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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA
BULLETIN 47

REVISION OF THE HAZELTON AND TAKLA GROUPS OF CENTRAL BRITISH COLUMBIA

By
H. W. Tipper

THE QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
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PREFACE

The stratigraphy of the Mesozoic rocks of central British Columbia has for many years been in a state of considerable confusion. This is partly because distinctive marker beds are lacking, partly because fossils are scarce and poorly preserved, and partly because much of the succession is lava whose attitude is impossible to measure. The succession was divided into two groups, the Takla and the Hazelton, but the limits of these were ill-defined and the distinction between the two not clearly established.

The author studied the Mesozoic beds in Nechako River area, and in this report defines the lithological characteristics and age of each group and proposes a practical means of determining the position of the mutual boundary. He also shows how the principles established might be applied in nearby areas.

J. M. HARRISON,
Director, Geological Survey of Canada

OTTAWA, July 18, 1957

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REVISION OF THE HAZELTON AND TAKLA GROUPS OF CENTRAL BRITISH COLUMBIA

CHAPTER I

REVIEW OF THE NOMENCLATURE OF MESOZOIC ROCKS OF CENTRAL BRITISH COLUMBIA

The Mesozoic volcanic and sedimentary rocks of central British Columbia have never been studied in detail. Since 1872 these rocks have been observed mainly in the course of reconnaissance mapping, and only in rare instances were they encountered in detailed mapping.

The nomenclature of these Mesozoic rocks is complex. Two group names, Hazelton and Takla, have assumed prominence, and in recent years most of the Mesozoic rocks mapped in central British Columbia have been assigned to one or the other of these two groups, depending on the proximity to the type area. In this way confusion in definition has resulted so that the two groups overlap in time and are not clearly distinguishable.

Within Nechako River area (*see* Figure 1) a thick assemblage of volcanic and sedimentary rocks of Late Triassic to Late Jurassic age is exposed (Tipper, 1955)[1]. All of this assemblage could be correlated with the Takla group to the east or part of it with the Hazelton group to the west, correlation depending on a general lithological similarity and partial time equivalence. Such a correlation would neither lessen the existing confusion in nomenclature nor materially aid in the stratigraphic understanding of the Mesozoic geology of central British Columbia.

The Mesozoic strata of Nechako River area are divisible into two groups, distinct lithologically and in time, which are capable of being distinguished beyond that area. In correlating these with the Hazelton and Takla groups, it is first necessary to revise and redefine the latter groups retaining as far as possible the original intent when the terms were first established.

This revision of the Mesozoic nomenclature is in all respects preliminary; the information, although representative, is incomplete and will remain so for many years. Such a revision now, however, should reduce the existing confusion and lead to a clearer understanding of the problem. The revision is restricted to rocks in central and western British Columbia,

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[1] Names and/or dates in parentheses are those of references cited in the Bibliography.

Figure 1. **Index map of central British Columbia**

wherever the names Takla and Hazelton have been used, and is based on work done in Nechako River map-area. The approach to the problem is as follows: (1) a review of previous work and tracing the evolution of the Hazelton-Takla nomenclature, (2) presenting the information from Nechako River map-area, (3) redefinition of the groups, (4) discussion of the geological history.

Evolution of the Terms Hazelton and Takla

The Mesozoic volcanic rocks of central British Columbia were originally mapped by Dawson and referred to the loosely defined Porphyrite group (Dawson, 1877, p. 250). This group was characterized by porphyritic andesite, hence the name Porphyrite. In his explorations in central British Columbia, Dawson encountered many lithologically similar rocks and correlated them all with the Porphyrite group. The name thus became widely used and occasionally was erroneously applied to Permian, Triassic, Cretaceous, and even Tertiary andesite and associated rocks.

The group was originally considered to be Jurassic (Whiteaves, 1878, p. 150) or Lower Cretaceous, probably Upper Jurassic, and as such was supposed to bridge the gap between the readily recognized Permian Cache Creek group and the Lower Cretaceous Jackass Mountain group. However, because of the lack of a characteristic and distinctive type section, the scarcity of fossils, and loose usage of the term, the name Porphyrite group soon degenerated into a purely descriptive field term, lacking stratigraphic significance. Later work has shown that the rocks of the type area are Triassic, rather than Upper Jurassic, that much of the strata correlated with the Porphyrite group is Middle Jurassic, and that accurately dated Upper Jurassic strata form a very small part of the rocks assigned to this group.

From 1906-09 Leach (1906, pp. 35-42; 1908, pp. 19-23; 1909, pp. 41-45) studied the Mesozoic strata in the vicinity of Hazelton and southward to Telkwa. He continued the practice of correlating the Mesozoic strata with the Porphyrite group, particularly the thick sections of volcanic flows near Telkwa. In 1909, however, he introduced the name Hazelton group for a thick section of water-lain pyroclastic material and sedimentary rocks near Hazelton (Leach, 1910, p. 62). This group was thought to be equivalent in time to flows of the Porphyrite group mapped near Telkwa. The important difference between the two groups, according to Leach, was that the Porphyrite group, as the name indicates, was an assemblage of porphyritic lavas, whereas the Hazelton group was of aqueous origin consisting of water-lain volcanic breccias and tuffs, with some true sedimentary strata at the top of the section. The age of the Hazelton group as a unit was not established but the upper sedimentary section was correlated on palæontological evidence with the Fernie group of Alberta and the Lower Shales of the Queen Charlotte Islands, hence a Jurassic age was indicated.

It was apparently not Leach's intention in 1909 to replace the name Porphyrite group by Hazelton, but further work in 1910 (1911, p. 93) evidently convinced him that a double nomenclature was unnecessary, and the name Porphyrite was abandoned. The Hazelton group was established as a Jurassic group and did not include the coal-bearing Cretaceous Skeena series, although the two were supposedly conformable. The division between the two was arbitrarily drawn below a prominent conglomerate section.

Several geologists in succeeding years adopted the usage initiated by Leach. In 1911 and 1912 Malloch (1912, pp. 72-90; 1914, pp. 76-77) mapping along the upper Skeena River and McConnell (1914, pp. 58-59) along the lower Skeena River agreed with Leach on most points and did not alter appreciably his interpretation. In 1915 MacKenzie (1916, pp. 62-63) mapped the volcanic rocks in the Telkwa area as the Hazelton formation and the sedimentary rocks as the Skeena formation. The Hazelton formation was described as "a great mass of pyroclastic, effusive, and probably intrusive volcanic rocks" of Jurassic age. The Skeena formation, on the other hand, consisted of "quartzose sandstones and argillaceous and sandy shales containing coal seams" of Early Cretaceous age. MacKenzie believed that the lithological change between the Hazelton and Skeena formations was indicative of an erosional interval and suggested the probability of an unconformity or disconformity.

O'Neill (1919) mapped all Mesozoic volcanic and sedimentary rocks in the Hazelton district as Hazelton group and assigned them to the Late Jurassic.

Brock (1921, pp. 81-94) examined the Mesozoic strata farther south, around Eutsuk Lake, in 1920. He correlated the volcanic strata there with Dawson's Porphyrite group but also indicated the equivalence and correlation of this group with Leach's Hazelton group.

In 1922 Schofield and Hanson (1922, pp. 14-21) discussed the Mesozoic nomenclature and correlation at length, with particular reference to the formation names of the Salmon River district. They retained local names for these formations but indicated their correlation with the Porphyrite group, of which they were considered a part. The age of the Porphyrite group was considered to be Late Jurassic. This discussion served to stress the age of the Porphyrite group as Jurassic, its dominant lithological characteristic as volcanic, and its relation to the overlying Skeena as probably unconformable. This was the last major attempt to retain the name Porphyrite in northern British Columbia.

From 1922 to 1924 Hanson (1923, pp. 35-51; 1924, pp. 29-46; 1925a, pp. 38-43) made reconnaissance surveys between the Salmon River district and the Skeena Valley and in so doing he encountered the Hazelton group in Leach's type area as well as the several formations mapped in the Salmon River district. He decided they were equivalent and advocated the adoption of the name Hazelton and the abandonment of the formation names of the Salmon River district. Thus the areal extent of the Hazelton group was increased and the name became firmly entrenched in geological literature.

In 1924 Hanson (1925b, pp. 19-37) mapped the Driftwood Creek map-area and added materially to the knowledge of the Hazelton group. Four or five subdivisions of the Hazelton group were attempted, based on lithologic differences, stratigraphic succession, and good palæontologic evidence. The three most important divisions were an upper volcanic, a middle sedimentary, and a lower volcanic. Fossils from the sedimentary division were correlated with the Bajocian stage of the Middle Jurassic.

Further mapping on Hudson Bay Mountain and in Zymoetz River valley by Hanson (1926, pp. 100-119) and Jones (1926, pp. 120-143) in 1925 added more information. The three divisions of the Hazelton group were maintained and a fourth was added, an upper sedimentary division presumably of Late Jurassic age. Evidence was obtained to show that the Skeena formation rests unconformably on the Hazelton group. Fossiliferous Upper Triassic rocks were found in a few localities, occurring as fault blocks and roof pendants in the plutonic rocks of the Coast Mountains. It is noteworthy that these rocks were not mapped as part of the Hazelton group, as the stratigraphic relation was not known.

For several years the divisions established by Hanson were the basis for mapping the Hazelton group. In several areas the middle sedimentary division was readily recognized, chiefly by fossils which were more abundant there than in other parts of the group. This Middle Jurassic division was obviously widespread and well represented and served as a basis for the tentative dating of other divisions. The Skeena series or formation was still considered to rest unconformably on the Hazelton group and was dated more closely as Lower Cretaceous by comparing its flora with that of the Kootenay and Blairmore.

In 1935 and 1936 Kindle (1937a; 1937b) studied the Hazelton group and Skeena series along Skeena River near Terrace. There the Hazelton group was mapped as two divisions: a lower volcanic section of Early Jurassic age, and an upper sedimentary division of Middle and Late Jurassic age. No reason for the datings was given. In addition, Kindle maintained that the upper part of the Hazelton group passed imperceptibly into the Skeena series and that there was no distinct lithological break or unconformity. However, the name Skeena was retained for the strata dated as Lower Cretaceous.

Armstrong compiled the geological maps for the Hazelton (Armstrong, 1944b) and Smithers (Armstrong, 1944a) areas from work done by himself and others. He agreed with Kindle that there was no break between the Hazelton group and Skeena series and accordingly discarded the name Skeena, combining that series with the upper sedimentary division of the Hazelton group. This new division was referred to as the Upper Jurassic and Lower Cretaceous unit. The Hazelton group, comprising two volcanic divisions and middle and upper sedimentary divisions thus was believed to range from presumably Lower Jurassic to Lower Cretaceous and to be a conformable succession throughout. The separation of the volcanic divisions was dependent on the presence and recognition of the sedimentary divisions, if the latter were absent the volcanic divisions were indistinguishable one from the other.

Duffell (1952) re-examined the area around Whitesail and Eutsuk Lakes and concluded that the main mass of Mesozoic strata exposed there was not divisible into readily distinguishable map-units. Small areas of Upper Triassic rocks and late Lower Cretaceous marine sedimentary strata were mapped separately, thus restricting the Hazelton group to the Jurassic.

The problem of Mesozoic nomenclature and correlation did not arise in the central and eastern parts of British Columbia until after 1937 when extensive reconnaissance and detailed study were commenced by the Geological Survey of Canada. Prior to 1937 little work had been done in the areas of Mesozoic rock and the few Mesozoic sections encountered were mapped as Porphyrite group or simply Mesozoic rocks on the basis of a general lithological similarity. Little or nothing was known of the stratigraphic succession, lithology, age or areal extent.

Armstrong's work in Fort St. James area between 1937 and 1946 (Armstrong, 1949) extended the knowledge of the Mesozoic strata and introduced a new name. Around Takla Lake and eastward, a thick assemblage of volcanic and sedimentary strata occurs, which in many aspects resembles the Hazelton group but differs in age. The only diagnostic fossils found in this strata indicated a Late Triassic and Early Jurassic age. Because of this age difference and the lack of direct areal connection with Hazelton strata, Armstrong concluded that this was a new group and named it the Takla group, the type exposures being around Takla Lake (Armstrong, 1946). The group was characterized by an Upper Triassic sedimentary division and a predominantly volcanic Lower Jurassic division. These divisions were not everywhere distinguishable and the group was mapped as one unit with Upper Triassic sediments indicated where known.

While Armstrong was studying the Takla group in its type area, Lord (1948) was working in McConnell Creek area northwest of Fort St. James area, where sedimentary and volcanic rocks containing fossils of Early, Middle, and Late Jurassic age are exposed. In addition, below the Lower Jurassic strata is an extremely thick section of sedimentary and volcanic rocks which for several reasons is considered to be most probably Upper Triassic (Lord, 1948, pp. 27-28). Two divisions were used in mapping, an upper one containing the Jurassic fossils and a lower one which is unfossiliferous. The sedimentary rocks of the upper division are mainly coarse grained, distinctly different from the fine-grained shales and argillites of the lower division. The sedimentary rocks of both divisions are lithologically similar to the rocks of the Takla group in adjacent areas. Because of this similarity and because the Hazelton group does not include Lower Jurassic and Upper Triassic rocks, it was apparently a logical step to correlate these rocks with the Takla group. The whole was considered as a conformable succession although the recognition of local unconformities, the abrupt change in sedimentary lithology from fine to coarse clastics, and the certainty of erosion of Permian or older strata during Middle Jurassic time (Lord, 1948, p. 22) would tend to indicate a tectonic disturbance in or near this basin of sedimentation and volcanism.

Armstrong accepted as valid Lord's correlation of these strata with the Takla group and stated that the Takla group "consists of an apparently conformable succession of interbedded volcanic and lesser sedimentary rocks ranging in age from Upper Triassic to Upper Jurassic" (Armstrong, 1949, p. 51). A close examination of the evidence fails to offer any concrete reason why Middle and Upper Jurassic rocks can be expected to occur in the type area. Fossils in the Fort St. James area indicate the presence of Upper Triassic and Lower Jurassic beds only. If Middle and Upper Jurassic strata were present diagnostic fossils would have been found, as, in McConnell Creek area, fossils in strata of that age are more abundant than in the older strata. No sedimentary sections in Fort St. James area approach the thickness of the sedimentary sections of McConnell Creek area. In Aiken Lake area, which is the direct northern extension of Armstrong's type area and east of the McConnell Creek area, Roots (1954) found only Lower Jurassic and Upper Triassic rocks. There the total thickness was only about one-third the thickness of the Mesozoic strata in McConnell Creek area.

The present status of the Takla and Hazelton groups is summarized adequately by Frebold (1953, pp. 1229-1246) in correlating the Jurassic formations of Canada. The Hazelton group is illustrated in his chart as

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a Middle and Upper Jurassic group, subdivided in some areas and undivided in others. The status of the Lower Cretaceous beds, formerly Skeena series, is not indicated. The Takla group is presented as spanning the entire Jurassic period, as well as including the Upper Triassic. From this chart it is apparent that several stages of the Jurassic are assumed to be represented for which there are no diagnostic fossils, a complete section being inferred from the great thickness of strata and the apparent lack of recognizable stratigraphic breaks.

A few other names of local significance had been used in mapping Mesozoic rock of central British Columbia, most of which were abandoned in favour of Hazelton or Takla group. The Nechacco series was established by Dawson in 1876 to include sedimentary rocks near Prince George (Dawson, 1878, pp. 72-73); these rocks were re-mapped as Takla group in 1946. The Nass, Bitter Creek, and Bear River formations of Portland Canal area had been mapped for several years as distinct units but were later found to be undefinable as such and were combined as the Hazelton group (Hanson, 1935, pp. 4-25), the formation names being abandoned.

One other name, Tachek, is still used for a small group of strata of presumably Jurassic and (?) Cretaceous age. This group, occurring on Tachek Mountain west of Babine Lake, was named by Armstrong (1949, p. 64) in 1948. Armstrong described it as follows: "It consists of a basal series of sedimentary strata 300 feet thick overlain conformably by about 2,000 feet of andesite breccia, andesite and rhyolite. The sedimentary strata, consisting mainly of tuff, shale, and conglomerate, and containing fossil plants of probable Jurassic age, overlie the Topley granite uncomformably...

"The Tachek group rocks bear some lithological resemblance to part of the Hazelton group but, in general, are fresher and less deformed."

Internal Relation of the Mesozoic System of Central British Columbia

Although many writers have indicated that the Hazelton and Takla groups are thick conformable successions representing most, if not all, of Jurassic and Late Triassic time, the palæontological evidence does not support this contention. Much of Late Triassic time is represented but latest Triassic time is nowhere indicated and McLearn and Kindle (1950, p. 130) have suggested a late Triassic emergence. Early Jurassic stages are fairly well represented in the Takla group (Frebold, 1953, pp. 1234-1235). Fossils indicate that lower Middle Jurassic strata occur as part of the Hazelton group and of the Takla group (Frebold, 1953, pp. 1234-1235, Plate I) in McConnell Creek area, but late Middle Jurassic is not indicated by fossils in any part of central and northern British Columbia. Of the Upper Jurassic strata, a small area with Callovian fossils occurs in Nechako River area, Oxfordian fossils were found in Groundhog (Frebold, 1953, p. 1235), McConnell Creek and Terrace[1] areas but elsewhere there is no palæontological evidence to indicate the presence of Upper Jurassic strata. Lower Cretaceous sedimentary rocks of the Hazelton group or Skeena series are fairly abundant in the valley of Skeena River and surrounding country.

From the foregoing it is apparent that the palæontological evidence does not suggest that either the Hazelton or Takla group is an uninterrupted succession, but rather that there are important gaps in the palæontologic succession. This might be accounted for in several ways. Strata of these missing ages may have been deposited and removed by subsequent erosion or they may never have been deposited because the area was emergent. In either case an erosional interval and hence an unconformable succession is indicated. It is, on the other hand, possible that strata of these ages are present but have not been recognized because diagnostic fossils are absent or have at least not been found. Although this may be true, it would be strange, if, during certain ages, conditions for preservation of fossils were so unsuitable that none has been found anywhere in a wide area. Especially as there is no reason to believe that conditions were not relatively uniform throughout the interval of time being considered, an interval during which some marine beds are exceedingly fossiliferous.

Some geologists have explained these time gaps by assigning to these intervals the thick, unfossiliferous volcanic assemblages. In most areas of central British Columbia water-lain volcanic breccias and tuffs and volcanic flows form by far the greater part of any section. Most of these rocks are unfossiliferous, many apparently structureless, and they are commonly several thousand feet thick. Successions of these rocks commonly occur above and below fossiliferous sedimentary divisions, their age being established by their stratigraphic position relative to these fossiliferous beds. It cannot, however, be assumed that these volcanic assemblages represent all time from one fossiliferous section to the next. Volcanic flows and pyroclastic rocks can accumulate very rapidly and the entire sequence may have formed in a relatively short span of time, possibly much shorter than that indicated by the fossils of two successive sedimentary divisions. It seems logical to assume, unless reasonable evidence to the contrary can be found, that the volcanic rocks cannot adequately be considered to cover the many missing intervals and that there is therefore no continuous sequence of sedimentary and volcanic strata.

If the tectonic environment is considered apart from the field evidence, the possibility of a conformable succession representing the entire Jurassic period is very remote. Eugeosynclines, comprising volcanic islands and

[1] Duffell, S., 1956, personal communication.

basins, are unquestionably the more active parts of the earth's crust as attested by modern examples. Thus disconformities, angular discordances, and erosional intervals should be expected to be typical of the Hazelton and Takla groups.

CHAPTER II

MESOZOIC GEOLOGY OF NECHAKO RIVER MAP-AREA

The known geological history of Nechako River map-area begins in the Permian and each subsequent period is represented, more or less. Only the Jurassic, Tertiary, and Quaternary periods are well represented, the evidence of the Permian, Triassic, and Cretaceous is scant and fragmentary. The characteristic feature for all of this time in this area was active volcanism, and all stratigraphic sections include volcanic flows, pyroclastic rocks, and sedimentary rocks derived in part or wholly from a volcanic terrain. During periods of quiescence in the Mesozoic, conglomerates, greywacke, and shale accumulated, mainly under marine conditions in basins that occupied much of the area. In the Late Cretaceous and Tertiary, volcanism was also widespread in the area and freshwater sediments accumulated in small basins during several intervals. Tertiary volcanism was characterized by intermediate and acidic flows except for the latest extrusions, which were basaltic. During the Pleistocene the whole area was overridden in an easterly and northeasterly direction by a glacier. The resulting till, sand, gravel, and silt are everywhere abundant reaching thicknesses in excess of 500 feet although the usual thickness is 5 to 25 feet. Batholiths, stocks, and dykes, of granitic to dioritic composition, underlie much of the area, and two distinct times of emplacement are indicated: Early Jurassic and Late Jurassic or Cretaceous.

Mesozoic Volcanic and Sedimentary Rocks

Takla Group

Lithology and Map-Units

The Takla group in this area is an assemblage of volcanic flows, associated breccias and tuffs, and sedimentary rocks consisting of argillite, conglomerate, greywacke and minor argillaceous limestone and quartzose sandstone. By far the most important lithologic types represented are andesite and basalt, in masses in which individual flows cannot be distinguished. These occur over wide areas and give little or no structural information. For these reasons the thickness of the group cannot be estimated with accuracy. Only partial sections can be measured and even then there is no assurance that flows and beds are not repeated or omitted.

For mapping purposes the Takla group has been divided into two units of which the first, the main unit (2), has the characteristic lithology and age of the group in the type area, and the second, the red bed unit (3), is a locally important assemblage of coarse clastic rocks related to the uplift and erosion of a landmass on the northern margin of the area.

Main Unit of the Takla Group (2)

Distribution. The main unit of the Takla group is distributed along the western margin of the map-area forming the low hills around Tetachuck Lake and southward. Although this group is mapped as including Upper Triassic and Lower Jurassic strata, the only fossiliferous Upper Triassic strata known in the area are a small ridge north of Ootsa Lake on the western margin of the area.

Volcanic Flows. Volcanic flows, which form by far the greater part of this group, are mainly dark green to grey and black, commonly porphyritic, rarely vesicular, amygdaloidal or flow-banded. Columnar jointing and pillow lavas were observed only once or twice.

Individual flows could be delineated only in a few places. These were from 20 to 75 feet thick, and some for which no margins were seen appeared to be over 100 feet thick. The flows grade into flow breccias and imperceptibly into bedded breccias and tuffs. The similarity of material in flows, breccia fragments, and matrix makes it difficult or impossible to delineate narrowly the margins of individual flows.

The most common rock type is a dark green porphyritic andesite in which the phenocrysts are greenish grey to grey plagioclase feldspar (andesine) or dark green or black augite. The matrix is a fine-grained mass of plagioclase with magnetite, epidote, and biotite. In some reddish brown andesites the groundmass has a high proportion of hematite instead of magnetite, but such andesites are rare. Greenish grey to black basalt makes up an appreciable part of the volcanic flows although apparently subordinate in volume to the andesites. Careful sampling and microscopic study would be necessary before the relative proportions could be determined. The basalts are commonly porphyritic with labradorite laths as phenocrysts ranging in size from a sixteenth to a quarter inch long and occasionally to an inch long. Some basalts are fine grained and in thin section are seen to be a cryptocrystalline aggregate of plagioclase, magnetite and mafic minerals.

Volcanic Breccias and Tuffs. Associated with the volcanic flows are bedded volcanic breccias and tuffs. The breccias contain fragments of andesite and basalt, flow breccia, bombs, and lapilli embedded in a tuffaceous matrix. Occasionally fragments of rocks of earlier periods are included, particularly Permian chert, limestone, and quartzite, but, in the main, the fragments are related to contemporaneous volcanism. The breccias are commonly unsorted, rarely contain rounded or subrounded fragments or show any water action, except near the upper limit of a bed. Coarse breccias grade rapidly into fine breccias and tuffs which are sorted and well stratified. These fine breccias and tuffs consist of angular to subangular volcanic rock fragments, plagioclase, augite, hornblende, and chlorite. Although most of the fragments can be related directly to explosive volcanic activity, various amounts of the constituent material of these rocks result from normal erosion. Thus many tuff beds grade upward into tuffaceous and carbonaceous argillites and greywackes.

Viewed in outcrop, the weathered surface commonly shows distinctly the fragments of the breccias and the bedding of the tuffs, but on a fresh surface the rock appears homogeneous and difficult to distinguish from the associated flows. Joints and fractures commonly occur without regard to fragments or bedding. The bedded tuffs commonly weather to a rusty brown and tend to be less resistant to erosion so that the coarser breccias and flows form the crests of the hills.

A careful examination of the sedimentary features of the bedded tuffs and finer breccias shows that they are in well-sorted beds from a quarter inch to 18 inches thick, evenly bedded and the thicker beds generally graded. Several beds 12 to 18 inches thick were noted, in which the fragments graded in size from an inch in diameter near the base to fine argillaceous material near the top. Several similar beds succeed one another without noticeable erosion between the beds. Also in a succession of such beds a tendency exists for individual beds to decrease in thickness upward so that the top of such a section is of banded tuff beds 2 inches or less in thickness. Unless interrupted by another volcanic outpouring the tuff beds may pass gradually into banded argillites and greywackes. Tuffs and breccia beds are almost impossible to trace laterally and little is known of the changes that may occur in that direction.

Although tuffs and breccias were observed in many outcrops, no data were obtained to indicate the number of such sections or the areal extent of any particular one. The thickest section exposed was 350 feet with both base and top concealed, and many sections 10 to 50 feet thick were observed in which either the base or top or both were exposed. There is, however, no reason to believe that any section seen was over 500 feet thick. This is not consistent with thicknesses measured in Fort St. James (Armstrong, 1949, p. 54) and McConnell Creek (Lord, 1948, p. 15) areas, where thicknesses of 1,000 feet or more are exposed.

Sedimentary Rocks. The sedimentary rocks of this group are mainly shales or argillites with minor limestone and greywacke. Two sections of argillites have been recognized as distinctly different in age but not very dissimilar in lithology. Other argillite sections in the group may be correlative with either of these or may represent completely different sections.

The argillite is hard quartzose rock that fractures into blocks with smooth, conchoidal or plane surfaces. The direction of fracture commonly bears no relation to the bedding, although ribs reflecting the bedding show on the weathered surface which gives the impression that a parting or fracture parallel to it might be expected. The weathered surface is generally rusty brown from the weathering of disseminated pyrite.

Argillites of this unit always display excellent bedding which varies in thickness from fine laminations a sixteenth inch thick to beds 2 feet thick. The usual thickness is one-half to one inch. The bedding is generally even throughout although minor crossbedding does occur. Distortion of the bedding and thickening and thinning were observed in a few places, particularly near the top of sections overlain by flows and breccias. This is interpreted as preconsolidation deformation. Although most beds appear to be dense and even textured, graded bedding does occur and is visible in hand specimen, the grains grading from fine sand size to silt size in thicker beds, or microscopically, from silt to clay size in the more finely laminated strata.

The argillites are grey to black and are generally quartzose, but may be calcareous and grade into an argillaceous limestone. Carbonaceous argillites are not abundant. Where argillites grade downward into tuffs, the tuffaceous material increases gradually but where argillites are overlain by tuffs there is an abrupt change.

Interbedded with the argillites are argillaceous limestone bands 2 to 3 inches thick. These are easily discerned in outcrop as they weather more readily than the argillite. Rarely do they form an appreciable part of any section. On Tetachuck Lake near Bryan Arm, a shell limestone 15 feet thick is interbedded with argillites, but is of local extent.

A unique section of interbedded tuff and greywacke is exposed at the northeast end of Tetachuck Lake. The bedding is coarse and poorly defined and is visible only on the weathered surface through solution of calcareous beds. The greywacke is made up of rounded to subrounded grains of volcanic rock embedded in a calcareous matrix. The sorting is poor and the grain size ranges from fine sand to very coarse sand with pebbles to a half inch in diameter scattered throughout. No fragments of other than volcanic rock were found, and they apparently indicate rapid erosion and deposition from a nearby volcanic terrain. This section, although limited in extent, is the youngest sedimentary unit of this division and as such may represent in part the initiation of the sedimentary environment that produced the coarser clastic sedimentary rocks of the succeeding Hazelton group.

Thickness. The thickness and the stratigraphic column of the Takla group can only be approximated, as a complete section was nowhere obtained. The following is a composite section compiled from observations made at Verdun Ridge north of Ootsa Lake and in the area around Tetachuck Lake and Chelaslie River.

Lithology	*Thickness (feet)*
Top not exposed	
Andesite, basalt; associated breccias and tuffs	2,000
Tuffs and interbedded calcareous greywacke	450
Andesites and andesitic breccias	1,000
Banded argillites with minor limestone; containing Lower Jurassic (?) fossils near top	700
Gap of unknown extent	
Andesitic flows, breccias, and tuffs	1,000
Very coarse breccia with blocks of fossiliferous, late Palæozoic limestone	30
Green to grey, banded tuffs and tuffaceous argillites with Upper Triassic fossils	20
Green andesitic breccias	50
Green andesite and basalt	200
Red shale	25
Andesite and andesitic breccias and tuffs	150
Banded grey to black argillites	40
Base not exposed	
	5,665

The section given above is incomplete and the thicknesses, of flows and breccias in particular, are only approximate. Field studies indicate thicknesses of volcanic rocks that are many times those indicated, but it is believed that this is due to repetition by faulting or to folding more intense than is apparent. The gap between the Upper Triassic and Lower Jurassic parts of the section does not indicate non-deposition or an unconformity, but rather that the contact relations are not recognizable. Strata mapped with this group in other parts of the area are correlated on lithologic similarity and stratigraphic position but in no instance can strata be directly correlated. The red shales of the Triassic section given above are actually equivalent to part of the red bed unit (3) of the Takla group and represent an interfingering of the two units of the group.

Age. The age of the main unit (2) of the Takla group has been established on the basis of two fossil collections. Pelecypods were collected from tuffaceous argillites on Verdun Ridge and identified by F. H. McLearn, Geological Survey of Canada, as *Halobia* sp. These indicate a Late Triassic age. Another collection of fossils from the south side of Tetachuck Lake near Bryan Arm contained pelecypods most of which are indeterminate. Included in this collection was a new species of *Trigonia* which McLearn believed to be indicative of a Jurassic age and most probably Early Jurassic. All strata mapped in this unit are, from field evidence, older than Middle Jurassic as they occur below fossiliferous Hazelton strata of that age. The great dissimilarity in the degree of metamorphism of this group as compared with Permian strata in the Fort St. James area makes it improbable that Permian strata have been erroneously included. The total absence of known Lower and Middle Triassic strata (McLearn and Kindle, 1950, p. 129) in British Columbia west of the Rocky Mountain Trench makes unlikely the possibility that strata of that age have been included there. For these reasons, the unit has been dated as Lower Jurassic and Upper Triassic.

Red Bed Unit (3)

The second map-unit of the Takla group, the red bed unit (3), is an assemblage of sedimentary rocks outcropping in the northwest quarter of the map-area and consisting primarily of red shales and interbedded conglomerate with lesser amounts of green and grey shales, orthoquartzite, greywacke, and black limestone. These sedimentary rocks are in part marine and in part nonmarine in origin and represent erosional detritus from an area to the north which was gradually uplifted, beginning in Triassic time and culminating with the complete exclusion of the sea from central British Columbia by Cretaceous time. The rocks of this unit represent the strata formed during the early part of this uplift, from Upper Triassic to late Lower Jurassic, and hence are equivalent in time to the main unit (2) of the Takla group. The principal lithological differences between these sedimentary rocks and those of the main unit are the colour and abundance of coarse clastic rocks. In this respect they bear a closer lithological relation to the Hazelton group but differ from the latter by their red colour.

Shales. Dark red, reddish brown, and brown shales are the most important and characteristic rock type of this unit. They are fine grained, poorly to well sorted, and rarely show graded bedding or distinct stratification lines. Most are interbedded with conglomerate or conglomeratic shale. The thickness of individual shale beds varies from 2 or 3 inches to 50 feet or more, but the usual thickness is between 2 and 4 feet.

The shales are best exposed north and south of Ootsa Lake. Southward they disappear beneath Hazelton group rocks and farther south, where they were expected to reappear, they are apparently absent. Northward from Ootsa Lake conglomerates are more plentiful and finally, along

François Lake, shales are no more the predominant rock type in the section. Eastward and westward the shales are covered with Tertiary volcanic rock and do not reappear.

The red shales owe their colour to finely disseminated hematite and the colour varies, depending on the proportion of hematite to other coloured constituents. Recognizable constituents of the rock are quartz or chert, feldspar, various amounts of chlorite, and sericite.

Green and grey shales are interlayered with the red shales in beds a quarter inch to six inches thick. Contacts are not sharply defined, but are rather a narrow zone of intermixing of the two types. These shales differ from the red shales, only in colour, and all other physical characteristics are the same.

Conglomerates. The conglomerates of the red bed unit vary in composition, colour, and physical characteristics. Although many conglomerate beds are poorly sorted and show no stratification, other beds are moderately to well sorted, possess a distinct stratification, and are crossbedded. The pebble size varies from a sixteenth inch to 18 inches but the usual size is from a half inch to two inches. Pebbles are everywhere subrounded or very well rounded. The colour of the conglomerates is generally grey, green, red, or reddish brown, the reddish conglomerates differing from the grey and green only in colour, which results from hematite in the matrix or as a coating on pebbles. Thickness of individual beds varies from 6 inches to more than 150 feet, the thicker beds occurring mainly in the northern part of the area.

The conglomerates contain pebbles derived mainly from four types of material: fine-grained andesite, porphyritic andesite, quartz, and grey chert, in order of abundance. The proportion of these, one to the other, varies although in most sections examined green andesite pebbles were always present and generally abundant. Black chert pebbles occur sparingly and are nowhere a dominant constituent. The matrix of the reddish conglomerates contains abundant hematite disseminated throughout and coating the pebbles. Chlorite is abundant in the matrix of the green conglomerates and chlorite schist pebbles were observed in some sections. Along François Lake the conglomerates of this division have a siliceous matrix producing a hard rock that breaks across the pebbles. Farther south around Ootsa Lake, siliceous conglomerates are rare, the cementing material being calcite or hematite which produces a friable rock that breaks around the pebbles. The younger conglomerate beds of this unit contain pebbles and cobbles of conglomerate similar to earlier conglomerates of the unit.

The contacts of the conglomerate beds with the shales and greywackes with which they are interbedded are generally sharp and distinct. A common occurrence is interbedded greenish conglomerate and reddish shale,

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between which there is no gradation. Although some channelling and erosion of the shales occurred prior to deposition of the conglomerates, the latter is generally spread sheet-like over the shales with slight intermixing of the two at the contact. Where reddish conglomerate and shale are interbedded, there is more tendency for the two to intergrade although there also the change in particle size is generally abrupt.

Greywackes. The greywackes of this unit are of minor importance. They are merely fine grained, better sorted and stratified equivalents of the conglomerates, with which they are always associated. They occur in beds 2 feet or less thick.

Marine Section. Most of the rocks described above are of continental origin, but the lowest beds of the red bed unit, occurring along François Lake, consist of well-bedded shale, white to greenish orthoquartzite, fine pebble-conglomerate, and black limestone, all of marine origin. This section is only 100 to 200 feet thick, but the base is not exposed. Individual beds are 6 inches to 1 foot thick. They are well sorted and stratified but without noticeable grain-sized gradation. The beds are of uniform thickness with distinct contacts and no crossbedding or ripple-marks. One band of black argillaceous limestone was seen to contain indeterminate marine fossils, thus indicating a marine environment for this section.

Thickness. It has not been possible to compile a stratigraphic section of this unit. Lateral variation is apparently rapid as no two exposed sections seemed comparable. An estimated 3,500 feet of strata are exposed south of Ootsa Lake and constitute the greatest thickness measured. However, this means little as beds have probably been repeated or omitted. Continuous exposure of shales and conglomerates north of Ootsa Lake places the minimum thickness in this region at more than 900 feet. As these sedimentary rocks interfinger in part with the main unit of the Takla group, some thick flows of andesite interrupt the sedimentary sequence but have been mapped with the red beds.

Origin of the Red Beds. As this unit is dominantly of a reddish colour and is mainly shales and conglomerates of terrestrial origin, it must be considered as a red bed sequence. Although reddish breccias and tuffs are a common feature of the Hazelton group in other parts of central British Columbia, they are not considered as red beds but as pyroclastic material with a primary red colour. Volcanic flows generally occur with the red tuffs and they apparently possess a primary reddish colour. For the red bed section in question, however, this explanation is not acceptable for three reasons:

1. In this region no reddish flows are known from which the red beds might be derived.

2. The red colour is not the colour of the fragments and pebbles but is derived from hematite contained in the matrix.
3. The particles are not typically tuffaceous but are true sediments derived from older sedimentary, volcanic, and metamorphic rocks.

Although the evidence is far from conclusive, these red beds are considered to be primary red beds according to Krynine's (1949, pp. 60-61) classification and as such, with the exception of the lowest part of the section, are of terrestrial origin. The evidence for a terrestrial origin is as follows:

1. The presence of wood fragments and carbonaceous imprints in the greywackes and conglomerate and one carbonaceous shale bed with thin seams of coal.
2. The coarseness of the conglomerate and the thickness of the beds are not what would be expected in a strictly marine environment.
3. The lack of sorting in the shales as well as in the coarser clastic sediments indicates rapid deposition without reworking by water. This is distinctly different from the marine part of the section where the sediments are well sorted.

The evidence that these are primary red beds, is fragmentary and in part negative. The coarser fragments and pebbles readily show effects of transportation and unquestionably many of the fragments, particularly the cherts, quartzite, and schists, are derived from Permian strata outside the area of deposition. Volcanic pebbles may have been derived from erosion of Mesozoic flows within the area but these too have been rounded in transport and may have come from an outside source. The poor sorting in the shales suggests fairly rapid burial and, hence, a suitable means of preserving the colour. The evidence of transport lessens the possibility that this is a lithified regolith or even slightly reworked regolith.

If these are transported primary red beds, they have been derived from a source area in which climatic and physiographic conditions have been suitable for the production of red soils (Krynine, 1949, p. 61; Van Houten, 1948, pp. 2083-2126). These soils must thus have been eroded from an uplifted area and the oxidized condition of the iron maintained in the basin of deposition, producing a sedimentary rock with a red colour. The alternation of non-red beds may have resulted from rapid erosion reaching, in places, unweathered rock, or the presence of reducing conditions in the basin for short periods. In later paragraphs it will be shown that the land area, as suggested by Armstrong (1949, pp. 121-122), lay north of François Lake and extended southeastward across the area. Weathering and erosion may have been operative since Permian time.

Age. The age of the red beds is considered to be Late Triassic and Early Jurassic, although no diagnostic fossils were found in the rocks of this unit. The evidence to support this age is as follows:

1. The red beds are overlain by the chert pebble conglomerate unit of the Hazelton group without apparent angular discordance and without evidence of a period of non-deposition. As the chert pebble conglomerate is very early Middle Jurassic or possibly late Lower Jurassic, the red beds are at least as old as Early Jurassic.
2. The lowest beds of this unit, the marine section, are intruded by the Topley granites of probable Early Jurassic age. Thus the marine section is Late Triassic or possibly Early Jurassic.
3. The Upper Triassic part of the main unit has some interbedded red shales that are identical with the red beds of this unit.

For these reasons this unit is dated as Late Triassic and Early Jurassic, the marine section being most probably Late Triassic and the terrestrial red beds mainly Early Jurassic.

Internal Structural and Stratigraphic Relations and Sedimentary Environment of the Takla Group

The Takla group as a whole is not considered to be a conformable sequence. The red beds record uplift and erosion within this section and a change from a marine to a nonmarine environment. Upper Triassic strata, although only sparsely recognized in this area, occur in many parts of British Columbia and record one of the most widespread marine inundations of the Cordillera. A period of non-deposition has been suggested by McLearn for latest Triassic time in British Columbia, and an erosion interval may therefore have occurred in this area. It appears that Lower Jurassic seas were not as extensive as those of the Upper Triassic, and the terrestrial red beds may represent a marginal plain between an uplifted area to the north and the Lower Jurassic sea. A suggested relationship of the Takla units is illustrated in Figure 2.

The sedimentary rocks indicate a marine environment not greatly affected by nearby land areas or islands and relatively quiet sedimentation except when interrupted by intermittent volcanism. The typical Takla group sediments are fine clastic rocks, both in this area and in the type area. Black argillaceous limestone is characteristic but not abundant. Coarse clastic rocks occur but are not characteristic. Apparently the accumulation of volcanic rocks did not alter the general sedimentary environment until the end of Early Jurassic time. The accumulation of coarse clastic material in a nonmarine environment in the northern part of the area indicated the progressive uplift of this region.

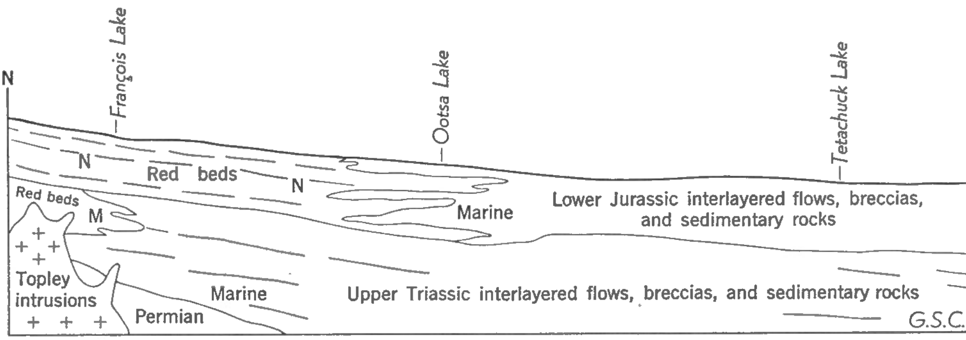

Figure 2. Diagram showing suggested relations between units of the Takla group. M—Marine, N—Nonmarine.

External Structural Relations of the Takla Group

The relation of the Takla group to older strata is not known from Nechako area. In Fort St. James area Armstrong stated "that the Takla group lies unconformably above the Cache Creek group (Permian) and that the period between Middle Permian and Upper Triassic was apparently one of igneous intrusion, uplift, erosion, and probably deformation" (Armstrong, 1949, p. 56). No evidence to confirm or refute this statement has been obtained in this area.

The chert pebble conglomerate unit of the Hazelton group overlies the Takla group apparently unconformably. This will be discussed under the Hazelton group.

The marine section of the red beds is invaded by the Topley intrusions but the overlying nonmarine red beds are not (*see* Figure 2). Boulders of the Topley intrusions occur in the chert pebble conglomerates of the Hazelton group immediately above the nonmarine red beds. Penecontemporaneous intrusion and sedimentation are suggested but not proved.

Hazelton Group

Lithology and Map-Units

With the close of sedimentation and volcanism of the Takla group, an important change occurred in the configuration of the marine depositional basin. It became more restricted, with the same landmass on the north and northeast but a new mass, probably volcanic islands, on the west and southwest margins. Thus was produced a northwest-trending basin which occupied the central part of Nechako River map-area. Within this basin Hazelton group sedimentary and volcanic rocks accumulated.

The Hazelton group consists of volcanic flows and pyroclastic rocks with interbedded sedimentary strata. The volcanic rocks do not differ greatly from those of the Takla group and it is generally difficult or impossible to distinguish one from the other. The sedimentary rocks show a dominance of coarse boulder-conglomerate, pebble-conglomerate and greywacke. Black carbonaceous shale and grey shale are interbedded with the sedimentary and volcanic rocks, and locally form thick sections.

For mapping purposes, the Hazelton group has been divided into three fairly distinct lithologic units which, with further study, might be defined as formations. It is not desirable on the scale of mapping to introduce formation names or to attempt a degree of refinement unwarranted by the scale of mapping. As in the Takla group, these units will be referred to as the chert pebble conglomerate unit (5), the Middle Jurassic unit (6), and the Upper Jurassic unit (7).

Chert Pebble Conglomerate Unit (5)

This unit, as the name implies, is characterized by chert pebble conglomerate but, although characteristic, this rock type is not the most abundant. Andesitic and basaltic flows with related tuffs and breccias comprise over 50 per cent of the rocks of this unit. The conglomerates are the next important rock type and are widespread in the area; although shales and greywackes are locally important, limestones were nowhere seen. These sediments were deposited partly in a marine and partly in a nonmarine environment, and there is thus a gradation from nonmarine sedimentary rocks in the northeast to marine rocks in the central part of the area.

Volcanic Rocks. The volcanic rocks of this unit, both flows and pyroclastics, do not differ greatly from those of the Takla group and it will suffice to mention here only the few different types that do occur. The flows in particular are similar and, because of the wide range of composition and texture in the lavas of both divisions, it is impossible by an examination of these rocks to differentiate the groups. The tuffs and breccias of the chert pebble conglomerate unit are interbedded, contain angular fragments, and show a fairly distinct sorting, but are generally ungraded. The fragmental rocks give the impression that they have been slightly reworked and sorted, so that distinct beds of similarly sized fragments occur. Unlike those of the Takla group, fragments of the Hazelton pyroclastic rocks are clearly visible on fresh as well as on weathered surfaces, due probably to a distinct difference in composition between fragments and matrix. Accumulations of volcanic rocks vary in thickness from a measured 1,700 feet of flows in one place to 1 foot or 2 feet of tuffs and breccias in others. Volcanic rocks are interbedded with or overlie chert pebble conglomerate; those that lie below the conglomerate are arbitrarily considered to be part of the Takla group, although this may not everywhere be true.

Sedimentary Rocks. The sedimentary rocks of this unit are chert pebble conglomerates, orthoquartzites, shales and greywackes. Because of the high chert and quartz content, most of these rocks fit into the quartzite series of Krynine's classification (1948, pp. 149-152), but, with an increase in chlorite, mica, and volcanic rock fragments, some members of the greywacke series appear. In general, the conglomerates, orthoquartzites, and shales are similar to one another in composition but differ in grain size.

The chert pebble conglomerate beds are distributed around the margin of the sedimentary basin and were deposited under both marine and non-marine conditions. The conglomerates are exposed in the northwest quarter of the area, along Chelaslie Lake and in isolated patches southeastward to the southern boundary of the area, and in the Nechako Range. In all these areas the conglomerates are interbedded not only with the volcanic strata of the unit but also with the finer clastic sedimentary rocks. The conglomerate beds vary in thickness from 2 to 3 inches to 25 feet or more, but individual beds show many irregularities with abrupt thickening or thinning, and lensing out. Laterally the beds may pass gradually into finer clastic rocks but generally, despite the variation in thicknesses, the conglomeratic beds are fairly persistent. Pebbles in the conglomerates are well rounded and vary in shape from tabular to almost perfect spheres. The conglomerates are moderately to well sorted and rarely display graded bedding. In finer phases of the conglomerates coarse crossbedding is common. Pebbles vary in size from a sixteenth inch to 3 feet in diameter but most are from a half inch to 2 inches in diameter. The composition of the conglomerate varies slightly, but most carry more than 90 per cent quartz and chert pebbles. The other 10 per cent of the pebbles is made up of argillite, andesite, greenstone, and rarely, pebbles of limestone, granite, gneiss, and schist. Almost all the pebbles are similar to rock types present in the Permian Cache Creek group, which outcrops north and east of the area. The granite pebbles, locally abundant near François Lake, are derived from the Topley intrusions outcropping nearby. The matrix is mainly sand-sized particles of the material contained in the pebbles. Where the cement is siliceous the rock is well cemented and impermeable but where calcite or limonite forms the cementing material the rock is very porous, permeable, and commonly friable. The chert pebbles are mainly of two kinds, black chert and grey chert, and the proportion of these one to the other varies from 100 per cent black chert to over 90 per cent grey chert. Black chert pebbles are characteristic of these conglomerates. With increased distance from the area of the Cache Creek strata, the percentage of andesite pebbles increases substantially to produce a greywacke conglomerate. Thus in the southwestern part of the area conglomerates consist of as much as 50 per cent green andesite pebbles, derived presumably from Takla group andesite or the erosion of penecontemporaneous volcanic flows.

Orthoquartzites and low-rank greywackes are interbedded with the conglomerates and differ from them only in grain size. They are of coarse sand size and have a "salt and pepper" appearance. Well-stratified, cross-bedded, or ripple-marked beds are common. Individual beds vary in thickness from 2 inches to 12 feet, but 2 to 3 feet is usual. The appearance of the orthoquartzites is deceptive; the black chert grains suggest at first a greywacke, but a microscopic examination shows a very high chert and quartz content, commonly 90 per cent. The conglomerates are both marine and nonmarine, whereas the orthoquartzites and greywackes everywhere suggest marine or near-shore features and the common presence of belemnite moulds confirms their marine origin. These rocks are more abundant near the centre of the sedimentary basin and outcrop in the Fawnie Range, north of Chelaslie Lake, and north of Euchiniko Lakes.

Shales and argillites form an important part of the sedimentary part of the unit. These rocks are invariably dark grey or black, fine grained, banded or massive, well sorted, and, because they are the least competent rocks in this unit, they are commonly sheared, contorted, and squeezed out. In composition many of the shales and argillites are merely fine-grained equivalents of the orthoquartzites and conglomerates, and may be referred to as quartzose or siliceous shales and argillites. However. carbonaceous, chloritic, and micaceous shales are more abundant, though always with a high quartz or chert content. The shales become tuffaceous when interbedded with pyroclastic strata. Calcareous shales and limestone are not known in the division. The shales are interbedded with conglomerates, orthoquartzites, greywackes, tuffs, breccias, and flows and occur in marine and nonmarine sections, as indicated by nonmarine flora and marine fauna. Although widespread, the shales form thicker sections near the centre of the basin of sedimentation.

Middle Jurassic Unit (6)

This unit is characteristic of the Hazelton group, both in lithology and age. It is primarily a sedimentary unit with some interlayered flows, breccias, and tuffs. The sedimentary rocks are commonly tuffaceous and mostly marine, but show by the type of fragments that land areas were nearby. The rock types are extremely variable and none can be said to be typical. They are, on the whole, less siliceous than those of the chert pebble conglomerate unit. The Middle Jurassic unit can be defined to a limited extent by this characteristic, but for positive definition palæontological evidence and a knowledge of its relation to the underlying unit are required. Rock types are andesite, rhyolite, related tuffs and breccias, greywackes, conglomerates, shales, argillites and arkoses. No one type is widespread or predominates in sections examined. The unit is exposed in three belts or localities in the area; as a syncline trending along Big Bend Creek and Euchiniko River, as a syncline forming the crest of Kuyakuz Mountain, and as a syncline on the crest of Fawnie Range. No other strata referable to this unit are known in the area.

Fawnie Range Section. The Fawnie Range section is less than 1,000 feet thick and is distinctly different from the other two. A generalized section is as follows:

Lithology	*Thickness (feet)*
Top	
Fine-grained rhyolite flows, flow-banded, grey to white	150
Coarse-grained, well-bedded orthoquartzites	175
Porphyritic rhyolite (absent in places)	50
Coarse rhyolitic breccia (absent in places)	350
Coarsely bedded conglomerate, interbedded shales and greywacke ..	200
Base	
	925

This section contains coarser clastic sedimentary rocks and more rhyolite than other sections of the division. The rhyolites are fine grained or porphyritic with quartz phenocrysts. Ferromagnesian minerals are lacking and the rock appears to be mainly a cryptocrystalline mass of quartz. The orthoquartzites are derived from these flows. They are well banded, crossbedded and sorted with well-rounded grains, and are compact, well-cemented rocks. The siliceous rhyolitic breccia has a light grey to dark matrix, not unlike the rhyolites, with fragments from a quarter inch to 30 feet in diameter of material derived from underlying divisions. The sedimentary rocks are coarse-grained, grey to brown conglomerate, shaly conglomerate and shale, derived apparently from a volcanic terrain as all fragments are from lavas or volcanic breccia. The shales, some of them reddish brown, are tuffaceous and commonly carbonaceous. Sorting is poor in these sedimentary strata and well-defined beds are lacking, although from a distance distinct banding is visible.

Kuyakuz Mountain Section. On Kuyakuz Mountain, the Middle Jurassic unit consists mainly of fine volcanic breccias, tuffs, argillaceous tuffs, tuffaceous shales, and argillites or shales. The apparent thickness of this section is at least 5,500 feet although some of this may be repetition. Flows are relatively unimportant, although green and reddish andesite occurs. Coarse detrital or volcanic sedimentary strata are absent, the coarsest fragments observed being a quarter inch in diameter. Most are fine-grained, well-sorted, dense strata varying in colour from black to brown, grey, and purple. Grey rhyolitic tuff and brownish shales occur, similar to those of the Fawnie Range section. The strata are mainly tuffaceous and examination shows that the rock comprises angular to rounded volcanic fragments, chlorite, feldspars, magnetite, and much fine, unidentified material. The rock is varied and lateral changes in composition, texture and colour are rapid. The frequent presence of belemnite moulds, as well as the fine texture and bedding, indicates a marine environment of deposition.

Euchiniko River Section. The third section of this unit, that along Euchiniko River, consists of all the rock types represented in the first two, plus several others. It is not completely exposed, as drift areas and Tertiary volcanic rocks divide it into several areas of outcrop. A composite section is as follows:

Lithology	*Thickness (feet)*
Top	
Interbedded arkose, shale, and minor flow-banded rhyolite	300
Black shale or argillite; ammonites near top	1,500
Tuff, volcanic breccia	200
Green andesite (absent in places)	750
Arkose and arkosic conglomerate	600
Conglomerate and conglomeratic greywacke	2,000
Rhyolite breccias (uncommon)	50
Andesite greywacke; abundant wood fragments and carbonaceous imprints	250
Base	
Andesite flows of chert pebble conglomerate division	
	5,650

Rocks of this section are similar in many respects to those of the other two. Most of the material is derived from volcanic rock or volcanic terrains. The andesitic greywacke is mainly green tuff and feldspar fragments that have undergone rapid deposition, reworking and burial, the fragments being subangular to subrounded. The conglomerate and conglomeratic greywacke contain 10 to 70 per cent chert pebbles reflecting the proximity to the northeasterly source area.

The arkose that occurs in this section consists of euhedral grains of feldspar in a greenish chlorite, biotite, and quartz matrix. Sorting is poor and on first glance the rock appears to be igneous. However, the rounding of the quartz grains, crude stratification, and interlayering with fossiliferous marine shales point to a marine sedimentary environment. The beds of arkose are from 2 to 50 feet thick but most are about 3 feet thick. The lack of sorting and the fresh, unbroken appearance of the feldspar grains point to rapid transport for a short distance and rapid burial. An arkosic conglomerate occurs in one place with irregular pebbles of granodiorite, 2 inches in diameter embedded in an arkosic matrix. The outline of pebbles is indistinguishable on fresh surfaces and can be seen on only weathered surfaces. The granodiorite pebbles and feldspar grains in hand specimen closely resemble rocks of the Topley intrusions. The proximity of the Topley intrusions, and the fact that they were, at the time, being eroded suggest the obvious source of the arkose. Furthermore, the evidence of short transportation and the presence of carbonaceous imprints and coarse clastic material all suggest that the arkose was deposited close to the northeast margin of the sedimentary basin.

Relations of the Three Sections. That the three sections described are correlative is not obvious from the lithology. All three, however, are stratigraphically above the chert pebble conglomerate unit, the Kuyakuz and Euchiniko sections contain Bajocian ammonites, brownish or grey shales are present in all three, and rhyolites are present in two sections and rhyolitic tuff in the third. For these reasons the sections are considered to be correlative in time and to have formed in a single, unstable sedimentary basin. They are, therefore, considered as one map-unit. A lithologic characteristic of the unit would be its heterogeneity rather than homogeneity. It is not known to contain sedimentary strata identical with or very similar to any in the underlying chert pebble conglomerate unit or in the overlying Upper Jurassic unit.

Upper Jurassic Unit (7)

The Upper Jurassic unit occupies a very small area along Nechako River near the northwest end of Nechako Range. It is lithologically distinct but is poorly exposed, and probably represents a downfaulted slice or block of a formerly more extensive sedimentary unit. About 400 feet of sedimentary rocks are exposed, consisting of interbedded black calcareous shales and argillaceous limestones. The shales are very fine grained, black, evenly banded, well sorted, and are in bands of a sixteenth to 1 inch thick. The limestones are black and fine grained, and occur in bands 3 to 6 inches thick. Spherical calcareous concretions about 8 inches in diameter enclosing exceptionally well-preserved ammonites occur within one band of shales.

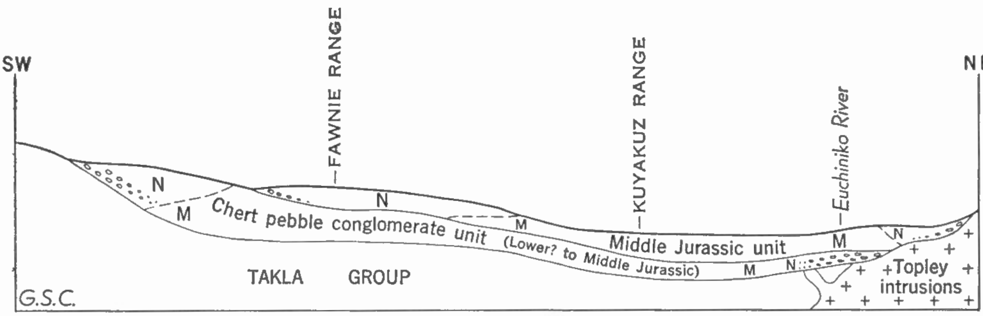

Figure 3. Diagram showing suggested relations between units of the Hazelton group. M—Marine, N—Nonmarine.

The calcareous nature of this unit, the fine, even bedding, and the distinctive fossils indicate that this section is a remnant of strata deposited in a marine basin of unknown extent.

Internal Structural and Stratigraphic Relations of the Hazelton Group

The strata of this group accumulated in a northwest-trending basin that occupied the centre of the area. The exact shape of this basin cannot be drawn precisely and was probably changing rapidly. Although there is no apparent widespread break in deposition between the chert pebble conglomerate unit and the Middle Jurassic unit, there was a broad tilting or shifting of the basin from west to east so that, in the Fawnie Range nonmarine sediments rest on marine, in Kuyakuz Mountain marine sediments rest on marine, and east of the Nechako Range marine sedimentary strata rest on nonmarine and apparently overlap onto the exposed Topley intrusions (*see* Figure 3).

The relationship of the Upper Jurassic unit to the two older units of the Hazelton group is not known. No contact was observed between this unit and any other Mesozoic unit or group, but because of its topographic position and structure relative to the other units, this unit is presumed to be a downfaulted block. Thus any suggestions regarding the stratigraphic relationship would be purely conjectural.

External Structural Relations of the Hazelton Group

The Hazelton group rests unconformably on the Takla group and contains detritus derived from the Topley intrusions. Although contact relations were rarely observed, sufficient evidence exists to indicate the truth of these statements:

1. The chert pebble conglomerate unit of the Hazelton group rests on Lower Jurassic, on Upper Triassic, and on red bed sections of the Takla group in different parts of the area.

2. An angular discordance was noted in beds of the two groups in the Fawnie Range.
3. The change in lithology between the two groups suggests a change in environment of deposition, from which it may be concluded that uplift and possible deformation occurred in the land areas near the sedimentary basins.
4. The gradual increase in coarse clastic sediments, beginning with the red beds of the Takla group and culminating with the widespread conglomerates of the lowest unit of the Hazelton group, points to a progressive uplift in the area of the present Topley granites.
5. Granite boulders of the Topley intrusions occur in the chert pebble conglomerate unit. If this granite mass, which intrudes the Takla group, was unroofed by Hazelton time, it is difficult to reach any other conclusion than that uplift must have occurred towards the close of Takla time.
6. By Middle Jurassic time, granitic debris from the Topley intrusions was forming arkosic sedimentary rocks.

There is no doubt that the Hazelton group rests unconformably on older strata. Whether this unconformity is an angular discordance, a disconformity, or an erosional interval cannot be stated with certainty. It would seem probable that all three possibilities are applicable, with the added possibility that in some deeper part of the basin, outside Nechako map-area, there is no unconformity at all. There is no evidence to indicate an appreciable time gap; possibly there was none.

Age of the Hazelton Group

The age of the Hazelton group can be defined fairly closely both from fossil evidence within the group and from relations with other stratigraphic units. Although twenty fossil localities have been found in the three units of the Hazelton group, only three of them yielded diagnostic fossils. From the other localities pelecypods, gastropods, brachiopods, and belemnites were obtained that either were of no stratigraphic significance or were unidentifiable.

The Upper Jurassic unit is dated closely by a collection of ammonites from a locality on the Nechako River, 2 miles upstream from Big Bend Creek. With regard to this collection, H. Frebold of the Geological Survey of Canada, comments,

> This collection consists exclusively of well preserved ammonites. They belong to *Lilloettia lilloetensis* Crickmay which is a typical Lower Callovian ammonite, that is also known from the Lower Callovian of Harrison Lake area and Alaska.

The Middle Jurassic unit is dated closely by two collections of ammonites, one from the south slope of Kuyakuz Mountain, the other from Euchiniko River, about a mile west of the mouth of Taiuk Creek. These collections were also examined by H. Frebold who comments as follows:

1. Collections from Kuyakuz Mountain.

This collection contains poorly preserved ammonites, probably belonging to the genera *Sonninia* and *Witchellia,* and some pelecypods (*Trigonia* sp., *Pleuromya* sp.). This fauna is of Early Bajocian (early Middle Jurassic) age. Its stratigraphic position is probably between the somewhat older *Tmetoceras* and the younger (Middle Bajocian) *Stephanoceras* beds in the adjacent Whitesail area. Beds with *Sonninia* that form part of the Hazelton group near Hazelton, B.C. and some beds of the Takla group in McConnell Creek area that contain *Witchellia,* are probably of the same age.

2. Collections from Euchiniko River.

Most of the many poorly preserved and not accurately determinable ammonites in this collection are Harpoceratids with affinities to *Sonninia* and *Witchellia.* The age of this fauna is probably Early Bajocian (early Middle Jurassic). Its stratigraphic position is probably the same as that of the Kuyakuz Mountain fauna.

These two Lower Bajocian collections occur near the top of their respective sections. As pointed out by Frebold, these faunas are younger than those of the *Tmetoceras* horizon, which is considered to be the oldest Middle Jurassic so far known in British Columbia (Frebold, 1951, pp. 18-21).

The chert pebble conglomerate unit yielded several collections of fossils, both fauna and flora, but no index fossils were present. It occurs immediately below the Middle Jurassic unit and appears to pass gradually into it in some places. There is, in any case, no significant stratigraphic break and for this reason it is believed that the chert pebble conglomerate unit represents the earliest Middle Jurassic strata and is correlative with the sedimentary strata of Whitesail Lake map-area that contains the *Tmetoceras* fauna. However, an Early Jurassic age must be considered as a possibility until a more exact dating of the unit is obtained.

In summary, the Hazelton group in this area apparently ranges from earliest Middle Jurassic to early Upper Jurassic. There is no evidence to suggest that deposition was continuous over this period of time at any one place; on the contrary, it is considered probable that diastems and disconformities are present.

Mesozoic Granitic Rocks

Two distinct periods, and possibly more, of intrusion occurred within the Nechako River map-area. As only the stratigraphic and tectonic aspects of these intrusions bear on the problems being considered, details of the petrography and petrology will not be given here.

Topley Intrusions

Occurrence. The Topley intrusions occupy a southeasterly trending belt crossing the northeast quarter of the map-area. This belt continues to the northwest for at least 80 miles and to the southeast for an unknown distance. Its maximum known width is about 50 miles and the average width about 30. This belt is not Topley intrusive rocks throughout, but is a series of granitic bodies separated here and there by Permian strata and overlain by irregular, discontinuous patches of younger volcanic and sedimentary strata.

Lithology. The composition, texture, and structure of the Topley intrusions in Fort St. James map-area have been described by Armstrong, (1949, pp. 92-97). In general, this description also applies in Nechako River map-area. Pink pegmatitic granite outcrops from François Lake southeast to Tatuk Lake, and foliated diorite and granodiorite outcrop in the Nulki Hills. Quartz diorite, diorite, granodiorite, and quartz monzonite are present but less abundant and appear to grade into the types mentioned above. As pointed out by Armstrong, there is no evidence to prove that these intrusions represent a single period of igneous activity but, unless evidence to the contrary is discovered, this is a reasonable assumption.

Age. The Topley intrusions were considered by Armstrong to be possibly of post-Middle Permian, pre-Upper Triassic age (Armstrong, 1949, p. 96), but in the writer's opinion they are post-Upper Triassic, pre-Middle Jurassic. This opinion is based on the following:

1. Boulders and pebbles of pink granite, identical with the Topley granites, occur in the chert pebble conglomerate unit of the Hazelton group. These boulders and pebbles are certainly derived from the Topley granites as they occur only where outcrops of Topley granite are nearby; elsewhere granitic pebbles are lacking. Similarly in the Middle Jurassic unit, arkoses derived from a granitic terrain occur near the contact with the Topley granites. As both these units are early Middle Jurassic, it is reasonable to assume that the Topley granites were exposed to erosion by earliest Middle Jurassic time, and hence were emplaced before then.
2. In the discussion of the red beds of the Takla group and its external relations it was stated that the Topley intrusions were younger than the marine part of the unit and possibly were emplaced penecontemporaneously with the upper part. It was indicated that the red beds are considered to be Upper Triassic and Lower Jurassic and, if this be true, the Topley intrusions must be Lower Jurassic or latest Upper Triassic.

3. On the southwest margin of the batholith, the Topley granites intrude green andesites and andesitic breccias and tuffs. These rocks are fresh and up to a few inches from the granite contact there is no apparent metamorphic effect. The age of these green andesites, in the light of the evidence given above, is Early Jurassic, Late Triassic, or Late Permian. Lower and Middle Triassic strata are unknown in British Columbia west of the Rocky Mountain Trench and the Early and Middle Triassic are believed to have been a period of uplift and erosion (Armstrong, 1949, p. 97). The andesites referred to are not therefore considered to be Lower or Middle Triassic. Permian andesites are not common, and where they do occur in Fort St. James map-area are the most altered of Permian strata (Armstrong, 1949, p. 43). They have been regionally metamorphosed and now occur mainly as chlorite and hornblende schists and amphibolites. Contact metamorphic effects are also pronounced. The andesites of Nechako River map-area being discussed are relatively unaltered, even near intrusions, and are therefore probably Upper Triassic or Lower Jurassic rocks. The intruding Topley granites can be no older than latest Upper Triassic. With this argument Armstrong is in agreement[1].

In discussing the age of the Topley intrusions, Armstrong offers eight reasons for a pre-Upper Triassic dating (Armstrong, 1949, pp. 96-97). None of these reasons is based on positive evidence and some can be refuted. The main point that Armstrong made was that the Topley intrusions were not in contact with Takla group rocks; this is now known to be untrue.

There is no evidence that any part of the Topley intrusions were emplaced before late Upper Triassic time or later than early Middle Jurassic. Nonetheless, as this is negative evidence, the possibility still remains. Actually the evidence presented points strongly to an Early Jurassic or latest Triassic age.

Upper Jurassic Intrusions

Lithology. Under this heading are included all other acidic intrusions in the map-area. They are composed of diorite, quartz diorite, granodiorite, quartz monzonite, and granite. Granite and quartz monzonite are the most abundant types and form large stocks and batholiths. From an inspection of the map these acidic intrusions would appear to be rather scarce. Actually, however, they are fairly abundant but as they erode

[1] J. E. Armstrong, 1954, personal communication.

rather easily, they formed pre-Tertiary topographic low areas and much is covered by younger volcanic rocks and glacial deposits.

Periods of Intrusion. These intrusions may have formed during more than one period of igneous activity, but suitable means of distinguishing the different periods is at present lacking and all have been tentatively included under one heading. All cut Takla group rocks and are thus of an Early Jurassic or younger age. Most of the intrusions moreover cut the Middle Jurassic unit of the Hazelton group but their relation with the Upper Jurassic unit is not known. Upper Cretaceous flows rest unconformably on many of the granitic bodies. The main masses of these intrusions are thus post-early Middle Jurassic and pre-Late Cretaceous. Possibly they are related in time to the final uplift that excluded the sea from central British Columbia in Late Jurassic or Cretaceous time.

CHAPTER III

DEFINITION OF THE HAZELTON AND TAKLA GROUPS

Bases for Redefining the Hazelton and Takla Groups in Nechako River Map-Area and Their Applicability to other Areas

Within Nechako River area, several factors were considered in assigning specific strata to either the Takla or Hazelton group. The principal of these were the relation to the Topley intrusions, the relation to the chert pebble conglomerate unit, and the palæontological evidence.

The Topley intrusions are believed to be Lower Jurassic and are known to intrude some Mesozoic strata and to supply detritus to others. Everywhere they intrude rocks that are similar to Lower Jurassic or Upper Triassic rocks but never any known to be, or to resemble Middle Jurassic rocks. Strata older than the Topley intrusions are therefore considered to be part of the Takla group and those that received detritus from the Topley intrusions to be part of the Hazelton group.

The relationships of the two groups with the Topley intrusions is reasonably clear in Nechako River, but elsewhere this is not so. Armstrong considered the Takla group to be younger than the Topley intrusions, but did not see the two in contact (Armstrong, 1949, p. 97). In Fort St. James area any granitic mass intruding Takla group rocks was considered to be part of the younger Omineca intrusions, though Armstrong admits difficulty in distinguishing them lithologically from the Topley intrusions (Armstrong, 1949, p. 107). The Hazelton group was mapped in contact with the Topley intrusions in Houston map-area but their relations were not known (Lang, 1942). The Tachek group of Fort St. James area is younger than the Topley intrusions and this group is considered to be correlative in part with the Hazelton group (Hanson and Phemister, 1929, pp. 63-64).

The chert pebble conglomerate unit has been chosen as the base of the Hazelton group for the following reasons:

1. Pebbles from the Topley intrusions first appear in this unit.
2. The conglomerate marks a distinct change in the Mesozoic sedimentary lithology. Older sedimentary rocks, with the exception of the red beds, are characteristically fine grained, whereas strata of this and succeeding units are, at least in part, coarse grained.

   Within Fort St. James map-area, most of the Upper Triassic sedimentary strata are fine-grained argillites, shales, and limestones, although near the central landmass conglomerates occur. Lower Jurassic sedimentary rocks are more varied and all contain at least some coarse-grained beds. In McConnell Creek map-area, the Takla group is subdivided into upper and lower divisions, roughly corresponding to Hazelton and Takla groups in their type areas, and a lithologic change from fine to coarse clastic sedimentary strata occurs between the two divisions. This change, however, apparently started in Early Jurassic time well before the start of the similar change in Nechako River area. In Smithers and Hazelton areas, apparently the deposition of coarse clastic sediments did not begin until Late Jurassic time and the Middle Jurassic sedimentary strata are shales, quartzites, and limestones. Farther southeast in Whitesail Lake area, the Middle Jurassic sedimentary rocks are argillites, greywackes, and some conglomerates (Duffell, 1952, p. 3). In Terrace area the Middle Jurassic sedimentary rocks are mainly greywacke and possibly some argillite. The overlying rocks, from which Upper Jurassic fossils were collected, consist of water-lain tuffs and argillite succeeded conformably by conglomerates, greywackes, and argillite that may be, in part, Lower Cretaceous[1]. In the Portland Canal area (Hanson, 1935, pp. 6-13), the Middle Jurassic sedimentary rocks are mainly greywackes, shales, and conglomerates but vary considerably. In Queen Charlotte Islands, the Lower Jurassic sedimentary rocks are fine grained and the Middle Jurassic characteristically coarse grained (McLearn, 1949, p. 5). Similarly in the Stikine River area (Kerr, 1948a, p. 21), the Triassic strata are fine grained, clastic sediments and the Jurassic coarse grained. Farther north, in Taku River area (Kerr, 1948b, pp. 19-21), the Triassic and Jurassic sedimentary rocks do not differ in grain size.

From the foregoing it is apparent that a relatively stable Triassic period of fine clastic sedimentation was interrupted by the deposition of coarse Jurassic sediments beginning as early as Lower Jurassic in the east, and as late as Upper Jurassic in the west, but commonly in the Middle Jurassic. Some relation exists therefore between the chert pebble conglomerate unit of Nechako River area and the other coarse-grained Jurassic sedimentary rocks. Apparently they mark the beginning of a period of coarse clastic sedimentation which probably parallels an intense tectonic activity.

3. The chert pebble conglomerate unit is well represented in Nechako River area and is a distinctive lithologic type. In several parts of

[1] S. Duffell, 1955, personal communication.

central and northern British Columbia similar sedimentary sections occupy the same stratigraphic position. Others may be younger or older, but most can be related to a Jurassic uplift in central British Columbia.

4. The chert pebble conglomerate unit is unconformable with the Takla group, at least near the margins of sedimentary basins. In the central parts of the basin this division may be essentially conformable with older strata but the change in lithology reflects marginal tectonic activity. Local unconformities have been recorded elsewhere in central British Columbia and the change in sedimentary lithology already discussed certainly reflects tectonism nearby. Unconformable relations, although apparently not recognized, are to be expected in many areas.

A consideration of the palæontology of Nechako River area and its significance have aided in a clearer definition of the Takla and Hazelton groups. In general, in the Takla group fossil localities are few whereas in the Hazelton group they are numerous, although many of the specimens collected are not diagnostic or are indeterminable. Because of the general lack of well-preserved index fossils and easily defined marker beds, great care must be used in correlation. Within the Middle Jurassic unit of the Hazelton group only two fossil collections contained index fossils, yet these confirmed the internal stratigraphic relations of the group as established on physical characteristics.

The correlation of Mesozoic rocks in one area of central British Columbia with those of another area has always been effected with little attention to sedimentary lithology. Palæontological evidence to suggest that two areas contain rocks of the same age is considered sufficient to assign such rocks to the same group. If a certain group is found to be of the same age as two other groups it is generally correlated with the one nearest. The important factor is the similarity of age.

Such a reliance on fossils for correlation in a eugeosyncline is justified because:

1. They may be the only unifying factor in heterogeneous rock groups of several areas; and
2. Formations or groups of a eugeosyncline are unlikely to transgress time. In such a tectonically active area the lithology of any one group or formation would be dependent on factors operative for short periods of time, and hence such a formation or group would be essentially the same age throughout. Thus, in dealing with large units such as groups, a diagnostic fossil becomes an indicator of a particular group.

In comparing the ages of rocks of Nechako River area with those of other areas, the basis of correlation is obvious. The Middle Jurassic strata of the Nechako River area are correlative with the Hazelton group, and the Upper Triassic and Lower Jurassic strata with the Takla group.

Some Broader Considerations in Defining the Hazelton and Takla Groups

In making a preliminary definition of the Hazelton and Takla groups, much conflicting evidence appears and it is difficult to offer any clear-cut criteria. Although it is unlikely that the characteristics of the two groups in one area could persist in all areas or that all pertinent information is available, sufficient is known to propose some limiting conditions that may find general application in central British Columbia.

The central land area is an important factor in the Mesozoic stratigraphy, and had a controlling influence on the character of sedimentary strata produced. Although it did not affect all strata mapped as Hazelton or Takla group, it was an important tectonic element and typifies what might be expected elsewhere. It appears to have been slightly positive during Late Triassic time, more so in Lower Jurassic time, and a major land area in all later time. Within this land area during Mesozoic time there were ultramafic and granitic intrusions, uplift, erosion, deformation, and volcanism, and in no way can it be dismissed as a few unimportant volcanic islands. Rather it was the most important Mesozoic tectonic element in central British Columbia.

The definition of the Hazelton and Takla groups is most difficult when the Lower Jurassic strata have to be assigned (*see* Figure 4). Upper Triassic sedimentary strata are almost invariably shales or argillaceous limestones clearly assignable to the Takla, and Middle Jurassic or later beds are generally conglomerates or greywackes typical of the Hazelton, but Lower Jurassic sedimentary beds may be either coarse or fine grained. Within Nechako River area, the Lower Jurassic strata are indistinguishable from Upper Triassic rocks, except for the red bed section which is locally important. In McConnell Creek area, Lower Jurassic strata are closely related to and inseparable from the upper division of the Takla group (equivalent to Hazelton group). In Fort St. James area, the type area of the Takla group, Armstrong recorded the occurrence of Lower Jurassic conglomerates, greywackes, and shales and postulated marine, near-shore, or nonmarine conditions. These beds are distinctly different from the Upper Triassic sedimentary strata. Thus in both McConnell Creek and Fort St. James areas the Lower Jurassic could rightly be considered to be part of the Hazelton group (although in the Fort St. James area Armstrong considered it part of the Takla group). In Nechako River area, the Lower

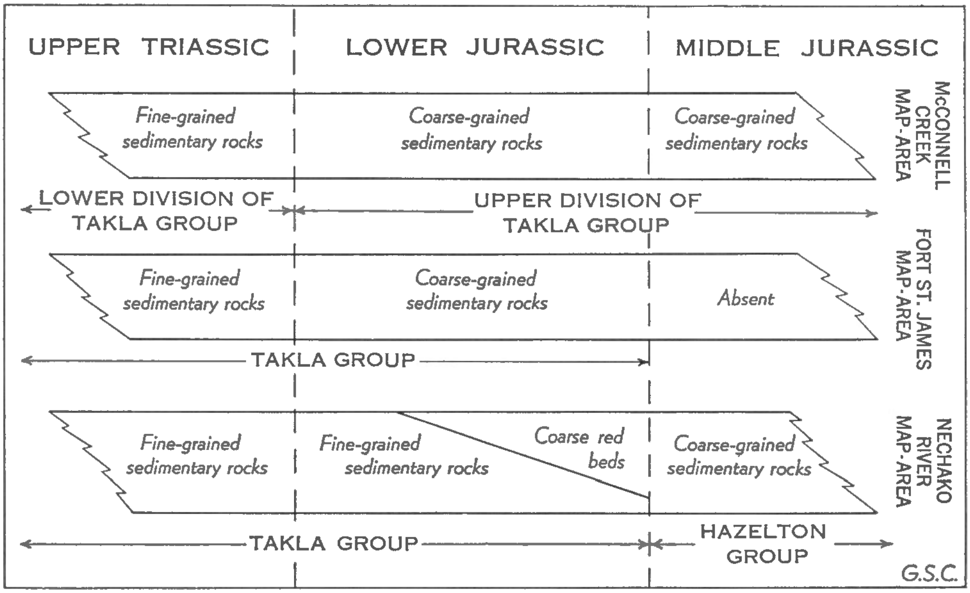

Figure 4. Variation in Lower Jurassic sedimentary rocks, central British Columbia.

Jurassic is more closely related lithologically to the Upper Triassic strata of the Takla group. Armstrong commented on the sedimentary environment of the Takla group as follows: "it seems probable that marine conditions prevailed in Upper Triassic time and fluctuating marine, nearshore, and possibly continental conditions in the Jurassic period" (Armstrong, 1949, p. 121). "Jurassic" in this statement should more correctly read, "Lower Jurassic".

With which group should the Lower Jurassic strata be correlated? (*See* Figure 4.) They never have been included in the Hazelton group, but in places there now seems to be some justification for so doing. Armstrong placed both Upper Triassic and Lower Jurassic in the same group but probably more for convenience than because there was no valid reason for separating them.

Early Jurassic time was apparently a transitional period in which environmental conditions changed from moderately stable to chaotic. During this time the Topley intrusions were emplaced and probably the land area previously mentioned became influential for the first time. The effect of these conditions was not felt everywhere at the same time, so that difficulty persists in mapping and correlating Lower Jurassic strata. It seems probable that in time the Takla group will be restricted to Upper Triassic strata, like the Nicola group (Duffell and McTaggart, 1952, pp. 29-31) of southern British Columbia, and the Lower Jurassic strata will be mapped as a new group. Until that is feasible there is no alternative but to map Lower Jurassic rocks with the Takla group where possible, as in Nechako River area, but as Hazelton group where they are lithologically inseparable from Middle Jurassic strata, as may be the case in McConnell Creek area.

General Definition of the Hazelton and Takla Groups

A study of the literature and a consideration of the evidence presented by various geologists permit a preliminary definition of the Hazelton and Takla groups. This is presented in an abbreviated form, with a further explanation of some items.

	Hazelton Group	*Takla Group*
Age	Middle Jurassic, Late Jurassic, and Early Cretaceous.	Late Triassic and Early Jurassic.
Outstanding characteristic	Variegated red to green bedded tuffs and breccias.	Grey, green to black, massive flows and breccias.
Volcanic lithology	Red, brown, purplish, or green andesite and basalt; generally only slightly altered; rhyolite common but not abundant; pyroclastic rocks commonly more abundant than flows but varies from one area to another.	Green to grey andesites and basalts; commonly altered to greenstone; red, brown, or purplish flows uncommon; rhyolite rare.
Sedimentary lithology	Sand-sized sedimentary rocks abundant with thick chert pebble conglomerates common; argillites and shales generally subordinate; limestone not characteristic.	Argillites, shales, and limestone characteristic; greywackes or sandstones less abundant but widespread; conglomerate occurs locally but not characteristic.
Environment of deposition	Any environment possible, generally marine or near-shore; nonmarine sedimentary rocks have been recognized in only a few areas.	Typically marine, rarely near-shore or nonmarine.
Source of sedimentary material	A land area in central British Columbia represented by present outcrop area of the Cache Creek group and Topley intrusions; probably a major arc of volcanic islands on site of present Coast Mountains; isolated groups of volcanic islands.	Some detritus derived from erosion of Cache Creek strata, but much of the sedimentary strata derived from the erosion or reworking of volcanic materials from volcanic islands.

Hazelton and Takla Groups, Central British Columbia

	Hazelton Group	*Takla Group*
Distribution of the groups	Hazelton group rocks occur almost entirely west of the belt of Cache Creek strata but do not include the strata of the Queen Charlotte Islands; northern and southern limits not defined.	Takla group rocks occur west of the Rocky Mountain Trench and mainly east of the belt of Cache Creek strata; northern and southern limits not defined; probably best to consider all Upper Triassic and most of Lower Jurassic strata as part of Takla group wherever they occur in central British Columbia.
Relation to Topley intrusions	Younger; received detritus from Topley intrusions.	Mainly older, may be in part contemporaneous.
Relation to Omineca intrusions	Considered to be older at present; may be in part or mainly younger.	Older.
Relation to Coast intrusions	Mainly older.	Older but not observed in contact.
Relation to other groups	Overlain unconformably and disconformably by Late Cretaceous and Tertiary sedimentary and volcanic rocks; unconformably above Takla group; Tachek group correlative in part.	Overlain unconformably by Hazelton group; overlies Cache Creek group unconformably.

In limiting the age of the Hazelton group to Middle and Late Jurassic and Early Cretaceous, the broadest age limits have been accepted. Leach's coal-bearing strata apparently are not everywhere definable as the Skeena series nor demonstrably distinct from the marine Jurassic beds. Current investigations by Duffell[1] in the Terrace area tend to confirm Armstrong's inclusion of the Skeena series with the Hazelton group, particularly in reconnaissance mapping. Further work on the upper part of the Hazelton group may decide the desirability and possibility of further subdivision.

The thickness of the groups varies and, in the present stage of investigation, is of little aid in correlation. Without suitable marker beds and with such thick sections it is not possible to say whether beds or flows have been omitted or repeated.

[1] S. Duffell, 1955, personal communication.

It has been suggested that the material for Hazelton group strata was derived from an island arc on the site of the Coast Mountains. This hypothesis has not been proved but is feasible. In Stikine River area, Kerr suggested a similar western source of detritus (Kerr, 1948a, p. 30). In the Tatla-Bella Coola area, on the site of the Coast Mountains, Dolmage recorded that the Jurassic is absent, suggesting that it was a positive area during all or part of Jurassic time (Dolmage, 1926, pp. 138-159). In Zymoetz River area, in the Coast Mountains, Hanson recorded a Triassic conglomerate with boulders of fossiliferous Permian limestones (Hanson, 1926, p. 103). Such boulders indicate a nearby land area. No Middle or Upper Jurassic strata are recorded for central or northern British Columbia between the belt of Cache Creek group strata and the Rocky Mountain Trench. This is also true in the Peace River country to the east, which is beyond the eugeosynclinal environment. Undoubtedly the northern Rockies was an emergent area during Middle and Late Jurassic time and marine areas were restricted to regions west of the Topley intrusions and the central land area.

The relation of these groups to the Omineca intrusions, as stated here, is not the usually accepted relation; the intrusions are generally considered to be younger than both groups. Unquestionably the Takla group is older than the Omineca intrusions but there is no evidence to suggest an age younger than Lower Jurassic for the Omineca intrusions. Lord and Armstrong considered the Takla group to include Middle and Upper Jurassic strata but, as already stated, these strata are considered by the writer to be a part of the Hazelton group. Because of the lithological change and at least one observed unconformity, there is reason to question Lord's contention of conformable relations between the Lower and Upper Jurassic strata. This was a key argument in the reasoning that led both Lord and Armstrong to assume a post-Late Jurassic age for the intrusions; that is, the sequence was conformable, the Lower Jurassic was intruded, hence the Upper Jurassic is older than the intrusions or the sequence would not be conformable. In contradiction, it is suggested that the area to the east of the Hazelton sea, the present area in which the Cache Creek and Takla groups are exposed, was uplifted gradually and eroded to supply detritus to the Hazelton group during Middle and Late Jurassic time. Thus, the Omineca intrusions may have been emplaced at any time between Early Jurassic and Early Cretaceous time in this positive area, and never come in contact with the depositional products of that time.

Both groups under consideration are older than most intrusions of the Coast Range. Until the ages of individual intrusions are known, present information indicates that the Hazelton group is the older. Kerr did, however, postulate pre-Jurassic intrusions in the Coast Mountains of the Stikine River area (Kerr, 1948a, p. 32).

CHAPTER IV

HISTORICAL GEOLOGY

The Mesozoic Era and Its Geological Record in Central British Columbia

The Cordilleran geosyncline, as represented in the Mesozoic era, is divided into two distinctly different parts by the Rocky Mountain Trench; to the east is a miogeosyncline and to the west a eugeosyncline. These two belts have been referred to by Kay (1951, pp. 35-49) as the Millard and Fraser belts, respectively, as such constitute the Cordilleran orthogeosyncline. The geological record indicates that these two areas differ distinctly in tectonic history and in the rock types developed. The rocks of the miogeosyncline are almost entirely of sedimentary origin. They were deposited under relatively stable conditions and are laterally persistent as lithological units. The rocks of the eugeosyncline are mainly of volcanic origin. They were formed under chaotic, unstable conditions, and are characterized by rapid lithologic changes in sedimentary and volcanic strata, both laterally and vertically. Although both of these areas were inundated by the sea during much of Mesozoic time, it is apparent that the pattern and fluctuation of the seas, the duration of the marine inundation, and the rock types developed are the results of basically different tectonic activity.

The Mesozoic eugeosyncline, in which the Hazelton and Takla groups originated, is considered to have been a broad area, parallel to the present coast-line, extending from the Rocky Mountain Trench to the western limits of Queen Charlotte and Vancouver Islands. This area is visualized as a unit, in that the entire area was essentially tectonically unstable and volcanism was a characteristic feature of its history throughout much or all of the Mesozoic era. Periods of quiescence and sedimentation of different duration in different areas punctuated the volcanic activity. Although most of this region was inundated by the sea at some time during the Mesozoic era, areas of older rock and volcanic islands remained as positive areas or landmasses through much or all of Mesozoic time.

The nature of the areas eroded, which supplied detritus for the sedimentary rocks, must be considered. The existence of Cascadia, the hypothetical western landmass or borderland of some geologists, has been discussed by Kay (1951, pp. 31-32) and Eardley (1951, pp. 62-63). Instead of a borderland, they postulated a volcanic arc or volcanic island belt from which detritus and pyroclastic material were derived to form the sedimentary rocks of the eugeosyncline. This arc formed the western margin of the eugeosyncline, and west of it was a marginal deep or tectogene and the open expanse of the Pacific Ocean. East of the arc were lesser volcanic islands and welts of older rocks or geanticlines, from which more detritus and volcanic material were delivered to the basins of sedimentation. East of this again were the miogeosyncline, the stable shelf and the central craton. This general arrangement compares in many aspects with modern arcs, and the geological facts already obtained suggest that it was true for the Mesozoic era. It seems unnecessary to involve a hypothetical landmass, Cascadia, about which nothing is known and for which there is no existing example.

The pattern of volcanic islands or chains of islands is not clear. The pattern of parts can be inferred from the distribution of sediments and pyroclastic material, but as yet no pattern for the whole has been established. The outer volcanic arc probably occupied the site of the present Coast Mountains and was the most persistent and tectonically active part of British Columbia. In published reports on areas flanking the Coast Mountains there are records of unconformities, nonmarine sediments, and near-shore sediments which are less prominent or absent in areas farther from the Coast Mountains. Moreover, in a few areas, and during part of Mesozoic time, the Coast Mountains are inferred to have been an uplifted belt (Kerr, 1948a, p. 32) from which detritus was supplied to adjoining basins. Thus, present information suggests that the Coast Range is the site of a former chain of islands. East of this arc smaller, less extensive chains were probably situated on the present sites of some intrusive masses around which unconformities and nonmarine sediments have been observed. It seems logical to assume that the tectonic forces which gave rise to volcanic activity were also conducive to later or penecontemporaneous batholithic intrusion. Only more detailed study can substantiate these assumptions and delineate the intricate patterns of volcanic islands which were probably undergoing continual modification.

Historical Geology and Palæogeography of Central British Columbia

A complete account of the palæogeography of central British Columbia would require much more information than is available at present. The most that can be done here is to indicate the position of the strand line at certain times, thus delineating areas of deposition and erosion. The intent is only to initiate a consideration of the topic and stimulate further detailed investigation.

The historical geology of central British Columbia has been discussed before. Schofield and Hanson (1922, pp. 29-32) considered the Pacific coastal area to consist of a broad geosyncline extending from the west coast to the Prairie Provinces. Within this trough, volcanism and sedimentation were essentially uninterrupted throughout the Mesozòic era. Detritus was derived from a western landmass now submerged below the Pacific Ocean. Malloch (1914, pp. 90-93) discussed the historical geology of the Groundhog region for Early Cretaceous time. Lord (1948, pp. 54-55) and Armstrong (1949, pp. 49-123) briefly referred to the historical events of the Mesozoic era in McConnell Creek and Fort St. James areas, respectively. McLearn and Kindle (1950, pp. 127-139) presented some historical facts relating to northeastern British Columbia.

In the following account of the Mesozoic history of central British Columbia all the available fragmentary evidence, accumulated in the past seventy-five years has been considered. Only the main events are described to explain, as the writer visualizes it, the geological environment existing during the formation of the Takla and Hazelton groups.

Permian and Early Triassic Time

The close of the Permian period was, according to Armstrong, accompanied by volcanism in Fort St. James area. Uplift, erosion, and probably deformation took place in Early and Middle Triassic time, and the seas were completely excluded from central British Columbia. Ultramafic bodies were emplaced in the central part of Nechako River area and these in turn were exposed to erosion by Late Triassic time.

Late Triassic Time

Practically all central British Columbia was inundated in Late Triassic time (*see* Figure 5) although small areas along the west coast remained elevated and supplied detritus to nearby basins. In addition to these a central area remained as a positive element, particularly in the areas of ultramafic rocks. This land area was at that time undergoing deep weathering with the formation of a thick regolith, and some of this material was transported and deposited in a nearby marine basin producing a limited marine red bed sequence. Elsewhere marine sedimentation took place with the accumulation of fine muds and tuffs interrupted by the outpouring of volcanic flows. In general this period of time did not feature chaotic conditions although volcanism was active. In latest Triassic time, however, all central British Columbia may once more have been emergent.

Early Jurassic Time

In Early Jurassic time the eastern part of central British Columbia became a tectonically active area. It was apparently again inundated but positive areas remained not unlike those of the Upper Triassic, although more extensive. A land area was coming into being in the eastern part of central British Columbia and the region was unstable. Coarse clastic

Figure 5. Suggested Upper Triassic and Lower Jurassic strand lines and marine areas in central British Columbia.

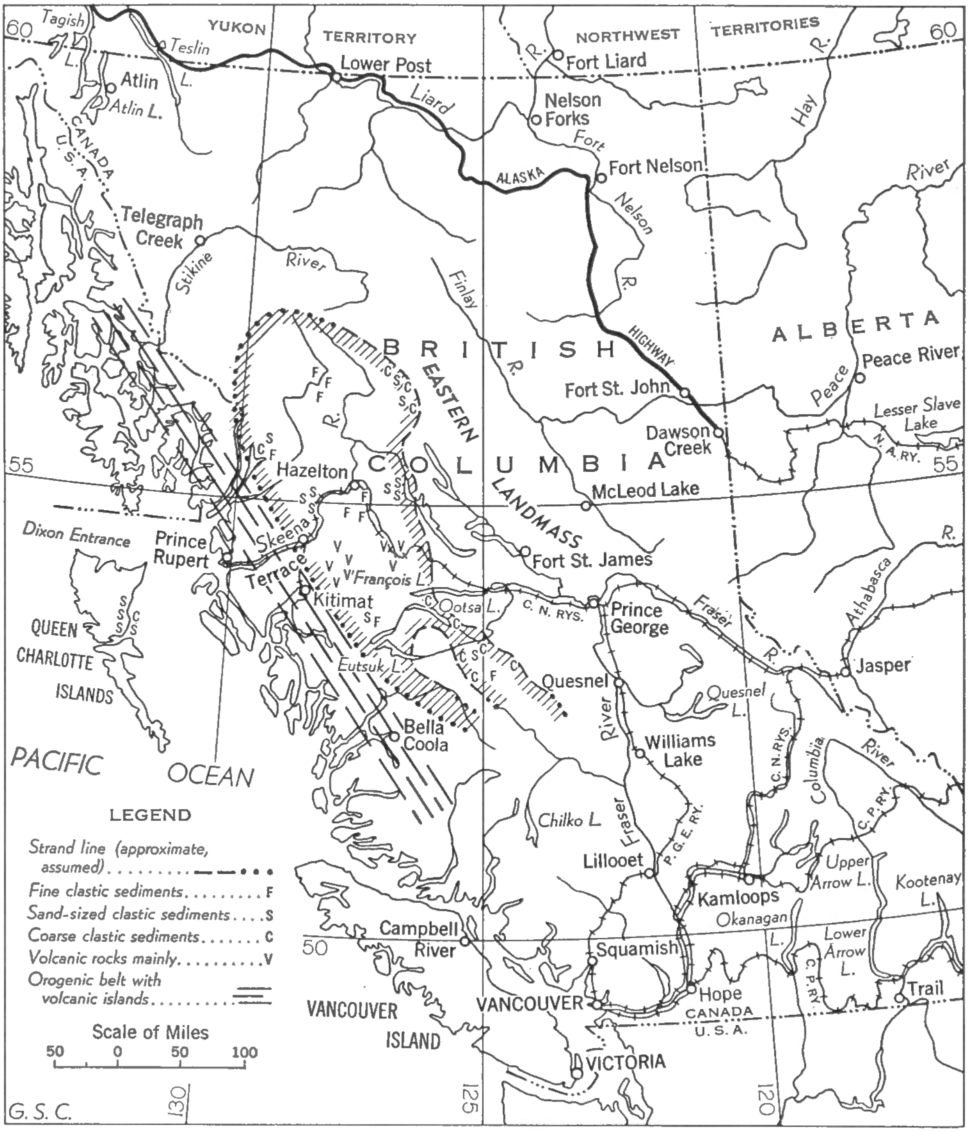

Figure 6. Suggested Lower Middle Jurassic strand lines and marine areas in central British Columbia.

Figure 7. ***Upper Jurassic and Lower Cretaceous marine areas in central British Columbia.***

material began to accumulate; red beds on the southwest side, conglomerates in many areas, and coal in a few places. This part of the basin was in a transition from deep to shallow conditions. Coincident with this activity, the Topley intrusions were emplaced.

Middle Jurassic Time

By Middle Jurassic time, the eastern half of the province was a positive area and was being further uplifted (*see* Figure 6). Erosion was active and Palæozoic detritus, as well as some from early Mesozoic rocks, was accumulating in distinct marine basins. Active volcanism was almost continuous. The central and eastern land area attained moderate relief and in this area the earliest granitic masses of the Omineca intrusions may have been emplaced. Similarly islands or land areas on the site of the Coast Mountains probably were also supplying detritus to the marine basins.

Late Jurassic Time

In Late Jurassic time the marine basins were more restricted (*see* Figure 7). Coarse detritus accumulated in the north in fairly broad basins but in the south the seas were greatly restricted. Strata of latest Jurassic time have not been recognized in central British Columbia.

Early Cretaceous Time

Most Cretaceous sedimentary strata indicate a nonmarine environment and contain coal. Marine areas were small, restricted basins near the Coast and were apparently short-lived. Late Lower Cretaceous sedimentary rocks record the last marine inundation of any part of central British Columbia.

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