Geology and Mineral Deposits of the Unuk River-Salmon River-Anyox Area

By Edward W. Grove

Bulletin 63
Frontispiece
Betty Creek strata, Bear River Ridge, looking east to Mount Otter in the Cambria Range.
GEOLOGY AND MINERAL DEPOSITS
OF THE
UNUK RIVER-SALMON RIVER-ANYOX AREA

FOREWORD

The regional geologic study presented in this bulletin began as a mineral deposit study suggested by the Stewart Village Council in the hope of stimulating the local mineral based economy. Bulletin 58, Geology and Mineral Deposits of the Stewart Area, 1971, was the first of a projected series of reports on the area.

Work at the Granduc copper-silver deposit northwest of Stewart culminated in mine production in late 1970. Along with the opening of Granduc, the Stewart economy surged with the completion of the Cassiar-Stewart Highway and the road link to Terrace and outside British Columbia.

Stewart has lost the marine link to Vancouver and 'boat days' but now has a paved airport, a paved highway system to the outside, and paved roads in town. Asbestos shipments from Cassiar through Stewart and tourism have provided new work and the current gold-silver boom has revived the local mining industry.

At the end of the exploration phase at Granduc in 1965, Dr. G. W. H. Norman (Newmont) suggested to the writer that the Stewart study be extended to include the Granduc area. Newmont's field notes, maps, and samples were made available and the regional study started in 1966 in the Bowser River and South Unuk area. The obvious continuity of strata through the region from the Iskut River to Alice Arm indicated the need to include the whole area in a single comprehensive study. The fieldwork was completed in 1970 and the first draft of this report was completed in 1973.

Two other regional studies adjacent to and relevant to this study have been published prior to the release of this bulletin. These include geology of the Hyder area, along the west margin of the Portland Canal, mapped by J. G. Smith (United States Geological Survey, Bull. 1425, 1977); a study of porphyry deposits of west-central British Columbia by N. C. Carter (B.C. Ministry of Energy, Mines and Petroleum Resources, Bull. 64, 1981). A variety of reports, including several theses, concerning various mineral deposits in the general area have also been completed in recent years.

One major inconsistency in stratigraphic nomenclature has not been resolved. The terms Bowser Group and Bowser Assemblage used in older publications to designate marine sediments of various ages have not been continued in this bulletin. The term Nass Formation, introduced by R. G. McConnell (1913), has been used within the Hazelton Group to refer to Upper Jurassic units in the general report area, including Bowser Lake. Tipper and Richards (Geological Survey of Canada, Bull. 270, 1976) introduced the new term Bowser Lake Group to identify Late Jurassic-Early Cretaceous marine sediments in the Hazelton area without defining a type section at Bowser Lake.

The complex Silbak Premier gold-silver deposits and others of the same type are still controversial and have gone through the classification cycle from hydrothermal related to plutons, to remobilized massive sulphide deposits, to the revised plutonic-volcanic type with complex hot spring associations. Significantly, work still persists on deposits found by prospectors 50 to 80 years ago. New deposits found in the general area are the molybdenum-gold-silver types found in acidic Tertiary stocks or plugs localized along the mineral zone shown on Figure 17 in this bulletin. These were all found by prospectors checking new exposures revealed by recent glacial ablation at Bitter Creek and at the head of Surprise Creek (Falconbridge). Recent glacial ablation has also been largely responsible for the new gold-silver developments along the Iskut River within the extension of the Lower Jurassic Unuk River Formation volcanic and volcanioclastic members.
ADDITIONAL SELECTED REFERENCES


This report represents new data on the geology of this region, much of which is relevant to the tectonic evolution of the Western Cordillera and to the concepts of metallogenesis in northwestern British Columbia. The study area includes part of the contact of the eastern Coast Plutonic Complex with the west-central margin of the successor Bowser Basin. Sedimentary, volcanic, and metamorphic rocks bordering the Coast Plutonic Complex range in age from Paleozoic to Quaternary. Geologically, geographically, and economically the country rocks of the area form a well-defined entity that the writer has called the Stewart Complex.

Several distinct periods of metamorphism, plutonism, volcanism, and sedimentation marked by deformation and erosion have been identified. The intensity of deformation has apparently decreased since the mid-Triassic Tahltanian orogeny, although plutonism has increased in activity since the Triassic and reached a climax in the Tertiary along the eastern margin of the Coast Plutonic Complex. Neogene volcanic activity marked by alkali olivine basalt flows has occurred periodically along major north-south, northeasterly, and east-west fractures.

Within this orogenic cycle metallogenesis is related to volcanic, sedimentary, and plutonic processes during each major tectonic phase, and these processes have combined to produce broad mineral zoning and a large array of mineral deposits which characterize this portion of the Western Cordillera. The numerous fissure vein and replacement vein deposits in the Stewart Complex, including the Silbak Premier mine, comprise a common group of simple ore and gangue minerals. The major massive sulphide deposits include the Granduc property at Granduc Mountain, and the Hidden Creek, Double Ed, Redwing, and Bonanza properties at Anyox. Porphyry deposits include the molybdenum deposit at Kitsault and the copper-molybdenum property at the Mitchell-Sulphurets Creeks.
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INTRODUCTION

The Stewart Complex is in northwestern British Columbia between latitudes 55 degrees 15 minutes and 56 degrees 45 minutes north, and longitudes 129 degrees 15 minutes and 130 degrees 45 minutes west. This study presents and discusses data on the geology of this region which is relevant to the tectonic evolution of the Western Cordillera and to the concepts of metallogenesis in northwestern British Columbia (Fig. 1).

The geological maps complementing this study include the 1:100 000-scale map of the Stewart Complex (Fig. 2), which is in three sheets (North sheet, Unuk River; Central sheet, Salmon River; and South sheet, Anyox). The geological maps are indexed on Figures 1 and 13, to show their order and relationships. The maps are accompanied by geological cross-sections (Fig. 3).

This geological study commenced in 1964 and continued until 1970. Initial work in the Stewart area was completed utilizing the few available roads. In 1966 work continued north of Stewart into the Bowser Basin aided by part-time helicopter transport to make a few traverses. In 1967 a month was spent in the Anyox area until a short-term helicopter contract was negotiated for the Unuk River section. The last reconnaissance work was completed during 1968 using a small boat on Portland Canal and Observatory Inlet.

Most of the area north of Stewart and between Alice Arm and Bear Pass was mapped using British Columbia Government air photographs. Base maps on a scale of 1 inch to one-half mile were compiled for the Unuk River section and maps at a scale of 1 inch to one-half mile published by the British Columbia Department of Lands and Forests were used in the rest of the area. Detailed topographic maps were not available for much of the region and the Federal Government 1 inch to 4 mile maps provided the only available contour information.

Location and Accessibility: The town of Stewart at the head of Portland Canal, which is near the centre of the map-area, has been the main locus of activity since 1900. The means of transportation to outlying points in the area are now by barge and by aircraft. The Cassiar-Stewart Highway, proposed to link the north coast with the British Columbia interior, has been completed for quite some time and a forestry road from Terrace, which penetrates as far as the Nass River at Meziadin Lake, has been joined to the Stewart road by a small bridge across the river near the lake. The Granduc mine, near the junction of the North and South Leduc Glaciers, has been connected to the concentrator site at Summit Lake by a 19-kilometre tunnel, which in turn connects to Stewart by way of a 50-kilometre, all-weather road. Other mine access roads in the area include the Kitsault River road which joins the old Torbrit and Dolly Varden mines to Alice Arm.

Previous Work: Mineral exploration was started in the general area about 1885 when placer miners on their way out of the Cariboo prospected Observatory Inlet and its arms north of the Nass River. Subsequently the Unuk River, Stewart, Portland Canal, Anyox, and Alice Arm districts became the focus of extensive prospecting, and in 1905 Fred
Eugene Wright, while investigating the geology of southern Alaska, was directed to explore the Unuk River which flows into Behm Canal. His results were put at the disposal of the British Columbia Department of Mines and published in the 1906 Annual Report (Minister of Mines, B.C., Ann. Rept., 1906, pp. H68-H74). It was not until 1924 that this area was reported on directly by George Clothier, resident engineer, and in 1932, J. T. Mandy produced a report and geologic map for the Unuk River area. At Stewart geological investigations commenced in 1906 with a report by H. Carmichael, Provincial Assayer. The first comprehensive geological study in the Portland Canal area was produced by
R. G. McConnell (1913) of the Geological Survey of Canada. This was followed in 1919 by J. J. O'Neill's work which was incorporated into a study of the Salmon River district by S. J. Schofield and G. Hanson (1922). Later Hanson studied the Bear River and Stewart map-area (1929) and incorporated these projects into a regional study of the Portland Canal area which included the then active Stewart, Alice Arm, Anyox, and Maple Bay mining camps. This report has served the industry as the major reference to the geology and mineral deposits of the Portland Canal area. At Hyder, Alaska, Westgate (1922) and Buddington (1929) of the United States Geological Survey made geological studies of the Alaskan portion of the Portland Canal. Buddington and Chapin (1929) also produced the first comprehensive study of the geology and mineral deposits of southeastern Alaska including small parts of adjacent British Columbia.

All of the above works, plus many descriptions in subsequent Annual Reports of the British Columbia Minister of Mines, have helped lay the foundation for the geological studies that have followed in recent years. The Geological Survey of Canada Map 9-1957, Operation Stikine, is the most recent attempt to compile the geology of the area north of Portland Canal between latitudes 56 degrees and 59 degrees along the east margin of the Coast Plutonic Complex. In 1959 Pan American Petroleum Corporation examined and compiled the geology of a large block of ground in the Bowser Basin from latitudes 54 degrees 45 minutes to 58 degrees between longitudes 126 degrees 20 minutes and 130 degrees 20 minutes providing useful regional concepts.

W. R. Bacon (1956) of British Columbia Department of Mines mapped the international boundary section between Salmon Glacier-Summit Lake and Mount Willibert including the Granduc mine area at the time the Leduc River and Portland Canal geology. In 1959 and 1960 geologists, directed by G. W. H. Norman of Granduc Mines, Limited, mapped the Unuk River area from Granduc north to Tom Mackay Lake in detail with special reference to the mineral deposits. These maps, on a scale of 1 inch equals one-half mile, were used in compilations of the western half of the Unuk River sheet for this study.

These major projects combined with special property reports by members of the British Columbia Department of Mines during the 1940's and 1950's, constituted the available information on the geology of parts of the map-area.

Since 1960 the Bowser Basin and the adjoining Coast Mountains area has undergone almost continuous exploration for metals and hydrocarbons. Properties such as the Granduc and B.C. Molybdenum mines have become economic and new mineral deposits have been located in previously inaccessible locations and also where recent glacial retreat has exposed new ground for prospecting. The geology and mineral deposits of the Alice Arm section have been studied by N. C. Carter, formerly of the British Columbia Department of Mines and Petroleum Resources. This material has been published since 1964 in the Annual Reports of the British Columbia Minister of Mines and Petroleum Resources.

The Hyder, Alaska, quadrangle, first compiled by Buddington (1929), was restudied by members of the United States Geological Survey, Alaskan Mineral Resources Branch in 1967-1968 under the direction of J. G. Smith.

Scope of the Study: The main purpose of this study was to determine the general geological setting of the mineral deposits and mineralized areas and to relate both to the broader regional framework. Areas with important mineral deposits or significant mineralization have received considerably more attention than the apparently unmineralized sections. The geology of most of the area was mapped at 4 inches to 1 mile and 2 inches to 1 mile and compiled at a scale of 1 to 100,000.

The regional setting has been determined from study of published and unpublished reports and discussions with other workers in the area. Subdivision of the stratigraphic succession and correlation between the various areas have been difficult because of rapid
facies changes, many local disconformities, lack of fossils in critical areas, and the extensive snow and ice cover. Recent work has shown the essential tectonic unity of the whole Jurassic sequence which includes all of the rocks currently known as the Bowser and Hazelton Groups. The term Bowser Group has been rejected because it has been used previously in Alaska for other rocks. It is expected that the new terminology presented in this report will establish a stratigraphic basis for other studies in this region.

The writer has traversed most of the Stewart Complex and examined the major mineral deposits and mineralized areas. The various rock units have been examined by both macroscopic and microscopic methods. The texture and mineralogy of the various ore minerals have been examined in polished sections and also by X-ray diffraction methods. Fossil assemblages have been examined and identified by W. R. Danner at The University of British Columbia and by paleontologists of the Geological Survey of Canada in Ottawa.

**Terminology:** The report generally presents accepted rock classifications such as found in Williams, et al., (1954). For the epiclastic volcanic rocks, terminology follows the classification of Fisher (1961, 1966). Metamorphic rocks are classified according to the facies concept outlined by workers such as Barth (1962), Mehnert (1968), and Miyashiro (1967); certain locally important units, the cataclasites, are described utilizing the definitions of Knopf (1931) and Spry (1969).

The nomenclature of the stratigraphic units has been presented within the terms outlined in the code of the *American Commission on Stratigraphic Nomenclature* (1961, 1970).

**ACKNOWLEDGMENTS**

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Thin sections and polished sections were prepared by R. Player, Lapidary, Mineralogical Branch, and chemical analyses were made by analysts of the British Columbia Ministry of Energy, Mines and Petroleum Resources.

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dington Vol., p. 313.


PHYSIOGRAPHY AND GLACIATION

Physiography: The map-area is a mountainous region dissected by stream erosion and modified by glaciation; most lies within the Boundary Ranges of the Coast Mountains. The boundary between the adjoining Skeena Mountains and Nass Basin has been shown by Holland (1964) to trace a curving line extending north from the Nass River, east to Kinskuh Lake, past the west end of Meziadin Lake to the east end of Bowser Lake to intersect the Iskut River. The map-area lies in the border zone between the Nass Basin and Boundary Ranges.

In the vicinity of the international boundary northwest of Stewart a large portion of the area is covered by permanent icefields, through which many nunataks project. Most of the terrane below 1800 metres elevation presents a crudely rounded appearance while the mountains above that show serrate ridges, horn peaks, and alpine glaciers. Local relief varies considerably from a few thousand metres in the Nass Basin to 1800 metres along the fjords with the maximum of over 2400 metres along the Bowser River. The highest peaks in the area are north and east of Stewart. These include Mount Jancowski (2990 metres), Mount Patullo (2730 metres), and Mount Mitre (2710 metres), as well as many more peaks and ridges which exceed 2100 metres. This topographic high lies east of the main 'granite' contact (Fig. 1) and forms a crudely ovoid upland area extending from Kitsault Lake to the south, northerly through the Mount Jancowski-Mount Mitre massif, to the Unuk River-Treaty Creek boundary.

Within the general map-area the major fjords and valleys trend northerly to northeasterly and are interconnected by easterly dissections. The areas above the low valleys and divides are covered by extensive icefields and most of the valleys contain glaciers. In general, permanent snow and ice cover most of the highland from Kitsault Lake to the Unuk-Treaty divide.

Drainage: Large streams channel runoff and meltwaters from the study area either directly into the coastal fjords or by circuitous paths into the Nass River system. Most of the major rivers in the coastal area follow deeply dissected narrow valleys leading from the major icefields and glaciers. Near the fjords the valleys broaden and are generally floored by flat gravel plains incised by the braided stream channels. At the river mouths, broad marine deltas extend into the tidal waters.

Most of the similar streams along the coastal section drop precipitously from the ridge tops and icefields almost directly into the fjords, have little or no bottom sands and gravels, and seldom form deltas. Inland, along the major rivers, the tributary streams generally have high gradients and are channeled along rock structures. Many of these streams carry a considerable load of detritus and alluvial fans have been built along the lower sections near the valley bottoms.

Glaciological Studies: The common occurrence of U-shaped and hanging valleys, the rounded nature of the low hills, and numerous lakes and drumlin-like forms in the Nass Basin indicate extensive glaciation. Ice from the Boundary Ranges and Skeena Moun-
tains moved along the Bell-Irving trench into the Nass Basin to escape along the Nass River. Ice moving from the highland west to the coast flowed into the fjords along the present coastal drainage system. During the present stage of glacial retreat, which is still continuing, drainage reversals occurred as the topography evolved; Tide, Summit, and Strohn Lakes are examples. Marine estuarine deposits exposed along the Bear and the Salmon River valleys form benches along the slopes which indicate an overall recent isostatic uplift of about 150 metres. At Anyox, along the west side of Granby Bay, a series of marine beaches or terraces is now about 200 metres above sea level.

Studies in coastal areas of adjacent Alaska (Klotz, 1907) and nearby Stikine (Kerr, 1948) indicated a glacial recession up until the 1860's, then a short rapid ice front advance, followed by a recession which has continued to the present. Presumably the glacial events in the Stewart district followed this pattern.

The distribution of present-day snowfields and glaciers in the Western Cordillera indicates to a degree major centres of the Pleistocene Cordilleran ice-sheet. The extensive icefields that still exist northwest of Alice Arm in the Boundary Ranges indicate one of the major centres of accumulation.

At present most of the glaciers in the map-area are retreating at about 50 metres per year in the terminal areas, exposing fresh rock outcrop for prospecting. The Granduc mine, located in 1951 on the edge of the South Leduc Glacier, was ice covered only three years previously in 1948, which indicated the importance of deglaciation to mineral exploration in this region (Fig. 4). Information gathered from old photographs and maps, together with observations, suggests that glacial ablation in the southern Boundary Ranges has been continuous but at various rates since about 1900.

The self-dumping, ice-dammed lakes found in the Coast Mountains formed as the result of the retreat of a tributary arm from the trunk glacier (Marcus, 1960, p. 90). Three large glacier-dammed lakes are known in the map-area.

On the basis of deep ice drilling results on the Salmon Glacier just east of Summit Lake, Mathews (1959) found that the average surface velocity of the Salmon Glacier was 91 metres per year, with an overall velocity of 77 metres per year. The 1970-1971 movement

![Figure 4. Recent levels of glacial ablation, South Leduc Glacier.](image-url)
of Salmon Glacier measured 800 metres; this fits the lower limit suggested by Post (1969) for surging glaciers. The surface of Salmon Glacier exhibits both large-scale and small-scale folds in the medial moraines; the area at the ice barrier has a chaotic broken surface. The data suggest that Salmon Glacier is a surging glacier that has probably surged periodically since 1922. Many other glaciers in this general area also surged during the 1970-1971 period, including the South Leduc, Berendon, and Frankmackie.

As the present Salmon Glacier retreats, it leaves behind a flat-floored gravel valley bottom which is reworked by the issuing river; smaller glaciers have little or no load and leave only polished rock flanked by marginal moraines. Transported talus is prominent on the ice of larger glaciers and is also plastered along steep valley walls where glaciers recently melted. Other glacial deposits include lake sediments at Tide Lake Flats and those exposed for a short time under Summit Lake when it emptied. Hanson (1932) showed the presence of at least 5 metres of varved clays at Tide Lake and recent erosion has cut deeper exposing at least 15 metres of thinly laminated sediments. Hanson's suggestion that the Tide Lake varved sediments represented 2000 years accumulation is probably large, considering the fact that glacial ice filled the Tide Lake valley only 500 years ago.