of the Cascades on the west, with Okanogan and Kittitas counties as its northern and southern boundaries, respectively. The surface of the county has a normal slope from the Cascade summit, with an approximate elevation of 7,500

feet, southeastward to the Columbia river, where the elevation above sea is from 600 to 700 feet only.

Chelan county is naturally divided into three drainage basins, those of the Wenatche, Entiat, and Chelan rivers, the first and last heading in the main divide of the Cascade range, and all flowing southeastward to the Columbia. Chelan river is the outlet of Lake Chelan, a very beautiful body of water occupying a great cleft in the granite mountains. The deep depression occupied by the lake extends northwestward beyond its head and is there known as the valley of the Stehekin river.

Chelan county is for the most part a region of ancient schists and gneisses, with large areas of granite. Intrusive rocks, in the form of dikes of andesite, diorite-porphyry, and acid quartzite-porphyries are of common occurrence. The basalt of the Columbia plain extends a little way into the southeastern corner of the county. Between Leavenworth and Mission, and extending northward and southward for several miles, is found a massive sandstone of Tertiary age, which represents an extension of the Swauk sandstone.

HORSESHOE BASIN DISTRICT.

Horseshoe basin is situated at the headwaters of the Stehekin river, very near the summit of Cascade pass. It is reached by a short trail leading off from the main trans-mountain trail, the latter leading up the Stehekin, over Cascade pass, and down the Skagit by way of Marblemount. This so-called basin is a great natural amphitheatre carved out by glacial action. It has an elevation of about 6,000 feet, and contains so much ice and snow that mining operations are mainly confined to the summer months. The mountain peaks which surround the basin are nearly destitute of timber, but in the valleys there is an abundance of hemlock, cedar, fir and pine, sufficient for all mining purposes. The streams furnish an abundance of water power, which can be harnessed very easily and made to do all the hoisting and lighting around the mines.

Gneiss and schist, with intrusions of granite and diorite, constitute the chief rock formations in the Horseshoe basin region. The ledges of ore are of unusual size, and are composed essentially of galena and chalcopyrite carrying gold and silver.

Black Warrior.—This claim lies between Horseshoe basin and Doubtful lake. It is on a well defined east and west ledge,

varying in width from 20 to 30 feet, with a pay streak from two to eight feet wide. The vein contents are galena and chalcopyrite, with good silver values.

Davenport.—This claim is on a ledge parallel to the Black Warrior, and between the latter and the head of Horseshoe basin. The ledge in some parts attains a width of forty feet, and stands about perpendicular. Development work on the property is much hindered by the great quantities of snow and ice which covers the ground throughout the year. The mineral contents of the ledge are chiefly galena and chalcopyrite. A ton of the ore shipped to a smelter gave a return of $69 in lead, copper, silver and gold.

Texas Jack.—This claim, now owned by the Chelan Copper Company, is located in the upper Horseshoe basin. The width of the vein between walls equals 30 feet in places, with a pay streak of about 20 inches. The vein has a northeast and southwest strike, with a dip of 75° to the northwest. The principal values are in copper and silver.

BRIDGE CREEK DISTRICT.

Bridge creek comes into the Stehekin river from the north about fifteen miles above the mouth of the latter stream. This creek drains a large area of granite, gneiss and schist, in which ledges of ore occur. In the district many claims have been staked, but upon none of them has development work assumed large proportions.

Butte.—This property, owned by the Butte Gold, Silver and Copper Mining Company of Spokane, is located on Bridge creek about twenty-five miles from the head of Lake Chelan. In the development of the property it has been necessary to build a good many miles of roads and trails. There are two veins upon the property and a tunnel has been driven upon each vein, one tunnel being at the present time 56 feet long and the other 42 feet in length. One vein which was stripped for 36 feet shows a width of 8 feet between walls.

RAILROAD CREEK DISTRICT.

Railroad creek heads among the high mountains constituting the summit of the Cascades, and flows eastward into Lake Chelan at a point about twelve miles from the upper end of the

lake. It is well fed by snows and glaciers, and as it makes a descent of over 4,000 feet in 20 miles it affords an abundant water power. The valley sides are covered with a goodly forest growth until the timber line is reached well toward the head of the stream. Throughout its course Railroad creek flows in granite, in which at several places veins of ore have been discovered. The two most prominent ledges that have been found are known as the Crown Point and the Holden.

Crown Point.—The Crown Point property is located near the head of Railroad creek about seventeen miles from Lake Chelan. The vein appears at the surface on the face of a bold granite cliff and is reached with some difficulty. It lies almost flat, dipping to the westward at an angle of five or six degrees. It has a width of from two to three feet and is composed chiefly of solid quartz with small quantities of molybdenite disseminated throughout the gangue. As a rule the molybdenite occurs in well formed crystals having the form of hexagonal pyramids and with diameters reaching an inch or more in length. Some times the molybdenite occurs in irregular masses having diameters of three or four inches. At the end of the short tunnel which has been driven on the vein chalcopyrite has made its appearance, and occasionally shows itself in conspicuous masses.

Holden.—On Railroad creek about eleven miles up the valley from Lake Chelan is the Holden group of three claims. The ledge outcrops upon a rather steep mountain side where the ore body has been laid bare by the snow slides which have swept down the mountain, carrying along with them all of the loose surface materials. The ledge shows very distinctly along the outcrop for a distance of several hundred feet. It is in the nature of a replacement vein where the granite which constitutes the country rock has been impregnated and largely replaced by chalcopyrite and iron pyrite. In the joints of the granite solid bands of ore occur. Between the joint planes the more soluble constituents of the granite have been removed and the metallic minerals above mentioned have taken their places. The vein has, therefore, no proper walls and the zone of replacement is somewhat illy defined, passing gradually from the rock containing a large percentage of ore to the rock which contains none at all. At one place a measurement made at right angles to the

strike and across the zone of replacement showed the latter to be 200 feet, at other places it is of course much narrower. The ore values are in gold, silver and copper. At the present time the extent of underground development is about 300 feet.

PESHASTIN DISTRICT.

BY A. E. KNAPP.

The Peshastin Mining District is in the southern end of Chelan county on the eastern slope of the Cascades. It lies between the ridges that define the water shed of Peshastin creek from Ingall creek on the north, to the summit on the south. Shaser, Scott, Ruby and Peshastin creeks afford abundant water power. Their channels are primarily the result of glacial action, the subsequent erosion having done little more than to concentrate the glacial debris and leave some good placer in the main creeks. The hills are generally well covered with fine timber, some of it excellent for lumber.

The geology of the district has been carefully studied by members of the U. S. Geological Survey, and briefly stated is as follows: The district is composed of intrusive serpentine, bounded on the north and south by slate. Dikes of more recent volcanic rocks are numerous. Most of the veins run nearly east and west with the formation, and are generally found in the serpentine. The ores are free milling and concentrating. Some of the slips or ledges where the veins intersect have all the characteristics of regular pocket veins, and gold is found at the point of intersection. Other veins carry their enriched portion along lines of crushing. None of the veins are regular in width throughout their course, except where they occur along lines of crushing. It is probable that the gold was first deposited in the veins with the sulphides but was afterwards changed through a process of leaching into free gold. The gouge along the vein walls is usually talc, very seldom clay, and considerable gold is sometimes found in the talc, having been carried there in solution. Many of the miners have had the erroneous idea that all the green talc must necessarily carry gold. Along the line of enrichment it does, but not throughout the entire vein. The ores are of a good grade, many of them over ten dollars per ton and going as high as one thousand dollars per ton.

Most of the development work has been done at Blewett,

where the Chelan Mining Company has a twenty stamp mill on the banks of Peshastin creek. The history of this camp is similar to that of many which dot the eastern slope of the Cascade and Sierra Nevada mountains, and in a few words is a history of mining instead of mines. The first discoveries in the district were placer. The rich oxidized ores exposed over the surface of the hills above the creeks were worked in arrastras, and the mines gophered. No attempt was made to work the mines underground until 1874.

The principal work has been done in the ledges on the properties of the Chelan, Eleanor, and Peshastin Mining Companies. The total estimated output of the camp is $1,500,000 and these ledges contributed a considerable portion of this.

The lack of correct knowledge or experience in the character of the formation has resulted in the sinking of a hundred or more holes and cuts where ores have been extracted, and no further effort made to follow the line of enrichment. The amount of good ore that the surface has furnished has seldom been equalled by any camp along the range. Mining operations are not expensive, for shafts and tunnels can be driven for about five dollars per foot with hand labor. No trouble from water is experienced in sinking shafts. Few camps have so little controversy over boundaries as Peshastin mining district. The original corners are well understood and respected.

Eureka.—This mine is on Peshastin creek, about a quarter of a mile south of Blewett. The vein of ore varies from twelve to eighteen inches in width, has a strike east and west, and a dip to the south. The mine belongs to the Phœnix Mining and Milling Company, but all the work has been done by leasers, who have kept no records of the amount shipped, so that it is not possible at this time to state how much ore has been extracted, or form any estimate of its total value. Much of the ore assays in gold as high as thirty dollars to the ton. The property was first opened up twenty-one or twenty-two years ago, and up to the present time about $3,500 has been expended in development work, represented by about 600 feet of underground workings.

Tip Top.—The eastern extension of the Eureka mine is known as the Tip Top, and was opened up about the same time.

A large amount of ore was taken out in early days, estimated in value at about ten thousand dollars. The vein here is about two and a half feet thick and dips northward, with an east and west strike. About five hundred or six hundred feet of tunnel has been driven, involving an outlay of about $4,000. The ore that is mined averages about twenty-five dollars to the ton in gold, and is treated by means of an arrastra, which is supplied with water by a ditch five hundred feet long.

Lucky Queen.—This mine is on the east side of Peshastin creek about a quarter of a mile north of Blewett, and was first opened up in 1894. There is one principal vein with a number of intersecting veins, and all stand nearly perpendicular. The ore is very pockety. About twenty tons have been sold to date, having a total value of about one thousand dollars. Two tunnels having a combined length of seven hundred feet, have been driven at an expense of about $3,500.

Culver.—The Chelan Mining and Milling Company has a group of five claims extending along Thompson gulch, from a point two thousand feet west of Blewett, and adjoining the Peshastin mine. This is an old property, having been first opened up in 1882, and since that time about three hundred thousand dollars worth of ore has been taken out. The vein varies in width from four to fifteen feet. It strikes east and west and dips to the southward. All the values are in gold, and the ore assays from five dollars to five hundred dollars per ton. There has been about four thousand feet of underground development work done, including tunnels, stopes, etc. The company has erected a twenty-stamp mill, and an aerial tram for handling and treating the ores. Steam power is employed. The total amount expended in all kinds of development work is estimated at one hundred and fifty thousand dollars.

Peshastin.—The Peshastin mine is in the town of Blewett. It is one of the oldest properties in the camp, having been first opened in 1874. The vein is from four to twenty feet wide, and like all other veins in the camp, has an east and west strike. It dips to the southward. Fifteen hundred feet of underground work has been done, representing an outlay of about eight thousand dollars. Four thousand tons of ore have been mined, having an average gold value of $15 per ton.

Olden.—The property belonging to Mr. John Olden, is located west of the Black Jack mine, and immediately south of the Peshastin. It is an old property, having been opened up about twenty-one years ago. There are two veins varying in width from one to six feet, dipping north, and with an east and west strike. All the values are in gold. Three hundred and fifty feet of underground development has been done. Up to the present time the total output is five hundred tons of ore, having a value of twenty-five hundred dollars. The ore is treated in an arrastra operated by water power. The estimated cost of all development work done is fifteen hundred dollars.

Pole Pick.—This mine is on the north slope of Thompson gulch about half a mile west of Blewett. It was opened up in 1884 and since that time has produced eight thousand tons of ore, having a total value of about sixty-four thousand dollars. There are three veins varying from one to four feet in width. The strike is east and west and the dip is to the northward. The values are in gold and silver, with a little lead. There are about two thousand feet of underground work, representing an expenditure of twelve thousand dollars.

Golden Eagle.—This property includes three locations on the west side of Peshastin creek just north of Blewett. There are two veins on the property, each having a width of about three feet. The strike is east and west and the dip north. Like most of the other mines in the district the ore is very pockety, ranging in value from fourteen dollars to sixty dollars per ton. The owners have expended about seven hundred dollars in development work, and now have a tunnel two hundred feet in length. They have about one hundred tons of ore on the dump. All the values are in gold.

Ivanhoe.—The Ivanhoe mine lies north of the Culver at the head of Thompson gulch, about half a mile west of Blewett. It is an old mine, having been first opened up eighteen or nineteen years ago, but has never been worked very extensively. About five hundred feet of underground work has been done, and twenty-five hundred dollars have been spent in development work. The vein is six feet wide and carries gold and silver with an average assay value of four dollars and a half per ton. The vein is perpendicular and has an east and west strike.

Black Jack.—This mine is on Peshastin creek above Blewett. It was opened up about the same time as the Eureka, or about 1880. Nine hundred feet of tunnel have been driven on the property at an estimated cost of five thousand dollars. Three thousand tons of ore have been taken out with an average gold value of ten dollars per ton. The vein is from two to four feet wide, and has an east and west strike, dipping to the southward.

SNOHOMISH COUNTY.

Snohomish county lies between the counties of Skagit and King on the north and south respectively, and extends from the summit of the Cascades westward to Puget Sound. Like the counties to the northward and southward of it, Snohomish has a low alluvial plain along the coast, which gives way in turn to low hills, foot-hills of the mountains, and finally to very high mountains as one travels eastward.

The eastern part of Snohomish county, embracing about two-thirds of its area, may be regarded as mineral bearing. The rocks found here are of the varieties typical of the northern Cascades, viz.: granite, diorite, slate, gneiss, schist, crystalline limestone, etc. At several points valuable veins of ore have been discovered, notably about Darrington, Silverton, Monte Cristo, and Index. The ores found in these districts are practically all of the sulphide type, making treatment by smelter methods a necessity. An easy method of transportation from the mines to the smelter is therefore required, and in this the mining properties of Snohomish county are favored much better as a rule than is the case elsewhere in Washington. Three lines of railway extend from tide-water into the heart of the mountains and into the midst of the mining districts, viz.: a branch line of the Northern Pacific to Darrington, in the northern part of the county; the Everett & Monte Cristo to the town of Monte Cristo, in the central part of the county; and the Great Northern to Index, in the southern part of the county. Of these rail-

ways the first and second were constructed primarily for the purpose of hauling ore from the mines, while the third is of course a part of a great overland system.

DARRINGTON DISTRICT.

BY D. A. LYON.

Darrington district is situated in the northeast corner of Snohomish county. Although it is unorganized, yet its boundaries may be considered to be the Skagit county line on the north, the Stilaguamish district on the south, and the summit of the Cascades on the east. The district is drained by the Sauk river and its tributaries. The principal town of the district, Darrington, is situated about 25 miles above the mouth of the Sauk. The district is one of the most accessible in the state. During the past year the Northern Pacific railway extended a branch line from Arlington to Darrington. There are also several good wagon roads leading into the district. Not only is the district well located as regards accessibility, but because of the low altitude the mining industry is not handicapped by the deep snows, as is the case in the higher Cascades.

Although more or less development work has been going on in the Darrington district for some years, none of the mines have ever been regular shippers. This has been due partly to the fact that capital has been wanting to develop the properties sufficiently, and also because there has been no way of getting the ores treated after they have been taken out, for the ores of the district are smelting ores. Now that the district has been entered by a railroad, it will be possible to interest capital in the mines and property holders now feel that the future of the district is assured. Most of the mines of the district are all at a higher elevation than Darrington, and as the district is developed it seems quite likely that a system of aerial tramways will be used for delivering the ores from the mines to Darrington, either for treatment at that point, or to be loaded and shipped to smelters at Tacoma and Everett. One of the largest property holders of the district informed the writer that ore can be mined and delivered at Darrington for $3.75 per ton. The rate on ore by rail from Darrington to Everett is $2, or to Tacoma $2.50 per ton. Thus, ore can be mined, freighted and smelted for about $10.75 per ton. As the ores of the district run from

$16 to $84 in value per ton, it would seem as if mining could be carried on in this district at a profit.

Darrington is not only a mining center, but it is situated also in the heart of a very extensive timber district, and in the near-by river valleys there are also large areas of agricultural land.

As to the rock formations of the district, we find in at least two places the same kind of fine grained black slate which is found along Ruby creek and on Slate creek. In the first of these places the slate is found on each side of Sauk river for a distance of about ten miles, and below the mouth of Whitechuck creek. The second locality is found on the west bank of the Sauk, beginning about three miles below Darrington, and extending for four miles. There are also large bodies of serpentine in the district. Most of the ore bodies have slate for a hanging wall and porphyry for a foot wall. The following are some of the more important properties of the district:

Burns.—The Burns group consists of seven claims which are situated on the west side of Gold mountain. The ore body has been exposed for a distance of 100 feet, and is shown to have an average width of 4½ feet. The ledge can be traced as far as the Sauk river, where it has an outcrop of 6 inches. It has an east and west trend and a dip that is nearly vertical.

Blue Bird.—The Blue Bird group of claims is owned by S. S. Gardiner and others of Everett. Between two and three hundred feet of tunneling has been done on this property, and 100 tons of good ore taken out which assays about $33 per ton. The vein of ore has an average width of eight feet.

Elwell-Darrington.—The property of the Elwell-Darrington Mining Company is on the east side of Gold mountain, and is located on an extension of the Burns group. The principal ledge is from 7 to 8 feet wide, with a pay streak varying from 2 to 3 feet in width.

Harley.—The Harley group consists of eight claims, which are situated about the middle of Gold mountain, and owned by Chas. Burns. The vein of ore is 4 feet wide and outcrops for about 150 feet. It carries mostly gold values, and assays $42 or $43 per ton.

Hunter and White Gander.—The Hunter and White Gander group, made up of six claims on the west side of Jumbo mountain, is owned by Burns and Neste. The development work consists of three open cuts and one 50-foot tunnel on the Hunter, and one 15-foot tunnel and two open cuts on the White Gander. The average assay value of the ore is between $15 and $20 per ton.

Molly.—This group is also located on Jumbo mountain, and is owned by Neste and others. The development work on these claims consists of two tunnels, one of which is about 170 feet in length, and another 50 feet in length. The average assay value of the ore is about $15 per ton, of which one half is in gold and the remainder in silver and copper. The same proportion holds good with the other ores of Jumbo mountain.

Sloman.—The property is situated on the north side of White Horse mountain. The ledge is about five foot wide, and a mill test made on the ore gave it a value of $33 per ton. The property has been developed to the extent of two tunnels of 50 feet each.

There are many other properties in the Darrington district which have been located for some time, and upon which a considerable amount of development work has been done. There is no reliable data at hand concerning these, and for that reason they can not be mentioned in this report.

STILAGUAMISH DISTRICT.

BY WM. S. THYNG.

The Stilaguamish mining district, of which the center is Silverton, lies upon both sides of the Stilaguamish river, in very nearly the geographical center of Snohomish county. Silverton is reached from Seattle, via Everett, by the Everett & Monte Cristo Railway, which follows the valley of the Stilaguamish river. The town of Silverton, located in the river valley, lies at an altitude of about 1,500 feet above sea level, while on both sides the mountains rise to a height of from 3,000 to 5,000 feet above sea level, with the characteristic rough contours of the Cascades.

Previous to 1897 a very large number of claims had been located in this district, both north and south of the river, and

many of the properties so located had already given great promise as future producers, and considerable ore had been shipped, when in November, 1897, the excessively high water in the Stilaguamish, caused by the melting snows above caused a number of very bad washouts along the line of the Everett & Monte Cristo Railway, putting a stop for the time being to all mining operations along the line. This shutdown, as it may be termed, of all the mines of Silverton, continued until early in the season of 1901, when the railroad having been extensively repaired, and even rebuilt at many points, mining operations were again resumed. The repairs made upon the roadbed were of so substantial a character, and so well protected is the road, that no future trouble is looked for from high water in the river.

The general direction of the Stilaguamish, as it passes through this district, is east and west, which is also the general trend of the mountains on both sides of the river. From the river valley at Silverton wagon roads and trails, principally the latter, radiate in all directions to the different mining properties located in the surrounding mountains. A broad mineral belt, averaging perhaps ten or twelve miles in width, and which contains most of the important ledges of the district, extends nearly north and south at this point. The individual veins or ledges extend in a general east and west direction, those lying to the north of the river showing a general tendency to strike a little to the north of east, while those on the south side of the river maintain a general strike to the south of east. The veins thus show, apparently, a tendency to converge as the river is followed downward or westward.

It seems altogether probable that the mineral belt described is the same which includes Darrington on the north and Index on the south, although the ores of the latter locality can hardly be called similar. The underlying or fundamental rock of the district is [illegible]btedly granite, with certain of the sedimentary rocks s[illegible]sed above. Follow[illegible]ng down the valley of the [illegible]uan [illegible]m above its junct[illegible]h Palmer creek to a [illegible] below Silverton a[illegible] a series of terminal moraines, [illegible]learly the glacial [illegible] up the river valley. At some poin[illegible] moraines immediat[illegible]verlie the granite formation.

While many true [illegible] veins are found in the district, still

a large number of ledges occur at contacts of granite and diorite. The characteristic ore is chalcopyrite, which in the majority of cases carries the gold values. The chief values found in all the ore thus far mined lie in copper, gold aud silver, which last usually occurs with galena, found in a greater or less amount in most of the ores. Pyrite, arsenopyrite (mispickel) and pyrrhotite are very frequently found associated with the more common chalcopyrite; zinc blende (sphalerite) is also frequently met with, and most commonly occurs associated with the galena. Small quantities of ruby silver, chiefly antimonial (pyrargyrite), are occasionally found, notably in the ore of the Forty-five mine.

The topography of the country is admirably adapted to economical mining, many of the mountain slopes being so steep that considerable depth may be obtained with a comparatively small amount of tunnel work. As but one of the mines of the district, the Forty-five, is or has been a regular shipper of ore, Silverton may fairly be considered as in its infancy as regards production, and it may readily be seen that an enormous amount of ore lies in the surrounding mountains, ready to be mined and shipped without the sinking of a single shaft. While the smaller creeks which drain the district and empty into the river from the sides, can not all be depended upon for a steady flow at all seasons, and hence do not offer the best facilities for water power, still outside of the question of power, they should furnish ample water for each individual camp.

The district has not by any means been thoroughly prospected at all points, although the ground has been fairly well covered within a radius of four or five miles from Silverton. Most of the region is heavily timbered, which, together with the thick surface soil at many points, makes thorough prospecting a difficult matter. Mr. R. H. Stretch, who has made a careful study of the geology of the district, is authority for the statement that a few miles east of Silverton, the overlying sedimentary rocks contain thin beds of coal, apparently semi-bituminous, which in all probability belong to the same age as the coal fields of Hamilton, in Skagit county, but lying on the eastern slope of a broad anticline along the crest of which the mineral zone has been developed. Mr. Stretch further believes that it is not unlikely that the general strike of one system of lodes—the northwest—is in

some way connected with the southeast course of Deer creek, which is continued in the bed of the Stilaguamish river from the mouth of Deer creek to the summit of Barlow pass. To this system belong such mines as the Forty-five and the Bonanza Queen, to the south and north of Silverton respectively, the fissure in each case having been traced through many contiguous claims.

Ore was first discovered in this region in the summer of 1891, when the Hoodoo, Independent, Anacortes and Bonanza Queen ledges were found and located. The first name of the camp was Independence, but in August, 1891, the name Silverton was adopted, and a town site was established the following winter. The railroad was built in 1892–3.

Forty-Five.— This is the only property in the district which has shipped any large amount of ore at the present time. It is owned and managed by the Forty-five Consolidated Mining Company, of which Mr. L. A. Dyer is president and Mr. N. B. Jones, superintendent; the offices of the company are in Seattle. The company owns six claims upon what is known as the Deu Pree lode, and located on an air line about two miles southeast of Silverton. The mine is reached from the town by pack trail, which passes through Marble pass at an altitude of 4,190 feet; the mine is also reached by wagon road from Sultan, a point to the southwest on the line of the Great Northern Railway.

The six claims owned by the company are the Herb, Norm, Mountain Ram, Magus, Deu Pree and Hard to Beat. The ore body is a fissure vein cutting through diorite, and strikes a few degrees to the north of west, dipping south at an average angle of 80 degrees. The average width of the ledge is not far from six feet, and the mineralization is quite uniform, there being no distinct pay streaks; the gangue material is largely quartz, much of it somewhat decomposed. Although the chief values are in silver and gold, the ore is very base, carrying an average of four per cent. of galena, and considerable amounts of zinc blende and iron pyrites, besides some chalcopyrite and mispickel; gray copper ore (tetrahedrite) is also found, sometimes in notable quantities. The greatest values in both of the precious metals are found in the galena, although some of the silver is associated with the pyrite; near the surface, considerable ruby silver,

mostly of the antimonial variety (pyrargyrite), is encountered, often in large enough quantities to form handsome specimens.

The main workings of the mine are located on the Magus claim, about 4,000 feet above the sea level. Here the main tunnel, No. 2, has been run in 232 feet to the vein, along which about 950 feet of drifting has been done; from this drift, a two-compartment shaft, 5 by 8 feet in cross-section, has been sunk a distance of 107 feet, and at the 75-foot level, 135 feet of drifting work has been done. From the main level, cross-cuts aggregating 150 feet have been run, chiefly to prospect for parallel ledges. On the Deu Pree claim, tunnel No. 1, the first one driven by the company, cuts the vein at a distance of 27 feet, and from that tunnel 100 feet of drifting has been done. About 175 feet of drifting has been done upon the Hard to Beat claim, the most easterly of the group. All drilling is done by hand, as, with the single exception of the Independent mine, no machine drills are used in the district.

The contours of the country, and present economic conditions, make it necessary to carry the ore by aerial tramway to Silverton, the nearest railroad point. A wire rope gravity tram of the Hallidie patent, brings the ore down the mountain side, a distance of 3,700 feet, to the headquarters camp, located at an altitude of about 3,000 feet. At this point the ore is roughly hand-picked and transferred to a second tram, of the same patent, 13,200 feet long, which runs via Marble Pass (whose altitude is 4,190 feet), to a point upon the railroad about one-quarter of a mile below Silverton, and from whence the ore is shipped. As the two parts, or legs of this main tram, on each side of Marble pass, are too nearly equal to admit of its running by gravity alone, additional power is had from an electric motor placed at the headquarters station.

Previous to the building of this tram, in 1897, high grade ore was taken to Silverton by pack train, and shipped from that point. The tram was completed just as the washout occurred upon the railroad, but considerable high grade ore was still shipped while the railroad was out of service, by wagon road, to Sultan. This shipment by pack train and wagons involved the accumulation of considerable ore of lower grade at the mine and headquarters camp, and in August, 1901, it was estimated that about 15,000 tons of this lower or second grade ore was still on hand.

Little Chief.—About a mile and a half due south of the Forty-five No. 2 tunnel is found the Little Chief property, owned by the Stilaguamish and Sultan Mining Company, of which Mr. J. W. Clise, of the Clise Investment Company, Seattle, is vice-president and general manager. Upon this property, which lies on the west side of Little Chief peak, about 300 feet of tunneling and 100 feet of drifting has been done, together with some 60 feet of cross-cuts. The company has also done considerable prospecting with diamond drill, but the mine has thus far never been a producer. The ore is low grade, with the chief values in gold and copper.

Independent.—Of the other properties upon the south side of the river, the Independent probably comes second in importance at the present time, to the Forty-five. This mine is located less than a mile to the southeast of Silverton, and of all the properties of the district, is probably the easiest of access. It is owned and operated by the Copper-Independent Consolidated Mining Company, of which Mr. M. D. Little, of Boston, Mass., is president, and Mr. Arthur W. Hawks, of Snohomish, general manager.

The ore body is a fissure vein in granite, and strikes very nearly north and south, with a steep dip. The values are in gold, associated chiefly with arsenopyrite, although considerable amounts of iron pyrite are found. The mineralization is quite uniform throughout the ledge, which is wide and has pronounced walls. The ore is of such character as to require concentration before shipping. The main opening consists of a drift about 500 feet long, from which a raise has been pushed up 120 feet to a short tunnel or drift above. That the vein matter upon the ledge is very soft is shown by the fact that it has suffered a large amount of erosion between the walls, forming a steep chasm, which has become the bed of a small water course. A three-drill air compressor was installed at the mine during the summer of 1901, and preparations made to put out ore for shipment, but since that time it has been impossible to obtain from the officers of the company any information as to advancement in development. One car load of picked ore has been shipped to the smelter at Everett.

Imperial.—The Imperial mine, owned and operated by the Imperial Mining Company, lies about one and one-half miles

east of Silverton. The president of the company is Mr. James E. Deu Pree, of Marysville, and Mr. M. Swinnerton, of Silverton, is superintendent. The company owns eleven claims covering three ledges, the most important of the claims being the Anacortes and the Mountain View. The main vein is in a contact of diorite and conglomerate. The chief values of the ore are in copper and silver, with some small amounts of gold. A total of about 400 feet of development work has been done, the main tunnel having an altitude of 2,500 feet.

Bonanza Queen.—This group of eight claims is located about one mile due north of Silverton, and on the west side of Deer creek. The property is still in the hands of the original locators, who are represented in Silverton by Mr. A. Sutherland. The claims cover four distinct ledges, of which the most important are the Bonanza Queen and the Oregon, running nearly parallel and side by side. It strikes southeast by south, and stands nearly vertical. The values are chiefly in gold and copper, which occur associated with mispickel. The vein is wide, and the mineralization, forming the pay streak, has taken place chiefly along the foot wall. A total of about 1,200 feet of development work, mostly drifting, has been done upon the property; the very abrupt slopes which are met with, particularly upon the most northerly claims, offering unusual facilities for cheap mining. The average altitude of this group is 2,700 feet.

St. Louis.—The St. Louis mine is on a ledge which is cut by Deer creek, about three miles north of Silverton. It is reached from town by a four-mile wagon road, following up Deer creek. The ledge is mostly of high grade ore but is very narrow, ranging usually from about 18 to 36 inches. The property has been opened by two drifts, connected by a winze, some of the work having been done by power drills. The main drift is about 600 feet in length, and shows good continuity of ore, which is mostly chalcopyrite, with copper values running about 20 per cent. Considerable silver and some gold is found associated with the ore. At the present time very little besides assessment work is being done upon the property. Some small shipments have been made.

Helena.—This group of claims, owned by the Deer Creek Gold and Copper Mining Company, is located some two miles

north of the St. Louis upon the divide between Deer creek and Clear creek. All of this divide is taken up in claims, which cover two systems of veins. The wagon road which leads past the St. Louis reaches to the foot of the divide, but in order that ore may be shipped in any quantity, a tram of some form will be necessary to bring it down from the mine. The granite formation is exposed for several hundred feet along the side of the mountain, and shows a ledge of great width carrying low grade ore. The main tunnel, which is located some 800 feet from the summit, is 124 feet long, and from it 125 feet of drifting has been done. Another tunnel has been started about 1,000 feet below to tap the main ledge. A number of small shipments aggregating about 150 tons were made before the railroad washout to the smelter at Everett, but at the present time nothing beyond assessment work is being done.

Another group of claims near by and well worthy of mention is that of the Four Brothers, owned by the Copper-Independent Consolidated Mining Company. About 130 feet of development work has been done upon this property, which lies west of the Helena group.

Although, outside of the Forty-five mine, no ore of any consequence was shipped from this district during the past season, 1901, a very large amount of assessment work and considerable further development was done, notably upon the Hoodoo group south of the river, and owned by the Stilaguamish and Sultan Mining Company, the Fraction, New Seattle, Cleveland and others.

Silverton is but 48 miles by rail from the Everett smelter, which fact in itself should be of the greatest value in the future successful development of the district.

MONTE CRISTO DISTRICT.

By Wm. S. Thyng.

This district is located in the eastern part of Snohomish county, about twelve miles southeast of Silverton. The town of Monte Cristo, which forms the terminus of the Everett & Monte Cristo Railway, is reached from Seattle via that road, making connection with the Northern Pacific branch line at Hartford Junction, or with the Great Northern Railway at Everett. Monte Cristo is located in the valley of the Sauk river, just

OUTCROP OF INDEPENDENCE LEDGE, MONTE CRISTO.

below its source; the town occupies an immense natural basin, with precipitous mountains rising upon all sides, which are cut in many places by steep gulches.

The first claim staked in the district was the Independence of 1776, located on the 4th of July, 1889. This claim is situated upon the east side of what is now known as Seventy-six gulch. The ledge has a most pronounced outcrop which can be traced a long distance up the steep side of the gulch, until it is finally lost under a large glacier. The ore body at the outcrop is composed largely of galena. It has been opened at several points by short drifts and open cuts, but no ore has been shipped and no work worthy of mention has been done upon it for several years. This is now one of the many properties in the district owned by Mr. John D. Rockefeller and his business associates.

All of the properties of this district, like those tributary to Silverton, underwent an enforced shut-down during the two years following the washout of the Everett & Monte Cristo Railway, which occurred in November 1897. During this period the only means of communication with the outside world was over the dismantled roadbed of the railway which follows the valley of the Stilaguamish river. Since the repairing and rebuilding of the railway, while this dirtrict has not enjoyed the marked revival of interest which has taken place in Silverton, it has nevertheless resumed its place as a large producer of ore. The output has been, however, almost entirely from the property of the Monte Cristo Mining and Concentration Company, which is, therefore, at the present day as well as in the past, the chief producer.

Monte Cristo. — The Monte Cristo mine, operated by the above mentioned company, of which the president and chief stockholder is Mr. John D. Rockefeller, and the superintendent Mr. William E. Sutton, is now operating three claims, viz.: the Pride of the Woods, the Pride of the Mountains, and the Eighty-nine. These are three of the fourteen claims upon which the mine is located. The company owns a total of thirty-five claims in the district. In the Monte Cristo mine about 12,000 feet of tunnel and cross-cut work have been done, besides a large amount of stoping. The principal vein, which has been formed in a fissure in diorite, strikes a little north of east with a dip ranging from 55 degrees to 70 degrees to the northwest. The values run

chiefly in gold and silver, although some lead is saved in smelting. The milling ore extracted from the mine averages $6 per ton in value, of which about $4 is in gold. This ore is concentrated in the company's mill, located in the town of Monte Cristo. In the concentration the ore is brought down from 3 or 3½ tons to 1 ton. The mine is located due east of the town, all of the ore being transported to the mill by two wire rope trams, of the Bleichert patent, one 3,600 feet and the other 6,250 feet in length. The mine during the past summer (1901) was producing ore at the rate of 3,500 tons per month, so that about 1,000 tons of concentrates were shipped monthly. While working, with the exception of the first two years of its history, the mine has produced an average of 39,000 tons of milling ore yearly. All of the ore which is mined is crushed and washed, the product containing an average of but ten per cent. of gangue matter. The loss in concentrating is stated to vary from 18 to 30 per cent. according to the degree of mineralization of the ore treated. All of the concentrates are shipped to the smelter at Everett.

During the summer of 1901 the Monte Cristo was the only mine in the district that was shipping ore. Other properties were either lying idle or else undergoing little besides assessment work.

O. and B.—Among the other properties which have shipped ore from this district in times past the O. and B. mine should be mentioned as perhaps the most important. This mine was operated until a short time before the railroad washout, when operations ceased, it is understood, on account of certain internal troubles among the owners. The mine is located about one-half mile south of Monte Cristo and has an elevation of some 1,200 feet above the railroad. The ore occurs as a fissure vein in diorite. The outcrop is exceedingly well defined and with the present development shows good continuity of vein. The ore consists mostly of pyrite and arsenopyrite (mispickel) with some galena and zinc blende in a gangue of quartzite. The development to date consists of two drifts about 70 feet apart, vertically, and aggregating about 600 feet in length. Considerable stoping has also been done, mostly from the lower, or main drift. The ore was hand-sorted at the mine and brought down to the railroad by means of a wire rope gravity tram. The tram has been removed since the shut-down of the mine. About twelve car-

loads of ore in all were shipped from this mine to the smelter at Everett.

The ore bodies in the district exist largely as lenticular masses with very little uniformity in strike and dip. It has been found in the development of a number of the properties, that on the flatter pitches in these lenses the mineralization is heavier than where the dip is steeper, but that at the same time the gangue minerals are quite largely disintegrated. At all depths so far reached, the greatest of which exceeds 1,200 feet from the surface, sphalerite (zinc blende) is encountered in quantities averaging about five per cent. of the total mineralization and carrying small amounts of disseminated galena. The pure galena which is found in these veins rarely occurs, however, at a greater depth than 150 feet and then usually accompanied by chalcopyrite in varying quantities. The arsenopyrite or mispickel, which carries the greatest amount of gold values, is found pure at all depths and rarely changes its value in gold; the iron pyrite undoubtedly decreases in value with depth, and in many instances is altered, or replaced by pyrrhotite. Realgar is found at all depths and runs downward from the surface in distinct and narrow chimneys.

The ore shoots themselves, so far as have been shown by the dovelopment work in the Monte Cristo mine, have never been less than 200 feet long (measured along the strike of the vein), and over 700 feet in depth. The ore shoots or pay streaks are readily distinguished on the eroded surface of the outcrop as well as under ground. The arsenopyrite, or white iron as it is locally called, carries values as high as 2½ ounces of gold and 6 or 7 ounces of silver per ton of ore.

Thus far in the development work of the district no faulting to any extent in the ore bodies has been discovered.

SILVER CREEK DISTRICT.

BY WM. S. THYNG.

This district, as the southern extension of the Monte Cristo mineral belt, forms practically a connecting link between the Monte Cristo district on the north, and the Index district on the south. Silver creek has its source in Silver lake on the divide about one and one-half miles southwest of Monte Cristo, and

joins the north fork of the Skykomish river at Galena, nine miles to the southward.

The mines in the district are properly tributary to Index, from which place an excellent wagon road, built and maintained by Snohomish county, follows up the north fork of the Skykomish river ten miles to Galena, the most southerly point of the district. From Galena, all of the different properties located further up on both sides of the creek, are reached by trail. The district received its name from the deposits of silver-lead ore first found in the neighborhood of Galena. As the country above was further prospected and developed, however, large bodies of copper and iron carrying gold were found, so that when the district becomes a producer, the ores shipped will be of a varied character. The district was one of the first discovered in the Cascades, and although it contains a very great number of properties, many of them high grade, the lack of transportation facilities thus far has been the cause of a disproportionately small amount of development work being done. A railroad built from Index into the district would undoubtedly awake the very greatest activity in mining work, and there are a considerable number of properties which could thus at once be placed upon a paying basis.

The country rock of the district is mainly granite, less of the overlying sedimentary rocks being found than at Silverton to the northward. The granite outcrops at a number of points along the entire length of Silver creek. The ore bodies are mostly true fissure veins, which have a general trend a little to the south of east. The ledges or veins are cut and faulted to some extent by probably a later series of fissures, which appear to have a general direction or strike of northeast and southwest. It should be remembered that the mineralization at the head of Silver creek, in the upper part of the district, is principally in copper and iron, the latter appearing chiefly as arsenopyrite, carrying the greater values in gold and silver; the lower part of the district, about and immediately above Galena, contains a large amount of silver-lead ore, although considerable chalcopyrite is still found here carrying some gold but taking second place.

Bonanza.—Possibly the most notable property in the district is that of the Bonanza Mining and Smelting Company, of which

Mr. Peter Chiodo, address Index, Washington, is president and general manager. This property consists of twelve claims, located on the west side of Silver creek, one mile above Mineral city, or about midway between Galena and Monte Cristo. These twelve claims are the Louise, Edison, Rattler, White Rose, Emma, Monarch, Northern Light, Leo, Maggie, Jessie, Juno and Red Rose. Considerable parallelism is found in the ledges covered by these claims, the general strike being a little east of north. Up to August, 1901, the development work aggregated some 1,500 feet; a main crosscut tunnel has been run into the mountain, a distance of over 600 feet and has cut five wide ledges of 60, 40, 15, 10 and 10 feet respectively. At a point about 100 feet beyond its present face this crosscut tunnel is expected to reach the Edison ledge, supposed to be 50 feet wide. Besides this main tunnel a considerable number of prospect tunnels and open cuts have been driven to prove the continuation of the deposits, all on a higher level. The ore is arsenopyrite and chalcopyrite, the former carrying gold. All five ledges contain concentrating ore at many points, which extends from wall to wall. The value of the ore is mostly in gold, which as before mentioned is found chiefly associated with the arsenopyrite. The value of the ore varies from $10 to $15 per ton. The veins are true fissures and the country rock is granite. (C. R. Redding, Index.)

Copper Chief.—The Copper Chief claims, four in number, operated by the Copper Chief Mining Company, are all located upon a ledge extending from a point on the west bank of Silver creek about midway between Galena and Mineral City for 6,000 feet up the mountain side. The ledge strikes about east and west, with a nearly vertical dip. The property was opened up in June, 1899, since which time about $5,000 has been spent in development work. A total of 320 feet of drifting has opened up considerable ore, of which the assays average $24 in gold, silver and copper. The vein is eight feet in width and the ore consists of chalcopyrite, galena and arsenoyyrite, which last carries most of the gold values.

Ontario.—The Ontario group of five claims, lying immediately south of the Copper Chief group, is located upon a ledge which is very nearly parallel to that of the Copper Chief. Work

was begun upon this property in March, 1900. A number of drifts have been run upon the vein at different levels, aggregating in length a little over 400 feet, and it is estimated that about 100 tons of ore are at present on the dump. The ledge is about six feet wide, and dips steeply to the north. The ore is chiefly galena, carrying paying quantities of lead and running high in silver. Some value in gold is also found, but associated chiefly with iron pyrite, which occurs in small quantities. The country rock of this property and also of the Copper Chief is diorite.

During the summer of 1901 a considerable amount of development work was done in the district over and above the necessary assessment work. As a result of a number of important properties having recently changed ownership, the season was one of considerable activity.

INDEX DISTRICT.

By Wm. S. Thyng.

The Index district, of which the town of Index forms the economical center and shipping point, is located in the southern part of Snohomish county. The town is situated at the junction of the north and south forks of the Skykomish river, and may be said to be practically surrounded by its tributary mining properties, although most of the more notable ones lie upon the eastern side; the property of the Bunker Hill and Sullivan Copper Mining company, which lies five miles to the northwest, is the most noteworthy exception to the last statement. Index lies upon the main line of the Great Northern Railway, 69 miles from Seattle, and but from 36 miles from the Everett smelter. The excellent transportation facilities thus enjoyed by the district gives it a signal advantage over the greater number of the mining districts in the Cascades, and indeed, over the greater proportion of the mines in the whole State of Washington.

The Index district is here considered as including all of the properties located along and on both sides of the north fork of the Skykomish river, both below and above Galena. The Silver Creek district, tributary to Index, and described elsewhere, is often considered as including all of the mines between Monte Cristo and Index, located along the courses of both Silver creek and the north fork of the Skykomish, the former stream joining

the latter at Galena, ten miles above Index. On account of the geographlcal features, however, as well as of the marked difference in the character of the ores above and below Galena, the first mentioned division is thought to be more logical and proper.

The mines of the district are located mostly at some little distance from the town, the nearest property of importance being that of the Index Mining company, to be described later. Some of the mines, notably the Ethel and the Sunset, are provided with excellent means of ore transportation to Index, by wagon road and surface tram. The Copper Bell, the property of the Bunker Hill and Sullivan Copper Mining company, has its own connection with the railway, at a point about five miles west of the station at Index. Thus far most of the other properties are reached only by trail, but a considerable number are so located that connection might easily be had with the nearest point upon the railway by means of aerial or wire rope tramways.

The fundamental formation of the district is granite, which is in places crossed by dykes of trap, and at other points is overlaid with what appears to be slate, probably metamorphosed shale, and which is considerably altered and softened at the surface. Small amounts of impure limestone are also found at certain points. So far as development has progressed there appears to be but little uniformity in the trend or direction of the important ore bodies, but by far the greater part of the ledges appear to be fissure veins, cutting the granite formation. The typical ores are chalcopyrite and bornite, the latter being generally found in greater proportion as depth is attained. Along with bornite, in many instances, a considerable amount of chalcocite (copper glance) is found, and in some few instances small quantities of tetrahedrite (gray copper ore) are met with. Silver is found in many instances in connection with the copper and iron and often in considerable amounts; gold is not so usual, however, and is rarely high in value, although in this district some veins have been discovered of what may be fairly considered true gold ore; this gold ore is claimed to be free-milling, although the properties have never been worked. Index is, therefore, to be properly considered a copper mining district, and as such it is, and always has been, exploited.

Ethel.—By reason of its great activity during the past season, that of 1901, and the amount of surface development accom-

plished, the property of the Ethel Copper Mining Company should probably receive first mention in this district. Mr. G. A. Pounder, Seattle, Washington, is president of the company, and Mr. G. C. Clark, Everett, is superintendent. The property is located five and one-half miles northeast of Index, upon Excelsior creek, and but a few hundred feet above the junction of the latter stream with the Skykomish. It is reached from the main county wagon road extending from Index to Galena, by its own wagon road, built mainly of puncheons; this road, which was built during the fall of 1900, at a cost of $2,000, is 2,500 feet long, and has an average and fairly uniform grade of 10 per cent. This road is built up to the headquarters camp, at which point a concentrating mill has just been erected, with a capacity of 100 tons per month. The mine property comprises a group of eight claims, five of which are at present being operated to a greater or less extent. The principal mine workings are located about 2,600 feet northwest of the millsite, or headquarters camp, and at an elevation of 600 feet above the same, and a surface tramway, part of which will operate by gravity, was built at the same time as the mill, for the purpose of bringing down the ore. The mine was opened in October, 1899, since which time a considerable amount of development has been done, the ore-body having been blocked out so that stoping could begin with the completion of the mill. Two main tunnels have been driven 175 feet apart vertically, to reach the vein; the lower tunnel is 460 feet in length, and from it something over 250 feet of drifting has been done upon the vein; a raise has also been pushed up from this drift, a distance of 75 feet; the upper tunnel reaches the vein at a point 213 feet from the surface, and from this tunnel drifting has been carried in both directions, aggregating 500 feet, with a rise 80 feet in height. Besides these two principal openings, about 600 feet of cross cuts have opened up the vein at a number of points. The main ore-body, so far as is shown by the developments to date, appears somewhat lenticular in shape, with an average width of about six feet. It is apparently a fissure vein, and strikes east and west with a vertical dip. The country rock is granite. The ore is chalcopyrite, bornite, and chalcocite (copper glance), the bornite being considerably in excess, particularly in the lower levels, or as depth is reached. The average copper contents of all ore mined are

about 4 per cent., and it has been found thus far that silver occurs in amounts averaging two ounces to each per cent. of copper in the ore. The gangue matter is essentially quartz, but at some points small amounts of calcite are found included in the vein matter. The elevation of the upper tunnel is 1,840 feet above sea level. During the summer of 1901, when a large amount of work was done in surface improvements and developments, about forty-five men were employed, of which number ten were working underground. The surface plant at the headquarters camp includes, besides the concentrating mill, a small air compressor, a very complete saw mill, and the necessary buildings for the accommodation of the men. It is estimated that about 5,000 tons of milling ore are now upon the dump, but no ore has at this date, August, 1901, been shipped.

Sunset.—The Sunset mine, owned and operated by the Sunset Copper Mining Company, is located about six miles northeast of Index on Trout creek. The property is reached from Index as follows: From a point immediately above the town, on the north fork of the Skykomish, the company has built a surface tram which follows up the river, along its east bank, four and nine-tenths miles, to the mouth of Trout creek; thence, crossing Trout creek a gravity surface tram, 1,300 feet long, runs up the side of the mountain; thence, a further surface tram, one mile long, leads to the mine. The property comprises eight claims, located upon three parallel ledges, which strike east and west, and dip steeply to the north. Up to the present time, only one of the three ledges has been developed to any extent. This ledge, which cuts the granite formation, varies in width from 3½ to 16 feet, but no figures of average width could be gained. It has been found that the percentage in copper contents is greatest in the swells or lenses. The ore is essentially chalcopyrite and bornite, the chalcopyrite only appearing upon the outcrop and in the workings near the surface, the bornite coming into evidence as greater depth is reached; the ore carries varying amounts of gold and silver, the percentage of gold being greater in the chalcopyrite, and that of silver in the bornite, rather a remarkable fact. The gangue matter is mostly quartz, showing some decomposition on the outcrop, but becoming very solid as depth is gained. The main tunnel, which is located at an elevation of 1,450 feet above sea level, struck the

vein at a depth of 200 feet, and from that point drifting was carried in both directions, aggregating about 500 feet, and a rise was made to the surface. From these workings about 150 tons of selected ore were shipped to the smelter during the summer of 1899. Besides the main opening just described, a number of short crosscuts, all at higher levels, have been made to the vein, besides some small open cuts.

Copper Bell.—This property, owned by the Bunker Hill and Sullivan Mining Company, is located five miles northwest of Index, and one-half mile from the Great Northern Railway. It consists of nine claims, of which but two, the Copper Bell and the Jumbo, have been developed. The two ledges represented by the developed claims lie parallel with a strike of north fifty-five degrees east. The angle of dip has not as yet been determined since no distinct walls have been found up to the present time, and development work has not as yet been pushed far enough in depth for any accurate measurements to be made. Copper occurs in both ledges in the form of chalcopyrite, which is stated by Mr. Eckerson, the superintendent, to average, so far, 8 per cent. in copper with $2 in silver to the ton, and a trace of gold.

The total underground development to date is about 1,000 feet, most of this work having been done upon the Copper Bell claim. The work upon the Jumbo claim, up to August, 1901, consisted of 90 feet of tunnel, 35 feet of crosscut and 20 feet of shaft. A four-drill, steam-driven, Leyner compressor was installed at the Copper Bell mine in the autumn of 1901, and at that time the intention was to push development work as rapidly as possible.

Index.—The property of the Index Mining Company, of which Mr. Lot Wilbur, of Snohomish, Washington, is president and general manager, consists of five claims located about two miles southeast of Index, and south of the Skykomish river. The mine is reached by a trail built by the company from a point upon the Great Northern Railway about one and one-half miles east of Index. This trail is something over a half a mile in length, and crosses the south fork of the Skykomish river by a suspension bridge, also built by the company. The five claims owned by the company are located upon three distinct ledges,

only one of which has been developed thus far. This ledge strikes northeast and southwest, and dips about one in three to the northwest. It averages about three feet in width, and although all of the vein matter contains some metallic contents, considerable concentration of the ore is found along both walls, forming two distinct pay streaks. The hanging-wall of the ledge is remarkably distinct and regular, and parts readily from the vein matter. The ore consists of bornite and chalcocite (copper glance), the latter occurring in greater amounts as depth is reached.

The development work, up to August, 1901, consisted of three drifts, the lowest having been driven 535 feet, with a shaft 70 feet deep, located about 160 feet from the portal; the second drift, 180 feet (vertically) above the first was 180 feet long, and from this opening a 35-foot raise has been made, 80 feet from the portal; the upper drift, 200 feet above the second, was 243 feet in length. Four car loads of ore have been shipped from these workings, and at the above date a considerable amount of very high grade ore, in sacks, was stored at the mine. No work was done during the summer of 1901. The only surface buildings consist of a small bunk-house, blacksmith shop and sorting shed.

Index-Bornite.—The Index-Bornite Copper Mining Company owns two claims, the Barry and the Hillside, located two and one-half miles east of Index. These claims are both upon one two-foot ledge, carrying bornite. The development work begun in June, 1899, consists of a 50-foot tunnel and a shaft 70 feet deep, and is stated to have cost together with some surface work, about $1,500. Surveys have recently been made for a second tunnel, to tap the ledge at a depth of 200 feet. The ore, besides its copper contents, also carries some silver, three assays made by Mr. C. R. Redding, of Index, showing 6.2, 3.8 and 8.6 ounces respectively of silver per ton; copper assays upon the same samples showing 16.1, 11.1 and 58.9 per cent. respectively.

Index-Independent.—The Index-Independent Mining company owns three claims about five miles southeast of Index. The property lies about one mile south of the railroad, from which it is reached by trail. The three claims, the Independent, Copper King, and Defiance, are all located upon the same vein, which

strikes north six degrees east and stands nearly vertical. Up to the present time the only claim developed is the Independent, upon which about 900 feet of tunneling, drifting and cross-cuting has been done. The ore consists of chalcopyrite, bornite, and chalcocite (copper glance), bornite being in excess; the gangue is mostly quartz, although some calcite is found in places. The country rock is granite. One carload of ore, whose assay value was $98.98 per ton has been shipped. (Ben. Evans, Index.)

Gunn's Peak.—Three and one-half miles northeast of Index lies the Gunn's Peak property, consisting of four claims, owned by the Gunn's Peak Copper Mining company. These claims are located upon three ledges of chalcopyrite, which intersect at a point about 100 feet ahead of the tunnel now being driven. The main ledge, called the Rainbow, runs northeast and southwest, and shows a width varying from one to thirty feet on the outcrop, which has been uncovered at points for a distance of 1,500 feet. The total development to date consists of about 350 feet of tunneling, and 100 feet of cross-cuts. Average samples are stated to assay as follows: Copper, 11.4. per cent.; silver, $1.92; gold, trace. The mine was opened in July, 1899, and the cost of all development work done both underground and on the surface is estimated at $7,000.

Other properties in the Index district which are sufficiently promising to deserve special mention are the North Star, owned by the North Star Mining company; the Forty-seven, owned and managed by Mr. H. McKinnon, Index; the Kitanning Copper Mining Company, Mr. W. C. Rutter, Index, superintendent; the Climax, Copper King, Nonpareil, Trident, and Mammoth.

KING COUNTY.

The broad mineral belt in which are located the mines of Monte Cristo, Silverton, and Index extends southward into the eastern part of King county. Most of the active development work in this county has been done in the territory tributary to the line of the Great Northern railway, on the streams flowing

northward into the south fork of the Skykomish river. Salmon creek, Money creek, Miller river and Foss river are the principal tributaries on which active operations have been carried on, while to the southward across the divides from the headwaters of those streams, many claims have been located on territory which is drained by Tolt river and the various branches of the Snoqualmie. The general physical features are much the same throughout the district. Except along some of the larger river valleys the topography is extremely rugged. Bordering the streams sharp granite peaks rise to a height of from 6,000 to 8,000 feet above the sea, their higher and steeper slopes more or less destitute of timber on account of the frequent and destructive snowslides of winter and early spring. The vein matter is usually of a softer nature than the surrounding country rock and for this reason many of the small lateral streams have chosen the veins for their channels. This has simplified the process of prospecting very greatly and therefore has been a factor in the development of the district. The prevailing country rock is granite, or closely allied rock, with a ramifying system of dykes of many varieties.

In the Miller river district it has been observed that the main joint plains have an approximate east and west direction and cross the main stream almost at right angles. In many of the prospects which have been opened up it is found that the ore has been deposited along these joint planes. The granite for some distance on each side of the vein frequently has some of its minerals replaced by ore so that it is often difficult to locate the exact contact between the vein and the wall rock. It often happens that parallel joints filled with ore are connected with each other by joints running at right angles to the main joints, thus making it very difficult to follow the main ore body. Many of the veins are, in part at least, replacement veins; that is, the ore, besides filling the previously existing fissures, has also more or less impregnated the wall rock on both sides of the vein. This is usually the case where the ore body is found to be more than a few feet wide.

Surface prospecting, in the higher parts of the district, is practically confined to the summer months on account of the deep snows of winter. The country is well watered; innumerable little rivulets fed by the snows and rain come trickling down

the mountain sides and unite to form torrential streams whose potential water power is one of the great resources of the district. This power can be harnessed at comparatively little expense, and it is a foregone conclusion that all the power employed for hoisting, lighting, and other purposes in the mines of this region will be furnished by the streams. Some of the mining companies have already made elaborate plans for utilizing the water power.

Below will be given brief descriptions of a few of the representative mining properties of that portion of King county that has just been described.

Great Republic.—The Great Republic Gold Mining Company has a group of ten claims on Miller river, about one and one-fourth miles from the town of Berlin, on the Great Northern Railway. The company has done about 1,100 feet of tunnel work on the claims and a considerable quantity of ore has been taken out. The principal values are in antimony, with small amounts of gold and silver. A five stamp concentrator has been installed at the town of Berlin for treating the ore.

Mono.—On the east side of Miller river, about two and one-half miles north of the town of Berlin, on the Great Northern Railway, is located the Mono group of eight claims belonging to the Co-operative Mining Syndicate, of Seattle. There is a good wagon road for about a mile, and a trail from this point to the claims. In the development of the property an upper tunnel has been driven for 80 feet, from it a drift 90 feet long has been made, and a winze 52 feet deep has been sunk. A second tunnel 140 feet lower down has been driven for a distance of 250 feet. Still lower down on the mountain side a tunnel has been driven 716 feet long, but the ore body has not been reached. Assays give an average value of about 4 per cent. copper, $1.25 in gold and $1.75 in silver per ton. The chief minerals are chalcopyrite and arsenopyrite.

Metropolitan.—The Metropolitan property is on the west side of Miller river, about nine miles from the Great Northern Railway at Berlin, and joins the Cleopatra property. Active development was only begun in August, 1901, and up to date this has cost about $2,000. The vein is about 16 feet wide at its maximum. The chief values are in gold and silver. (H. J. McIntosh, superintendent.)

Apex.—At the head of the west fork of Money creek, about eight miles southwest of Skykomish, and six miles from the nearest point on the Great Northern Railroad, is situated the Apex mine, upon which considerable work has been done. The vein averages about four feet in width and dips about 22 degrees to the southeast. The average assay value is about $35 in gold and $15 in silver and lead. The principal mineral is arsenopyrite.

This property was first opened in 1893, and up to the present time development work aggregating a cost of $15,000 has been done. Tunnels of a total length of 1,800 feet have been driven, with about 60 feet of stopes. The ore was carried out to the railway by means of pack animals. The smelter returns on the 300 tons of ore which have been shipped aggregate $15,000. Water power is used to operate the ventilating fan which is used in the longest tunnel. (John Maloney, Skykomish.)

Yellow Jacket.—The Yellow Jacket group of ten claims is located on the west side of the east fork of Salmon or Roaring cre and on the south side of the pass leading into the Golden Tunn It is about three and one-half miles from Baring station on t reat Northern Railway. There is a good wagon road for about o third of this distance and the rest of the way is by a trail. Development work was begun on the property in June, 1900, and up to the present time about $9,000 has been expended. The amount of underground workings, including tunnels and crosscuts, is approximately 540 feet. A tunnel has been run along the hanging wall, and crosscuts made every 100 feet. The vein upon which the work has been done has a strike that is nearly east and west and a dip southward at an angle of about 60 degrees. The average assay value or the ore is about $16, nearly all gold, but with a trace of silver. It is in part free milling, but there is some sulphide ore present.

Climax.—The Climax property is about four and one-half miles southwest of Baring, on the Great Northern Railway, and is located on the south end of Little Index mountain. There are eight claims in the group. About 200 feet of tunnel has been driven and a large number of surface cross-cuts made. The principal minerals are bornite and chalcopyrite, carrying silver and copper. The property was first opened in 1897, and since

that time about $4,900 has been expended in development work. No regular shipments have yet been made, but about ten tons of ore have been packed out in order to make a smelter test. This ore assayed from $50 to $100 per ton.

Carmack.—The Carmack Gold and Copper Mining Company has a group of five claims on the south fork of the Snoqualmie river, about 22 miles southeast of the town of North Bend, near the point where the wagon road over Snoqualmie pass crosses the south fork. This property was opened up in 1899 and up to the present time the company has expended about $15,000 in development work. About $3,500 of this has been used for hoisting machinery, buildings and other surface improvements. They have driven 375 feet of tunnel and shafts. Three veins have been worked, the first 12 feet in width, the second two and one-half and the third one foot. Up to date about 20 tons of ore have been shipped, having a total value of $1,200. The values are in gold, silver and lead.

Dutch Miller.—The Dutch Miller property is situated a very short distance west of the main divide of the Cascades. From it the drainage is westward to the middle fork of the Snoqualmie, and northward to Foss river, a tributary of the Skykomish. The outcrop upon which the location was made in 1896 stands at an elevation of a little less than 5,700 feet above sea, and at a distance of about eight miles from the Great Northern Railway at Foss river crossing. The ore vein has a maximum width of eighteen and one-half feet, and strike of north 70 degrees west. The principal mineral is chalcopyrite, and the principal values are in copper and gold. Several small shipments of ore have been made to a smelter, the returns averaging $37.65 per ton after the smelter charges were paid. The development work done consists of a shaft, a tunnel, and a considerable amount of open or quarry work upon the main ore body. The cost of all improvements made upon the property approximates $14,700. (H. P. Fogh, president, Seattle.)

KITTITAS COUNTY.

The southeastern half of Kittitas county lies within the domain of the Columbia lava, which does not contain as far as known any metalliferous deposits. On the other hand the northwestern half of the county, composed of the typical rock formations of the northern Cascades, has within it at several places important ledges of ore. These are found more especially to the southward and westward of Mt. Stuart. On Clealum creek and its several branches the ore veins are easy of access and many of them have reached a fair stage of development. In regard to the mining properties of this region sufficient data is at hand for a description of the iron ores only, which is given in another section of this report. Along Swauk creek, in about the central part of the county, the most important placer gold deposits of the state occur, as far as known, and a brief description of these will now be given.

SWAUK DISTRICT.

As early as 1867 placer gold was discovered on Swauk creek in the vicinity of Liberty, and the region has been a good producer ever since, but like all old placer camps, in its history it has suffered a series of fluctuations. The earlier methods of working the pay gravel were more or less wasteful and inefficient and as newer and more economical methods are being introduced it is found that ground can now be made to pay which formerly had to be passed over. The gold is found in the Pleistocene gravels which constitute the floor of the valley, and which occur also as terraces at varying altitudes above the present stream level. The country rock is sandstone and shale of early Tertiary age, cut by a large number of basaltic dikes. Along the contacts between the dike walls and the sandstone are many brecciated veins from two to six feet wide carrying free gold in a gangue of quartz and calcite. These veins have been worked to a considerable extent and are usually considered as the origin of the placer gold now found along the streams. Good pay gravel has been found on Swauk creek between the mouth of Baker creek and the mouth of First creek. Below First creek fine gold in

small quantities has been found all the way down to the mouth of the Swauk, and recent discoveries of pay gravel in the vicinity of Thorp would seem to inspire the hope that good pay may be found farther down the Swauk than has yet been thought possible. A considerable amount of gold has been taken out of Williams creek, which enters the Swauk at Liberty. All the good pay gravel is found within three or four feet of bed rock and about seventy or eighty feet below the present level of the stream.

The largest nugget yet found in the district was found within the last year on the Elliott claim, on Williams creek, and had a value of $1,100. Another nugget, $1,004 in value, was found on a bench of Swauk creek above the mouth of Baker. Fine gold may be had by panning almost anywhere from the surface downwards, but not in sufficient quantities to pay with the present methods of working. Owing to an insufficient supply of water in the streams sluicing and hydraulicking can only be carried on during the short seasons of high water in fall and spring. Along Swauk creek good pay gravel has been found on bed rock along the terraces bordering the stream, which are sometimes above the level of the present stream bed. On Williams creek and its tributaries shafts must be sunk seventy or eighty feet to bed rock on the old channels and the gravel hoisted to the surface to be washed. Considerable water has been encountered in these workings, sometimes to such an extent as to cause an entire suspension of operations.

The gold found in the stream gravels is all more or less waterworn. Along the talus slopes bordering some of the creeks and gulches fine wire and crystal gold has been found in paying quantities. The gold of Williams creek and its tributaries is supposed to have come from the western slopes of Table mountain, where these streams have their source. On Baker creek and on Swauk, above the mouth of Williams, the gold is probably derived from the Teanaway range on the west. The Williams creek gold is worth more per ounce than is that of Swauk above the mouth of Williams, owing to its smaller percentage of silver. The Baker creek and upper Swauk gold is worth about $13.50 per ounce, while that on Williams creek and its tributaries is worth $14.50 to $15 per ounce.

It is not possible to form even an estimate of the total output of these placers. The early workers did not keep any accurate

record of their output, and the present operators are keeping their information to themselves. At the present time there are several companies and individuals at work on Williams creek and its tributaries and on Swauk creek. Hydraulic operations have been carried on for several years with varying success. There is a very large amount of gravel that has never yet been prospected and which may be reasonably supposed to contain some good pay streaks, so that for a number of years to come we may look for a more or less steady output from this district.

PIERCE COUNTY.

The coal deposits of Pierce county have been known for many years, and the coal mines have now reached an advanced stage of development, contributing very greatly to the wealth and prosperity of the county. In the last few years a vigorous search has been made for metalliferous deposits, and the seeking has not been wholly in vain. A mineral belt has been discovered in the central part of the county, having a general north and south course, and lying between the coal-bearing sandstones on the west and the comparatively recent lava flows of Mount Rainier on the east. This belt is not large, but at different places within it some valuable ledges of metallic minerals have been found. The most important veins of ore as far as known occur on the Carbon river, in the neighborhood of Fairfax, and this district will now be described.

CARBON RIVER DISTRICT.

By Wm. S. Thyng.

The Carbon river district is located in the southeastern part of Pierce county, mostly to the westward and northwestward of Mount Rainier, many of the properties being even upon the lower slopes of that mountain. The district is reached from the town of Fairfax, the terminal of one of the Northern Pacific coal routes. This town, which is located to the west of the principal

properties, will be their natural shipping point when the mines begin to produce ore. Fairfax is forty-two miles from Tacoma by rail. At the present time probably the most important properties in the district are those of the Washington Co-operative Mining Syndicate and of the Montezuma Mining Company. These two companies, in addition to their copper mining interests, are at present developing upon a large scale some extensive coal deposits at Fairfax. The companies are operating in very close harmony and it is their intention to carry on their future mining operations in the district in conjunction.

Surprise.—Probably the most important group of claims in this district is what is known as the Surprise group, located on the east slope of Bald mountain, on Shiplake creek, ten miles by trail northeast of Fairfax. The country, as might be expected in that locality, is extremely rough, the steep slopes of the mountain side giving good facilities for mining operations, it being possible to attain considerable depth without sinking shafts and to avoid the necessity of building expensive pumping plants. Both water power and timber are practically without limit. The Surprise group comprises thirteen claims, twelve of which lie on a magnetic east and west line, while the thirteenth claim, known as the Hog Back, located near the center of the group, lies in a north and south direction. All of the development work to date has been done upon the Surprise claim, the most southeasterly one of the group. Upon this claim three distinct ledges are found. The development aggregates 365 feet of tunneling and drifting, but to the present time only 40 feet of depth has been reached by the main tunnel or drift. The company owning the property has recently acquired a right in a tunnel being driven by the Clipper mine at a vertical distance of 300 feet below, from which tunnel it is proposed to run a cross-cut 360 feet to the main Surprise ledge. By the use of this tunnel a considerable depth of ore may thus be obtained and the work of mining considerably facilitated. The ledges on the Surprise claim carry both chalcopyrite and bornite and with these considerable hornblende is associated. The main ledge upon which all of the work has been done to date, averages between four and five feet in width, with a distinct pay streak of 22 inches; its dip is seventy degrees to the southward and very

uniform. The vein occupies a true fissure in a country rock of syenite, the gangue matter closely resembling this country rock.

Upon the Hog Back claim mentioned above as the only one of the group running north and south, three distinct ledges are found, with chief values in gold. The gold is associated, however, with some small amounts of copper and iron, chiefly chalcopyrite. The elevation of the main tunnel, at what is called the headquarters camp, is 4,160 feet above sea level.

During the summer of 1901 a considerable amount of development work was done upon this property, both underground and in surface improvements. It is the intention of the owners to begin very soon the operation of the property upon a large scale. A small air compressor has been installed at the mouth of the Clipper tunnel for use in driving the above-mentioned crosscut to the Surprise ledge, and it is understood that considerable work has already been done upon this crosscut.

Clipper.—This property is located southeast of and immediately adjoining the Surprise group. Comparatively little work has been done outside of the main tunnel that was mentioned above. Mr. T. H. Wilkins, address Fidelity building, Tacoma, is the chief owner of the property.

Chicago.—The Chicago group of six claims, owned by the Montezuma Mining Company, is located about nine miles from Fairfax at a short distance from the main trail leading to the Surprise mine. This group is then about two miles east of the Surprise. The property has not up to the present time been developed, nothing beyond assessment work having been done. The ore is chalcopyrite, carrying some small amounts of gold and occurs in a fissure vein in diorite.

East Lake.—The East Lake group of six claims, owned by the Washington Co-operative Mining Syndicate, is another property not as yet developed. This group is located about one-half of a mile due east of the Surprise, being between that property and the Chicago. A number of veins are found here, all with a general eastward strike. The ore is chalcopyrite, and the country rock is syenite.

Blue Star.—The Blue Star group, consisting of fourteen claims, is located on Cowcowan creek, a tributary of the Carbon

river, and is six and one-half miles by trail from Fairfax. There are nine known veins or ledges running through these claims, most of them strong and well defined and showing at the outcrops widths varying from eight inches to eight feet. Most of these ledges strike east and west; but one well-defined vein is found running almost due north and south. The ore is chalcopyrite of good appearance, with varying values in both gold and silver. The country rock is gneiss. Comparatively little development work has as yet been done upon this property. A tunnel having a length of about 40 feet has recently been driven, and it is understood that the present owners propose immediate development work.

Tacoma.—This property is located upon the Mowich river, seventeen miles, by pack trail, southeast of Fairfax. Four claims are embraced in the property, owned by the Washington Cooperative Mining Syndicate. Adjoining these claims the Montezuma Mining Company owns a group of five claims. The country is heavily timbered and is provided with an abundance of water power. The main ledge, upon which all development work to date has been done, averages feet in width. It strikes northeast and southwest and dips eighty degrees to the southeast. The outcrop is exceedingly well defined upon the north side of the Mowich river, the mountain rising very abruptly from the creek bed, with practically no vegetation upon it. The ore is chalcopyrite, disseminated throughout the ledge, but as development has progressed a rich streak about three feet in thickness, consisting of chalcopyrite, intimately mixed with calcite, is found along the foot wall. The property was first opened by a drift, along the hanging wall, located about 175 feet above the bed of the creek. This drift has been driven for 200 feet along the vein, with five cross-cuts to the foot wall aggregating 100 feet in length. Late in the summer of 1901 the company installed a small air compressor and is now engaged in driving another drift about 125 feet below the first, working with machine drills. The air compressor is run by water power. The ore is stated to contain from five to thirty-three per cent. in copper, with $2 in gold and $3.50 in silver per ton, or in all having an average value of $60 per ton. This property is admirably located for mining work and may be expected to give a good account of itself in the near

future. No ore except for purposes of experimental treatment has as yet been shipped.

It is the purpose of the Washington Co-operative Mining Syndicate to erect a smelter adjoining its coal property at Fairfax. The company will then be practically self-contained and in a position to smelt its own ore as well as those of the other properties of the district. If the calcite, occuring with the ores along Mowich river, is found to continue in depth, it will be of great importance in forming a flux in smelting.

LEWIS AND SKAMANIA COUNTIES.

ST. HELENS DISTRICT.

St. Helens mining district is located in part in Lewis county, but the main portion of it lies in the northwest corner of Skamania county, north of Mount St. Helens. Spirit lake, which marks the southern boundary of the district, is a body of water five miles long by one or two miles wide, lying about six miles north of the summit of Mount St. Helens. The district is reached either by stage road from Castle Rock to Spirit lake by way of the middle fork of the Toutle river, sometimes known as Green river, or by wagon road and trail from Chehalis by way of the Cowlitz and Cispus rivers. There is another trail up the north fork of Toutle river, which connects with the wagon road at Olson. The district is situated far back in the mountains, but by following the larger valleys no very heavy grades are encountered. The topography of the district is very rugged, resembling in some respects a deeply dissected plateau. Spirit lake lies at an elevation of 3,100 feet above sea level. Mount St. Helens lies immediately to the southward, while to the northward are a number of peaks, the highest one of which is 6,300 feet.

The country to the north and east of Spirit lake is of syenite. A large number of porphyry dikes cut through the syenite, having a general strike of north 25 to 30 degrees west, and dipping westward 60 or 70 degrees. To the northwestward of the

syenite belt the country rock is mostly quartzite, more or less broken up, traversed by a series of veins standing almost perpendicular and whose general strike is northeast and southwest. The veins of the district are often of great width and carry sulphide ores, mostly of copper and iron, with some lead. They are true fissure veins and are found along the contact between the porphyry dikes and the country rock. They can often be traced for considerable distances.

The valleys are heavily timbered with fir, cedar, yellow pine, hemlock and larch. Higher up on the mountain sides the timber gets smaller and more scarce as the timber line is approached. Some of the finest timber in the state is found along the north fork of Toutle river. The small mountain streams furnish an abundance of water-power, which some of the mining companies are planning to utilize as soon as the machinery can be gotten in place.

Discoveries of metalliferous deposits in the district were first made in 1891, and the district was organized on September 22, 1892. It was first known as the Green river district, but owing to confusion arising between it and the Green river coal district of King county, the name was afterwards regularly changed to the St. Helens district.

At the present time the greatest activity in the Spirit lake region is in the mines on Paradise creek, formerly known as Lake Canyon creek. There are several groups of claims belonging to the Mining Corporation, Limited, of Portland, represented by Dr. Henry W. Coe. They are pushing development work on the Sweden, Bronze Monarch, Norway, Young America and other groups. Winter supplies were taken in during the summer of 1901 in order that work might be actively prosecuted during the following winter.

Sweden.—The Sweden group embraces eight claims, located at the mouth of Paradise valley on the north shore of Spirit lake and six miles northwest of Mount St. Helens. Besides smaller veins there is the Paradise lode thirty-three feet in width, which has been traced a distance of three thousand feet. The veins strike north fifteen to thirty degrees west, and dip southwest about seventy-five degrees. A tunnel is being driven along the foot wall of the Paradise lode, and at latest reports had reached a depth of fifty feet. The ore which is being taken out of the

tunnel averages in gold $3.25, silver six ounces, copper nine per cent. There is now on the dump four hundred tons of ore, carrying total values estimated at nine thousand dollars. The company is now installing machinery for a large water power plant which when completed will furnish power for drilling, hauling, lighting, etc.

Bronze Monarch.—Adjoining the Sweden group on the northwest, and upon the same great lead, is the Bronze Monarch group upon which a tunnel is being driven, now three hundred feet in length. There are now about one thousand tons of sulphide ores on the dump ready for treatment which the owners of the property think will average twenty-eight dollars per ton in gold, silver and copper.

Norway.—One thousand feet farther up the mountain from the Bronze Monarch another tunnel is being driven on the same vein on the Norway group, consisting of nine claims. The tunnel is now in a distance of three hundred and fifty feet. The ore is of the same character as that found in the two lower tunnels. The vein here is about twenty-five feet in width. There is about one thousand tons of ore on the dump valued at $28,000.

Young America.—The Young America group consists of five claims adjoining the Norway and Bronze Monarch groups on the northeast. The vein which is now being worked shows in the bed of the creek a width of twelve feet, and can be traced by its outcrop for more than two thousand feet. A tunnel fifty feet long has been driven on the vein.

The Mining Corporation, Limited, owns other claims along the lake front and in the immediate vicinity and this winter (1901-2) are building boats and barges on the lake for transportation of the heavy machinery and ores during the summer of 1902.

Chicago and Yellow Metals.—About two and a half miles northeast of the lake are the Chicago and the Yellow Metals groups, also belonging to Dr. Coe and his associates. The property is reached from Spirit lake by way of the trail over Norway pass, having an elevation of seven hundred and fifty feet above the lake. There are about twenty claims in the two groups, which are located in a general way upon the extension of the

great Norway-Sweden-Denmark vein. This vein has been identified upon the two Octavius claims at the southern end of the group near the bottom of the valley of North Toutle river. A tunnel two hundred feet long has been driven on the Chicago claim and a cross-cut started which will reach the vein at a depth of six hundred feet. The vein at this point is twenty-five feet wide and carries gold, copper and silver which have a maximum value of $60 per ton.

Samson.—The Samson group, sometimes known as the Earl group, consisting of twenty claims, lies four miles northeast of the Chicago and Yellow Metals group, at the base of Goat mountain on North Toutle river. About six hundred feet of tunnel has been driven on the property but only with indifferent success. It has now been taken under a working arrangement by the Mining Corporation, Limited, and this company is driving a prospect tunnel to crosscut small veins which outcrop along Samson creek. At the base of the mountain below the tunnel there is a big ledge or deposit five hundred to a thousand feet wide, all mineralized, but of very low grade, averaging not more than three dollars in gold, silver and copper.

Index.—Two and a half miles to the northwest of the Chicago lies the Index group, which has been owned for many years by the Olson Brothers, but who have recently given a two years' working bond upon the property to the Mining Corporation, Limited. This company is now contracting for half a mile of tunnel work upon this and their other properties for the spring of 1902.

Polar Star.—The Polar Star mine, owned by the Cascadia Mining and Development Company, is located two and a half miles below the Samson group on the north fork of Toutle river near Black Falls. A crosscut tunnel has been driven a distance of eighty feet, revealing a mineralized ledge twelve feet wide carrying copper and iron sulphides, with from six inches to three feet of solid ore. Seventy-five feet from the mouth of the tunnel a drift has been run eighty-four feet and considerable ore taken out. A shaft has also been sunk to a depth of thirty-five feet.

Juanita.—The Juanita property, owned by Messrs. U. M. Lauman, W. A. Reynolds, and David Stewart, is located about

half a mile from the source of the north fork of Toutle river. During the summer of 1901 a tunnel 50 feet long was driven. The vein is six and a half feet wide, and carries values averaging $37 in gold and copper. The strike of the ledge is about north 10 degrees west. About $500 has been spent in development work.

Washington.—This property is situated near Norway pass. It has upon it a well defined fissure vein which makes a good surface showing. The vein strikes nearly north and south and dips about seventy-eight degrees to the westward. A tunnel 50 feet long has been driven upon the ledge.

Ripper and Chief.—The Ripper and Chief properties, belonging to Messrs. McClure and Hostetter of Agate, Washington, are located about four miles northeast of Spirit lake. Both claims are on the same lead, which is about four feet wide, and which carries gold and copper yielding maximum values of about sixty dollars per ton. The chief minerals are galena and chalcopyrite. About one thousand dollars has been spent in development work.

REDUCTION PLANTS IN WASHINGTON.

BY MILNOR ROBERTS.

Washington produces a great variety of ores, requiring many kinds of treatment to extract the values, thus necessitating reduction plants of various types. Examples of nearly every stage of development in the industry may be seen in the state, from the pan, cradle, and sluice of the wandering prospector, to the great custom smelters, handling hundreds of tons of ore daily, with a minimum loss of the metals.

The headings under which the reduction plants will be described are as follows:

I. Smelting works.
II. Chlorination and cyanidation plants.
III. Stamp mills (amalgamation.)
IV. Arrastras.
V. Concentrators and combination plants.

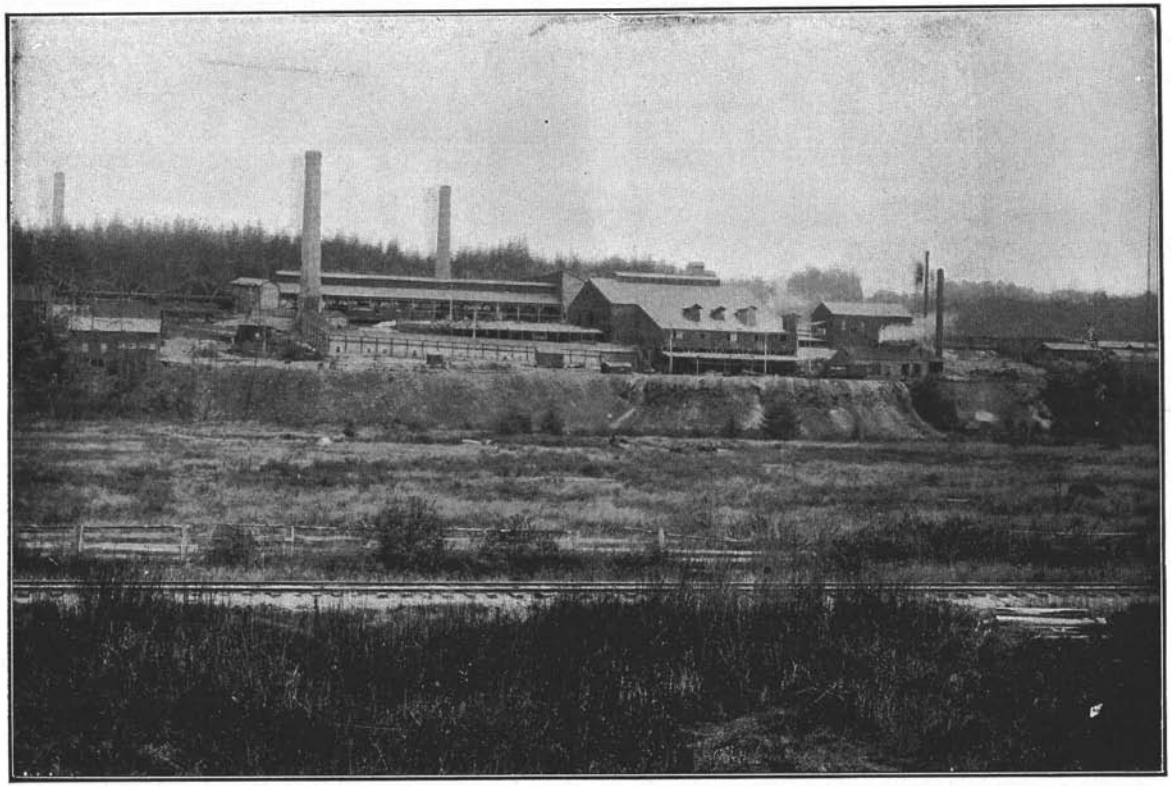
Although no attempt is made to enumerate all of the reduction plants in the state, except the smelters, the following pages contain brief descriptions of some of the most important representatives of the classes mentioned above.

I. SMELTING WORKS.

THE EVERETT SMELTER.

[The Puget Sound Reduction Company.]

Everett, "The City of Smokestacks," owes her title in no small measure to the smelting works of the Puget Sound Reduction Company, which are situated on the outskirts of the city. Although at present no company operating in the Pacific Northwest is fitted to undertake the work of treating crude ores to produce refined gold, silver, and copper, yet the Everett smelter turns out these three metals in a condition that requires only a



THE EVERETT SMELTER, OWNED BY THE PUGET SOUND REDUCTION COMPANY.

short final process—that of parting the dore bars and electrolytic refining of the blister copper—to put all in shape for the market. In addition to this, the company has recently built and is operating the only arsenic plant in the United States.

ORES.—The supply of ore is drawn from very wide sources—from Alaska, South America, and occasional shipments from the Orient, as well as from the states of Montana, Idaho, Oregon, California, Nevada, and British Columbia. This company holds contracts for the output of some of the most important producing mines in the State of Washington; the Cedar Canyon group, the Forty-five, and the Monte Cristo. Other regular shippers are the Rambler, the Hercules, the Bunker Hill and Sullivan, and the North Star. The latter furnishes thirty car loads of ore a month, carrying about 50 per cent. lead. Occasionally a shipment of quite rich ore or concentrates is received, a recent example being several hundred tons of four-hundred-dollar ore from the Tonapah Mining Company, in Nevada.

SAMPLING.—On arrival, the ore is distributed, the oxidized ores being sampled at the sampling works, while the roasting ores are crushed, sampled and handled at the sulphide mill.

Owing to the wide difference in the character of ores treated, the system of hand sampling is still pursued. Sampling of car load lots is usually done by taking a tenth or a fifth of the whole. This sample is run through a Blake crusher and a set of rolls, and is then quartered repeatedly until reduced to 100 pounds. Such a weight can be conveniently crushed to pea size in rolls, and further reduced by quartering to three or four pounds, when it is dried, ground to 80 mesh by a small gyratory crusher, and sent to the assay department. When a small lot of ore arrives, after it is crushed, every tenth shovelful goes to the rolls for sampling.

ROASTING.—All ores which contain sulphur in excess of six per cent. are roasted. Mechanical furnaces are used exclusively, two with double deck, one single deck, and all mechanically fed. To meet the requirements of an increasing business, five Bruckner roasting cylinders of the largest size are being installed at present.

BLAST FURNACES.—Two blast furnaces are of large size, having an area of 36″ x 180″ between tuyeres. No. 1 has 20 tuyeres,

with a cold blast under 20 to 30 ounces pressure per square inch. Furnace No. 3 has an area of 42″x120″. This is now used solely for the purpose of making 50 per cent. copper matte, but is about to be replaced by a furnace of the same size as the regular ore furnaces.

PRODUCTS.—The base bullion from the blast furnaces in the form of bars weighing approximately 100 pounds each, is assayed for gold and silver and sent to the refining department. About 500 bars are charged at one time into a reverberatory: the impurities,—copper, arsenic, antimony, etc.—rise to the surface of the molten lead, and are skimmed off from time to time with perforated ladles. These skimmings are returned to the blast furnace. The remainder is run into a circular zincing kettle 7 feet in diameter and 3½ feet deep, capable of holding 20 tons. A fireplace underneath, with blast connections, serves to keep the temperature of the lead bath just above the melting point of zinc. A weight of zinc equal to three times the amount of silver and gold present in the lead, is now added in the form of broad flat bars, easily melted. Instead of the customary three zincings, here the zinc is added in only two lots, and is mechanically stirred each time by a steam-driven propeller screw with four blades, revolving about 200 times per minute. The kettle is allowed to cool down to a temperature just above the melting point of lead, the gold and silver contents alloy with the zinc, which being lighter, gradually rises to the surface of the lead bath and is skimmed off. The process is finished when cupellation of small samples of the lead shows that the proportion of silver remaining is less than .24 of an ounce per ton.

The skimmings of zinc containing the gold, silver and a little lead, are charged into graphite retorts, along with powdered coke as a reducing agent. Crude oil is being burned under these retorts at the present time. The zinc is oxidized, passes over into a condenser and is there reduced to metallic zinc; this is tapped out from time to time, run into moulds, and sent back to the zincing kettle. Five or six hours time is required for retorting, and the loss of zinc in the whole process is less than 25 per cent. The resulting rich alloy of gold, silver and lead goes to a small concentrating reverberatory, one bar at a

time. As it melts, air is admitted to oxidize the lead to litharge, while the precious metals settle in the bowl of the furnace. The alloy is dipped out and run into bars of 85 pounds weight, containing a very small amount of lead. A tilting furnace is used for the last melting, during which the impurities rise to the surface and are drawn off. The balance is shipped in the form of dore bars to the Seattle Smelting and Refining Company. The dore bars are .990 to .995 fine in gold and silver; by the process of parting, they are separated into fine gold, for deposit at the United States assay office at Seattle, and fine silver, which is shipped by this company to the Orient direct.

The lead from which the values have been extracted by means of zinc, is run into a lower kettle (similar to the first), where it is again heated; after steam has been passed through it, slow cooling follows. A scum forms on the surface, which is removed, and the soft lead is run into 200-pound pigs, commercially pure. That portion made from imported lead ores is re-exported to the Orient, especially to the markets of Japan and China.

Copper matte, from the blast furnaces, is handled by the English reverberatory process, and the product, blister copper, is shipped to electrolytical refineries for segregation. After the elimination of the gold and silver contents, along with other impurities, the refined article is known as electrolytic copper.

The production of commercial arsenic was begun in the year 1901 and is now a regular branch of the company's operations. Several hundred tons have been produced at the rate of about five tons per day. Volatilized arsenic, together with antimony, sulphur, etc., from the roasting of Monte Cristo ore, is condensed in a series of chambers, then charged with one-fourth its weight of very pure coke into a refining reverberatory. The refined material, which is commercially pure, is sold and known as "Standard" arsenic, the only brand produced in the United States. Besides its use in the drug trade, a small amount of arsenic finds its way into many common products, notably paris green, glass, dyes, tanning mixtures, wall paper, paints and metallic alloys. In the year 1900 the United States imported 5,765,559 pounds of this article, mostly from England and Germany, but since then the demand has fallen off considerably.

THE TACOMA SMELTER.

[The Tacoma Smelting Company.]

The plant of the Tacoma Smelting Company is situated on the water front of Tacoma, about three miles west of the main shipping wharves. A length of nearly half a mile of shore land has been purchased by the company, and in the immediate neighborhood of the smelter an area of seven or eight acres of solid ground has been built up in the bay with slag. By means of this newly made land extending out into deep water, ocean vessels may now land at the company's short piers and discharge cargoes of ore within a hundred yards of the furnace doors. A railway track extends from the city along the bay shore through the smelter yards, with switches and bunker-tracks arranged to deliver ore directly into bins or roasters, as may be required. Passenger traffic with Tacoma is carried by the Point Defiance electric line, which runs near the settlement made up of the three hundred employes and their families.

No smelter on our western tide-water need lack material; Mexico, Central America, Peru, Chile, British Columbia, Alaska, and even Japan, all contribute their wealth of mineral, while the nearer districts, Eastern Oregon, various parts of Washington, the Cœur d'Alenes and Montana, assist the smelters by supplying variety in the ores, the prime factor in furnace operations. The Bunker Hill and Sullivan mine, in the Cœur d'Alene district, is daily supplying to this smelter an average of 75 tons of lead-silver concentrates, and the famous Alaska-Treadwell mine, on Douglas island, furnishes the same amount of gold concentrates. From all other sources combined, about 250 tons are received daily, placing the total day's work of the present plant at 400 tons. By the 1st of May, 1902, a large new copper blast furnace will be ready for operation, increasing the smelting capacity by one-half.

Sulphurets are roasted in three double-deck mechanical roasting furnaces, 12 feet wide by 140 feet long, capacity 70 tons in 24 hours. The pattern of these roasters is a very effective local modification of the Brown patent continuous slot and rail system. Instead of the usual fragile tile hanging from the roof-arch, an iron hood (cast in one-piece sections 4 feet long), containing the rail-block and leaving a continuous slot, prevents the heat of the roasting sulphides from injuring the chain and

wheels which convey the rabble-arms. One man on a shift is the whole force required to feed the ore into the upper deck of the roasters at the west end, below the ore-bins and freight cars. When the rabbles have carried the ore to the east end, it drops down to the lower deck and is carried back to the west end, having lost all but 3 per cent. of its sulphur during the 10 or 12 hours required in passage. The Treadwell concentrates need very little fuel to assist in the roasting, so that only the three upper fireplaces along the side are used to start the furnace, the four lower ones remaining cold.

The roasted ores, or concentrates, fall into a horizontal trough, through which runs an endless chain with conveying paddles attached. From this trough the material drops into a similar one at right angles, in which it is carried up a steep slope into a bin, and is then mixed by mechanical churning with two per cent. by weight of Roche Harbor lime. The moist, warm mixture is fed to a White Mineral Press (made by Chisholm, Boyd & White, Chicago), from which it emerges on a conveyor belt, in the form of circular briquettes, four inches in diameter and two inches high. The briquettes fall from the belt into cars with network sides; these cars are run into a flue filled with hot gases from the roasters. Four hours in such an atmosphere bakes the briquettes into cakes sufficiently hard to withstand being charged into blast furnaces without pulverizing.

By the first hand-labor employed since the ore has left the receiving bins, it is now weighed, wheeled to the charging floor, and mixed with other suitable ores, coke, lime-rock, matte and slag. There are four water-jacketed blast furnaces as follows: One small copper furnace 33″x84″, which handles nearly 100 tons a day, one lead furnace of the same size, and two other lead furnaces, 36″x120″, and 36″x160″, these latter treating 130 to 140 tons per day. A cold blast is used under 1.5 to 2 pounds pressure; the tuyeres have an automatic shut-off, to prevent the back-flow of furnace gases when the blast fails—a successful scheme patented by George Klink, one of the local furnacemen. The draft from each furnace is carried down to underground flues connecting with two large stacks, 115 feet high. A copper furnace built on the latest plans by the Allis-Chalmers Company, Chicago, is being erected at the western end of the plant, on the water's edge. Its capacity will be 200 tons, its size 42″x160″,

with steel jacket extending up to the charging door, and blast heated by stove to 800°. This furnace has its own stack, 150 feet in height.

The products at present are:

1. Lead bullion, which is shipped to the Selby Smelting and Lead Works, San Francisco.

2. Copper matte, containing about 60 per cent. copper; this is now being sent to the American Metal Company, New York, but with the new copper furnace, converters will be set up to make blister copper.

3. Matte from the lead furnaces, composition very variable, averaging about 2 to 4 per cent. copper, 10 to 15 per cent. lead and several ounces silver. This is crushed by rolls, roasted in two reverberatories (size 18 x 72 feet), and again fed to the blast.

4. Slag, of which the shells from the slag pots are re-smelted, and the remainder is used only to build ground on the water-front.

In the crushing and sampling department, numerous ore bins and sampling floors are provided. Two sets of crushing rolls, two Blake crushers, jaw-opening 7 by 9 inches and 7 by 11 inches, besides various appliances for hand sampling, crush the crude ore and matte, and reduce to a minimum the labor of preparing samples for assay. Mr. Peter Daly has charge of the assay department, where wet and fire assaying, and electrolytic analyses are conducted.

The Snoqualmie Falls Power Company supplies a current of 22,000 volts, which is transformed at the smelter to 440 volts, and is developed to an aggregate of 460 h. p. by four motors. A fifth motor of 75 h. p. will come into use hereafter to run the blast blower for the new copper furnace. The company's large steam plant has been kept intact as a precautionary measure. At present, however, steam is kept up in only one boiler, for use when the electric current fails. So many repairs are constantly needed about a smelter that it is almost a necessity to have a foundry at hand, as is shown by the amount of work done by the small cupola set up here. Over 350 patterns have been turned out by the local pattern-maker. The machine shop is fitted with a lathe, drill-press, planer, bolt-cutter, shaper, etc.

Under the careful and progressive superintendence of Mr. F. W. Clark, experiments are constantly being tried in quick

methods of handling the ores and slag, and in improving the furnace practice. Apparently, it is the aim of the management to maintain an establishment that shall be independent, so far as possible, of outside labor and sources of supply. Whenever practicable, the company prepares material of all sorts on its own ground, thereby avoiding delay in transportation and the losses due to market dealings.

THE NORTHPORT SMELTER.

[Northport Smelting and Refining Company, Limited.]

BY WILLIAM S. THYNG.

The Northport smelter, employing between 400 and 450 men, is operated in close conjunction with the mines of the British-America Corporation, at Rossland, British Columbia. In fact the Northport plant is now run exclusively upon the ore from the Le Roi and the Le Roi No. 2 mines, in Rossland. This ore is brought from mines to smelter, 17 miles, over the Red Mountain branch of the Spokane Falls & Northern Railway.

The smelter is located upon the east bank of the Columbia river, just above the town of Northport, in the northern part of Stevens county. The plant, under the management of Mr. Oscar Szontagh, has recently undergone a number of radical changes. It has been found that the ore may be smelted and a matte of the required grade for shipment produced without roasting, or calcining, the matte resulting from the first fusion, a practice pursued by the former management, and one which had been in vogue, in fact, since the smelter was built. When Mr. Szontagh was appointed general manager, in November, 1901, a new double-decked, straight line calcining furnace had just been completed, to be used in addition to the two single-decked calciners formerly employed. This new furnace, however, has not been used, and it seems probable that it will not be necessary, at least as long as Rossland ores alone are treated at the plant. These three calcining furnaces therefore lie idle at the present time.

Another important change over former practise was made during the spring and summer of 1901, when the double battery of stalls, in which a considerable portion of the ore was roasted, was torn out, with the intention of extending the roast yard and using longer heaps, in which form all the ore is now roasted.

The area which was covered by the stalls has not yet been utilized, however, it having been found that the original roast yard gives ample capacity for the present output of the plant.

All Le Roi ore is broken and sampled before leaving the mine at Rossland, and comes down ready for roasting. The ore from the Le Roi No. 2, however, is sampled at the smelter. As was before stated, all roasting is now done in heaps, the heaps measuring 350 feet long, 82 feet wide at the bottom, and 18 feet high. The raw ore, when piled, averages from 8 to 9 per cent. in sulphur, which percentage is brought down to between 3 and 4 in the roasting. In the operation, each ton of ore is tied up for from 30 to 40 days; this makes allowance for time used in piling and tearing down, the latter being generally begun before roasting is completed in the center of the heap. A total of about .02 cord of wood per ton of ore is used.

The company at present operates five blast furnaces, with a total daily capacity for 1,100 tons of ore; three of these furnaces measure 38 inches by 120 inches, and the other two, 42 inches by 160 inches, at the tuyeres. A sixth furnace, to have a daily capacity of 280 tons, is now on the ground, and is to be erected shortly; this last, unlike those already in operation, will be a boshed furnace.

It is aimed to produce a matte of the required grade for shipment, in two fusions, but three are sometimes found necessary. The ore treated averages about 2 per cent. in copper and 24 per cent. in iron. Matte from the first fusion contains generally from 25 to 30 per cent. copper and from 8 to 10 ounces of gold; the sulphur contents running about 25 per cent. All matte is shipped east for refining, the requirements in this shipping matte being: Copper, 40 per cent., or over; gold, 15 oz., or over; this grade matte also runs about 25 per cent. in sulphur. The amount of silver in the Le Roi ores, and consequently the amount in the final matte produced, varies rather widely, but probably from 26 to 30 oz. will represent a fair average in the matte.

All matte from the first fusion is cooled in spilling plates, to facilitate rapid cooling and its subsequent breaking up for charging into the furnace for second fusion; these spilling plates, which have been introduced here by Mr. Szontagh, are of cast iron, and measure 24 inches by 48 inches, by 2 inches in depth,

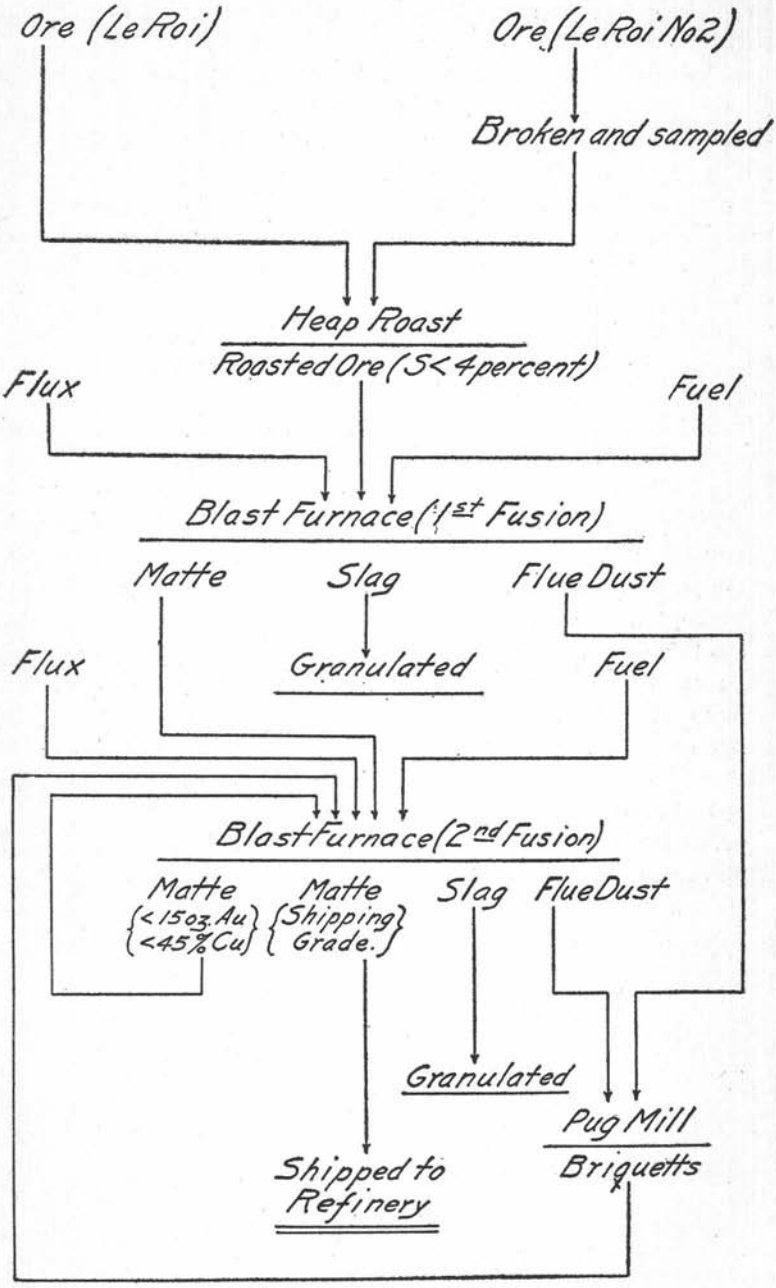
each plate thus having the same capacity as an ordinary matte pot.

The dust chamber, which is 428 feet long, with a cross-section area of 110 square feet, is designed for easy and rapid discharge through side gates. With the plant running at its full daily capacity of 1,100 tons, about 15 tons of flue dust are caught and removed each day. This flue dust is briquetted immediately, using lime as a binding material, and is again put through the blast furnace. The stack at the end of the dust chamber is 182 feet high and 10 feet in square section.

All limestone used for flux is obtained from a quarry owned by the company, and located about four miles south of Northport, on the line of the Spokane Falls & Northern Railway. This limestone is unusually pure and free from silica. The coke used in the blast furnaces is obtained partly from the western part of Washington, and partly from the eastern states.

No figures have been given by the management as to the amount of matte shipped daily, or monthly, but assuming the average copper contents of the ore treated, as 1.8 per cent., and knowing the total daily capacity of the furnaces for ore to be 1,100 tons, we have: $1100 \times .018 = 19.80$ tons copper treated per day; 19.80 tons of copper contained in a 45 per cent. matte, which may be taken as about the average grade, are equivalent to about 44 tons of matte, which is perhaps not far from the daily output. These figures are, of course, very general, and may be taken only as representing an estimate.

A resume of the different processes employed in the transition from ore to shipping matte, follows in graphical form:


Ore (Le Roi)
Ore (Le Roi No2)
Broken and sampled
Heap Roast
Roasted Ore (S< 4 percent)
Flux
Fuel
Blast Furnace (1st Fusion)
Matte
Slag
Flue Dust
Flux
Granulated
Fuel
Blast Furnace (2nd Fusion)
Matte
<15 oz. Au
<45% Cu
Matte
Shipping
Grade.
Slag
Flue Dust
Granulated
Pug Mill
Briquetts
Shipped to
Refinery

THE REPUBLIC MILL. OWNED BY THE REPUBLIC REDUCTION COMPANY.

II. CHLORINATION AND CYANIDATION PLANTS.

THE REPUBLIC MILL.

[The Republic Reduction Company.]

At the mouth of tunnel No. 4 of the Republic mine, is situated the sampling mill of the Republic Reduction Company, which handles custom ores for the district in general, as well as the ore from the Republic mine. The reduction plant is located higher up the hill-slope, on account of lack of suitable space below. It is therefore necessary to hoist all the ore after crushing and sampling, and this is done by means of a self-dumping skip running on an inclined surface tramway 400 feet long, operated by a small friction hoist located at the foot of the tramway in the sampling mill. One of the main advantages in having the crushing and sampling performed in a building built for that purpose only, is the avoidance of placing heavy machinery in the roasting and cyanide plant, and the absence of dust there.

Receiving bins with a capacity of 500 tons occupy the top level of the sampling mill. From these bins the ore goes direct to a No. 5 Gates crusher and is carried by elevator No. 1 to a revolving trommel. The screened material goes to a set of rolls, 15 by 36 inches, high grade Gates, and the ore that fails to pass through the trommel is returned to another Gates crusher, style H, from which it falls again into elevator No. 1. Ore that has passed the rolls is ready for the Brunton automatic sampler. The main portion goes to one of the storage bins for sampled ore on the lowest level of the mill, while the sample portion goes by way of an elevator to small crushing rolls, and from thence to two more sampling machines, the final resulting sample being about one per cent. of the original weight. This small sample is treated by hand in the sampling room and reduced by quartering and small crushing machinery to a size and fineness suitable for assaying.

A tramway running under the lower storage bins serves to carry the sampled ore to the inclined skipway mentioned above. The skips dump their load automatically into the 500-ton storage bins on the top floor of the reduction mill. The latter is built

on seven different levels, vertical range 65 feet, and horizontal area 280 by 315 feet. Two revolving dryers, 5 by 26 feet, occupy the second level, while the main engine room and boiler house is situated on the north side of this section. Six return tubular boilers, 60 inches by 16 feet, with a combined capacity of 500 h. p., furnish steam for a 180 h. p. Lane and Bodley Corliss engine for driving the fine crushing machinery and dryers, an air compressor and a 40 h. p. engine and generator for electric lighting. An engine of 80 h. p. in the sampling department and three others elsewhere about the works complete the power plant.

On the fourth level stand the fine crushers, two sets of 15 by 36-inch rolls, two sets of 15 by 26-inch rolls, three 8-foot ball mills, and the usual number of elevators, screens, etc. The fine ore goes to the ore bins and roasters on the fifth level. Three straight-line roasting furnaces, hearths 12 feet by 100, capacity 75 tons apiece daily, prepare the ore for the 16 leaching tanks on the sixth level.

The roasted ore is stored in bins with 300 tons capacity, and is drawn from them into cars running above the leaching tanks. Each tank is 6½ feet deep, 22 feet square, and has a capacity of 110 tons of ore. Three tanks, in which the fresh solution is mixed and standardized, are located above the leaching tanks.

On the next level are the precipitating tanks where the values are recovered from the solutions. Two tanks 10 feet in diameter and 14 feet deep hold the gold solutions, the two precipitating tanks are 12 feet wide by 8 feet deep, and the filter presses are four in number with 36 sections apiece. The solutions that have been used run into a 24-foot sump tank 5 feet deep. Three steam pumps handle the solutions.

The refining of the precipitates is performed on the lowest level of the mill. Steel tanks, filters, and furnaces are provided for getting rid of the bases and producing bars of the precious metals. From the solution tanks, the tailings are flushed or shoveled out through gates in the bottom of the tanks.

The values are precipitated by means of zinc dust (brought from the flues of European zinc works). The solution is first agitated by introducing a current of compressed air, and on the addition of the zinc, precipitation takes place almost immediately. The excess of zinc and impurities is dissolved out by

sulphuric acid. The precipitate is passed through filter presses and the caked mass dried and fused in the ordinary way, the resulting gold averaging .900 fine.

The original capacity of the plant was 200 tons per day, but it was arranged so that it could be enlarged indefinitely without interfering with the steady working. After the completion of the plant six Griffin mills were installed. The buildings (which are of wood, whitewashed inside and painted outside, with roofs of corrugated iron), include an assay office, laboratory, storerooms, blacksmith and machine shops. A large brick flue 435 feet long leads up to a steel stack 112 feet high near the top level of the mill. The wood used for fuel in the furnaces is brought in by a five mile flume. The main sources of ore supply have been the Ben Hur, Lone Pine-Surprise, San Poil and Blacktail mines, besides tailings from the old Pelatan-Clerici mill of the district.

THE MOUNTAIN LION MILL.

[The Mountain Lion Gold Mining Company.]

Automatic handling of the ore is one of the leading features of the Mountain Lion Mill at Republic. A self-dumping skip, operated by electricity, hoists the ore in the main shaft of the mine. Ore that fails to pass the grizzlies drops into a Blake crusher with a jaw 9 by 15 inches, then into a bin of 200 tons capacity. An automatic tramway 400 feet long carries the ore from the mine to the mill, where it is received in a bin of 500 tons capacity.

The batteries consist of 20 stamps of 1,200 pounds weight, which drop 8½ inches at the rate of 100 per minute; their rate of crushing is 100 tons per day to pass a 40 mesh screen. The coarse pulp, after running over amalgamated copper plates, is fed into 5-foot Huntington mills, one mill receiving the pulp from a battery of 5 stamps. When crushed to 80 mesh, it passes into steel leaching tanks, five in number, where it is agitated by propeller blades and leached for seven hours with cyanide solution, strength .5 per cent. The leached pulp passes from the leaching tanks into eight filtering tanks, each 6 feet deep and 24 feet in diameter. Further treatment is effected here by a solution of half the original strength, or .25 per cent., varying with the character of the ore, and requiring 24 hours time. In order to save cyanide solution, after the rich solution

Department of Geology
Southern Illinois University
Carbondale, Illinois 62901

has been drawn off from the filter tanks, the tailings are leached again; this solution is run into two sump tanks, and then back to two storage tanks where it is standardized again. Precipitation by means of zinc shavings takes place in two zinc boxes with sixteen compartments each.

The power plant consists of three Fraser and Chalmers boilers of 100 h. p., a Bates-Corliss and an Ide engine, 125 h. p. each, a 3-phase generator, 125 h. p., built by the General Electric Company, and two motors of 20 and 75 h. p. The surrounding region furnishes wood in abundance, and the water supply is drawn from Mud Lake, 2,000 feet south of the mill. Both mine and mill are lighted by electricity, which is also the power used for pumping, hoisting and milling.

III. STAMP MILLS (AMALGAMATION).

THE BLEWETT MILL.

[Chelan Mining Company.]

Blewett, in the center of the Peshastin mining district of Chelan county, is reached by wagon road from Leavenworth on the Great Northern Railway, 16 miles, or from Clealum on the Northern Pacific Railway, 32 miles distant. The Chelan Mining Company, of Seattle, now owns the stamp mill located at the mouth of Culver canyon, commonly known as the Blewett Mill, formerly owned by the Culver Company, and later by the Blewett Gold Mining Company. The ores treated are from the company's mines, as well as custom ores from the district at large.

The batteries consist of four sets of five stamps each, with Fraser and Chalmers automatic feeders, and double discharge, only single being used. 950 pound stamps, with chrome steel shoes and dies, drop 6½ inches at the rate of 90 per minute. The pulp is screened through diagonal slot screens, equivalent to 50 mesh, and falls on copper plates four feet wide and ten feet long, sloping 1½ inches per foot. The lower plates are silvered, 14 feet long, 4 feet wide, and falling two inches per

foot. Four Union tables receive the pulp, after which the slimes pass over canvas tables with a three inch fall. The canvas is swept four times in twenty-four hours, and the fines are saved in settling boxes. Under former management, the tailings carried values of several dollars, which ran into the creek. Outside parties becoming aware of this built a small cyanide plant with two tanks, having a capacity of about 10 tons per day, and thereby recovered a considerable amount of fine gold. The plant is no longer in use.

Wood is burned under two boilers (4 by 12 feet, used alternately), which furnish steam for a Corliss engine of 50 h. p. A flume 500 feet long brings water from the creek to a tank set 20 feet above the level of the stamp battery. A Hallidie aerial tramway with buckets holding 250 pounds each, carries the ore from the mine 4,000 feet distant and dumps it into two receiving bins of 400 tons capacity. The usual system prevails in regard to the different floors of the mill, the order here being, crusher, feeding bin, battery, and concentrating floors. Mention should also be made of the assay office and sampling room.

EUREKA MILL.

[Eureka Mining Company.]

The Eureka Mill is located just below the mine of the same name, in the Slate creek district, on the west side of the Cascade range, about 15 miles south of the international boundary.

The ore is brought from the mine by a tramway worked by gravity, and is crushed to 40 mesh by 10 stamps dropping 7 inches 104 times per minute. The free gold is saved on amalgamated copper plates, while the sulphides, with small amounts of sylvanite, are concentrated on two Wilfley tables. The slimes are treated on canvas blanket tables.

MAMMOTH MILL.

[Mammoth Gold Mining Company.]

This five-stamp mill, located at Barron, receives ore from the mine by an aerial tramway. A partial saving of values has been effected by amalgamation and concentration, but other machinery better suited to the ore will be required.

STAMP MILLS IN THE PALMER MOUNTAIN DISTRICT.

Black Bear Mill, five stamps with concentrator, run by water-power. Located at Loomis, to treat ore from the Black Bear mine, two miles distant on Palmer mountain.

Ivanhoe Mill, at mine on Palmer mountain. A ten-ton mill with Dodge pulverizer, amalgamating plates, concentrator and slime tables.

At Triune mine, near Golden, a ten-stamp mill with four Frue vanners, operated by steam power.

On Wannicutt lake, a ten-stamp mill which treats ore from the Spokane mine, one mile distant.

MT. BAKER MILL.

[Mount Baker Mining Company.]

A ten-stamp mill is being completed this spring, 1902, to treat ore from the Lone Jack ledge. As the mine is at an elevation of 6,000 feet, an aerial tramway will probably be found the cheapest method of hauling to the mill, 4000 feet lower. It is expected that amalgamation will give a high percentage of the assay value of the ore, but there are tellurides present, which will be saved on concentrating tables.

GREAT EXCELSIOR MILL.

[The Great Excelsior Mining Company.]

The present equipment comprises a five-stamp battery and a Parker rotary four-stamp mill; 50 additional stamps have been ordered, along with New Standard concentrating tables.

IV. ARRASTRAS.

Throughout Washington and especially in the Cascade range, in regions remote from the railway, the traveler frequently finds arrastras, sometimes in operation, more often idle, and many of them out of repair. Without doubt two reasons for the popularity of the arrastra, particularly for use in prospecting this region, are the abundance of suitable rock which can easily be trimmed into shape for lining the pit and making drags that

wear well, and the presence of numerous streams which furnish convenient water power. With increase of depth in the mines and lack of free-milling ores, the arrastras are abandoned.

SWAUK CREEK DISTRICT.

Several arrastras are found on Swauk creek near Liberty. Water power is used exclusively. In one case a large overshot wheel runs two arrastras and a two-stamp mill. Usually horizontal wheels are used, geared to a revolving center post with arms which drag four grinding blocks, the ore being fed in egg-size.

PESHASTIN DISTRICT.

On Peshastin creek, near Blewett, three arrastras have been in recent use, and the remains of several old ones indicate that prospects in the district have been tested by this method for many years. Whether other forms of treatment would yield greater values from the same ores is still an open question.

The present arrastras are from three to twelve feet in diameter and about three feet deep, built of the most suitable pieces of stone to be found at hand. The favorite source of power is a horizontal water-wheel, run by the force of impact of a stream of water shooting out several feet from the end of a flume. The wheels are from sixteen to twenty-four feet in diameter, and sometimes attain a speed of eighteen revolutions per minute. The drag-blocks consist of granite boulders (weighing half a ton or more when new), which are fastened to the revolving arms of the mill by means of chains. From one to three thousand pounds per day is the crushing capacity.

SLATE CREEK DISTRICT.

The form of the arrastras on Slate creek does not differ greatly from that used elsewhere. Many of them have been running intermittently from the earliest days of the district.

IV. CONCENTRATORS AND COMBINATION PLANTS.

THE WAUCONDA MILL.

[Wauconda Gold Mining Company.]

BY A. J. EDWARDS.

Prominent among the mills employing combination processes is that of the Wauconda Gold Mining Company, whose main property is situated at the town of Wauconda, Okanogan county. A sixty-ton mill, to treat the Wauconda ores by the Rossman process of pan amalgamation, was erected during the fall of 1901, under the superintendence of officers of the Rossman Company, of Minneapolis. The mode of treatment consists of coarse crushing by stamps, further reduction in a pulverizer, coarse concentration, and pan amalgamation of concentrates.

The ore is crushed by a Gates gyratory crusher in the sampling mill at the tunnel mouth, and is conveyed by tramway to the ore bins at the mill, 800 feet distant. The main mill building is 50 feet in width by 70 feet in length, built in six benches. On the top bench is the engine and boiler plant (capable of furnishing 70 h. p.), and also the dynamo for lighting the company's buildings and the mine. The next bench contains the batteries—a five-stamp battery of latest design from the Allis-Chalmers Company, and a two-stamp battery, both automatically fed by Challenge feeders. The third and fourth benches contain the two revolving pulverizers, two concentrators, and ten amalgamation pans, all of the Rossman type. Three Rossman settlers and the tailings sluices occupy the two lower benches. Advantage is taken of a convenient hill slope to permit of using gravity to a great extent, and unlimited ground is left for tailings.

The ore passes through batteries and the pulverizers, and from thence into the concentrating pans. These, like much of the other machinery, are of the Rossman design and introduce new features for the work. It is sufficient to say of them that while the pulp is held suspended in water in the pans, the lighter portion, including the worthless gangue, is allowed to flow away and the heavier portions are retained. This method does not appear to allow of an extremely close concentration, the Wauconda

ores being concentrated only from six or eight to one, but it is an exceedingly simple and inexpensive operation. The percentage of values remaining in the tailings is low, and the process accomplishes very effectually the object of reducing the quantity of pulp which the pan must treat, and consequently increases the capacity of the mill to a considerable extent.

After this operation the concentrated pulp is elevated by a Frenier pump to hoppers, where the excess water is removed and returned for use again in the batteries, while the thickened pulp is charged from the hoppers with the chemicals and mercury into the amalgamating pans. The object of the chemicals is to assist in freeing the gold from any substance rendering it refractory, so that it will readily amalgamate. The Rossman pans differ from other pans in various particulars of form, and these differences effect a radical increase of efficiency. The pans are somewhat smaller than usual and are charged with from 250 to 350 pounds of pulp at once. The time employed is only about 30 minutes for a charge, so that the ability to thoroughly amalgamate in such a short time more than compensates for the small charge. When amalgamation in the pans is complete, the pulp passes to the settlers, where the mercury amalgam is separated and the tailings sent to the dump. The mercury is retorted as usual. Every effort has been made in designing the mill to make the operating as nearly automatic as possible, so that the labor required will be reduced to a minimum.

The sampling mill at the tunnel mouth contains a machine shop which is fitted with a large iron lathe, power drill, emery wheels, wood saws and blacksmith forge. A Root blower, for ventilating the mine, and a Gates ore crusher are also in this building. The sampling mill portion is fitted with a complete set of Rossman machines, including rolls, pulverizer, amalgamating pans and settler. These are similar in design to those in the big mill but of reduced size, the diameter of the pans being 24 inches, while the regular pans are 36 inches. Charges of 50 to 70 pounds of ore can be treated in these pans, making it possible to carry out complete tests of the ore, both as to values and methods of treating, as the work progresses.

Since the sampling mill was opened, in October 1901, a number of large samples of Wauconda ore have been worked, usually 50 pounds at a time. During the early part of December, the

work on the big mill was so far advanced that a good sized preliminary run was made. It is expected that the mill will be in continuous operation by the beginning of spring. The work which the two mills have already done makes it possible, however, to speak with considerable certainty as to the adaptability of the method selected for treating the Wauconda ore and its success in so doing. The numerous 50 pound samples worked in the sampling mill gave values of from $10 to $18 per ton and the values remaining in the tailings ranged from only fifty cents to $1 per ton, indicating a very uniform saving of about 95 per cent. The tailings of the preliminary run in the big mill indicated a similar large per cent. of recovery. The average value of the ore as shown by all these samples taken from the different drifts in the mine and from general averages of the dump was about $12. The results from treating the concentrates in the amalgamating pans were equally satisfactory, showing that a most efficient system has been chosen.

The low cost of treatment by this method, about $1 in excess of cost of free milling under similar conditions, is another important consideration. Much fuller information will of course be available as to the efficiency with which the Wauconda ore can be treated after the mill has been in operation for a month or so.

GOLDEN ZONE CONCENTRATOR.

[Golden Zone Mining Company.]

The concentrating and amalgamating plant of the Golden Zone Mining Company is situated in the Palmer Mountain district, sixteen miles north of Loomis, and three miles south of the British Columbia line.

Ore is brought from the mine by a wire ropeway of 1,100 feet single span, and an incline 600 feet long. Power is furnished by a 50 h. p. engine and boiler. The ore is crushed in two sets of Cornish rolls and a Huntington mill, and amalgamated on copper plates arranged in three steps. A single hydraulic classifier and three Wilfley tables reduce thirty tons of ore per day to two tons of concentrates, carrying about $200 in gold. Since the mill began work, early in 1900, about 100,000 tons of ore have been handled. The concentrates are shipped to the smelting works at Tacoma and Everett.

RUBY CONCENTRATOR.

[Washington Reduction Company.]

Although no work has been done in the line of silver-lead concentrating in the district about Ruby since the fall of silver in 1893, the complete concentrating plant at Ruby deserves mention on account of the work done before that time.

An aerial tramway, run by gravity, brought ore from the First Thought mine, one mile distant. Beginning at the mine, the tramway runs up over a ridge, then descends by a long slope to the mill, the relative grades being such that the greater weight of the loaded buckets on the mill-side served to keep the endless cable in motion. Electricity, generated by water power, ran the milling machinery, which consists of two rock crushers, two Dodge pulverizers with screens, and eight Frue vanners. The slimes were run over canvas strakes. During the few months that the mill was in operation it produced $40,000 in concentrates.

OLD DOMINION CONCENTRATOR.

[Old Dominion Mining Company.]

Another silver-lead mill which has been lying idle for some time, is that of the Old Dominion mine, one of the best developed and most productive mines in the Colville district, having yielded about $2,000,000 in silver, lead and gold.

The mine tramways from two different levels are carried out by trestlework over the edge of a smooth hill slope below the tunnel mouth. The mine ore is dumped into a steep chute 80 feet long leading down to the crushing floor of the mill. After passing over grizzlies and undergoing preliminary crushing and sizing in rolls, the ore travels by gravity to the concentrating floors where the jigs and slime tables are placed. The mill is run by steam power, with wood fuel.