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GEOLOGY OF TESLIN MAP-AREA, YUKON TERRITORY (105C)

Robert Mulligan

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GEOLOGY OF TESLIN MAP-AREA, YUKON TERRITORY (105C)

By
Robert Mulligan

DEPARTMENT OF
MINES AND TECHNICAL SURVEYS
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PREFACE

Except for its northwest quarter and for the strip along the Alaska Highway near Teslin Lake, the geology of Teslin map-area was virtually unknown until the present study. A placer-gold deposit on Iron Creek, which was worked during the early thirties, and minor occurrences of base metals and asbestos indicated the need for such a study on economic grounds.

The area lies athwart the boundaries between major geological elements of the northwestern Cordillera, and the study has furnished new data on the orogenic history of the region.

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

OTTAWA, January 12, 1961

Memoir Nr. 326. Geologie des Kartenblattes Teslin (Yukonterritorium). Von Robert Mulligan

Beschreibt die Geologie eines Gebietes im südlichen Yukonterritorium, das aus sedimentären, vulkanischen, metamorphen und eruptiven Gesteinen besteht, die im Alter vom Präkambrium bis zum Tertiär reichen.

Мемуар 326. — Геологическая карта — Лист Теслин, Юконская территория.
Роберт Муллиган.

Описание геологии одного района в южном Юконе, сложенного осадочными вулканическими, метаморфическими и плутоническими породами. Возраст пород простирается од докембрия до третичного периода.

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GEOLOGY OF TESLIN MAP-AREA, YUKON TERRITORY

Abstract

The Teslin area, latitude 60°00′ to 61°00′N, longitude 132°00′ to 134°00′W, is one of subdued mountains and broadly rolling upland areas separated by the main river valleys. Pleistocene glaciation, preceded and followed by alpine glaciation, left widespread deposits in valleys and upland areas.

Geologically, the area is divided almost diagonally by the northwest-trending boundary between a trough of late Palaeozoic and Mesozoic stratified rocks lying to the southwest, and a broad terrain of mainly early Palaeozoic and Proterozoic(?) rocks that underlie the eastern part of the Cordilleran region. This main geological boundary lies, for most of its length, about 4 miles northeast of the Teslin Valley.

Northeast of this boundary a regionally metamorphosed sedimentary-volcanic complex is locally overlain by less extensively metamorphosed Mississippian strata. Southwest of it, the Permian, Upper Triassic, and Lower Jurassic(?) strata are unmetamorphosed. The metamorphic contrast suggests a pre-Permian interval of diastrophism, but mica from the complex has an indicated age of about 220 million years.

The stratified rocks are folded on mainly northwesterly trending axes, and invaded by granitic and ultramafic bodies. The granites are probably Late Cretaceous. The ultramafic bodies are mostly confined to a Permo-Triassic volcanic belt but some intrude probable Lower Jurassic folded strata.

A gold-placer deposit on Iron Creek was worked during the early thirties. A few minor base-metal occurrences are known, notably in limestone skarns. Scattered veins of chrysotile asbestos occur in some ultramafic bodies.

Résumé

La région de Teslin, située par 60°00′ à 61°00′ de latitude nord et 132°00′ à 134°00′ de longitude ouest, est une région de montagnes réduites et de plateaux largement ondulés que sillonnent les vallées des principaux cours d'eau. La glaciation du Pléistocène, précédée et suivie par la glaciation alpine, a laissé des dépôts étendus dans les vallées et les régions des plateaux.

Du point de vue géologique, la région est divisée presque diagonalement par une ligne, orientée vers le nord-ouest, qui passe entre une fosse de roches stratifiées de la fin du Paléozoïque et du Mésozoïque, au sud-ouest, et une grande étendue de roches qui remontent surtout au début du Paléozoïque et au Protérozoïque(?) sur laquelle repose la partie est de la région de la Cordillère. Cette importante limite géologique se situe, sur presque toute sa longueur, à environ 4 milles au nord-est de la vallée de la rivière et du lac Teslin.

Au nord-est de cette ligne, un complexe de roches sédimentaires et volcaniques caractérisé par un métamorphisme régional est par endroits recouvert de strates mississipiennes marquées par un métamorphisme moins prononcé. Au sud-ouest de cette ligne, les strates du Permien, du Triasique

supérieur et du Jurassique inférieur(?) ne sont pas métamorphisées. Le contraste métamorphique porte à croire qu'il y a eu un intervalle de diastrophisme avant le Permien, mais le mica de ce complexe a donné un âge d'environ 220 millions d'années.

Les roches stratifiées sont plissées suivant des axes orientés, pour la plupart, vers le nord-ouest, et elles ont été envahies par des masses de roches granitiques et ultramafiques. Les granites remontent probablement à la fin du Crétacé. Les massifs ultramafiques se limitent pour la plupart à une zone volcanique permio-triasique, mais certains d'entre eux font intrusion au sein de strates plissées qui remontent probablement au Jurassique inférieur.

Un placer aurifère situé le long du ruisseau Iron a été exploité au début de la décade 1930-1940. On connaît l'existence de quelques venues secondaires de minerai de métaux communs, tout particulièrement au sein de skarns de calcaire. Il existe, éparpillés au sein de certaines masses ultramafiques, des filons d'amiante chrysotile.

Chapter I

INTRODUCTION

Location

Teslin map-area, latitude 60°00′ to 61°00′N, longitude 132°00′ to 134°00′W, is in the south-central part of Yukon Territory and adjoins the following map-areas: Whitehorse on the west, Atlin, British Columbia on the south, Wolf Lake on the east, and Quiet Lake on the north. The Bennett area is contiguous on the southwest, the Laberge area on the northwest, and Jennings River on the southeast.

Access and Travel Routes

The area is accessible by the Alaska Highway from Whitehorse near mile 916 on the northwest, and from Dawson Creek (mile zero) and Edmonton on the southeast. All-weather roads also extend from Carcross on the west and Atlin, British Columbia on the south. The Canol road is usually open in summer to Pelly River at Ross River post on the north and for some distance beyond. In pre-highway days the main access routes were by Teslin River from Hootalinqua on Yukon River and by overland trail from Tagish and Carcross. Trails, now little used, extend to the south end of Teslin Lake from Telegraph Creek on Stikine River, and from Taku River, giving access from Wrangell and Juneau, Alaska, respectively. Overland trails from Teslin to Atlin, and from the head of Nisutlin Bay to Wolf Lake and the upper Liard country were formerly common travel routes.

Within the map-area only a few well-marked or cut trails were found. Most are shown on the accompanying map. The main river and creek valleys are generally passable for horses, with only occasional cutting required. A few of the passes in Big Salmon, Thirtymile, and Englishmans Ranges may be crossed (not including that at the head of Sidney Creek), and upland moors are good travel routes where the slopes leading to them are gentle and not too rocky. The worst obstacles to travel are the great areas of dead fall and second growth, mostly old burns, and large areas of muskeg and boggy creek-bottom that interrupt the valley terraces and line much of the bottom land in all parts of the area.

Feasible water routes for small boats are Teslin River and Lake, and Nisutlin River below Sidney Creek. The part of Nisutlin River below the Quiet Lake portage is passable with difficulty. Some parts of Wolf River are navigable (*see*

Physical Features). The Squanga Valley is passable for 12 miles by lakes and short portages, and a string of lakes and beaver-dammed streams east of the south end of Little Atlin Lake form a useful canoe route in the southwest part of the area.

Settlements, Facilities, Industry

The chief settlement is at Teslin (mile 804) where all commonly needed supplies are available. The native village and white population are served by a public school, Roman Catholic and Anglican churches with resident pastors, a post-office, RCMP station, and a Game and Forestry Branch representative. The Department of Transport operates a secondary airport, and meteorological and communications service. Meals, lodging, gasoline, oil and facilities for minor repairs are available at Teslin River (mile 837), Morley River (mile 777), and Squanga Lake (mile 849), as well as at Teslin. Commercial telegraph service is available at Brooks Brook (mile 830), where the district camp and permanent settlement of highway maintenance crews is located. Telephone landlines connect all these places with Whitehorse and other Alaska Highway and outside points. An emergency landing strip lies beside the highway at mile 843.

In 1959, productive industry had been practically non-existent for many years. A placer gold property on Iron Creek has been inactive since the mid-thirties. Sawmills have operated from time to time near Teslin, mainly for local use. Fur-trapping is still carried on by some of the natives, and outfitting and guiding of big-game hunting and fishing parties by a few. Potential resources other than mineral include good spruce timber, notably along Nisutlin River, and hydroelectric power on Teslin River. The supply and service of highway travellers, road maintenance, and Department of Transport services are probably the main sources of income.

The native people of Teslin, a branch of Interior Thlingit, form a close-knit community still strongly attached to their country and traditions, although literate and thoroughly adapted to white institutions.

Previous Geological Work

The first recorded geological observations in the area were made by C. W. Hayes (1892)[1] who, with F. Schwatka and M. Russel, entered the region from Taku River in 1891 and passed down Teslin Lake and Teslin River. Arthur St. Cyr made the first topographic surveys in the area in 1897 and 1898.

R. G. McConnell (1898) ascended Teslin River, Teslin Lake, and Nisutlin River to its source, and published some general notes regarding the geology adjacent to the route.

J. C. Gwillim (1901) mapped the Atlin area adjoining the Teslin area on the south, as far east as Teslin Lake. He extended his observations northward into

[1] Numbers in parentheses are dates of publications by the authors concerned, as listed in the Bibliography.

Teslin area along Lubbock River and Little Atlin Lake in the southwest corner; and just west of Teslin Lake.

E. J. Lees (1936) mapped the northwestern part of Teslin map-area in 1935, tying in his work with that of the previously mapped Whitehorse and Laberge areas on the west and northwest.

C. S. Lord (1944) and E. D. Kindle (1946) carried out geological reconnaissance work along part of the Alaska Highway and Canol road, respectively.

Field Work

The writer carried on geological mapping of the area during the field seasons 1950 to 1953, assisted by R. Burwash and K. C. Campbell in 1950, B. McClennan and W. Shepticki in 1951, D. Ford in 1952, and R. Shreve in 1953.

A base-map, scale 1 inch to 2 miles, with 500-foot contour intervals was prepared by the Topographical Survey. Air photographs, available from the National Air Photographic Library, scale about 1 inch to 3,000 feet, were used to great advantage. The topographic map, scale 1:250,000, has been published as sheet 105C of the National Topographic Series. Other maps, scale 1:50,000 with 100-foot contours, covering a strip of country adjacent to the Alaska Highway and Atlin road are now available.

Acknowledgments

The writer wishes to acknowledge the capable work of his assistants. It is also a pleasure to acknowledge the valuable service of Bobby and Frank Jackson and Peter Smarch of Teslin who were employed on the field party during several seasons. Residents of the district were most cooperative and helpful, especially the McCleerys, formerly of Teslin, and R. T. Porsild of Teslin River lodge.

Chapter II

PHYSICAL FEATURES

Topography

Land Forms

Teslin map-area is one of subdued, generally rounded mountains, surmounting and merging with broadly rolling upland interstream areas, and is divided into north-northwesterly trending ranges by the main river valleys.

The altitude of the main valleys averages about 2,200 feet for Teslin and Atlin-Little Atlin Valleys—the main base-levels of erosion—ranging up to 2,500 and 3,000 feet respectively for the Nisutlin River and Wolf River Valleys within the confines of the map-area. The higher summits of the ranges lie from about 6,000 to 6,875 feet altitude. The local relief, therefore, varies from about 3,000 to a maximum of 4,700 feet near the northwest corner, but the average elevation of interstream areas above the main valleys is considerably less.

According to Bostock's (1948) classification, the area lies mainly within that physiographic division of the Canadian Cordillera known as the Yukon Plateau, which, in this part is subdivided into the Teslin Plateau and the Nisutlin Plateau, partly separated by a southeastward projection of the Big Salmon Range.

Teslin Plateau extends southwest from Teslin Valley to the Coast Mountains. Within the map-area it has in large part a well-defined plateau-like character, showing extensive remnants of an old peneplain surface at about 5,000 feet elevation (Pl. IV A). The highest part is the first divide west of Teslin Valley along which several peaks surpass 6,000 feet elevation. They are themselves broadly rounded or almost flat-topped, suggesting a former peneplain at about that elevation, but broad summit areas lie at all intervening elevations. The lowest part of the surface is a conspicuous broad trough-like area that extends southwest from Teslin between Mount Bryde and Dawson Peaks. The surface is breached also by the sharp cross-trench followed by the Alaska Highway (Pl. IV A).

The Big Salmon Range, between Teslin and Nisutlin Valleys, is in general somewhat higher and considerably more rugged but dwindles gradually southward from a maximum elevation—the highest in the map-area—of 6,875 feet. The range is decidedly asymmetric, dropping sharply on the west from the divide to a throughgoing subordinate trench that separates the lower foothills east of Teslin Valley from the main range. On the east the surface slopes much more gradually to the valley of Nisutlin River but the eastern aspect of the divide is nonetheless rugged, being made up largely of precipitous cirque walls and intervening arêtes. In fact the whole range, as especially evident in oblique aerial photographs, shows a typical 'biscuit-board' topography; the northeast-facing cirques have evidently been carved into a well-developed former upland surface (Pl. I).

The so-called Nisutlin Plateau, which occupies the area east of Nisutlin River, consists largely (like the Teslin Plateau) of broadly rolling interstream areas ranging upward from about 5,000 feet elevation, but it is more varied and is conspicuously surmounted by the main masses of Thirtymile and Englishmans Ranges. These constitute a northwestward extension of Cassiar Mountains, breached by the valley of Wolf River. They are as rugged and on the average as high as the Big Salmon Range, and perhaps even more sharply dissected (Pls. II, III). The divide areas are likewise made up dominantly of precipitous northeast-facing cirques and knife-edge ridges. Patches of snow and ice that lie throughout the summer are more common in cirques of the Englishmans Range than elsewhere in the map-area. Thirtymile Range is asymmetric like the Big Salmon Range but less conspicuously so, sloping more gently east than westward. The slope terminates in an extensive low interstream area, almost a plain, between the upper tributaries of Wolf River and Nisutlin River.

Drainage

The drainage of the entire area is to Yukon River, either by way of Teslin River and its tributaries or, along a southwestern fringe, by little Atlin Lake, Lubbock River, and Atlin Lake south of the Alaska Highway, and by Michie Creek and Marsh Lake north of the highway. A continental divide between the headwaters of Wolf River and those of Liard River, a tributary of Mackenzie River, lies within a few miles of the northeast corner.

Teslin Lake and Teslin (formerly known as Hootalinqua) River occupy a relatively straight valley running northwest for 250 miles from the divide with the Stikine watershed in northern British Columbia to the confluence of Teslin and Yukon Rivers.

Teslin River has an average width of 500 to 600 feet. Below Swift River it flows at speeds up to 4 miles per hour in a meander belt that occupies almost the whole valley, there about 1½ miles wide. It is cutting laterally into drift deposits that cover the valley-floor and form shoals and bars in several places. Near the mouth of Swift River it is confined to the west valley-wall, one of two places where bedrock outcrops along the river. Steep bluffs of silt form the other bank, evidently lacustrine deposits resulting from an old fan that at some stage of deglaciation emanated from the valley of Swift River, damming the main river. Similar deposits extend as terraces up to and along Teslin Lake. Above the vicinity of Swift River, meanders are few and the current is generally slow except for a riffle at the double bend just below Johnsons Crossing. There bedrock outcrops at low water at the upper bend and gravel bars opposite the creek at the lower bend require some care in navigation.

Teslin Lake is 60 miles long, 1½ to 2 miles wide, and has an elevation of 2,239 feet above sea-level. It is bordered by terrace remnants, drift, and alluvium except for small bedrock outcrops near Morley Bay, Teslin, mile 815, and the bay and islands opposite mile 810.

Nisutlin River, the main tributary, rises in Pelly Mountains and enters its southward-trending broad valley from the east, 12 miles north of the map-area. It enters Nisutlin Bay by several shallow distributaries in an extensive delta. Its average width is about 300 feet. Some riffles and gravel bars occur in the fast-flowing stretch (up to 6 miles per hour) below the confluence with Wolf River, and the few bedrock exposures are the only ones on the river. From there up to the mouth of Sidney Creek the river meanders slowly between sandy terraces and low clayey silt banks. From the mouth of Sidney Creek to Carey portage, southeast of Quiet Lake, it is rapid (up to 5 miles per hour) and shallow, with numerous gravel bars and shoals that extend across practically the whole width in places and are barely passable at low water. Above the portage, rapids are reported to be numerous.

Quiet Lake, elevation 2,580 feet, is about 20 miles long and is walled by steep rocky mountains on the west. It and its tributaries flow northwest via Big Salmon River to the Yukon.

Wolf River has perhaps half the volume of Nisutlin River above the confluence. It is navigable with some difficulty for about 4 miles; the remainder of the lower west-flowing course is in a canyon, with numerous rapids and cataracts. Between a point a mile or so above the bend and the outlet of Fish Lake the river can be descended by raft or small boat at a fairly high stage of water but skill and care are required to avoid shallow submerged rocks. The trip by raft requires about 14 hours, mostly consumed in long sluggish meandering stretches. The source of the river is in Wolf Lake, about 10 miles east of the map-boundary, whose northeastern feeders, like those of Red River, rise on the continental divide to Liard River and the Mackenzie system.

The large creeks commonly rise in almost flat passes and meander sluggishly in broad drift-filled valleys. Rock canyons are rare. Box canyons occur where Squanga, Lone Tree, and Fat Creeks enter Teslin Valley and on a few small creeks that empty into the canyon stretch of Wolf River below Fish Lake. A very few creeks have bedrock exposed in their middle or upper reaches. Some have well-developed gravel terraces but the drift is mostly ill-sorted glacial debris. Muskeg is very common, even at the headwaters of creeks and the drainage is, on the whole, remarkably disorganized.

Solifluction processes have been active on steep and even gentle slopes, in many places producing mud-flows, rock glaciers, crude terraces, stone stripes and other similar phenomena. Permafrost may underlie some deeply moss-covered and shaded north-to-east slopes.

Geomorphology

Erosion Surfaces

The land forms, suggesting two erosion cycles with partial peneplanation and subsequent rejuvenation, were described in the foregoing section. An old, perhaps late Cretaceous, erosion surface is reflected in the flat-topped or gently rounded summits of many mountains over 6,000 feet elevation, most notably Mount Bryde and Hayes Peak. Lees noted rotted granite suggesting an old erosion surface on a high ridge ('Bar 5900') north of Sidney Creek, with freshly scoured and striated granite nearby. A younger, probably Tertiary, surface is represented in broad, gently rolling upland areas around 5,000 feet elevation, typically developed around Mount White (Pl. IV A) and in remnant 'benches' on the flanks of higher mountains.

Conspicuous patches of red earthy material on the surface of the limestone on the hill (latitude 60°30′; longitude 132°15′), locally known as Red Mountain, may be residual or interglacial soils on an old erosion surface.

Drainage Changes

Some suggested major drainage changes are worthy of note. Lees (1936, p. 6) suggested that Quiet Lake may have drained by a low, lake-dotted valley (Carey's Portage) to Nisutlin River in preglacial time. On the other hand, Nisutlin River has one major barbed tributary entering its broad upper valley from the southeast, just north of the map boundary. In this section the river is flowing rapidly in what may be an incised meander belt. It seems probable that this northernmost part drained north through Fish Creek and Big Salmon Lake at some stage of development.

What may be an abandoned channel along the west flank of Nisutlin Valley collects the drainage from all the eastward-flowing creeks from the Canol Road Pass north to Sidney Creek. This valley continues as a marshy lowland through Sidney Lake to Quiet Lake and may have carried all the eastward drainage in that direction. On the other hand, it also extends southward to join the present Nisutlin Valley opposite Thirtymile Creek, and the drainage was probably in the southward direction at some earlier time.

An old valley extends through the pass that may have been an important watershed at an earlier time between "Red Mountain" and the north end of Englishmans Range south-southwest of Fish Lake. The upper canyon of Wolf River is evidently post-glacial, and the upper part of the river probably flowed north through the broad plain and long creek to the Nisutlin. South of the pass the valley is traceable by several remnants with beheaded and misfit streams, except in the vicinity of English Creek, to the bend of Caribou Creek. Beyond this point it continues as a broad through-going valley, one branch of which extends to the outlet of Morley Lake. The elbow of capture at the bend of Canyon Creek appears to be of very recent origin.

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Numerous other instances of stream capture are found in the southwestern part of the area. The present drainage via Squanga Creek of the broad valley through Squanga Lake, for example, is clearly the result of glacial debris in the Squanga-Michie Creeks divide.

Glaciation

Continental Glaciation

Everywhere the manifestations of continental glaciation are striking. These manifestations take the forms of widespread and profound stream dislocation, countless lakes, ponds, and swampy areas only haphazardly or not connected, some locally conspicuous erosional features, and a great abundance of drift deposits with various characteristic forms.

From these phenomena it seems evident that ice covered the whole map-area, possibly excepting the highest mountains, at some time during the Pleistocene. Definite indications of more than one advance were not recognized, but the record is confusing. In the northernmost part of Big Salmon Range, for example, old cirques were rounded and scoured by westward-flowing ice up to an elevation of about 6,000 feet (Pl. I), whereas in Thirtymile and Englishmans Ranges farther east (the direction from which the ice flowed) clear signs of transgression by an overriding ice-sheet do not extend much above the 5,000-foot level.

The highest level reached by the ice-sheet may have been well above 6,000 feet. The lack of erosional phenomena at higher levels may be due to a lack of suspended debris and/or rapid disintegration and consequent obliteration of the evidence. However, the highest mountain masses do seem to have acted as barriers to the moving ice. Lees (field notes) mentioned transverse grooving and striae at 5,900 feet, across a ridge north of upper Sidney Creek. It is clearly apparent in the air photographs that ice erosion was especially heavy in the particular area mentioned, and it seems a reasonable deduction that a large volume of ice, dammed up behind the highest peak (elevation 6,875), was deflected northward over the divide into the valley of Slate Creek.

The most striking erosional features definitely attributable to continental ice are to be seen in the northeasternmost part of the map-area. North of Fish Lake crag-and-tail topography is especially well defined and cuts directly across the stratification and foliation of the rocks. The indicated direction of flow varies from about S75°W just north of Fish Lake to a few degrees north of west farther north.

South of Fish Lake (Pl. III) crag-and-tail topography is conspicuous on air photographs up to about 5,000 feet on the north slope of Englishmans Range but is not recognizable in the high rugged alpine-glaciated terrain farther south. The inference is that flowing ice from the east was deflected around the northern flank of the range. Likewise the high summit area of Thirtymile Range seemed to have acted as a partial barrier. Passes up to about 5,000 feet are flattened, scoured, and bounded by facetted spurs. Eskers are recognizable in some, and rude terraces, evidently deposited by ice-marginal streams, are stranded high on the valley-walls west of the passes. Other cols at about 5,500 feet do not show these features.

A similar distinction may be seen in Big Salmon Range south of Sidney Creek, although glacial grooves and *roches moutonnées* were noted by the writer at 5,500 feet just south of the Sidney Creek divide. Just west of Mount Grant (Peak 6552), grooved topography is faintly traceable up to 5,500 feet, the indicated direction of flow being a little south of west. Farther down the west slope of the range grooves become more pronounced. The westward direction is maintained down to about 5,000 feet, and the writer found good striae trending S70°W on the ridge near Hill 5073, southeast of Swift Lake. At lower levels closer to Teslin River, however, the trend of grooving can be seen to swing more northward towards parallelism with the river. One photo taken north of Cone Mountain shows a change from roughly west at about 5,000 feet to N60°W at about 4,000 feet, and nearly northwest at 3,700 feet. West of Teslin River the valley-wall is heavily scoured, and grooving trends parallel with the river, but on the ridge-tops beyond, at about 5,000 feet, the trend is again about N60°W. The inference is that the generally westward flow of ice at about the 5,000-foot level was continuous across the northern part of the map-area.

It is possible that the discrepancy between observed maximum levels of continental ice erosion at different places may involve a later advance—to a maximum of about 5,000 feet—than that which caused the grooving and scouring at the higher levels. The late development or rejuvenation of some alpine cirques may be connected with such a late advance, but the writer does not consider the evidence sufficiently clear to justify this as a working hypothesis.

The same flow-pattern is apparent as far south as Hayes Peak, just west of which a glacially polished outcrop on a granite ridge at about 5,000 feet showed grooves trending N75°W. Elsewhere no marked coherent pattern is apparent, except in the southwest part of the map-area where the strongly furrowed topography has a crag-and-tail aspect, indicating an overall west-northwest movement. This is most apparent about longitude 132°50′ on the southern border. Furrowed topography extends up to at least 4,500 feet on the west flank of Dawson Peaks (southern border of the sheet at longitude 132°35′), which evidently formed a major barrier to a northwesterly flowing icemass.

At lower levels ice was confined mainly by the major northwest-trending valleys. Stagnant ice lay in the valleys during a long period of deglaciation when tremendous volumes of drift accumulated within the valleys, in ice-ponded streams along their walls, and along those of tributary creeks far up towards the headwater divides. These rudely terraced upland deposits are only less striking than the ubiquitous and bewildering complexes of meltwater channels, mainly lateral overflow channels resulting from damming of tributary streams at the ice margins. Most are in drift deposits; a few are cut into bedrock. At one point (latitude 60°50′, longitude 132°30′) near the north boundary eight such channels form a parallel sequence, ranging down from about 4,400 to about 3,200 feet elevation.

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The bottoms of large valleys are floored by morainal deposits of all kinds, commonly with kame-and-kettle topography, pitted outwash plains, remnants of alluvial fans and anastomosing complexes of eskers. An outstanding example of this type of topography is in the valley of the large creek that crosses the southern boundary at longitude 133°30′. Another is in the valley in the west-central part of the area that contains the upper Squanga Lakes and the headwaters of Michie Creek.

Large lakes covered most of the main valleys during and perhaps after deglaciation. One covered the broad lake-dotted plain in the northeast part of the area, presumably dammed on the south by ice or outwash at the head of the present upper canyon of Wolf River. On the north a series of clearly defined parallel crescentic beaches rises to about 3,500 feet elevation near the northeast corner. The lake may have drained to Nisutlin River until the recent Wolf River canyon was opened, and the overflow channels previously mentioned may be related to the beach terraces. Another lake probably existed in the Nisutlin Valley above the present confluence of Wolf River, where the prominent high sandy terraces begin.

In Teslin Valley the highest terraces extend upstream from a point near the mouth of Swift River. There the silt banks that confine the river on the east (*see* under *Drainage*) rise 300 feet or more to a pitted plain marked by kame-and-kettle topography and esker complexes. Higher up towards the valley-wall a few remnant beaches or terraces are discernible on air photographs. The deposits are evidently the remains of a fluvioglacial outwash fan, emanating from the valley of Swift River, that at some time dammed the river for a considerable period. The resulting lake probably extended up the valley at least to the southern map-boundary.

The lower part of Caribou Creek, in the southeastern area is carved in unconsolidated deposits several hundred feet thick that were probably laid down in a proglacial or post-glacial lake.

Alpine Glaciation

Although most mountains of about 6,000 feet elevation or more have a modified, cirque form on north to easterly slopes and a few carry remnants of snow and ice accumulation from one year to another, it is only in the higher, named ranges that the present land forms are dominantly the results, only superficially modified of alpine glaciation. The northeast slopes of Englishmans, Thirtymile, and Big Salmon Ranges are formed mainly of precipitous cirques and intervening arêtes (Pls. I, II). A few remnant summits, for example Peak 6550 in Thirtymile Range, have been carved into distinctly pyramidal or 'Matterhorn' forms.

The cirque floors range from about 4,600 feet to about 5,700 feet elevation. The walls rise steeply as much as 1,500 feet to knife-edge ridges or to rounded summit areas that slope gently to the south and west. The main northeast-trending ridges slope gently down to the lower flanks of the ranges, confining the main streams within U-shaped valleys. Some of these streams head in broad amphitheatres that are crescentic groups of small cirques. Others, though bordered by similar, commonly hanging cirques, head in flat passes up to 5,000 feet elevation, that show distinctly the effects of through-going, westward-flowing ice (*see* p. 8).

Two distinct ages of alpine glacial activity are readily recognizable. The older cirques have blurred outlines; their bounding ridges were rounded and notched, and in some their floors were scoured by an overriding ice-sheet (Pl. I). Their main development thus clearly preceded the main recognized stage of continental glaciation. The younger cirques (Pl. II) are sharply etched, with knife-edged bounding ridges. They commonly have flat floors, at about 5,000 feet elevation, that are dotted with tarns and virtually devoid of cover, though rimmed by talus accumulations. Some of these appear to transect the older cirque forms. One just north of Mount Grant (Peak 6552 in Big Salmon Range), for example, transects the old arête that forms the main north ridge of the mountain.

Depositional features attributable mainly to alpine glaciation are prominent on the northeast flanks of Big Salmon and Thirtymile Ranges. They comprise a striking complex of drift ridges that cover the floors of the glacial amphitheatres and glaciated valleys down to the ends of the intervening main ridges. In general the deposits form a concentric crescentic pattern of closely spaced ridges emanating from, and transverse to, the axes of the individual cirques, and merging downstream into a composite pattern of ridges lying perpendicular to the main alpine valleys (Pl. II). Longitudinal ridge-forms—lateral and medial moraines, eskers, and terraces—are not conspicuous fractures.

The ridges appear to be predominantly recessional moraines. However, they appear in places to swing contourwise into and around old cirques, and some of the larger ridges seem to be related to transverse-notches in the intervalley ridges, by which they may be roughly correlated from one valley into the next. Thus it is possible that the deposits may be largely the result of ice-marginal meltwater channels during deglaciation. In general, though, the pattern is more varied and less characteristic in those valleys that head in low passes, and were undoubtedly the channelways for through-going ice. The latter, too, have patches of bare, scoured rock floor near the passes—a feature virtually absent in the 'blind' valleys. Some transverse drift ridges and heaps of debris at the mouths of fresh young cirques are interpreted as terminal moraines.

The reason for the late rejuvenation and perhaps new development of some small cirques and not of others remains a puzzling problem. The high-level old cirques in general were not rejuvenated. They have sloping floors mostly without tarns and sharply channelled by draining streams. The young cirques have relatively flat clean floors, dotted with tarns and commonly hanging but rarely above the 5,100-foot level. It seems probable that aside from specially favourable localities, their recently active headward erosion was due to damming-up of ice and snow in them by a long enduring coalescent ice-sheet across their mouths.

Related Subjects

Climate

The climate of Teslin map-area is fairly typical of the central part of the Cordilleran region at these latitudes. The winters are long and moderately but not extremely cold, with a minimum of four or five hours daylight in midwinter. The rivers begin to open in May but are not free of ice until June. About the beginning of June grass begins to grow and leaves appear on the trees. Quite suddenly it is full summer, with warm days and long hours of sunlight to temper the cool short nights. In June and July it is possible to read or travel in the open at midnight on clear nights. By the middle of August the shortening of daylight hours becomes conspicuous, frosty nights are common, and the foliage rapidly takes on its autumn colours. By early September snow appears on the hills after rainy weather and may reach the valley bottoms, but good weather usually recurs and may last well into October.

The effect of altitude on temperature is considerable. Even at 2,000 feet above the valley bottoms, snow flurries or night frosts may occur at any time during the summer.

Precipitation also varies a good deal, increasing with increasing altitude in general, but also and more particularly with respect to topographic environment. Each mountain range has its 'rain-shadow' in the next broad valley to the east. Thus the area around Teslin is noticeably drier than the mountains around Squanga Lake; and the Teslin area in general is much more moist than the Yukon Valley country to the west, especially the country around Carcross and Whitehorse, which lies well within the pronounced rain-shadow of the Coast Mountains.

Meteorological records have been kept at Teslin since 1941, and are included in the monthly reports for all Canada published by the Meteorological Office, Department of Transport. The following data are from the monthly summaries for the years in which the field work for this report was done.

		Temperature		Precipitation (inches)	
Year	Month	Max.	Min.	Total	Snow
1953	Dec.	37	23	1.17	11.6
	Nov.	35	−12	1.16	11.6
	Oct.	58	15	1.81	14.7
	Sept.	66	26	0.61	T
	Aug.	84	33	2.43	0.0
	July	78	39	2.96	0.0
	June	76	32	1.48	0.0
	May	72	11	1.52	1.5
	Apr.	55	8	0.34	2.1
	March	42	−30	0.97	9.7
	Feb.	37	−16	0.24	2.4
	Jan.	33	−50	0.73	7.3

1952	Dec.	38	−17	0.56	5.6
	Nov.	46	8	0.33	3.3
	Oct.	55	16	1.95	2.0
	Sept.	65	19	2.40	0.4
	Aug.	82	27	1.95	0.0
	July	81	30	1.01	0.0
	June	73	25	1.73	0.0
	May	61	21	0.11	0.6
	Apr.	46	− 4	0.94	8.3
	March	42	−17	1.70	17.0
	Feb.	37	−32	0.93	9.3
	Jan.	33	−50	3.60	36.0
1951	Dec.	36	−44	0.71	7.1
	Nov.	46	−21	1.70	17.0
	Oct.	54	− 7	0.91	4.0
	Sept.	77	14	0.58	0.9
	Aug.	78	34	0.48	0.0
	July	88	40	1.35	0.0
	June	80	32	1.02	0.0
	May	66	18	0.63	0.6
	Apr.	49	10	0.79	7.2
	March	44	−34	1.39	13.5
	Feb.	36	−46	0.54	5.4
	Jan.	34	?−44	0.83	8.3
1950	Dec.	24	−30	1.16	11.6
	Nov.	43	−34	0.85	8.5
	Oct.	56	0	1.37	8.6
	Sept.	74	24	0.90	0.0
	Aug.	80	30	0.87	0.0
	July	79	32	3.21	0.0
	June	89	29	1.28	0.0
	May	61	21	0.27	T
	Apr.	51	− 0	0.55	5.5
	Mar.	41	−18	0.06	0.6
	Feb.	31	−29	0.99	9.9
	Jan.	25	−55	0.18	1.3

The figures do not tell the whole story. The summer of 1951 was, as the records show, an exceptionally warm dry one; 1953 was a wet season, but is not so unfavourably remembered as 1952 when, except for a dry spell from July 20 to August 6, it rained nearly every day in the northeast part of the map-area.

Vegetation

The area is well wooded up to a sharply defined tree-line that rarely departs by more than 100 feet or so from 4,500 feet in elevation. Only the main valleys, notably the Nisutlin, have extensive stands of timber suitable for sawing into lumber or structural timber, but material good enough for rough construction, mining purposes, and fuel grows well back up sheltered valleys and slopes.

The main forest conifers are white spruce (*Picea glauca*), pine (*Pinus contorta*), alpine fir or 'balsam' (*Apies lasiocarpa*) and black spruce (*Picea mariana*). White spruce is most prolific in the moist, alluvial bottom land soils of the main valleys, but grows into fine trees up to 18 inches in diameter on moist drained terraces and sheltered mountain slopes at least 1,000 feet higher. Pine grows abundantly on dry sandy terraces in river and creek valleys, either in dense stands (typical lodgepole pine) or as well-spaced large trees (jack pine?), that also grow nearly to timber-line on dry or rocky southern slopes. The lighter green of 'jack pine country' is readily distinguished from the dark green of spruce forest from as much as 10 miles away on mountain slopes, and is a most useful guide to the best route for travel. Balsam fir begins to take over at about 4,000 feet or so and is almost exclusively the timber-line tree. The highest trees are very stunted, sharply tapered forms, with long spreading branches (Pl. IV A). They form dense copses and commonly present an almost impassable barrier to travel. Dry balsam wood (if any can be found) makes good fuel but sparks excessively. Black spruce is found mainly in muskeg where as elsewhere it usually dies after growing to about 20 feet.

The large deciduous trees are the poplars and locally white birch. Aspen is abundant mixed with white spruce and pine, and forming limited pure stands. Balsam poplar is important only in the low moist main valleys.

Willow rarely develops into trees but forms dense thickets along moist valley bottoms and streams. Patches of scrub willow are found locally 1,000 feet above timber-line on sheltered slopes where much snow accumulates. Alder also forms thickets along stream valleys and moist slopes, and even grows as a dense underbrush among jack pine high on rather dry southern mountain sides.

Most important of the low shrubbery is the ubiquitous dwarf birch or 'buckbrush' (mostly *Betula glandulosa*) of these latitudes. It covers tremendous areas of gravelly terrace land from the lowest to the highest levels. It is also widespread on mountain slopes, especially around timber-line where it may form a barrier only slightly less impenetrable than the scrub balsam. Juniper grows locally as a low shrub on dry rocky slopes. Labrador Tea (*Ledum groenlandicum*) is probably the most common of low shrub-forms on shady moss-covered slopes.

Good grass-meadows on valley terraces are sufficiently abundant to provide feed for pack-horses in most parts of the area up to timber-line, and patches occur locally some distance above. Mosses form a thick carpet on most shady slopes, and a lichen heath covers most of the upland surfaces. Alpine gardens near upland snow accumulations and fresh mud-slides have a great variety of small flora. Fireweed forms large communities, especially on freshly burned-over land, and wild roses are common on dry terrace slopes.

Edible fruits are abundant, and include Mountain Cranberry (*Vaccinium Vitis-Idaca*), black 'moss berries', blueberries, raspberries, gooseberries, black and red currants, and strawberries.

Other edible plants (*see* Porsild, 1937) include several varieties of mushroom, and a small plant, called bear-root by the natives, whose tuberous roots are very tender and palatable even when raw.

A comprehensive account of the flora along Canol road, which is fairly representative of the area, is given by Porsild (1951).

Fauna

Bears are the most abundant large animals. Grizzly bears are most common in the high country northeast of Teslin Valley and black bears in the generally lower country to the southwest. Only one brown bear was seen. Moose are fairly common, though not abundant, throughout. Woodland caribou are rather scarce, though seen at one time or another in all parts of the area above timber-line. The largest herd seen (about 16) was within 10 miles of the Alaska Highway. Goat inhabit only the most rugged mountains. Sheep were not seen, although some sign was found.

Smaller animals include wolf, coyote, beaver, muskrat, mink, fisher, marten, wolverine, lynx, fox, marmot, porcupine, woodchuck, rabbit, squirrel, pack-rat, and other small rodents.

The most abundant fish is the grayling, which is exclusive and plentiful in all the larger creeks and even in some of the mountain tarns without any apparent surface drainage. Lake trout is plentiful in parts of Teslin Lake, and whitefish is occasionally caught.

Game birds are spruce and blue grouse, ptarmigan, ducks, and geese. Loons inhabit most of the lakes. Large eagles, hawks, and vultures are common, as are camp-robbers, jays, and various smaller birds.

Mosquitoes are a serious pest until after the first heavy frosts, about mid-August. Black flies were not found to be much of a nuisance though considered so in the relatively dry low valleys where the settlements are situated.

Chapter III

GENERAL GEOLOGY

Geologically, Teslin map-area is divided almost diagonally by the northwest-trending boundary between a trough of late Palæozoic and Mesozoic stratified rocks lying to the southwest and a broad terrain of mainly early Palæozoic and Proterozoic rocks that underlie the eastern part of the Cordilleran region.

The boundary extends from a point near the northwest corner, parallel with and a few miles east of Teslin River and Teslin Lake, to the vicinity of Nisutlin Bay. Northeast of this line the bedded rocks comprise a metamorphosed assemblage largely of uncertain age and a locally overlying, less extensively metamorphosed assemblage of Mississippian limestone and other sedimentary rocks. Southwest of the line, practically unmetamorphosed Permian and (?) Pennsylvanian sedimentary rocks that underlie most of the country west of Teslin Lake are separated from Upper Triassic and probably Lower Jurassic mainly sedimentary rocks by an intervening belt of mainly volcanic rocks. These volcanic rocks extend for some distance north and south, west of Teslin River and Teslin Lake. A strip of country east of the northern part of Teslin Lake is occupied by sedimentary and interbedded distinctive volcanic rocks, very probably of Upper Triassic or Lower Jurassic age.

Two small areas of volcanic rocks just touching the map-boundaries overlie other rocks with definite angular unconformity and are probably Early Cretaceous. Some similar dykes may be in part contemporaneous with them.

Except the Cretaceous volcanic rocks just mentioned, all the stratified rocks are folded along mainly northwesterly trending axes and invaded by numerous large and small granitic bodies and an appreciable number of ultramafic intrusions. The granitic rocks are probably mainly or all Late Cretaceous; the ultramafic rocks are somewhat older but some cut strata that are probably Lower Jurassic.

A pre-Permian interval of deformation and regional metamorphism is suggested by the contrast in metamorphism between Mississippian and older rocks, and the late Palæozoic and Mesozoic assemblages. Age of mica from the schists of the older assemblage has been determined to be about 214-220 million years (*see* p. 25).

Small areas of partly weathered, semiconsolidated gravels, perhaps preglacial, occur along some creek bottoms. Recent glacial, fluvioglacial, and alluvial deposits floor the larger valleys for the most part, and mantle much of the remaining area.

Table of Formations

<table>
<tr><th>Era</th><th>Period</th><th>Formation or Unit</th><th>Lithology</th></tr>
<tr><td>Mesozoic and (?) Cenozoic</td><td>Cretaceous and (?) Tertiary</td><td>14</td><td>Volcanic andesite and dacite porphyry, in part older than 13; feldspar-quartz porphyry dykes may be contemporaneous or younger</td></tr>
<tr><td rowspan="11">Mesozoic</td><td>Cretaceous</td><td>13</td><td>Granite, granodiorite, diorite; gabbro, hornblendite, pyroxenite; syenite, monzonite</td></tr>
<tr><td rowspan="4">Jurassic or Cretaceous</td><td colspan="2">Not in contact, probably intrusive</td></tr>
<tr><td>12</td><td>Diorite</td></tr>
<tr><td colspan="2">Intrusive contact</td></tr>
<tr><td>11</td><td>Peridotite, pyroxenite, serpentine</td></tr>
<tr><td rowspan="4">Upper Triassic and/or Jurassic</td><td colspan="2">Intrusive contact</td></tr>
<tr><td>10</td><td>Augite porphyry and augite-feldspar porphyry: lava, breccia, agglomerate; argillite, sandstone, greywacke, conglomerate; chert</td></tr>
<tr><td colspan="2">Probably partly contemporaneous</td></tr>
<tr><td>9</td><td>Argillite, siltstone, sandstone, greywacke, conglomerate, limestone; minor lava</td></tr>
<tr><td rowspan="2">Upper Triassic</td><td colspan="2">Not in contact</td></tr>
<tr><td>8 Lewes River Group</td><td>Limestone, argillite, sandstone</td></tr>
<tr><td rowspan="5">Palæozoic and/or Mesozoic</td><td rowspan="2">Permian and/or Triassic</td><td colspan="2">Probable conformity with 8, possible disconformity with 9</td></tr>
<tr><td>7</td><td>Volcanic rocks, chert, minor argillite, quartzite, limestone</td></tr>
<tr><td rowspan="3">Permian, possibly later</td><td colspan="2">Not in contact with 7-10, intrusive contact with 11, 12</td></tr>
<tr><td>6</td><td>Conglomerate, greywacke, limestone</td></tr>
<tr><td colspan="2">Probably unconformable on 1-3; relationship to other rocks unknown</td></tr>
</table>

Table of Formations (Concl'd)

Era	Period	Formation or Unit	Lithology
Palæozoic	Permian and (?) Pennsylvanian	Fault (?) contacts, possible disconformity with 7	
		5 Cache Creek Group (in part)	Limestone
		Partly contemporaneous	
		4 Cache Creek Group (in part)	Argillaceous and quartzitic siltstone, greywacke, chert; minor limestone and conglomerate
	Mississippian	Not in contact, probable unconformity	
		3 Englishmans Group (in part)	Argillite, quartzite, phyllite, chert; arkose, greywacke, grit, conglomerate; limestone; minor greenstone
		Probably local disconformity, partly (?) contemporaneous	
		2 Englishmans Group (in part)	Limestone
	Mississippian and earlier	Probably local disconformity; in part may be equivalent to 2, 3, and younger rocks	
		1 Big Salmon Complex	Quartz-mica schist and gneiss, quartzite, slate; greenstone, albite-epidote amphibole gneiss and amphibolite; limestone; quartz-plagioclase-amphibole-garnet gneiss
Palæozoic?		A	Quartz-hornblende and quartz-feldspar-hornblende gneiss and amphibolite; diorite (?) in part gradational with, in part intrusive ? into 1

Description of Formations and Map-Units

Unit 1—Big Salmon Complex

Distribution

The Big Salmon Complex, unit 1, is confined to the northeastern half of the map-area, east of the main northwest-trending boundary that separates the map-area into two geologically dissimilar halves. Together with granitic intrusions and a separately mapped metamorphic complex, the rocks make up the main mass of Big Salmon Range and the west flank of Thirtymile and Englishmans Ranges, east of Nisutlin and Wolf Rivers, respectively. Rocks immediately east of Teslin Lake south of Morley Bay are included in the unit although they may well be equivalent to units 2 and 3.

General Description

The Big Salmon Complex comprises various rocks of sedimentary and volcanic origin, whose metamorphosed condition in general distinguishes them from those of other units. In this respect the unit corresponds to the Yukon Group of areas to north and west. However, it locally underlies Mississippian limestone of unit 2 with apparent conformity, and is believed to be mainly equivalent to Mississippian and earlier Palæozoic formations in Wolf Lake and McDame areas to the southeast. The age of the metamorphism, as indicated by the potassium-argon ratio of muscovite from the schists, has been determined as 214 million years (*see* p. 25).

Part of the complex may be the metamorphosed equivalent of units 2 and 3. On the other hand, a part near the western border of the outcrop area is of apparently relatively low metamorphic grade, and is not certainly distinguishable from nearby similar rocks of unit 9. The structure is generally highly complex and reliable stratigraphic subdivision is not feasible. In some places subdivison according to predominant lithological type is possible, however, and this has been attempted on the map.

Lithology

Probably the most abundant rocks are micaceous quartzites, and quartz-mica schists and gneisses (1a) in which biotite is the characteristic if not the chief micaceous mineral. These rocks are mainly light to dark grey, occasionally shades of brown or purple, and commonly thin bedded or finely banded. Some sections consist chiefly of nearly pure quartzite; these are white, buff, or pale green, and coarsely bedded. Some very fine grained or cryptocrystalline cherty quartz is in vein-like bands closely spaced among the quartzite beds from which it is apparently derived by solution and reprecipitation. These rocks are best developed along the central ridges of Big Salmon Range. They are also prominent just east of the upper and lower parts of Nisutlin River, near Morley River, and flanking the limestone band in the southeast corner.

Dark grey or brown to black argillaceous quartzite, slate, and graphitic schist, more or less micaceous, occur commonly in the quartzite-rich sections, and predominate in a few places (1b). They are characterized by well-developed slaty cleavage and break into thin slabs, locally as much as 10 feet across, most notably along the contact northeast of Teslin Lake. The cleavage is probably secondary, but primary banding is obscure.

Dark argillaceous rocks and derived slates and schists form a band extending from Slate Mountain near the northwest corner southeast into the valley of Sidney Creek, and also make up most of the ridge west of Iron Creek. A broad band outcrops at latitude 60°42′, longitude 133°28′, apparently extends southeast behind Cone Mountain, and may be represented in the broad areas of 1b near Peak 6227 north of the Canol road. Two miles west of the peak, similar argillaceous rocks may be in fault contact with rocks of unit 10. They are not conspicuously slaty, and the distinction is uncertain.

Green, generally schistose chlorite, biotite, and epidote-rich rocks and amphibolite (1d) make up a substantial part of the unit; these, and albite-rich gneiss and albite-epidote amphibolite (1e) are believed to be largely of volcanic origin. The greenstones vary from unsheared, relatively unaltered rocks in which porphyritic, amygdaloidal, and fragmental structures definitely indicate a volcanic origin to banded quartzose rocks of evidently sedimentary origin. Augite, almost entirely pseudomorphed by uralitic hornblende, actinolite, and chlorite, is prominent as phenocrysts in meta-lavas and flow breccias in many places, especially north and east of Mount Morley, and on the flanks of Englishmans Range near latitude 60°22′, longitude 132°08′. Accompanying original feldspar is everywhere replaced by sodic plagioclase and zoisite-epidote saussuritization assemblages. Elsewhere, more highly deformed and altered rocks of presumably similar original nature have been reduced to albite-epidote-amphibole schists and amphibolite. Rocks banded in various shades of green and containing more or less granular quartz, along with epidote, chlorite, biotite, and secondary green amphibole, are widely distributed through the outcrop area. Some of these appear to be tuffaceous quartzites or meta-greywackes derived in all probability from a volcanic terrain. Biotite spangles on the surface are a conspicuous feature of the greenstones in many places.

The albite-gneiss (1e) is typically exposed southeast of Mount Morley in the southeast corner of the map-area. It is a speckled greenish grey foliated rock with numerous discrete elliptical grains of white albite up to 2 mm long in a groundmass composed chiefly of chlorite, biotite, and epidote-group minerals. The porphyroblastic nature of the albite augen is shown by their common occurrence as simple twins with the twin-plane oriented perpendicular to the foliation, and by trains of inclusions that pass through the crystals parallel with the foliation (Pl. V A). Quartz is occasionally prominent and with it abundant sericitic white mica, the rock grading into a quartz-mica schist. Interbanded with these are dark green amphibolites, in which green hornblende, actinolite, epidote minerals, chlorite, and minor albite are the chief constituents.

Distinctive gneisses (1f) outcrop along the borders of the granitic mass at latitude 60°23′, longitude 132°48′, northeast of Teslin Lake. A strong lineation or foliation is marked by smeared-looking amphibole that has the deep blue-green colour and other optical properties of soda-rich hornblende. The feldspar is fresh, and is mostly plagioclase probably in the range oligoclase-andesine. Quartz commonly makes up about 25 per cent of the rock. Brown biotite, epidote, and garnet occur in various proportions and sphene and apatite are locally abundant. Cataclastic structure is marked by a suturing and preferred orientation of quartz grains and by distorted and broken compound plagioclase crystals. Some of the rocks contain appreciable amounts of potassium feldspar and grade into granite-gneiss.

The limestone (1c) is nearly all white or light grey and moderately to strongly recrystallized. Most is massive but some is banded in shades of white or bluish grey. A thick, buff-coloured band in the northern part of Big Salmon Range was reported by Lees but no buff-coloured or apparently dolomitized limestone was seen by the writer. No fossil remains or structures of recognizably organic derivation were found in place but some obscurely fossiliferous float (*see* p. 24) was found near a unique occurrence of black limestone bands at latitude 60°37′, longitude 133°14′. Limestone is closely associated with greenstone in the valley of Sidney Creek, and thence northwestward towards the northwest map-boundary. Near the southeast corner at latitude 60°13′, longitude 132° 05′ limestone and greenstone definitely interfinger in numerous bands. The major limestone band east of Mount Morley may similarly grade into volcanic rocks along strike. Limestone occurs as lenses elsewhere in thick volcanic sections and is associated with greenstone in a number of places. In some it appears to overlie, in others to underlie, greenstone and many bands are unrelated to greenstones. Skarn, composed chiefly of coarsely crystalline epidote and garnet, locally pyrite-bearing, occurs in several places along granite contacts in Big Salmon Range, notably at latitude 60°41′, longitude 133°14′; latitude 60°30′, longitude 132°53′; and latitude 60°27′, longitude 132°50′.

Metamorphism

The higher relative metamorphic grade of the rocks assigned to the Big Salmon Complex has been recognized by previous workers (Lord, 1944) and is a valid overall distinguishing feature although its stratigraphic significance is dubious in some places. The characteristic metamorphism manifests itself both in mineralogy and in structure.

Mineralogically, the unit is characterized by the presence of biotite as a component of schists and gneisses. This is in apparent contrast with the most highly deformed rocks of unit 3, as well as those of all other only moderately deformed and presumably younger units. Thus greenschists underlying the limestone (unit 2) east of the upper Nisutlin River are conspicuously spangled with brown biotite

(Pl. V B), whereas in schists typical of unit 3 these conspicuous biotite flakes are lacking (Pl. VI A). This would seem to indicate a lower metamorphic grade for the latter (cf. Harker, 1932, p. 212 and Fig. 94 B). However, very fine biotite is seen to be present and, like the sericitic mica and the chlorite of the greenschist, is oriented consistently parallel with the primary crenulated banding. The distinctive biotite of the greenschist is in relatively coarse flakes, averaging 0.3 mm by 1 mm, that cut across the primary banding, commonly at right angles. The porphyroblastic nature of the biotite is further manifested by trains of inclusions parallel with the crenulated primary banding. Thus it is evidently post-deformational, and cannot be taken as direct evidence of greater age for the rocks in which it occurs. The presence of biotite in general may, however, record higher temperature conditions during or subsequent to deformation, thus indicating greater depth of burial and, indirectly, greater age.

Structurally, the regional metamorphism that characterizes unit 1 (and related parts of unit 3A) is expressed by the widespread development of cleavage, schistosity, and, more locally, gneissosity in the bedded rocks. In many places a pronounced pencil-structure results from the tendency of the rocks to break into long subcylindrical fragments marking the axial parts of small drag-folds. In such places, notably east of Nisutlin River north of about latitude 60°43′ and north of Morley River, the schists are intensely and intricately crumpled. East of Nisutlin River the folds range in size from several tens of feet down to minute corrugations measuring 0.6 mm from crest to crest. The origin of these structures involves the simultaneous development of platy minerals: graphite, sericite, chlorite, and in part biotite—as described in the previous section and appropriate illustrations. On the smallest scale the minute corrugations are seen (Pls. V B, VI A) to pass into a planar structure due to slippage on the 'steeper' limbs of corresponding corrugations in adjacent bands. As a rule these slippage planes are irregular, discontinuous, and commonly arranged *en échelon,* but converge in places into distinct fractures to which the planar minerals (and acicular amphiboles) have been drawn into complete parallelism. North of Morley River, in the southeast corner a lineation, marked by pencil structure, results from the presence of minute crenulations on foliation surfaces. The southeastward plunge of the lineation is parallel with that of the limestone band that outlines the major anticlinal structure.

The age of the metamorphism, based on a potassium-argon determination on muscovite from the schist is 214-220 $\pm$ 25 million years (*see* p. 25).

Internal and External Structure

No major section is well exposed and various fragmentary sections are too complex in structure and too variable in lithology to permit any reliable stratigraphic interpretation.

In the southeast corner of the map-area, north of Morley River, a southeasterly plunging anticline is indicated by the arcuate outcrop pattern of a major limestone band and divergent dips in the associated rocks. This member consists of white crystalline limestone with some white, grey, and greenish quartzite interbeds, totalling perhaps 500 feet thick. Within the arc and presumably underlying the limestone is a heterogeneous assemblage of quartzite, quartz-mica schist and gneiss, and quartz-chlorite-epidote-albite gneiss of unknown thickness. Overlying the limestone are several hundred feet of varicoloured light quartzites which are succeeded by feldspathic and quartzose mica gneisses, green albite-epidote-chlorite-mica gneiss and schist, and amphibolite that outcrop with low variable dips for several miles southwards towards Morley River.

Similar limestone is interbedded with greenstone at latitude 60°12′, longitude 132°04′. It is overlain by biotite-muscovite quartzite and gneiss, greenish chlorite-mica schist and feldspathic gneiss which in turn apparently underlie the limestone of unit 3 near the point where it crosses the eastern map-boundary at latitude 60°15′.

Farther north along the flank of Englishmans Range, at latitude 60°25′, longitude 132°08′, chloritic schist and green augen gneiss outcrop near limestone of unit 3, which there carries diagnostic Mississippian fossils. These rocks and the slate, quartzite, and chert to the east dip westward and are assumed to be overturned, but the contacts are covered and this assumed simple relationship is open to question for reasons discussed in connection with units 2 and 3.

In the vicinity of Wolf River a composite section would seem to involve similar unfossiliferous limestone on the limbs of the aforementioned anticline enclosing greenish epidotic quartzites and schists, and overlain on the east by several hundred feet of light quartzites; these in turn being separated from overlying fossiliferous (unit 2) limestone by at least 1,500 feet of greenstones.

This uppermost greenstone member in various stages of metamorphism appears here and there bordering the fossiliferous limestone east of Nisutlin River north of Thirtymile Creek. At latitudes 60°47′ and 60°56′ it apparently overlies a considerable thickness of quartzite, quartz-sericite-biotite-garnet schist, crystalline limestone and limy quartzite, argillaceous quartzite, and schist, forming the supposed base of the exposed section.

In Big Salmon Range, west of Nisutlin River no fossiliferous horizon marker is present. A thick crystalline limestone member, closely associated with greenstone on one hand and black argillaceous schist and quartzite on the other, apparently extends along Sidney Creek and probably northwestward to the corner of the map-area. The analogy of this assemblage to the sequence of units 1-3 in Thirtymile Range is striking but not necessarily significant.

Another limestone band in the vicinity of Cone Mountain apparently dips beneath a thick section of black argillite, argillaceous quartzite, and quartzite. At latitude 60°42′, longitude 133°29′ it is exposed near to, and is probably unconformably overlain by, conglomerate that may be the base of unit 10.

Farther southeast, near latitude 60°36′, longitude 133°20′, the position of the boundary and the identity of the boundary rocks are highly uncertain. Black argillaceous slates of unit 1 (?) are identical with those at latitude 60°37′, longitude 135°15′, being little metamorphosed except where they grade into unit A with the appearance of hornblende metacrysts. The rocks assigned to unit 9, however, include similar black argillaceous rocks, interbedded with greenish slates and minor greenstone. The assumed fault undoubtedly exists but evidence of major displacement on it is not impressive.

The situation at latitude 60°25′, longitude 133°11′, southeast of Johnsons Crossing is similar, in that augite porphyry typical of unit 11 occurs east of the main dividing gully. The limestone and the chloritic schists and black slates north of it are typical of unit 1. The rocks are cut by a network of faults and are considerably deformed, altered, and silicified but, though one fault can be pointed out as the probable contact, the attitudes on both sides of it are similar and evidence of major displacement is not impressive.

The rocks on the south boundary, east of Teslin Lake—chiefly micaceous, chloritic, limy schist, limestone, and rusty weathering black and bluish quartzite, in that order—are strongly deformed and metamorphosed and generally comparable to those of unit 1 north of Morley River. South of latitude 60°00′, in Atlin map-area, however, the limestone band apparently trends eastward. There is a possibility that it may continue through drift-covered country to link up with fossiliferous limestone, considered equivalent to unit 2, in the southwest corner of Wolf Lake map-area. This arcuate pattern would parallel that of the limestone band north of Morley Lake, marking an upper horizon in the same southeasterly plunging anticlinal structure.

Age and Correlation

Greenschists of unit 1 underlie fossiliferous limestone of unit 3 east of Nisutlin River in Thirtymile Range and Englishmans Range, and are therefore mid-Mississippian or older. They extend into Wolfe Lake (Poole, 1958) map-area where similar rocks form part of an assemblage that overlies Middle Devonian strata, and are considered equivalent to greenstones of the Sylvester Group in McDame map-area (Gabrielse, 1954).

The greenstones and related rocks are considered to be the youngest members of the unit; the lower age limit is unknown. Greenstone and greenschists in Big Salmon Range are considered equivalent to those of Thirtymile Range. The thick sections of argillite, quartzite, and limestone may belong to older systems. The notable absence of conglomerate is not considered significant because conglomerate is not reported as an important member of older Palæozoic formations farther southeast. Fossiliferous float collected near limestone at latitude 60°38′, longitude 133°15′ was reported upon (P. Harker, pers. comm.) as follows: "This rock contains a number of small colonies of algal growth, probably *Girvanella.*

Such forms are known to have considerable geological range and can give no indication of age. No other fossils were found in the sample."

A large mass of greenstone lies east of Quiet Lake, about 8 miles north of the map-boundary. West of the lake north of that point, several thousand feet (Lees, 1936, p. 10) of limestone, argillite, and quartzite dip eastward towards the lake. Fragmentary indeterminate fossils in one limestone band were reported by Lees. The writer found only crinoid fragments in dark limestone in the area described but fossils found by Wheeler (pers. comm.) west of Quiet Lake were reported by D. J. McLaren of the Geological Survey of Canada to include *Favosites* and *Hexagonaria* (species of), probably of Devonian age.

The limestone and associated rocks near the southern boundary east of Teslin Lake may be metamorphosed equivalents of units 2 and 3.

The age of the main regional metamorphism that characterizes the group is in doubt. Judging from the conspicuous absence of such metamorphism in Permian rocks west of Teslin Lake and in probably Permian (unit 6) at latitude 60°45′ on the eastern map-boundary, its age is Permian or earlier.

An age of 214 ± 25 million years was determined (R. K. Wanless, Geological Survey GSC 59-9) from the potassium-argon ratio of muscovite from the schist. Biotite from the same collection gave unsatisfactory results but the runs on muscovite were reported as "good". A check sample, taken near mile 778, indicated 222 million years. This age corresponded well with the field data suggesting pre-Permian metamorphism, according to the Holmes B scale. However, in 1959-60 it was generally considered equivalent to early Triassic, and cannot on that basis be considered as supporting evidence for a mid-Palæozoic orogeny.

Unit A

Unit A consists of pseudodioritic gneisses, in part sheared and altered, that outcrop in irregular bodies within that part of the area northeast of Teslin River occupied by unit 1. The boundaries are gradational and the bodies as mapped include much unit 1 material.

Lithology

The component rocks vary in appearance and composition, ranging from a mesocratic quartz-hornblende or feldspar-quartz-hornblende gneiss, or a micaceous, epidotic, or chloritic augen gneiss, to a black medium- to coarse-grained hornblendite. Hornblende is a characteristic and in amphibolitic varieties the chief constituent. It commonly occurs in blurred grains and bunches with subparallel orientation, and contrasts with the light coloured components to produce a gneissic texture. Elsewhere it occurs as well-formed prisms nearly half an inch long in random orientation in a finer grained light or greenish groundmass. The hornblende characteristically has a poeciloblastic or sieve-texture, enclosing quartz, feldspar, and other minerals. Quartz in partly recrystallized clastic grains is found in all but a few amphibolitic varieties, and makes up more than 50 per cent of some specimens. Feldspar generally occurs in minor amount or is absent, but it is a major constituent in some places, especially in the southernmost body in which a dioritic texture is best developed. Except in a few specimens that contain potash feldspar, it is glassy sodic plagioclase. The plagioclase rarely shows twinning but is commonly zoned, with included foreign material confined mainly to certain zones. This, like the sieve-texture of the hornblende, may indicate a secondary origin for these minerals. Potassic feldspar, where present, is characteristically fresh, and makes up large areas containing numerous inclusions of altered plagioclase, quartz, hornblende, and secondary minerals. It is accordingly believed to be of metasomatic origin. Biotite, chlorite, epidote, and clinozoisite occur in various proportions, in some places to the exclusion of hornblende. Garnet is a minor, but not uncommon, constituent except in the southernmost body. Some specimens also have a little sphene.

At the north end of the southernmost body the rocks are largely hornblendite and possibly pyroxenite. Some of these are so serpentinized as to mask the original identity of some constituent minerals, possibly including enstatite. A sample of asbestos reported to be from this area proved by X-ray methods to be tremolite.

Origin, Structure, and Contact Relationships

The rocks of unit A are believed to be in large part derived from those of unit 1 but are of a higher degree of metamorphism. However, some parts of the southernmost body, at least, may represent sheared and altered diorite of intrusive origin. Likewise, the northern bodies (not seen by the writer) may be in part or entirely intrusive. South of Sidney Creek rocks of the unit, though they grade imperceptibly into and include much material of unit 1, occur in recognizable zones, substantially as mapped by Lees (1936, map-unit 7). For these reasons his map-unit has, with minor changes, been retained.

Near the southernmost tongue, the rocks are bordered on both sides by black argillite. The contacts are transitional, metacrysts of hornblende appearing in the argillite and becoming more numerous over a distance of several hundred feet as the typical pseudodiorite is approached.

Age and Correlation

The rocks resemble, in some respects, the amphibole gneisses farther south mapped as unit 1f. They are certainly older than the granitic intrusions to the east, and their condition may be the result of a distinctly earlier period of metamorphism or intrusion.

Foliated amphibolite, hornblendite, hornblende-rich diorite, and sheared granodiorite occur amongst the same group of metamorphic rocks (unit 1) farther north in the Big Salmon Mountains in Laberge map-area (Bostock and Lees, 1938, pp. 1, 10). The sheared granodiorite is said to exhibit the same schistose structure as displayed by the Yukon Group beds, and was tentatively considered to be of Precambrian or early Palæozoic age. Unit A is likewise largely older than the latest, presumably Upper Mesozoic, period of deformation. It may well date from the post-Early Mississippian, pre-Permian interval of deformation and metamorphism discussed under unit 1. The same or other similar intrusions, since removed or concealed by erosion, may have furnished the coarse feldspathic material in the arkose of unit 3. It is noteworthy, however, that a conscious search failed to turn up fragments like the rocks of unit A in coarse greywackes of unit 9.

An independent age determination by potassium-argon ratio could not be made because insufficient mica was present in specimens certainly belonging to the unit. Two specimens rich in white mica were included in the schist sample of unit 1 supplied for age determination. It is doubtful if its age could be conclusively established by this method because micaceous specimens are not definitely distinguishable from the schists of unit 1.

Englishmans Group (Units 2, 3)

This group comprises fossiliferous limestone (unit 2) and associated sedimentary rocks (unit 3) including apparently unfossiliferous limestone that form a geographically continuous assemblage believed to be wholly of Mississippian age.

Unit 2

Unit 2 consists essentially of intermittent bands of fossiliferous limestone lying in a northwesterly trending belt between rocks of unit 1 on the west and those of unit 3 on the east. The belt crosses the eastern map-boundary at latitude 60°15′, and extends almost to the northern map-boundary east of Nisutlin River.

Lithology

The unit consists essentially of limestone, chiefly white but in part dark grey. Some is buff weathering but none appears to be dolomitic. The white limestone contains abundant chert, in nodules and irregular masses in certain bands, and fossils are commonly replaced by silica. The dark grey limestone is generally banded, is distinctly sulphurous, and carries the best and most abundant fossils. Locally the limestone is somewhat recrystallized but in the main it is characteristically less altered than the recrystallized limestone of unit 1. The northern bodies west of Thirtymile Creek, however, are locally strongly corrugated like the associated, probably underlying schist.

Limestone breccia generally occurs within narrow belts and may be tectonic features but here and there rounded fragments of foreign material are also present and the rocks may be true conglomerates. Beds of massive and banded chert a few tens of feet thick are present in several such localities. Some are partly crushed and mashed with limestone to form a pseudoconglomerate. Lenticular beds of sandy phyllite occur here and there, notably east of Thirtymile Creek (latitude 60°39′, longitude 132°32′). About 6 miles north of this point two distinct bands of limestone are separated by several hundred feet of argillaceous quartzite.

Two miles north of the same point much of the limestone has abundant nodular structures, some of which are subcircular in section and suggest an organic origin. The nodules appear to consist of fine silky needles but effervesce freely in dilute HCl and the solution gives a scanty yellow precipitate with NH_4MoO_4 (phosphate test).

North of latitude 60°43′ much of the limestone is in relatively sandy beds in which crinoids are commonly found (and silicified brachiopods? at latitude 60°57½′) but not corals. The beds are intercalated with phyllite and quartzite.

Age and Correlation

Fossils were reported upon by Peter Harker of the Geological Survey of Canada, December 1, 1952, as follows:

(1) (Latitude 60°25′, longitude 132°08′) *Spirifer* sp. ex gp. *S. striatiformis* Meek; clisiophyllid coral; fragmentary brachiopod; gastropod, indeterminable; *Spirifer* sp; coral fragment—*Hapsiphyllum* sp;

(2) (Latitude 60°36′, longitude 132°30′) *Lithostrotion* sp. Fragment of large phaceloid form;

(3 (Latitude 60°33½′, longitude 132°18′) *Triplophyllum* sp.

Remarks on Stratigraphy

Harker states that fossils from lot (1) are probably of about the same age as the upper part of the Banff Formation of the southern Rockies, now considered to be Kinderhook/Osage in terms of the Mississippian time scale of Central U.S.A.; those from lots (2) and (3) are possibly somewhat younger. The fossils are scanty and not too well preserved, and cannot be precisely dated, but it would be reasonable to regard the strata from which they were collected as of middle Mississippian age.

Other details of collections considered significant by the writer are as follows:

(1) No spiriferoid brachiopods were identified from localities other than (1) above.

(2) Silicified closely packed small cylindrical corals like those prominent at locality (2) were found in abundance west of Thirtymile Creek at latitude 60°37′, longitude 132°37′, and latitude 60°40′, longitude 132°41′. At the first of these a coquina of distinctive pure white completely silicified brachiopod-like shells was found some distance above (?) the lithostrotionid (?) horizon and just below the contact with black argillite. A few similar shells were found at the latter point and an identical coquina at latitude 60°41′, longitude 132°45′.

(3) A few similar silicified brachiopods (?) were seen at latitude 60°57½′, but otherwise no fossils other than crinoid stems, such as occur generally through the unit, were recognized north of the last-mentioned locality.

(4) The locality of lot (3) is not shown on the map. No limestone was found in place there, but near the place where the fossiliferous specimen was picked up a band of float has a narrow vertical distribution. It appears to be near the base of the lowest exposed conglomerate bed.

(5) Silicified corals are fairly abundant at the fossil localities shown south and west of the last-described point (Hill 5885), and are very abundant at latitude 60°29′, longitude 132°14′, where the fauna appears very similar to that at locality (3).

(6) At latitude 60°16′, longitude 132°02′, only a single rugose coral was found, but a few miles southeast in the same outcropping band some lithostrotionid fossils were reported (Poole, W. H., pers. comm.).

Internal and External Structure

No well-founded conclusions have been reached regarding the structure and stratigraphy of the limestone except as noted in the description of fossil localities.

The thickness is also in doubt, due to structural uncertainties. At latitude 60°30′, longitude 132°21′ an apparently flat-lying section is probably 1,500 feet thick. South of latitude 60°41′ the thickness of limestone is thought to be of about that order but at latitude 60°24′ it may be thinner, and from there south to latitude 60°17′ this typical limestone does not appear. The possibilities in this section are discussed in connection with unit 3 (p. 35). North of latitude 60°41′ the limestone is somewhat thinner; some bands have been much exaggerated in order to show on the map. At latitude 60°52′, longitude 132°44′ the limestone is only 20 feet thick.

Unit 3

This unit consists typically of unmetamorphosed, dark weathering sedimentary rocks that make up the main mass of Englishmans Range and Thirtymile Range. They are for the most part separated by the fossiliferous limestone of unit 2 from the typically metamorphosed rocks of unit 1.

The part mapped as unit 3A consists chiefly of phyllite and quartzite northwest of Thirtymile Lake and north of Fish Lake in the northeastern part of the map-area.

Lithology

The typical rocks are dark argillaceous slates and quartzites, with locally abundant chert. Arkose (3a), conglomerate (3b), greywacke, and brownish grits and sandstones are minor but distinctive components. Limestone mapped as 3c is doubtfully correlative with unit 2. Definitely volcanic rocks are in very minor amount, but some fine green-and-purplish mottled rocks of uncertain origin are locally prominent and distinctive. A little very fine rather soft pinkish phyllite has dubious value as a horizon marker in some places. Unit 3A consists of graphitic slate, sericitic phyllite and quartzite, and sheared and silicified equivalents.

The argillaceous rocks are generally fissile but do not cleave into large coherent sheets, and phyllitic structure is only exceptionally developed. They vary from very fine, black carbonaceous shale to light grey argillaceous quartzites. Some massive, white, light varicoloured, and finely banded quartzite is interbedded with the argillaceous varieties.

Chert is commonly interbedded with both argillite and quartzite. Some is finely interbanded in beds less than an inch thick, much in massive beds a foot or more thick, and some sections 100 feet or more thick consist almost entirely of bedded chert. It is creamy to pinkish weathering but varies from black to light grey, buff, pink, or greenish on fresh fractures. Chert is especially prominent along the lower west flank of Englishmans Range above the limestone, and is associated in abundance with the otherwise similar but soft pink phyllite and with the fine-grained mottled rocks.

Arkose (3a) occurs in substantial amount in several parts of Thirtymile Range, notably just northwest of Wolf River and south of Thirtymile Lake. It varies from a fine grit to a fine conglomerate and consists chiefly of quartz, feldspar, and rock fragments up to an inch across, in a mixture of finer fragments and sericitic material, the whole commonly well stained with iron rust. The fragments are very heterogeneous in size, and vary from subround to sharply angular in shape. Some large feldspar grains, though broken, are in almost euhedral crystals. Large quartz and feldspar grains commonly protrude from the weathered surface. Much of the feldspar is fairly fresh with distinct plagioclase twinning, but is definitely detrital. Rock fragments include fine- and medium-grained siltstone and sandstone, not greatly recrystallized, large pieces of highly sutured and recrystallized quartzite, occasional fine sericite or carbonate-rich rocks, altered fine feldspar porphyry, and fine microlitic lava (Pl. VI B). The rock as a whole is locally sheared and the finer interstitial material slightly schistose but not sutured or recrystallized. Brownish, rather friable greywacke, grits, and sandstone are rather widely distributed, especially with the arkose, and below and amongst the conglomerate lenses west of Wolf River. They contain more and better-rounded quartz grains but are similar to and gradational with the arkoses.

Conglomerate is of two types, intraformational and probably basal. Intraformational conglomerate makes up most of the upper part of Hill 5885, at latitude 60°33′ west of Wolf River, and a few lenses farther north. It lies above and is interbedded in numerous lenses with brown sandstone, grits, argillite, and chert. A narrow band of limestone float, some richly fossiliferous (*see* under *Unit 2*), lies just below the base of the conglomerate but none was seen in place. The conglomerate consists chiefly of chert, in subround to angular fragments of pebble to boulder size, with some fairly well rounded quartzite and reddish banded material. A minor amount has black argillite fragments and is non-cherty. This conglomerate section may be nearly 500 feet thick, but in the ridges to the north it is in thinner, more scattered lenses and not coarser than cobble size. Some of the arkose previously described is actually pebble-conglomerate. All these fragmental rocks are mutually gradational. The basal types of conglomerate are described below.

The only rocks considered to be definitely volcanic in origin and definitely distinct from unit 1 are peculiar greenstones that have apparently a very restricted distribution near latitude 60°35′, longitude 132°23′, and latitude 60°43′, longitude 132°31′. These have closely spaced ellipsoidal structures up to 8 mm long, are buff to reddish brown and filled variously with calcite, quartz, glassy and twinned fresh feldspar, chlorite-group and epidote-group minerals, and indeterminate material. The interstitial material, green to black, is a fine felted mass of acicular minerals, in fluidal, dendritic, and random arrangements, opaque grains, various secondary minerals, quartz, and brown-stained carbonate granules. The rocks are most probably amygdaloidal and/or variolitic lavas. At the first locality they are reported to be associated chiefly with chert. At the second, a very little superficially similar rock immediately overlies the upper band of limestone, and is associated with massive pitted greenschist. Similar but less distinctive pitted and white-spotted greenschist, partly fragmental-looking, accompanies brown grit and minor limestone at the top of the limestone just across Thirtymile Creek, but some rocks overlying the lower band east of Thirtymile Creek were also thought to resemble these.

Greenish to purplish grey, faintly mottled, rather distinctive rocks occur in some abundance for 2 to 8 miles along the steep west flank of the mountain north of Mount McCleery (latitude 60°19′, longitude 132°02′). They are very fine, hard massive rocks, without diagnostic structures but commonly streaky and fragmental looking. Fine amphibole and altered feldspar are recognizable in most sections and small feldspar-porphyry fragments in some but not much quartz was seen in any. A rather coarser fragmental rock farther north contains various meta-volcanic fragments. These rocks are associated with abundant chert; they may have originated as tuffs, tuffaceous greywackes, or flows.

In the same general area, about 2½ miles northwest of Mount McCleery, and also about 2 miles south, very fine, rather soft, lustrous to translucent pink phyllite is interbanded with green slates and fine gritty rocks near and on the lower steep mountain slopes. Some is interbedded with hard but otherwise similar pink, green, and varicoloured chert at the former locality. Very similar rocks were seen also west of Wolf River at latitude 60°26′, longitude 132°18′ where they appear to be in the upper unit 1 greenstone.

Limestone (3c) that outcrops in several high passes in the Englishmans Range (Pl. IV B) is unlike that of unit 2 in several respects. It contains abundant chert throughout, it lacks the dark grey sulphurous zone of unit 2, and it is apparently unfossiliferous. It contains abundant interbedded quartzite especially towards the top of the section, which just north of Mount McCleery is several hundred feet thick as exposed west of the fault. It appears in some places to overlie argillaceous quartzite typical of unit 3. However, what is apparently the same limestone appears to overlie greenstone west and southwest of Mount McCleery and thus to represent the otherwise missing band of unit 2.

Rock bodies classified as 'basal conglomerates' include some that appear to mark the base of unit 2, and others whose relationship to units 2 and 3 are indefinite.

What may be sheared conglomerate occurs at the contact between limestone and contorted phyllitic quartzite west and south of Hill 4938 west of Thirtymile Creek, latitude 60°41′, longitude 132°38′. Farther south, at latitude 60°38′, longitude 132°38′, a little chert-conglomerate or pseudo-conglomerate with chert and some friable fragmental greenish grits appears to underlie the limestone. At latitude 60°31′, longitude 132°20′, just west of Wolf River schistose sheared rusty conglomerate contains fragments of chert, mostly lenticular, also of pitted greenstone. Nearby at latitude 60°30′, longitude 132°21′, a mangled schistose conglomerate has fragments of banded quartzite and greenstones. One and one half miles northwest of Mount McCleery in Englishmans Range, at latitude 60°20′, longitude 132°05′, a sheared conglomerate or breccia has lenticular angular fragments of pebble to boulder size in a green, very limy matrix. This body seems to lie within a sequence of normal argillaceous quartzite and argillite.

The above are all minor occurrences. A more spectacular conglomerate occurs in Thirtymile Range at latitude 60°34½′, longitude 132°22′, just over 2 miles northwest of the chert-conglomerate hill. There the limestone is in contact with coarse conglomerate and apparently interbedded green quartzite. The fragments are mostly greenstone, altered augite-feldspar porphyries, and amygdaloidal lavas typical of unit 1, but limestone occurs also in blocks up to 2 feet across amongst greenstone boulders. The significance of this is not clear. If it is a true basal conglomerate it apparently overlies the limestone (unless the blocks are derived from an older limestone).

Unit 3A

Unit 3A is confined to the northeast quarter of the map-area and includes rocks that may be equivalent to unit 1. For the most part it lies in uncertain stratigraphic relationship to thin lenticular sandy crinoidal limestone beds or is interbedded with them. The limestone is believed to be mainly equivalent to unit 2 although no diagnostic fossils have been found in it.

Unit 3A consists chiefly of quartzose and argillaceous schists and phyllites. Most are rich in white mica, some are graphitic, but biotite is rarely developed.

For several miles north and south of latitude 60°52′, longitude 132°43′, massive quartzite and quartzose phyllite is highly contorted, the wavelength of drag-folds varying from microscopic to tens of feet.

West of the nearby limestone band a section at least several hundred feet thick consists largely of relatively unmetamorphosed greenish grit, greywacke, and conglomeratic greywacke. These rocks are interbedded with slate and quartzite and give way to these types near the limestone bed at the top of the hill. A thin white quartzite bed forms a fairly persistent horizon marker just west of the limestone band and appears also on the ridge south of the above-mentioned point. The limestone band east of the point overlies partly contorted argillaceous slate and quartzite and apparently faces east. North of Thirtymile Lake some sheared and schistose greenish greywacke and arkosic grits are interbedded with dominantly argillaceous and quartzitic schists. The rocks may be equivalent to those of unit 3 south of the lake. East of an assumed fault extending southeast from Thirtymile Lake the rocks are chiefly highly silicified quartz-muscovite schists (quartz-biotite schist immediately southeast of the lake). The rocks extending northward from the vicinity of Fish Lake are also highly deformed and silicified quartzose schists.

The typical rocks are severely deformed and minutely crenulated, with the development of sericitic mica along the foliation surfaces (Pl. VI A). Thus the rocks are not distinguishable on the basis of dynamic metamorphism from those of unit 1. Biotite is rarely developed, but its absence cannot be considered a criterion of lesser age although it may indicate a lower grade of metamorphism (*see* p. 22).

Structure and Relationships

Unit 3 outcrops mainly east of unit 1, and in most places is separated from that unit by the fossiliferous limestone of unit 2. It is characteristically less metamorphosed than unit 1.

The consensus of field data is that the limestone (unit 2) overlies greenstones of unit 1 with local disconformity and underlies the main mass of unit 3, possibly also with local disconformity. However, in parts of Englishmans Range where the presence and identity of unit 2 is in serious doubt, it has not been possible to elucidate the contact relationships with any certainty.

At its northernmost limit of exposure fossiliferous limestone of unit 2 overlies, with apparent conformity, quartz-biotite-amphibole-epidote-albite greenstone and schist typical of unit 1. Similar greenstone and schist extend southward, west of the limestone, to about latitude 60°42′. Green amphibole-quartz gneiss apparently underlies the limestone near the mouth of Thirtymile Creek and a thick section of greenstone does so in the vicinity of Wolf River. Some suggested instances of local disconformity are marked by dubious conglomerate occurrences. Farther southeast, near English Creek the rocks may be overturned, and from there south to latitude 60°17′, unit 2 is not recognizable, although a limestone member (unit 3c) appears locally to have about the same stratigraphic position.

At the base of unit 3 west of Wolf River, black slate overlies coral-bearing limestone at latitude 60°32½′, longitude 132°19′, and is succeeded by a thick section of chert-conglomerate, grit, and chert. Black slate, likewise dipping gently northeast, is also exposed about 1½ miles northwest of that point but 3 miles northwest of it the east contact of the limestone is with coarse conglomerate composed chiefly of greenstone with a few blocks of limestone. Farther west, at latitude 60°35′, longitude 132°27′, black slate and chert dip beneath fossiliferous limestone at a moderate angle but a poor cleavage is more nearly horizontal, suggesting that the strata are overturned. Black slates and argillaceous quartzites overlie fossiliferous limestone in small infolded patches and sections in a number of places southwest of these localities, also west of Thirtymile Creek.

The limestone that dips gently to moderately beneath the main mass of unit 3 east of Thirtymile Creek presumably belongs to unit 2 but is not certainly fossiliferous. Furthermore, two limestone bands are present; arkosic grits like those that apparently overlie fossiliferous limestone farther east lie below the lower limestone at latitude 60°43½′, and are interbedded with argillite and argillaceous quartzite like that below the limestone farther southwest across Thirtymile Creek. However the latter band may be equivalent to the upper band east of Thirtymile Creek, which is capped by pitted green grits with some possible lava. No other useful horizon markers are present in unit 3 and the top is not recognized. A minimum thickness of 2,500 feet of strata is apparently exposed in the section east of Thirtymile Creek. Judging from the consistent northeasterly dips elsewhere in Thirtymile Range the whole section in that area may be many times that thickness.

The rocks of Thirtymile Range, including those west of Thirtymile Creek, have for the most part been thrown into broad open folds, a few of whose axes have been indicated on the map. Locally however, and particularly north of about latitude 60°45′, the rocks have been closely folded, intensely deformed, and largely converted to schists and phyllites. They are broken by numerous faults, only a rather arbitrary few of which can be mapped at this scale. Many of the northerly striking longitudinal faults, in particular, are marked in the field by massive quartz dykes and stockworks, some 100 feet or more thick.

The strikes and fold axes trend west of north in the southern half of the area, swinging to northward in the vicinity of Thirtymile Creek, and to northeast in the area north of Thirtymile Lake. The continuation of this trend is supported by the occurrence and attitude of the limestone and accompanying rocks near the north boundary at longitude 132°28′.

The major structure of Thirtymile Range may thus be a faulted syncline, plunging gently to moderately southward at its northern fringe.

In Englishmans Range the relationships are even more uncertain; the rocks have been broken into a complex of fault-slices along the fringe of the large granite batholith. At latitude 60°28′, longitude 132°11′ argillite, argillaceous quartzite and chert dip gently to moderately towards the fossiliferous limestone but are bounded on the west by a massive ridge of chert and quartz that may be a fault-breccia. Farther south near English Creek a similar assemblage seems to dip mainly west but no contact with the fossiliferous limestone is exposed. The limestone (unit 3c) outcropping in the passes is generally flat lying but is bounded on one or both sides by steep longitudinal faults (Pl. IV B). It may wrap around the argillite and quartzite of Mount McCleery, outlining a tilted syncline, but is not exposed between those rocks and the greenstones (1?d) at latitude 60°17′, longitude 132°02′. No limestone is exposed along the contact north of latitude 60°20′, which is obscured by talus.

The structure and relationships of the rocks in this area can only be guessed at. There is some suggestion of faulting. One possibility is that the rocks of unit 1 have been overthrust onto those of unit 3.

Another possibility involved is that greenstone that Poole (1958) found east of the limestone in Wolf Lake area and which he believed to overlie the limestone is equivalent to that (1d) south and west and possibly northwest of Mount McCleery. It may pinch out farther north. This possibility is not supported by observed contact relationships at latitude 60°17′, longitude 132°02′, however, and in any case would not resolve the structural enigma in that part of the area.

Metamorphism

The typical rocks of units 2 and 3 as exposed in Englishmans Range and Thirtymile Range have only exceptionally been metamorphosed and only to a low phyllite grade. Contact effects of the granitic batholith of Englishmans Range and the stock south of Thirtymile Lake are negligible, being limited to the development of spotted slates among the argillites and of skarn in adjoining limestone.

Northwest of a line drawn through Thirtymile Lake (as a rough boundary), however, the rocks (3A) have in general been dynamically metamorphosed into graphitic and sericitic phyllites. Likewise, those west of upper Wolf River, east of a sharply defined line that marks the assumed fault, are highly silicified quartz-muscovite schists (quartz-biotite schist on Hill 4590) and those north of Fish Lake are similar. Elsewhere biotite is not conspicuously developed except just east of the granodiorite stock west of Thirtymile Lake but a little fine biotite was seen to accompany sericite in some thin sections of crenulated schists from northern outcrops east of Nisutlin River.

These metamorphic effects were discussed in more detail in connection with units 3A and 1. The inference is that although the typical rocks of units 2 and 3 escaped the regional metamorphism that characterizes unit 1, stratigraphically equivalent rocks were affected by it and the metamorphism mainly post-dates the deposition of these rocks.

Age and Correlation

The fossiliferous limestone bodies of unit 2 are all believed to represent essentially the same lithological unit although its stratigraphic relationships are inconclusive.

The several fossil collections (*see* p. 28) suggest an appreciable time-range from Upper Banff (Kinderhook/Osage?) to somewhat higher ("Middle Mississippian").

On this basis, the base of unit 3 is Middle Mississippian. Its upper age limit is unknown. Poole (1958) found a "Lower (?) and Middle Mississippian" limestone near Screw Creek in Wolf Lake area that is disconformably (?) overlain by massive chert-conglomerate and other rocks. This latter assemblage he relates to the Nizi Group in McDame area (Gabrielse, 1954), then considered to be Upper Mississippian and perhaps younger. The Upper Mississippian and (?) younger age of the Nizi is now (Gabrielse, pers. comm., 1959) considered dubious. The chert-conglomerate mass (3b) at latitude 60°33′, longitude 132°19′, northwest of Wolf River may, therefore, be stratigraphically equivalent to the Nizi, as may also be the nearby coarse arkose and conglomeratic lenses farther north.

Cache Creek Group (Units 4, 5)

Permian limestones (unit 5), associated and partly interbedded with sedimentary rocks (unit 4), occupy practically the whole southwestern part of the map-area. They are entirely unmetamorphosed, unlike the older Palæozoic groups with which they are nowhere in contact, and generally resemble Cache Creek assemblages of southern and central British Columbia.

Unit 4

This unit is confined to the southwestern part of the map-area, west of Teslin Lake and south of the Alaska Highway.

Lithology

The unit consists of argillaceous and quartzitic siltstones and sandstones with intercalated greywacke, abundant chert, locally conglomeratic greywacke, and very minor limestone. In a few places separation according to predominant lithological type is possible and has been attempted on the map. Through most of the area, however, the various rock types alternate with monotonous regularity, and no such separation is feasible. The rocks, though considerably deformed and dipping at all angles, are little altered and rarely schistose.

The siltstones vary from shaly black highly argillaceous to rather coarsely bedded light quartzitic types. Much is finely banded in light and dark grey layers, a fraction of an inch thick. They show no distinct grain gradation, and cleavage at an angle to distinct bedding is nowhere well developed. The fine-banded rocks predominate in two mappable bands (4d). Much argillite, especially along the

Atlin highway, contains abundant hard black cryptocrystalline chert in streaks and nodules.

Coarser siltstones or sandstones are well-cemented, massive, hard, quartzitic types in light to dark grey, buff, greenish, or reddish colours. Graded bedding is uncommon. Most contain argillite and chert fragments. Fragments range from typical mud-flakes to irregular streaks and masses. In many places irregular masses of argillite reaching a size of several inches make up most of the rock, giving it a conglomeratic aspect.

The greywackes are also characterized by argillite and chert fragments, and merge in character with the coarser siltstones or sandstones but are generally coarser, more fragmental in texture and have a greater variety of mineral constituents. They are thick-bedded, massive, tough rocks without perceptible banding or grain gradation. Most vary from light grey or buff to green.

The green rocks, in particular, resemble tuffs, but are seen on microscopic examination to be not essentially different from the others examined, a large proportion of the specimens having been chosen from the most volcanic-looking rocks encountered. Most contain fragments of feldspar and ferromagnesian minerals, fine-grained porphyries and other typically volcanic fragments that are evidently derived from a volcanic terrain. However, a large proportion of the fragments are subrounded and detrital quartz is more or less abundant throughout. The rocks are chiefly, if not entirely, water-lain and are everywhere interbedded with rocks of obviously sedimentary origin.

The composition of the greywacke was determined from thirty-eight thin sections as follows:

Quartz was estimated at 30 to 35 per cent in six sections, 10 to 30 per cent in fourteen, less than 5 per cent in nine, including two in which the quartz content is negligible. Most of the sand-sized grains are subrounded; the smaller are more commonly sharply angular. Feldspar is only identifiable where fresh enough to show plagioclase twinning and is probably much more abundant than apparent. Seven sections showed a little, which is fairly fresh. Three were found to contain more than 15 per cent definitely and one arkosic variety has abundant fresh plagioclase. Hornblende is by far the commonest ferromagnesian mineral. It is present as detached grains in substantial amount in twelve sections and is recognized in several others. A bluish green alkaline amphibole was identified in one section, estimated to contain at least 10 per cent total amphibole. Hornblende was described as a major constituent in one section that contains little quartz but otherwise there appears to be no consistent relationship between hornblende and quartz content.

Augite, with or without hornblende, is recognizable in five sections and may amount to 5 per cent in one. These ferromagnesian minerals are notably fresh, though in shattered anhedral grains.

The lithic fragments of undoubted volcanic origin are fine hornblende, feldspar-hornblende, and augite porphyries, and occasional amygdaloidal and variolitic rocks. These are most conspicuous in specimens that carry detached ferromagnesian grains in abundance and suggest a volcanic origin for the latter. A large proportion of the fragments are very fine, dark, and altered looking and much of this material is probably also volcanic. The remainder probably is fine argillite or argillaceous siltstone.

Fragments of exotic origin include scattered small grains of clear, fine-grained quartzite and gneiss, in which the grain boundaries appear somewhat sutured. These were noted in twelve sections but are nowhere abundant. A very few flaky fragments appear schistose. Detrital limestone grains were noted in six sections but are at all abundant in only one, from near the southeast limestone bands of unit 5. This rock is conspicuously spotted with small red patches which proved to be rather well-formed rhombs composed chiefly of rusty carbonate. Recognizable granitic fragments are extremely rare. One section (Pl. VII A) contains a few fair-sized grains of fine feldspar-quartz and feldspar-quartz-hornblende porphyries, perhaps aplite or granophyre. One rather arkosic-looking rock contains some apparently composite grains of quartz and feldspar. A black variety showed one area of fine amphibolite.

A comparison of the greywackes of units 4, 9, and 10 is given under unit 9.

Although conglomeratic facies of the greywacke, containing chert pebbles and irregular masses of argillite, appear here and there, the only conspicuous development of conglomerate is in the area about 6 miles southwest of Squanga Lake. There, in several bands encountered along the length of the ridge, rounded granitic pebbles (one gneissic) were noted among other fragments, chiefly chert and argillite. The associated rocks are greywacke, quartzite, and argillite typical of the unit.

Chert is widely distributed, makes up a substantial proportion of the unit, and in some areas mapped (4a) is predominant among the exposed rocks. Some is in massive beds, intimately interbedded with argillite or siltstone but most is banded or ribbon-chert, composed of layers 2 to 4 inches thick that are separated by thin, slaty, commonly greenish partings. Most of these are considerably distorted, some intricately contorted and drag-folded. In some the chert layers have been broken and drawn out into lenticles and quite commonly the broken fragments of layers have been jostled and rounded to such a degree that the rock can only be distinguished from a true chert-conglomerate by the proximity along strike of less-contorted banded chert. In colour the chert ranges from creamy white or pink shades to black. The weathered surface is generally a chalky white to buff, but from a distance large outcrops commonly appear distinctly reddish. Although most abundant in the southern part of the outcrop area, its prevalence is thought to be due to high resistance to erosion rather than to stratigraphic position. However, a broad band seems to extend parallel with the northeastern band of limestone (unit 5?) for a considerable distance. Some of the predominantly chert bands may be hundreds or even thousands of feet thick.

Limestone (4b) in thin beds occurs in three localities in the southwestern part of the outcrop area. It is light to dark grey and carries some possibly organic material but no identifiable fossils. It is associated with chert, chert-conglomerate, and argillite.

Unit 5

Distribution

Unit 5 is confined to the area west of Teslin Lake and south of the Alaska Highway except for one small area southwest of and another northeast of Squanga Lake. The main mass forms the prominent mountains northeast and southwest of Little Atlin Lake and extends into the contiguous Whitehorse, Bennett, and Atlin map-areas where it is widely exposed. Two narrow bands and an isolated mass are exposed west of the southern part of Teslin Lake. In a third area, west of the northern part of Teslin Lake, a series of outcrops forms a broken band extending from a point about 13 miles northwest of Teslin for some 18 miles towards Squanga Lake.

Lithology

The unit consists essentially of limestone in three main and two minor separate localities, as set forth above. They differ somewhat lithologically and may not be stratigraphically equivalent. In the northeast section the age is not definitely established.

The main limestone mass of Mount White and the southwest corner of the map-area is almost uniformly white or light grey, massive, and fine grained, and rarely appears to be recrystallized. Towards the northeast limit of exposure it is locally dark grey, black, or banded, and has discernible bedding structures. The attitudes are erratic, however, and are considered of little value as indications of the major structure. Black limestone is exposed at latitude 60°23′, longitude 133°42′, and at latitude 60°21′, longitude 133°48′. Green slate and chert (unit 5?) adjoin the serpentine body southeast of the latter point and the exposed rocks northeast of it consist of interbedded limestone and chert, near the valley floor.

Some dark reddish to black cherty and argillaceous rock, intercalated in the limestone, outcrops in the creek canyon at latitude 60°02½′, longitude 133°57′, west of Lubbock River. This band, though intricately contorted, appears to dip rather gently southeastward. It demonstrates the unreliability of local attitudes as an indication of major structure, and suggests that the limestone is greatly thickened as a result of close folding. Some red and green mottled volcanic (?) rocks form a band 300 feet wide lying in or on the limestone at latitude 60°07′, longitude 134°00′.

In the southeast occurrence, west of Teslin Lake, a band of limestone up to 1,500 feet wide extends almost continuously for 3 miles northwest from the southern map-boundary. The band appears to dip at 45° to 60° southwest and may be 1,000

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feet or more thick. Two miles southwest, a smaller band of limestone is intermittently exposed. Both bands disappear northward under drift-covered lowland but one or both are probably represented by limestone outcropping in a shallow canyon at latitude 60°02′, longitude 132°47′, where several small masses are associated with minor schistose green conglomerate and abundant chert, in part flat lying. Similar limestone forms an isolated exposure 4½ miles farther northwest.

The limestone of the main band is in large part brecciated and sheared, partly reddish, with interbeds of rusty argillaceous schist and light bluish to black chert. The reddish limestone breccia contains tests of fusilinids. The limestone of the smaller band to the southwest is not so conspicuously brecciated but is mottled in greyish green to purple colours. One of the numerous round to oval-shaped purple patches was identified as a rugose coral. A sheared and schistose conglomerate appears to dip beneath the limestone. Argillite and argillaceous schist and fine quartzite, dark and light, partly banded chert, and some interbedded greywacke, without any apparently systematic sequence, border the limestone bands on both sides.

The limestone outcrops of the area may mark the surface trace of a gently plunging fold. If so, although it is not clear whether the fold is a syncline or an anticline, its axial plane must be overturned to the east.

In the northeast occurrence, west of the northern part of Teslin Lake, the limestone band (unit 5?) is about 2,000 feet across at latitude 60°20′, longitude 133°19′, where it appears to form part of a consistent homoclinal sequence. The dips in the limestone and banding rocks are 50°-55° southwest, and the band may there be about 1,600 feet thick. One and one half miles farther southeast the band is about 3,000 feet wide but may have been thickened somewhat by small-scale folding. The limestone in these sections is white to medium grey, distinctly banded in large part but generally massive, homogeneous, and clean. Though argillaceous beds in the adjoining rocks are somewhat schistose the limestone is not, and cleavage in the banded argillaceous quartzites is essentially parallel with the banding. The limestone is fine grained and only slightly recrystallized.

Farther northwest where the limestone band passes through the granite mass it is coarsely recrystallized, and disintegrates on weathering into a mass of loose subequidimensional angular fragments resembling coarse rock salt. Skarn, consisting of coarse garnet, diopside, and tremolite, is locally developed at the contact, notably at one point where the contact is slightly offset along a cross-fault. The northeast contact, in the same general locality, is with a succession of granitic and meta-quartzite bands. Apparently the pure quartzite bands, like the limestone, are highly resistant to assimilation.

In the vicinity of latitude 60°18′, longitude 133°13′, where the limestone veers to a northeasterly trend its attitudes are erratic and the structural relations are not clear. It is overlain and underlain at intervals along the length of the ridge by chert, argillite, and fine greenish tuff-like rock. Also associated with the limestone in several places towards the east end is a conglomerate or breccia consisting of large round cobbles of chert and cobbles and boulders of limestone in a greenish matrix consisting largely of small chert pebbles. Some boulders are of limestone breccia which itself contains fragments of white and grey banded limestone. As a whole the band seems to be flat-lying there and might conceivably represent downwarped parts of the lower surface of a band now mainly removed by erosion. However, the strikes of some apparently steep-dipping segments are rather consistently northeastward, and suggest dragging out of the band along the nearby mapped fault, which is marked by broad zones of shiny black fragmental gouge and numerous quartz veins.

What appears to be the same band is exposed at two points farther southeast. It was not observed to cross the intervening spur but may do so in a drift-floored gully. At the southeast extremity, near Teslin Lake, part of the limestone contains numerous fragments of large crinoid stems, but no fusilinids or other diagnostic fossils were found anywhere in this northeast limestone band. The rocks lying northeast of the limestone in this segment are largely greenish fragmental rocks of probably volcanic origin, unlike the thick assemblage of argillaceous and quartzitic rocks northeast of the northern segment.

The isolated limestone mass northeast of Squanga Lake, and that 5 miles southwest of the lake north of the highway are provisionally assigned to the unit to accord with the regional stratigraphic interpretation.

Age and Correlation

Fossils collected from the limestone of unit 5 have been reported upon by Peter Harker of the Geological Survey of Canada as follows:

(1) East of Little Atlin Lake near Atlin road
Crinoid stem
Fusilinids, poorly preserved and not identifiable, Permian.

(2) West of Teslin Lake, latitude 60°01½′, longitude 132°44′
From major limestone band
Fusilinids, possibly *Schwagerina acris* Thomson and Wheeler, too poorly preserved for accurate comparison.
Schwagerina acris occurs elsewhere, associated with the late Permian *Yabeina* fauna.
From minor limestone band
Single rugose coral, poorly preserved, similar to some collected by J. D. Aitken from Atlin Lake in rocks of similar lithological type. Permian?

From about the same locality as (1) above, M. L. Thompson (pers. comm. to J. D. Aitken) collected fossils along the Atlin road at 5.2, 5.5, and 5.8 miles respectively south of the junction, which he identified as *Triticites* sp., Upper Pennsylvanian or Lower Permian; *Yabeina* sp., Upper Permian; *Fusilina* sp. and *Fusilinella* sp., Middle Pennsylvanian.

This range of ages within so short a distance within the same continuous limestone mass seems remarkable, especially as most collections from the same mass in Bennett and Atlin map-areas were regarded as Guadalupian (Upper Permian).

Fossils collected from the Teslin Formation and the supposedly underlying Kedahda Formation in Tuya-Teslin map-area (Watson and Mathews, 1944, p. 17) carry fusilinids referred to the Permian.

The limestone of unit 5 is therefore Permian, in part Upper Permian, but may range down into the Pennsylvanian.

No diagnostic fossils were found in the limestone band west of the northern part of Teslin Lake. Its age may possibly be Upper Triassic.

Structure and Relationships

Except in the southeastern part of the outcrop area west of Teslin Lake—where definitely Permian limestone is interbedded with the typical unit 4 assemblage—it has not been found possible to work out the precise stratigraphic relationships of units 4 and 5 within the map-area.

A fault, marked by a quartz stockwork, separates unit 4 from the great limestone mass of Mount White on the northwest at the only place (latitude 60°22′, longitude 133°41′) where an exposed contact was observed. Throughout the area southeast of this fault, attitudes are erratic but rather commonly westward and, close to it, a northeasterly strike-trend seems to be significant.

This is in contrast with the area northeast of the subsidiary trench extending south-southeast from Squanga Lake, where the rocks strike generally northwest, parallel with the regional trend of fold-axes, and dip almost uniformly southwest. Taken together with the southeast dips across the valley to the west, these attitudes would appear to mark a southeasterly plunging syncline. This interpretation, with its implication that the main mass of unit 4 overlies the limestone of unit 5, is considered untenable in the light of regional stratigraphy. Consequently, as detailed below, these rocks are thought to be overturned but reliable top-determinations are lacking, and furthermore the age of the limestone is not definitely established.

The same general lithological assemblage extends southward into Atlin map-area (Aitken, 1960), where also it appears to be incontrovertibly part of the Permian sequence. There lavas and pyroclastic rocks are interbedded with chert, argillite, and limestone but none is known to extend within 10 miles of the mutual boundary, their place being taken by volcanic greywackes similar in description to the greywackes of unit 4 in Teslin area.

In the vicinity of Hall Lake, about 10 miles southeast of the boundary, limestone forms two broad bands and extends, as a major lithological unit, southeastward into the Tuya-Teslin area (Watson and Mathews, 1944) where, as the 'Teslin Formation', it is considered to overlie the Kedahda Formation. The latter consists of quartzite, chert, and argillite with some volcanic greenstone and minor limestone, and is correlative with unit 4 in Teslin map-area.

It is not clear whether the northward depletion of the major limestone unit in Teslin area is mainly a lithological or a structural phenomenon, but a lithological facies change is thought to be at least an important contributing factor.

The overall structure involving units 4 and 5 is interpreted as an anticlinorium, in part plunging under and in part faulted against Mesozoic rocks bounding them on the northwest. They represent for practical purposes, the northern limit of out-cropping Permian-Pennsylvanian rocks in the northwest Cordillera. However, the mainly volcanic rocks (unit 7) that separate the assemblage from Upper Triassic and younger rocks to the north may be partly of latest Permian age. Volcanism may have been continuous during the Permian-Upper Triassic interval. In the northwestern part of the outcrop area the great limestone mass of Mount White appears to represent the latest Permian sedimentary rock. Its physiographic relationships to the presumably younger volcanic rocks north of the Alaska Highway call for a fault, and such a fault would be co-extensive with a major fault postulated by Wheeler (1961) in Whitehorse map-area. However, the vertical separation on this hypothetical fault east of a point about 5 miles southwest of Squanga Lake appears to be negligible. This is about the point where the fault that delimits the main bulk of the limestone mass on the east would, projected north-northwestward, intersect with the fault along the Alaska Highway. Thus the main mass of Mount White may be an upthrust block contained within these two faults. Northeast of that point the limestone definitely extends down to the highway, and may underlie the drift-floored area centred around Squanga Lake.

Southeast of Squanga Lake the limestone band (unit 5?), although bounded on the east in part by a narrow band of well-graded sedimentary rocks (4d), is in the main bounded by greenstones (7) similar to those lying north of the highway farther west. If these relationships and identifications are correct, the limestone and associated sediments must be overturned and perhaps overthrust upon the volcanic rocks southwest of Teslin Lake. The marked irregularities and discontinuities in the limestone band might be the result of tear-faults associated with such a structure. Likewise the arcuate pattern of distribution of ultramafic bodies around the Permian assemblage may be due to localization as a result of such a fault system. However, a possibility remains that the volcanic-sedimentary assemblage east of the limestone is older, and is overlain, perhaps disconformably, by the limestone. This might explain the northeast outcrop-trend at latitude 60°18′, longitude 133°13′, and the conglomerate in the vicinity of the contact in that locality.

Unit 6

Unit 6 outcrops in a small group of hills at latitude 60°45′ on the east border of the map-area and a single exposure (possibly float) lies 5 miles northwest of this. Eastward the outcrop area is known to extend some 10 miles towards Wolf Lake.

Lithology

Within the map-area the unit comprises limestone, greywacke, and conglomerate, which are intruded by peridotite of unit 11 and by dark diorite comparable to unit 12. The limestone is mostly very dark; a part has numerous small rusty pits on the weathered surface that suggest pyrite crystals but none was seen on fractured surfaces. The limestone is mainly fine grained but is locally recrystallized. The rock classed as greywacke is a dark grey, fine-grained rock of quartzitic texture, and gritty weathered surface, but spotted with small white remnants of altered feldspar crystals. In thin section altered tabular plagioclase crystals and pale green uralitic hornblende are recognizable in a generally dark chloritic groundmass with scattered fine clastic quartz grains. The rock may be tuff or lava. It is apparently interbedded with limestone. The conglomerate consists chiefly of pebbles, mostly less than 2 inches in size but ranging to a foot or more, and generally fairly well rounded. They are mostly of chert, white vein quartz, quartzite, and weathered granite. Granitic pebbles are prominent. A section of one showed much cloudy sericitized plagioclase, with scarcer fresh potassic feldspar, much sutured quartz and scattered flakes of chlorite after biotite. A much larger body of conglomerate is exposed just east of the map-boundary. Other representatives of the group in Wolf Lake area include chert, andesitic breccia, tuff and minor lava, various greywackes, quartzite, and argillite.

Structure, Relationships and Age

The rocks are folded and intruded by peridotite-serpentine and dioritic rocks but are much less severely deformed than nearby rocks of unit 3A in contrast with which they are virtually unaltered. They were not seen in contact with unit 3A but undoubtedly overlie it unconformably.

Fossils found in the conglomerate in Wolf Lake area (Wheeler, pers. comm., 1959) have been tentatively dated as Permian. There was some doubt whether they were in the fragments or the matrix. The age is, therefore, Permian or Mesozoic, but probably Permian.

Unit 7

This unit comprises various volcanic and minor associated sedimentary rocks, chiefly of Triassic and probably Permian age but including rocks that may be equivalent to several other units of widely different ages.

Distribution

The type area of unit 7 is north of the Alaska Highway from the west boundary to the ridge east of Squanga Lake. Two small areas of this unit were mapped south of the highway. A broad band extends along the west side of Teslin River and Teslin Lake for some 40 miles. Rocks in an area northeast of Teslin Lake near Teslin village are now assigned to this unit, and an area west of the lower part of Nisutlin River is included, with reservations, on the basis of lithological similarity.

Lithology

Unit 7 comprises various lavas and fragmental volcanic rocks, with some interbedded argillite, siltstones, locally much chert, and a few minor bands of limestone. Minor differences in lithology are apparent in the several outcrop areas (*see* under *Distribution*), which are accordingly described separately.

(1) *North of Alaska Highway*

In the type area, from the west boundary to the ridge east of Squanga Lake, most of the rocks are greenstones and dark grey to green, fine-grained, massive rocks of dubious origin. Some of the greenstones show vague ropy or fragmental structures on brownish weathered surfaces. A few are finely porphyritic, with white altered plagioclase crystals up to 3 mm long in a fine-felted to aphanitic bright green groundmass. One thin section contained plagioclase fresh enough for identification, which proved to be An_{15}. Some of the rocks are amygdaloidal. A section of one of these showed shapeless to lenticular masses of alteration products and carbonate. The dark groundmass contained abundant small ferromagnesian grains that suggest augite but might be zoisite-epidote minerals. A rather distinctive type occurs on the flanks of the Ridge 5534 north of Mount White, also in both prongs of the ridge northeast of Squanga Lake. This has distinct spherulites with more or less definite radial structure in the low-birefringent fillings, scattered through a partly fluidal mass of alteration products.

Some fresh-looking, grey and black, fine porphyries occur near the western boundary of the map-area at about latitude 60°30′. One thin section showed partly resorbed quartz and altered plagioclase phenocrysts, with small spherulitic bodies in a groundmass network of fine dark alteration products. Another contained numerous amygdules with multiple border zones, large feldspar phenocrysts (probably albite) and fine needles of altered hornblende (?) in a groundmass of alteration products with a distinct fluidal arrangement. The rocks on the Atlin highway 2 miles south of Jakes Corner, also across Little Atkin Lake from that point, are green volcanic-fragmental rocks identical with those described in preceding paragraph, as are also some in the small area south of Squanga Lake mapped as unit 7(?).

Chert—some thick bedded and some fine banded—and chert-pebble conglomerate in thin beds are scattered rather abundantly through the section north of the Alaska Highway for at least 5 or 6 miles from the west boundary. Some few hundred feet of argillite and siltstones also occur at intervals, interbedded with the lavas and abundant fine-grained, dark, nondescript rocks thought to be of pyroclastic origin.

Chert, interbedded with meta-volcanic rocks, was noted near the west boundary of the map-area at about latitude 60°30′ and about 3 miles north of that point. It is present in abundance in the ridge north of the west end of Squanga Lake and occurs in many other localities, including the ridges south of Hayes Peak.

The rocks (unit 7?) at latitude 60°25′, longitude 133°49′, east of the large serpentine plug were described as mainly quartzites and argillite. Specimens are brecciated beyond recognition but the limestone is unmistakable. The curving trend of photographic lineaments suggests that the limestone (5?) just north of the highway farther east may be part of the same band. On the other hand these rocks may be related to those of unit 8.

A thin lens of limestone also occurs, interbedded with greenstone and chert, in the slope southwest of Squanga Lake. The curving trend of lineaments that involves all these rocks appears to wrap around the south end of the large serpentine body west of Squanga Lake.

Practically all the volcanic rocks are much altered; over wide areas they are partly recrystallized, dioritized, or serpentinized and contain numerous small to large diorite and peridotite, pyroxenite, and serpentine bodies.

The rocks that make up Streak Mountain appear somewhat different. Although those at the southwest limit of exposure (like those at the end of the ridge farther southwest) are argillaceous siltstones or quartzites, the main mass consists of dark massive flows with a few ledge-forming, light-banded tuffs, green and black slates, and chert beds. The lowest lavas in the southwest flank are dense black rocks that show flow-structures on weathered surfaces and lenticular amygdules up to a foot long in roughly parallel orientation. Dense, dark, massive beds and occasional greenish agglomeratic interbeds extend up to a broad ledge that seems to mark a tuffaceous horizon.

Dense but rather crystalline-looking massive flows with few tuffaceous and cherty interbeds make up the upper part of the mountain. All the rocks sectioned are considerably altered and nearly all contain abundant actinolitic amphibole, some in radiating rosettes. At least one showed relict pyroxene cores in uralitic amphibole. The topmost rocks, diabasic in appearance, contain relatively fresh plagioclase (An_{40}) laths and uralitized pyroxene crystals in an ophitic fabric. Probably most of these lavas are of originally basaltic composition.

(2) *West of Teslin Lake and Teslin River*

On the upper parts of the ridges directly south of Hayes Peak the rocks are greenstones, nondescript altered rocks, and chert, like those of the type area north of the Alaska Highway.

On the northeast flank of Hayes Peak, andesitic greenstone, agglomerate, and breccia, with minor associated sedimentary beds, make up an apparently homoclinal section that may be 5,000 feet thick. Much of the lava is massive and aphanitic but much is porphyritic, with altered phenocrysts of feldspar, hornblende and perhaps augite, up to ¼ inch long. Breccia and agglomerate are fairly abundant, and most of the intercalated fine clastic rocks are probably tuffaceous. The breccias contain angular volcanic fragments that weather somewhat lighter than the matrix. Similar rocks are fairly well exposed north of Little Teslin Lake (where they are slightly schistose), and west of the mouth of Squanga Creek. About latitude 60°35′ there are some intercalated white, rhyolite-like bodies that may be aplites related to a small dioritic intrusion. Farther northwest, about latitude 60°37′, some of the greenstone is described as red and mottled red and green andesite, somewhat foliated and sheared. The rocks at the north end of the outcrop area are also in part mottled and much sheared, and seem to be involved in a zone of dislocation and dioritic intrusion.

Southeastward along the southwest side of Teslin Lake the thick sequence of andesitic greenstones at Hayes Peak gives way to a mixture of pyroclastic and sedimentary rocks with few good flows. Thin beds of limestone, intercalated with argillite and probably tuff, appear at latitude 60°20′ and latitude 60°10′. Chert and chert-conglomerate make up part of the shoreline and offshore islands just northwest of the latter point. Southeast of it, chert and argillite are intercalated with green, fine tuff beds and some few doubtful flows. These rocks are not certainly distinguishable from some farther southeast that are included in unit 4.

(3) *Northeast of Teslin Lake*

On the point south of Teslin and southeastward along the shore, sheared and altered, light weathering green massive volcanic rocks are well exposed. They are speckled with the greenish black remains of numerous altered mafic phenocrysts and show the outlines of numerous rounded pebbles and boulders of similar porphyry up to 2 feet in diameter. Thin sections show that they consist chiefly of secondary carbonate, chlorite, and albite. Some biotitic argillaceous quartzites and argillites are intercalated with tuff-like rocks farther east near the highway. Three miles east on Nisutlin Bay, recrystallized limestone is interbedded with banded amphibolite of apparent volcanic origin, and near the granite contact amphibolitic or biotitic greenschist contains large lenses or fragments of limestone.

The metamorphism of these rocks seems to increase towards the granite contact. The mafic porphyries most nearly resemble the augite porphyries of unit 10 but the presence of limestone suggests kinship to unit 7. The few exposed rocks northeast of Teslin are likewise nondescript sheared greenstones.

The rocks west of the lower part of Nisutlin River are massive andesitic greenstones, breccias, and agglomerates with some fine, greenish tuffs, a little chert, argillite, and limestone. Although these rocks are, in composition, not unlike many of those in unit 1, in which the area is nearly enclosed, their relatively unmetamorphosed condition and general similarity to unit 7 make it advisable to group them with the latter unit.

Internal and External Structure

The structural relationships of these rocks to each other and to those of other units are uncertain. For the most part they strike northwesterly reflecting the regional trend of folding. An exception is the western part of the area north of the Alaska Highway, where the strike is north of east, parallel with that of unit 8 rocks to the north. There the strikes suggest conformity with unit 8. In the small area south of Judas Creek mapped as unit 7 the dips and absence of conglomerate also suggest conformity, although these dips seem to be anomalous to the overall structural relationships. However, local attitudes throughout are probably due in greater measure to faulting than to folding.

The contact with unit 5 south of the highway is probably a major fault.

Southwest of Teslin Lake the dips appear to be generally southwestward though attitudes are highly erratic in places. If the identity and sequence of the units are as assumed the rocks must be overturned, in whole or in part, depending on the extent to which they are folded.

West of Teslin River the volcanic rocks of the unit are assumed to represent an anticlinal core. The non-appearance of a typical Lewes River Group (*see* under *Unit 8*) sequence suggests that the relationship of unit 9 to unit 7 may be one of unconformity. Thin conglomerate bands mark the contact north of Squanga Creek, the only place where the contact is reasonably well exposed, but the transition from volcanic to dominantly sedimentary rocks seems to be gradual and no angular discordance can be detected. It may be significant that maroon and mottled andesites, perhaps comparable to those described near the north end of this outcrop area, are locally prominent at the northeast margin of unit 9, in what is thought to be possibly the basal part of that unit.

Age and Correlation

The rocks of unit 7 may not all be of the same age. In the western part of the map-area near the Alaska Highway the typical assemblage lies between late Permian limestone of unit 5 and Upper Triassic limestone of unit 8. The rocks may correspond to volcanic rocks "low in the (Upper Triassic) Lewes River Group beneath the thick section of clastic sedimentary rocks" in Michie Creek and M'Clintock valleys, a short distance west of the boundary meridian in Whitehorse map-area (Wheeler, 1961).

A little greenstone, chert and argillite (*see* under *Unit 5*), perhaps erosion remnants, were found on the major limestone near the serpentine body east of Mount White, and west of Lubbock River. Rocks of similar description wrap around the outcrop area of the same limestone unit in the adjoining part of Whitehorse map-area (Wheeler, 1961), Bennett map-area (Christie, 1957), and Atlin map-area (Aitken, 1960). In Bennett map-area they occupy the area between the Permian limestone and the Lower Jurassic Laberge Group, which they underlie with structural conformity, and the lower part of the assemblage contains fossils of late Palæozoic age. Greenstone and chert of unknown thickness overlie the latest Permian fossiliferous beds in Atlin map-area and are considered to be part of the Permian succession. On these grounds, unit 7 is believed to be mainly latest Permian to Upper Triassic in age. Part of the unit along Teslin Lake may, however, be older than the Permian-Pennsylvanian (?) sequence represented by units 4, 5.

The rocks forming Streak Mountain are in fault contact with unit 9 to the north and may be isolated by faults. The major structure is not clear, but the rocks are rather distinctive and may be of a different age.

The age of the rocks northeast of Teslin Lake referred to unit 7 is highly uncertain. Those north of Nisutlin Bay may be relatively unmetamorphosed facies of unit 1 pre-Permian rocks.

Lewes River Group (Unit 8)

This group is restricted to an area near the west boundary of the map-area about latitude 60°25′.

Lithology

The unit consists of one or possibly more beds of massive white limestone and associated black argillite, argillaceous sandstone, and a little chert. This well-bedded and well-graded sequence without lavas or coarse clastic rocks contrasts sharply with the greenstones and nondescript rocks that occupy the rest of that part of the area.

Internal and External Structure

The massive limestone bed at latitude 60°24′, longitude 133°56′ may be as much as 500 feet thick and the underlying black argillite probably 100 feet or more. The relationship to these of the sandy argillite and argillaceous quartzite in the ridge north of Judas Creek and in the low hill southwest of the first-mentioned point is uncertain. The rocks are cut by a network of faults, and the structure can only be guessed at in broad outline.

The outstanding structural feature of the unit is the northeastward strike of the rocks, which is in contrast with the main regional northwest trend of formations in both Teslin and Whitehorse areas. The main limestone band is definitely traceable, curving from a southwesterly to a westerly trend. Just beyond the boundary meridian it disappears, but a similar limestone band appears on the north side of Judas Creek which repeats the southwest to westerly curving trend. Traced the other way, the band extends northeast to the end of the ridge, whence its continuation may be represented by a prominent band at the east end of the ridge north of Judas Creek.

In the preliminary map a parallel band of limestone was shown extending southwest from the end of the ridge north of Judas Creek to a small mass of limestone found at the southwest terminus of the band as mapped. However, the existence of this band is considered unlikely, as it would probably be visible from the ridge south of Judas Creek.

The east-northeasterly curving strike of the rocks and the distribution of limestone suggest some sort of plunging fold structure. The presence of Laberge conglomerate above a southwest-dipping sequence of Triassic (Lewes River) rocks 2 miles west of Mount Michie (latitude 60°30′, longitude 134°06′) in Whitehorse area (Wheeler, 1961) points to a synclinal structure. This is compatible with the assumed sequence of units in Teslin map-area, but appears to conflict with observed attitudes in the rocks south of Judas Creek. Other problems also remain unresolved and no simple structural solution of the relationships of the units can be offered.

Age and Correlation

No fossils were found in unit 8 in Teslin map-area, but fossils collected from what is undoubtedly the same limestone band nearby in Whitehorse map-area (Wheeler, pers. comm.) have been identified by E. T. Tozer, Geological Survey of Canada as *Spondylospira lewesensis*. The age is thus late Norian, and the unit corresponds to an upper part of the Lewes River Group.

Unit 9

Rocks of unit 9 are confined to the northwestern part of the area, on both sides of Teslin River and extend as far south as Squanga Creek and the Canol road.

Lithology

The unit consists of argillite, argillaceous and quartzitic siltstones and sandstones, greywacke, conglomerate, a little limestone, mostly black, and some associated volcanic rocks. The argillites are mostly dark grey to black. Some beds near the northwest boundary are distinctly limy and grade into fine black limestone. The siltstones and sandstones vary from dark grey or black to light grey, buff, or reddish colours. Most are well bedded and many are finely banded.

Some fine argillaceous varieties are fissile but secondary cleavage at an angle to the bedding is nowhere well developed. Greywacke, interbedded with the argillite and siltstones in massive beds several feet thick, is most abundant and massive where closely associated with conglomerate and volcanic rocks, and grades into conglomerate along and across the strike. The colours are notably variable—light to dark grey, buff, brown, green, and black. As in unit 4, soft black argillite flakes and irregular, more equidimensional chert fragments or accumulations are characteristic, but large irregular argillite masses are less in evidence. The abundance of fragmental chert in this unit is notable because of the virtual absence of bedded or banded chert. Many greywackes contain a substantial amount of volcanic material; some closely resemble associated flows and may be partly pyroclastic in origin. Their composition is closely akin to that of the conglomerates, into which they grade.

Limestone (9b), in lenticular beds locally 50 feet or more thick, is a minor constituent of unit 9. Most is very dark but some bands are streaked and veined by light grey or white recrystallized calcite. In some places, especially near the northwest boundary, the limestone is very fine grained and grades into black argillite. Elsewhere it has a coarser, granular texture (partly masked by recrystallization) and evidently is a calcarenite consisting of detrital grains (Pl. VIII B). This type is closely associated with conglomerate, which characteristically contains pebbles of black limestone, indeed in places black limestone grades into conglomerate along the strike.

Conglomerate forms lenticular bands, up to an estimated 70 feet thick, interbedded with greywacke, sandstone, and finer clastic material, and occasionally associated with black limestone in persistent zones (9a) as much as 2,100 feet in breadth southwest of Teslin River and near the western boundary of the map-area.

These conglomerates are characterized by pebbles, cobbles, and boulders of black and grey limestone as well as chert, greenstone, greywacke, locally rather abundant granitoid rocks, and some referred to as quartzite. In a number of places black limestone forms blocks and irregular masses 20 feet or more across. In several instances it was noted that these contained rounded cobbles of grey limestone, chert, and other foreign material. The inference is that these represent accumulations of detrital limestone, compacted mainly by recrystallization.

In other zones, notably those near the eastern border of the outcrop area north and south of 100 Mile Creek, conglomerate is associated with abundant volcanic rocks. There some bands have the character and appearance of agglomerate or flow breccia, though limestone and chert pebbles and cobbles are still prominent constituents. Coarse fragmental rocks, described as flow breccias, also occur in the hill just west of the mouth of 100 Mile Creek.

Conglomerate with sandy interbeds makes up bands estimated to be several hundred feet thick in the mountain southeast of Streak Mountain. Cobbles up to 8 inches across comprise chert, greenstone, occasional fine-banded argillite, and coarse greywackes containing argillite fragments. Rounded pits prominent on weathered surfaces are probably the moulds of limestone pebbles. At the eastern limit of this area thin conglomerate beds contain pebbles up to 2 inches or so across, including chert, argillite, grey limestone, and granitic rocks.

Volcanic rocks (9c) included in the unit comprise a few definite lavas and some hundreds of feet of fragmental rocks of dubious origin. East of the granite plug southwest of 100 Mile Creek (latitude 60°41′, longitude 133°48′) the lavas are dense greenstones, locally vesicular or amygdaloidal and rarely containing altered phenocrysts of feldspar and pyribole. These lie structurally above a west-dipping thick sequence of massive greywacke.

Another intermittently exposed and perhaps discontinuous band extends along the northeast margin of the area occupied by the unit. Few of the rocks sectioned are completely lacking in fragmental structures, but in some, flow-structures are fairly definite. Most contain fresh augite and relatively altered plagioclase feldspar, and vary from green to red or black. Those near the northwest boundary include some black rocks with fresh augite, fairly fresh plagioclase, and calcite-filled amygdules, which appear to be basalts. Those in the vicinity of 100 Mile Creek (latitude 60°46′, longitude 133°36′) and northwest of Cone Mountain (latitude 60°42′, longitude 133°29′) are mostly green but commonly mottled in reddish colours, with abundant aphanitic red cherty (?) fragments. They also contain augite, relatively altered plagioclase, and calcite-filled rounded areas that may be amygdules. Similar rounded calcite masses that are abundant in interbedded entirely fragmental rocks are, however, interpreted as grains of detrital limestone.

The greywacke of unit 9 appears to be essentially a finer phase of the conglomerate into which it grades. Of thirty-eight thin sections that represent the unit, six are of single pebbles from conglomerate, six are more or less definite lavas, and the remainder are greywacke, fine conglomerate, and possibly volcanic fragmental rocks, all composed largely of rounded grains of considerable variety. Of the fine fragmental rocks only two were estimated to contain more than 10 per cent quartz, in subrounded to subangular detrital grains. Most contain less than 5 per cent and a number of sections showed none. Plagioclase feldspar, in fairly fresh subhedral to subrounded grains is present in most sections; it makes up to 30 per cent of some arkosic varieties, and is the dominant constituent in a few. The feldspar-rich sections as a rule contain only a minor amount of quartz. Augite is the commonest ferromagnesian mineral. Subangular fresh detached grains amount to probably 10 per cent of some sections (Pl. VII B), especially among the clastic volcanic looking rocks along the eastern margin. Clastic augite is also prominent in the greywacke and conglomerate southeast of Streak Mountain. Augite porphyry is also common as detrital grains. A good sized cobble was found in conglomerate southeast of Mary Lake (latitude 60°37½′, longitude 133°56′). Hornblende is not abundant except in a few hornblende-granodiorite pebbles, and in one arkosic greywacke southeast of Mary Lake. Epidote, in altered lithic fragments and probably detrital grains, is fairly abundant in some sections. Lithic fragments make up a large proportion of most sections; most are subrounded and appear to be detrital in origin. Volcanic rocks are well represented and include feldspar, augite, and augite-feldspar porphyries, amygdaloidal and fine variolitic rocks, and fine microlitic to aphanitic lavas. Some of the lava fragments, especially the augite porphyries, appear quite fresh; others are extensively altered, and many are not positively identifiable. Feldspar in the porphyries is more altered than is augite. Nonvolcanic lithic fragments include argillites, chert, and fine quartzitic siltstones, locally abundant carbonate, occasional well-recrystallized quartzite and quartzitic gneisses, some few granitoid rocks, and others that may be arkose. The argillite fragments are generally tabular rather than rounded. One was seen to contain limy layers and one was definitely schistose. The carbonate is partly in rounded sand-sized detrital grains. The quartzite and gneiss fragments are classified as such by reason of the highly sutured appearance of the component quartz grains (Pl. VIII A) and are evidently derived from an older metamorphic terrain.

Some granitoid roundstones and fragments are seen in thin section to consist of subhedral to euhedral, partly cloudy and partly resorbed, plagioclase crystals closely spaced in a comparatively fine-grained network consisting chiefly of quartz. In one section the quartz is medium grained and rather extensively sutured. These rocks may possibly be arkoses. Definitely granitic roundstones and fragments include hornblende granodiorite or quartz diorite and rare biotite granite. Granitoid boulders up to 15 inches across were noted at one place but are generally much smaller and nowhere make up more than a small percentage of the conglomerate.

Greywackes of Units 4, 9, and 10 Compared

The greywackes of units 4, 9, 10 are indistinguishable in hand specimens, all consisting of more or less rounded, sand-sized or coarser fragments of considerable variety with scattered argillite flakes and cherty accumulations. Some statistical differences are, however, apparent from the microscopic study of thin sections, as follows:

	Unit 4	Unit 9	Unit 10
Number of thin sections	36	20	5
Quartz			
found in	all	7	2
maximum percentage	35	10–15	1
average percentage	15	5	—
Feldspar	rarely abundant or fresh	commonly abundant and fresh	recognizably abundant in two
Augite	present in a few	abundant in many	abundant
Hornblende	abundant in many	appreciable in only one	negligible
Volcanic detritus	less prominent, chiefly hornblende and hornblende-feldspar (?) porphyry	more prominent, chiefly augite-feldspar and feldspar porphyry	major constituent, augite and augite-feldspar porphyry
Quartzite and gneiss	relatively common	relatively fewer (?)	none recognized
Detrital limestone and carbonate	relatively scarce	relatively common	none recognized

The study fails to establish distinct differences in source or depositional environment but some conclusions seem justified:

1. The greywackes are all essentially intraformational. Very little material was derived from hypothetical highlands of metamorphic rocks to the east.

2. In the supposedly Permian greywackes (unit 4), relatively little material was of pyroclastic or contemporaneous volcanic origin. Contemporaneous volcanism supplied much of the material in the Triassic-Jurassic greywackes of unit 9 and a major part in those of unit 10.

3. The augite and augite porphyry fragments of unit 9 may be derived from contemporaneous extrusions in unit 10, which is, therefore, probably not younger.

4. The abundant detrital carbonate in unit 9 is derived from, or contemporaneous with the late Triassic Lewes River limestone.

Metamorphism

The rocks of the unit show no signs of regional or local, severe dynamic metamorphism. No strong metamorphic effects were noted at contacts with granitic intrusive bodies. Some limestone is extensively altered near the ultramafic rocks. Some of these (*see* under *Unit 11*) are thought to be serpentinized limestone, and some to be assimilated fragmental rocks.

Internal Structure

The internal stratigraphy of unit 9 is not known with any degree of certainty. Structures, as revealed by aerial photographs, are complex. The strata are broken into blocks by numerous transverse, oblique, and strike faults of unknown magnitude. Strikes, although generally northwesterly, vary by as much as 90 degrees from this direction in some blocks. Dips are generally steep and variable, and apparently consistent moderate dips measured over considerable areas are commonly incompatible with the major structures as seen in the photographs. For this reason most measured attitudes have been omitted from the map.

No members of the unit are sufficiently persistent or consistent in lithology to serve as horizon markers. The black limestone and limestone-rich conglomerate zones may represent a single horizon, repeated by folding or strike faulting, but if so the lithology is variable across the strike. It is thought that the lavas and volcanic conglomerate (apparently devoid of limestone roundstones) along the eastern margin that are succeeded up the slope by massive limestone at latitude 60°48′, longitude 133°38′, may represent an older horizon. However, no comparable sequence is found north of lower Squanga Creek (latitude 60°31½′, longitude 133°30′) where conglomerate is assumed to overlie the greenstones assigned to unit 7.

Again, the volcanic rocks west of Teslin River at latitude 60°41′, longitude 133°48′, appear, by reason of their unique character and superpositional relationship to massive greywackes, to represent a younger horizon than the other exposed strata. However, they are not unlike common rocks of unit 7 and may represent a core of these rocks, faulted up to their present position.

External Structure

The problem of the relationship of unit 9 to unit 7 has been touched upon in the preceding section. This involves the further problem of the disappearance of unit 8 west of Squanga Lake. If the general sequence of units is correct, then either:

1. Part of unit 9 must be equivalent to unit 8, although different lithologically, or
2. A major unconformity must exist between units 7 and 9.

The matter is complicated by the probable southeastward gradation of the Lewes River Group of Whitehorse area (to part of which unit 8 is considered to be equivalent) into volcanic rocks. Some possibilities are discussed under *Age and Correlation*.

The contact of unit 9 with unit 7 northeast of Squanga Lake is probably a longitudinal or oblique fault. A transverse fault, at about the place where Lees delimited a contact on the north slope of Streak Mountain, is clearly apparent in the aerial photographs.

The contact with unit 1 along the northeast margin follows a drift-filled, major subsidiary trench, except as hereafter noted. Northwest of Cone Mountain, at latitude 60°42′, longitude 133°29′, volcanic fragmental rocks of unit 9 cross to the east side of the through-going trench but the actual contact with unit 1 is covered. The exposed rock lying beween these volcanic rocks and the crystalline limestone of unit 1 is a coarse conglomerate that may be the base of unit 9. However, the deformed and altered nature of the nearest exposed rocks on both sides and the presence of abundant iron rust in the soil and groundwater strongly suggest a fault contact.

Southeast of Cone Mountain no clear-cut, well-exposed contact with unit A was found. At latitude 60°36′, longitude 133°20′, black argillites east of the mapped (but not definitely established) fault are not unlike nearby rocks of unit 9, but are also similar to argillites of unit 1 at latitude 60°37′, longitude 133°15′, just northeast of the narrow tongue of unit A. These argillites grade imperceptibly into unit A rocks as if through a metamorphic aureole. At neither of these last-described places is there any sign of either an unconformity or a major fault.

Age and Correlation

Indeterminate fossil remains, including ammonite fragments, occur in limestone masses forming part of the conglomerate of unit 9. Similar conglomerate along the northwest extension of the belt in Whitehorse map-area (Wheeler, pers. comm.) appears to lie not far above uppermost Triassic beds of the Lewes

River Group. The conglomerate is there taken to mark the base of the Lower Jurassic Laberge Group. In that part of Whitehorse map-area the Lewes River is said to be "impossible to differentiate from Laberge on the map." The limestone lenses and limestone-rich conglomerate of unit 9 are probably derived largely from, and may be partly contemporaneous with, Upper Triassic limestone of the Lewes River Group, and of unit 8.

Unit 9 as a whole probably includes rocks of both the Upper Triassic Lewes River and the Lower Jurassic Laberge Groups.

The conglomeratic members of unit 9 closely resemble the Nazcha Formation of Tuya-Teslin map-area (Watson and Mathews, 1944, p. 17). The nearest exposures of that formation are about 70 miles southeast of Teslin map-area. The Nazcha consists largely of conglomerate in which pebbles of limestone and augite porphyry are prominent and contains a little limestone. It overlies Permian strata unconformably and contains fossils comparable to those of an Upper Triassic horizon, and is equivalent to part of the McLeod Group (Kerr, 1925, p. 90A) of Dease Lake area.

Unit 10

Unit 10 is an assemblage of fairly fresh volcanic augite porphyries and pyroclastic and interbedded sedimentary rocks that occupy a strip from the outlet of Teslin Lake northeast to near Nisutlin Bay. These rocks are moderately deformed, intruded by peridotite, and altered near the granite of Big Salmon Range. They are of unknown but probably Mesozoic age. The abundance and coarsely porphyritic nature of the augite porphyries are the outstanding features that serve to distinguish unit 10 from units 4 and 9, both of which it resembles in many respects.

Lithology

Unit 10 consists of intermediate to basic green lavas characterized by large, well-formed augite, and occasional hornblende and feldspar phenocrysts, and interbedded with fine to coarse pyroclastic rocks, greywacke, sandstone, argillite and minor chert. Some of the porphyries are intrusions contemporaneous with the lavas. Porphyritic lavas and associated minor intrusions are most abundant in areas mapped as (10a). Towards the eastern boundary of the strip the rocks (10b) are apparently chiefly volcanic but are considerably sheared and altered, and are less distinctive. The sedimentary rocks are interbedded with the volcanic members but also form bands (10c), possibly 1,000 feet or more thick in places, in which flows are relatively scarce.

The typical augite porphyry is a light green to brownish weathering rock having conspicuous well-formed black augite crystals commonly a quarter to half an inch long and exceptionally much larger. The freshly fractured surface is light greyish to dark green to black. Feldspar, in stubby and lath-shaped crystals, is visible in only a few flows. In or associated with these are occasional long hornblende prisms. Some of these flows are amygdaloidal. The augite is generally fresh, typical and easily recognizable in thin section. Some is partly to entirely pseudomorphed by uralitic hornblende or, rarely, converted to chlorite. Most of the feldspar is much altered. The few phenocrysts fresh enough for identification proved to be oligoclase-andesine, about An_{30}.

The groundmass is a greenish mixture of fine crystals, fragments, and alteration products, including much chlorite, some carbonate, and probably epidote group minerals.

One thin section of amygdaloidal feldspar-augite porphyry showed the amygdule filling to be mostly feldspar with some chlorite. Another thin section showed feldspar and hornblende laths intergrown with augite in an ophitic arrangement. It is not otherwise distinguishable from the lavas and is probably an intrusive facies. Many thin augite porphyry bodies intercalated with sedimentary rocks are probably sills; some cut across the bedding and are certainly dykes.

Many of the rocks are definitely fragmental, composed of broken augite and feldspar crystals, and fine porphyry fragments. These range from fine-banded tuffs to coarse flow breccias, and agglomerates or volcanic conglomerates in which fragments of nonvolcanic rocks are prominent as subrounded pebbles and cobbles. Many of the sandy textured rocks contain an abundance of fairly well rounded fragments and some contain a few grains of detrital quartz. These are evidently water-lain and intergrade with the greywackes, as the agglomerates do with conglomerate.

The sedimentary members comprise argillite and argillaceous siltstones, sandstones, greywacke, conglomerate, and chert. Some sections hundreds of feet thick are composed chiefly of grey to black shaly argillite, with interbeds of fine varicoloured hard siltstone, cherty argillite, and clean sandstone. Dirty sandstones or greywackes are characterized by tabular fragments of dark, soft argillite and shapeless masses of hard, dark and light chert. Many are green and few of the rocks sectioned contain more than a scattering of detrital quartz, but these are probably not typical sedimentary greywackes which in the field are indistinguishable from those of either unit 4 or 9. The specimens examined in thin sections consisted chiefly of fresh augite, and altered feldspar and porphyry fragments, with locally a few quartz grains and other nonvolcanic materials. Much of the material is fairly well rounded and evidently water-lain but most is evidently of contemporaneous volcanic origin. A comparison of the greywackes of units 4, 9 and 10 is given under *Unit 9*. On the spur north of Deadmans Creek, sandstones or greywacke grading into fine conglomerate are interbedded with argillite and sandy argillite. Some beds are finely banded (about 0.1 inch), others 2 feet thick. Some beds have numerous roughly aligned cavities whose peculiar shapes suggest large pelecypods. Similar cavities were seen in argillaceous sandstone at the lake shore near mile 816 but the cavities were considered of doubtfully organic origin.

Conglomerate or agglomerate occurs in numerous scattered lenses among sandstone and greywacke as well as among the volcanic members. Volcanic porphyries are the most common fragments but white, black, and banded fragments are

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locally prominent. On the lower ridges 3½ miles southeast of Brooks Brook some agglomerate-conglomerate contains numerous baked sedimentary pebbles and a large fragment of what appears to be a semi-digested granite gneiss among a variety of porphyries and aphanites. Black pyroxene crystals more than an inch in cross-section are embedded in porphyry that is apparently matrix material. No limestone pebbles like those that characterize conglomerate of unit 9 were seen in the coarse fragmental rocks of unit 10.

Chert is not a major component of unit 10 but is interbedded here and there with argillite and banded sedimentary rocks and makes up one large bluff about a mile east of mile 819. Some chert is in beds a foot or more thick but most is typical ribbon chert in bands about 2 inches thick with brown weathering, thin, slaty argillite partings. The chert is mostly white weathering or pink stained and varies from light grey or green to black on fresh surfaces.

Internal and External Structure

The rocks of unit 10 for the most part dip moderately northeast, but occasional reverse dips show that they have been thrown into open folds. None, except those near the granite at Nisutlin Bay, is highly schistose but some along the east margin are more sheared and altered than the rest. The unit is in contact with only one other bedded unit (1) and that is exposed only in the area east of mile 833. There the main contact passes through a drift-floored canyon but rocks typical of unit 10 appear in a fault-slice east of it. A network of faults marks the contact area and these are probably subsidiary to a main fault passing through the canyon. No direct evidence of unconformity has been found at the contact.

Unit 10 surrounds a lens of peridotite as though intruded by it. It was not seen in contact with granite but is undoubtedly older.

Age and Correlation

No fossils have been found in unit 10, and its age is not definitely known. Augite-porphyry lavas are prominent among the rocks of the Shonektaw Formation of Tuya-Teslin map-area (Watson and Mathews, 1944, pp. 18-20), which is believed to overlie the Upper Triassic or younger Nazcha Formation. The latter in turn bears considerable resemblance to unit 9. On the basis of this analogy, unit 10 would be somewhat younger than unit 9. However, because of the prominence of augite and augite porphyry in the fragmental rocks of unit 9, it is thought that these materials were derived from unit 10 itself or from the same source as the lavas of unit 10. On this basis unit 10 is believed to be contemporaneous with or partly older than unit 9.

Ultramafic Intrusions (Unit 11)

The ultramafic rocks of unit 11 occur mainly in the west-central part of the map-area, where they form several large and small stock-like or lenticular bodies and many small irregular masses and stringers that are too small to show on the map. Most of these intrusions are spatially related to the volcanic rocks of unit 7. Two bodies lie farther to the northwest in an area of unit 9 and one east of Teslin Lake in the outcrop area of unit 10. One large stock outcrops in the northeastern part of the map-area; another small body lies near the east boundary at latitude 60°45′. A small body north of Sidney Creek was mentioned by Lees (not mapped).

General Description and Lithology

The larger masses form prominent hills, broadly rounded but locally rough surfaced due to shattering and heaving of joint blocks by frost action. They are generally light brown, occasionally weathering locally to almost white, and are practically bare of vegetation.

This unit consists entirely of ultramafic rocks: peridotite, pyroxenite, and serpentine. Although variations and gradations occur within bodies, the types are not interbanded with any regularity. Parts of all bodies, and possibly all of some, consist of serpentine, but the typical rocks of the Hayes Peak area, also the northwesternmost body, that east of Teslin Lake, and those of the northeastern part of the map-area are remarkably fresh.

As typically exposed in Hayes Peak west of Teslin Lake, the fresh peridotite is a medium-grained, brown weathering, rather soft green to black mottled rock. It commonly shows conspicuous silvery flashing cleavage faces of distorted pyroxene crystals that in places stand out in relief in the rough weathered surface. The rock is medium grained, equigranular, and ranges in composition from peridotite to dunite. It consists chiefly of olivine, enstatite, variable amounts of secondary minerals, chiefly antigorite and probably talc, and rare veins of chrysotile asbestos.

The olivine is in subequidimensional grains up to about 6 mm across. Cleavage is distinct in many grains. Strain-shadows, undulatory extinction and twin-banding are conspicuous, but the grains are not sheared, or very much shattered (Pl. IX A). The characteristic irregular network of cracks is present but the cracks, like the intergranular spaces, are very narrow and contain only very fine amorphous-looking yellowish and dark material. The olivine is quite fresh and, judging from the almost certainly positive sign, is near forsterite in composition. The optical direction Z is perpendicular to the trace of the cleavage, a feature of considerable help in distinguishing some grains from enstatite.

The enstatite is in subhedral, tabular or prismatic crystals up to 6 mm long that are commonly bent and broken. The crystals have very distinct cleavage and resemble bundles of fibres on the fresh surface. They are mainly fresh, with the characteristic low birefringence (about 0.010) and the principal optic axis Z parallel with the trace of the cleavage.

Some sections show the enstatite largely broken down in border areas and interior patches into a fine-grained mixture of bladed and scaly material, both of which have a relief close to that of Canada Balsam. The bladed material has a low birefringence (less than 0.010) and is pleochroic in pale green colours. The relative relief varies on rotation of the plane of polarization. This material has a somewhat lower birefringence than the chrysotile. It resembles the bladed material that borders and cuts across the cross-fibre veins (Pl. X) and is identified as antigorite. The scaly material has a much higher birefringence (around 0.030) and is tentatively identified as talc.

These secondary minerals are scarcely represented in some sections but make up a substantial part of others, including those that contain cross-fibre veinlets. The cross-fibre veins range up to an inch in thickness. They are seen in thin section (Pl. X) to consist of sheared fresh olivine interbanded with fibrous chrysotile and passing into chrysotile across the width of the fibre bands. Both components were identified by optical and X-ray methods. At the vein boundaries the chrysotile fibres curve towards parallelism with the contact but are otherwise perpendicular to it, and suggest only very minor relative movement of the vein-walls. The chrysotile shows interference colours up to pale yellow and probably has a birefringence of about 0.013.

The fibre-veins are delimited by material composed chiefly of antigorite, in random blades and radiating sheaves, and the same material forms irregular veinlets cutting diagonally across the fibre bands. This antigorite has the same relief as the chrysotile but shows only grey interference colours, and has a birefringence probably not higher than 0.010. Some black opaque material, apparently magnetite, is scattered along the border zones of the fibre-bands but is not noticeably more concentrated than in the remainder of the boundary material. Concentrations of heavy minerals from the typical peridotite consist almost entirely of magnetite. Chromite is apparently very scarce, but some reddish brown subtranslucent interstitial grains seen in thin section may be chromiferous spinel.

Some fairly typical peridotite contains minor amounts of clinopyroxene and pale amphiboles but these are generally restricted to pyroxenitic facies. Diopsidic pyroxene occurs in minor amounts with olivine and enstatite east of Mount White. Shearing in two directions at right angles is marked there by narrow intersecting stringers filled with yellowish serpentine. Peridotite south of Little Teslin Lake contains broken olivine grains with some relict orthopyroxene in a network of serpentine. A pyroxenitic facies of peridotite northeast of Teslin Lake consists chiefly of fresh augite with minor interstitial olivine. Typical fresh-looking peridotite near the northwest corner of the map-area and near the east boundary at latitude 60°45′ contains masses of bladed talc (?) and some secondary amphibole. Fresh dunite west of Teslin River at latitude 60°43′, longitude 133°50′ consists chiefly of shattered grains of olivine with serpentine-filled fractures, and intervening areas of radiating bladed antigorite intermixed with very fine talcose material. This ultrabasic body and that about 8 miles to southeast have some special features, which are discussed in some detail.

Elsewhere the ultramafic rocks rarely show a little relict olivine, or more commonly pseudomorphs after olivine in a formless mass composed chiefly of low birefringent serpentine that locally shows anomalous ultra-blue extinction colours. These rocks range from light to dark green or black and commonly weather to light green or almost white, besides the usual reddish brown. They commonly show fibrous structure only on slickensided fractures. Many are interbanded with hard hornfels-like rock or enclose 'horses' of unassimilated country rock. The ultramafic body west of Squanga Lake shows many kinds of serpentinites, some containing abundant magnetite. One variety consists of subparallel veinlets—about ten to an inch of section—of yellow fibrous material and magnetite that cut the otherwise colourless (in thin section) serpentine.

Pyroxenitic facies are widely distributed among the peridotite, commonly within and near contact zones, among the serpentinites, and in separate bodies within the spatially related greenstones. They consist primarily of coarse clinopyroxene, commonly augite and occasionally probably diopside, but a few intermediate varieties are mostly enstatite. They commonly contain a little olivine, or serpentinous pseudomorphs after olivine. Some contain pale monoclinic amphibole, perhaps pseudomorphous after pyroxene, and bladed secondary amphibole (tremolite?) commonly cuts across serpentinous groundmass components.

The ultramafic bodies west of Teslin River have some distinctive features that seem significant because of their close spatial relationship to the limestone and lime-rich conglomerates of unit 9.

The long narrow ridge-forming body at latitude 60°43′, longitude 133°50′, lies almost along the strike of black limestone and lime-rich conglomerate immediately north of it. It consists in part of typical fresh-looking homogeneous peridotite. In thin section this is seen to be made up of fresh relict olivine grains and fragmental patches in a groundmass composed partly of a network of reticulate to radiating serpentine and talc but also containing abundant carbonate. Some interstitial patches consist exclusively of fairly coarse crystalline carbonate.

Another typical peridotite shows partly serpentinized olivine in large discrete grains set in a mass of random-bladed antigorite and talc, also as fine granules intimately mixed with the shreddy remains of large carbonate individuals (Pl. IX B). Neighbouring carbonate individuals up to 5 mm across are virtually free of olivine. They are cut and partly separated by fine serpentinous networks but otherwise have a texture identical with that of the black calcarenite limestone (Pl. VIII B) lying immediately to the north. One nearly white mottled rock was found to consist of dark pseudomorphs of olivine in a mass of high birefringent material, some of which at least is granular carbonate.

Part of the peridotite has a distinct brecciated or conglomeratic appearance, the fragments or inclusions weathering lighter than the reddish brown matrix. In thin section this was seen to be thoroughly serpentinized but with a patchy texture that reflects the fragmental nature although fragment boundaries are practically obliterated.

The large ultramafic body 8 miles southeast of this also lies along strike of, and partly in contact with, black limestone and conglomerate. No fresh peridotite was noted and no fresh olivine was seen in thin sections. One pyroxenitic 'dyke' was seen to contain fresh augite but the rocks are mainly serpentinites showing no recognizable pseudomorphs in the featureless or partly reticulate serpentinous assemblage. One section shows shearing across a fine crenulated banding in low-birefringent colourless serpentine. Fine granular carbonate shows a distribution parallel with the banding.

Origin

The ultramafic bodies of the area fall into the general class of 'alpine type' intrusions (Benson, 1926), that is they are not part of a stratified or layered sequence of basic and ultrabasic rocks but consist entirely of peridotite, pyroxenite, and serpentine. This class is typical of orogenic zones in many parts of the world.

Within the area, a vague distinction may be made between large stock-like masses that interrupt the fold structures of the enclosing rocks and small irregular bodies and stringers that occur in swarms within a large area of altered volcanic and associated sedimentary rocks assigned to unit 7. This latter association is so intimate as to suggest a genetic relationship to the greenstones, and indeed the spatial relationship to comparable greenstones applies also to most of the large stock-like bodies of the area, at least in the southwestern half. It is noteworthy that distinctive dioritic rocks (unit 11) also occur characteristically within the same greenstone belts, and commonly in close spatial relationship to the ultramafic rocks.

The amount of study devoted to these rocks in the field does not justify the formulation of a hypothesis as to their origin, but some of the considerations involved are thought to be worth discussion. It seems clear that the bulk chemical composition of greenstones would be more favourable for the development of ultramafic rocks than would that of any of the other rocks. On the other hand, as pointed out above, impure carbonate rock as well as greenstone has locally acted as the host material for ultramafic emplacement. The possibility of such development is a well-authenticated fact (*see,* for example, Harker, 1932, pp. 84, 85, 78 regarding ophicalcite and forsterite marble) although prior magnesia metasomatism of the calcareous limestone may be necessary.

It is thought that hydrothermal activity interacting with severe dislocation and deformation along zones of shearing and/or thrust faults might provide the physical-chemical conditions necessary for reconstitution. Thermodynamic objections to the development of ultramafic bodies at temperatures compatible with those called for by field evidence have been largely overcome as a result of Bowen's (Bowen and Tuttle, 1949) revelations regarding the relatively low temperatures at which even olivine-enstatite rocks may be formed or be stable.

A close spatial relationship to dioritic, partly hybrid bodies has been remarked upon. The two rock types may be co-products of a metasomatic or magmatic differentiation series. If the former, the ultramafic bodies would represent a mafic front of dioritization, analogous to those of the Sutherland migmatite region (Reade, 1931) or the Newry Complex (Reynolds, 1944).

Finally, the possibility must be considered that part or all of the ultramafic rocks were intruded directly from a peridotite substratum of the earth's crust, having risen to within the zone of fracture perhaps as a result of the wholesale ejection of volcanic material.

Regarding mode of emplacement, some degree of mobility of even the smallest ultramafic stringers is suggested by their occurrence among, and cutting the bedding structures of, slates and argillaceous quartzites 3 miles southwest of Streak Mountain, at latitude 60°32′, longitude 133°42′. The large relatively homogeneous bodies that interrupt the fold structures have evidently been emplaced as intrusions, whether cold or hot. Their generally unsheared condition would seem to preclude a cold-intrusion hypothesis but as pointed out below (*Internal and External Structure*), there is locally abundant evidence of heavy shearing in the vicinity of contacts. Furthermore, the existence of mild cataclastic textures and intergranular strain-effects bears witness to some degree of movement. It may be that at the elevated temperature attendant on intrusion, grain-growth and recrystallization—particularly of independent-tetrahedral-group minerals such as olivine—can keep pace with deformation (cf. Bowen, 1949, p. 455). Such a process would result in the equigranular allotriomorphic texture that characterizes the olivine-rich peridotite.

Regarding the chrysotile veinlets, no clue was seen in the megascopic structures or microscopic textures as to their origin or localization. They were seen only during the first traverse of an ultramafic body, were hastily noted, and were not revisited.

Internal and External Structure

No substantial evidence of wholesale shearing was noted in the interior parts of any large ultramafic body, though the rocks are extensively jointed and blocky in many places, and joint surfaces commonly show slickensiding on thin serpentine films. A well-marked unidirectional trend of closely spaced lineaments is visible in aerial photographs, however, particularly in the bodies north of the Alaska Highway west of Teslin Lake. In the smaller bodies structural features are obscured by their intimate relationships to altered and commonly much-sheared invaded rocks.

Within contact zones both the ultramafic and invaded rocks are commonly sheared; the country rocks are altered, silicified and cut by networks of quartz veins, so that actual contacts are difficult to define. Through broad transition zones, altered remnants of country rock alternate with sill-like bodies of ultramafic rocks and, as these are generally of the pyroxenitic facies, distinction is often uncertain. The contact zones are further obscured by frost-heaving and extensive development of felsenmeer and talus. It is nowhere clear whether the tabular bodies of ultramafic rock that alternate with those of country rock are intrusions or fault-slices. The contacts, where actually observed, are generally concordant, but large-scale discordance along strike is evident from the distribution of the rocks.

Many of the small bodies and swarms of bodies appear to be localized by faults. The outcrop pattern of most large bodies suggests that they too mark general zones of major dislocation. In particular, the curving series of outcrops bordering the granite body northwest of Hayes Peak, and their apparent continuation westward to and beyond Squanga Lake, are thought to be connected with some unrecognized but major structural feature. It has already been suggested (*see* under *Units 4-5*) that the Hayes Peak arc is a manifestation of a hypothetical overthrust fault.

The ultramafic bodies in the northeastern part of the map-area show no sign of deformation subsequent to emplacement. The southernmost of these is emplaced in relatively undeformed rocks presumably much younger than all others in that part of the map-area.

Ultramafic rocks are cut by diorite dykes of unit 13 notably on the southeast flank of Hayes Peak and west of Squanga Lake. No sharp contact with granite was seen actually exposed. West of Hayes Peak the peridotite is highly sheared near the contact. Granite fragments amongst peridotite boulders are probably from underlying dykes. Granite delimits ultramafic bodies in several places, shows no alteration near the contact, and is undoubtedly younger.

Age

Most of the ultramafic bodies are emplaced in Permian or Triassic greenstones of unit 7, from which they may be in part derived. They cut the fold structures of these rocks and are thus post-deformational. Some may be older than Upper Triassic, but there is no positive evidence of this. The northwesternmost bodies are emplaced in, and cut across the fold structure of unit 9, some of whose rocks they have apparently assimilated. These include conglomerate and calcarenite that are believed to be at about the base of the Jurassic. The ultramafic rocks are older than the granite, which is believed to be post-Lower Cretaceous, pre-Tertiary.

No ultramafic bodies are known to cut the early Cretaceous Tantalus Formation or Hutshi Group of Whitehorse and Laberge map-areas, which overlie folded Lower and Middle Jurassic rocks of the Laberge Group with structural unconformity (Wheeler, J.O., pers. comm.).

Considered collectively as intrusions, the ultramafic rocks of Teslin area are therefore of post-Lower Jurassic and probably pre-Cretaceous age.

Unit 12

Diorites of unit 12, like the ultramafic rocks (unit 11), are widely associated with the volcanic rocks of unit 7, and many small bodies are present in addition to those mapped. Similar diorite is associated with ultramafic rocks and the conglomerate and limestone (unit 6) near the eastern map-boundary north of Wolf River.

The central parts of larger bodies are light to moderately dark, medium grained, and homogeneous, with a typical dioritic texture. Border zones and entire small bodies are typically greenish, full of inclusions, and generally grade imperceptibly into volcanic greenstones. Local dark, coarse-grained, border facies appear to be mafic segregations resulting from the dioritization of the greenstone. Specimens of typical diorite consist of secondary minerals, evidently derived chiefly from hornblende and plagioclase feldspar.

A thin section of diorite from the south shoulder of Hayes Peak consists of coarsely intergrown altered plagioclase and pale uralitic hornblende with colourless cores of augite. Another from Hayes Peak area has andesine with pale green amphibole and abundant alteration products. A specimen from the body west of Squanga Lake consists of brownish green hornblende, completely altered feldspar, and a very few tiny angular grains of quartz.

The diorite of unit 12 intrudes, and is younger than, the greenstone of unit 7. It has been seen to cut ultramafic rocks (unit 11) on Hayes Peak and west of Squanga Lake, but is believed to be closely related to them in age. It was not seen in contact with granite (unit 13), but is believed to be older.

Coast and Cassiar Intrusions (Unit 13)

Granite, granodiorite, and minor dioritic facies form masses of various sizes distributed throughout the map-area. That along the north boundary west of Quiet Lake is part of a batholith that extends at least 10 miles north into Quiet Lake area, and the disconnected series of stocks extending southeast through Big Salmon Range to Morley River are probably connected with it. The large mass along the east boundary in Englishmans Range is part of a small batholith that is probably an offshoot or satellite of the Cassiar batholith. The mass bordering Atlin Lake in the southwest corner extends southward for 25 miles in Atlin map-area.

Typical specimens from the various bodies differ somewhat in appearance and composition, but except for those bodies separately designated (units 13a, b), the differences are not outstanding.

Lithology

The classification system used, based primarily on megascopic features but found to be valid on microscopic examination, is as follows: granite—potassic feldspar equal to or in excess of plagioclase (oligoclase), quartz generally more than 20 per cent, ferromagnesian minerals scarce, mostly biotite; granodiorite—potassic feldspar definitely subordinate to plagioclase (calcic oligoclase or andesine), quartz rarely more than 15 per cent, ferromagnesian minerals prominent, mostly hornblende. Quartz diorite has negligible potassic feldspar, but may have as much as 15 per cent quartz. The term monzonite is reserved for intermediate members of the quartz-deficient series (13b), as in the original definition (Johannsen).

The body surrounding the north end of Atlin Lake is composed of medium-grained, rather dark, hornblende-biotite granodiorite and quartz-diorite. The plagioclase is sodic andesine and the scarce potassic feldspar is a patchy micro-perthitic or intergrowth type. Quartz runs about 15 per cent.

The three stocks west of Teslin River are all medium-grained, mesocratic, hornblende-biotite granodiorites of rather constant grey colour. The plagioclase is An_{33} in cores of some zoned crystals, decreasing to sodic oligoclase at the rims and is clouded by sericite. The minor potassic feldspar is relatively clear, untwinned, only occasionally microperthitic. Both biotite and hornblende are visible in most specimens, but hornblende probably predominates. Quartz makes up about 15 per cent of the specimens examined. Some sphene, magnetite, apatite, and zircon are accessory.

The stock west of Hayes Peak (latitude 60°24′, longitude 133°18′) is mostly pinkish, medium- to coarse-grained, leucocratic biotite granite with lavender-coloured quartz. The ratio of potassic feldspar to plagioclase is about 2:1. Patchy microperthite is prominent and some microcline is present. Quartz amounts to about 33 per cent. Scarce biotite is the only ferromagnesian mineral. Pegmatitic phases, composed of coarse microperthite, quartz, and myrmekite, are associated with skarn near the limestone contacts. The skarn contains garnet octahedra more than an inch across and large bladed columnar aggregates of white diopsidic pyroxene. Some dark dioritic phases occur within the main body of granite.

The series of bodies extending along Big Salmon Range from Mount Morley to Sidney Creek are mainly medium-grained, in part porphyritic, biotite granite, with occasional biotite granodiorite and diorite border facies. The quartz is noticeably lavender to smoky coloured. In places cataclasis has obscured this feature; such rocks are sub-gneissic, the foliation striking parallel with the bedding of the enclosing rocks. A little red garnet is present in some granites, both gneissic and homogeneous, and sphene is a fairly prominent accessory. The granite on and north of Mount Morley consists mostly of microperthite and microcline, with minor plagioclase and abundant dark smoky quartz. Some muscovite, garnet, and sphene are present as well as biotite. Northwest of Nisutlin Bay the rock is mostly granite consisting of microperthitic feldspar and microcline with minor plagioclase, lavender-coloured to grey quartz, biotite, locally abundant garnet, accessory sphene, and rare zircon. A cataclastic texture is prominent and the rocks are commonly gneissic; they appear to grade into the plagioclase-quartz-amphibole gneisses of unit 1f, but the difference is distinct. Northwest of Canol road the granite is similar, but not so commonly gneissic, and garnet is not conspicuous. The quartz is smoky rather than lavender coloured. Coarsely porphyritic granite is abundant on the ridge north and south of Canol road. Hornblende granodiorite facies occur here and there and some dark dioritic border and satellitic bodies were noted around latitude 60°40′, longitude 133°12′, and latitude 60°49′, longitude 133°23′. Some trains of granite float amongst the pseudodiorite (unit A) suggest underlying dykes, but no actual contact between the types was seen at close quarters.

The granite west of Quiet Lake, according to Lees (1936, p. 18), is coarse-grained to porphyritic biotite granite. Some miles north of the map-boundary an occurrence of granite-gneiss and one of tourmaline-bearing pegmatite near a contact with limestone were noted. Occurrences of skarn near limestone contacts south of Sidney Creek are mentioned under unit 1.

The stock east of lower Nisutlin River is medium-grained, pinkish biotite granite with prominent microcline and microperthite, minor plagioclase and about 35 per cent lavender to smoky quartz. That south of Thirtymile Lake is coarse to porphyritic, pinkish biotite granite with microperthite crystals nearly an inch long and perhaps 60 per cent quartz in the one section examined. The minor plagioclase is intermediate oligoclase. The large stock touching the north boundary east of Nisutlin River is coarsely porphyritic, amphibole-biotite granodiorite, with abundant colourless quartz. The phenocrysts are commonly over an inch long, are pale pink, and are commonly Carlsbad twins, but all show complex plagioclase twinning and zoning in thin section; many are fractured and compound crystals. Only a few grains of potassic feldspar were seen amongst the interstitial quartz, which is strongly sutured and makes up 40 per cent of the section. The amphibole is a deep blue-green alkaline variety with low 2V about X, strong dispersion R greater than V, and low gamma minus beta. Some biotite is also present and a little sphene is accessory.

The two stocks west of Thirtymile Lake range from diorite to granodiorite in composition. Quartz is scarce or absent in most parts but a thin section from the east body showed about 10 per cent along with minor microcline and intergrowth feldspar, major plagioclase, hornblende, and accessory sphene, apatite, and ilmenite or titaniferous magnetite. The western body has little or no quartz, but may have a little potassic feldspar, together with altered plagioclase, albite, deep green alkaline (?) amphibole, and rather abundant epidote and sphene. A coarse, pyroxenite-hornblendite facies along its southern border has abundant apatite, together with sphene, epidote, and yellowish opaque mineral. The small stock west of Wolf River at latitude 60°33′, longitude 132°16′, is a dark, fine- to medium-grained gneissic-looking rock. It has abundant hornblende and altered plagioclase, both with abundant inclusions, and intersertal quartz and untwinned clear feldspar, at least partly potassic. The last two are partly in large areas having optical continuity.

The Englishmans Range intrusion is a pink, buff weathering, coarse-grained and commonly porphyritic biotite granite with abundant rather smoky grey quartz. It consists of about equal parts potassic feldspar, plagioclase, and quartz, with minor biotite and black opaque-mineral. The potassic feldspar is a patchy perthitic type and is cloudy. The plagioclase is fresh, occurs as inclusions in the potassic feldspar and as cores rimmed by the latter.

Some rusty garnet-amphibole-epidote skarn, found near contacts with limestone at latitude 60°21½′, longitude 132°05′, contains pyrite, and a little gold, silver, and base-metals. Tourmaline-quartz concentrations noted by Poole farther east (pers. comm.) were not encountered within the map-area. Contact facies are normal in granularity and not gneissic. The contacts are sharp and generally show little metamorphic effect on the invaded rocks, although sill-like sheets emanate from the main granite body in some places. About latitude 60°31′, longitude 132°08′, however, inclusions of a roof-pendant type are abundant and are considerably metamorphosed.

The large stock (13a) forming Mount Bryde (latitude 60°06′, longitude 133°13′) is a heterogeneous mass, in part banded, of dark and light, medium- and fine-grained intrusive rocks. The darkest rocks are hornblendites and hornblendite-pyroxenites. The hornblende is green, and similar hornblende forms borders and patches in otherwise colourless augite of the pyroxenites. Lighter facies are probable gabbros and diorites, composed of augite, green hornblende, highly altered plagioclase feldspar, and occasionally a little quartz. The lightest facies is probably granodiorite, composed of altered plagioclase, quartz, green hornblende, biotite, and probably some potassic feldspar.

The composite body (13b) lying southeast of the mouth of Thirtymile Creek is likewise heterogeneous. The western part consists of alkaline rocks ranging from syenite to black gabbro or even peridotite. The syenite is light pinkish, and medium to fine grained. It consists chiefly of potassic feldspar and a little plagioclase, green alkaline amphibole, a little pyroxene and brown biotite, and rarely quartz. Apatite and sphene are prominent accessories. Darker, fine to coarse bladed facies contain potassic and plagioclase feldspar in about equal proportion, pyroxene, green amphibole, brown biotite, and a little olivine. These are typical monzonites both in composition and textural appearance. The one gabbroic facies examined is composed chiefly of augite with nearly 10 per cent olivine. The central part of the mass is light coloured hornblende granodiorite, and the easternmost tongues are more nearly diorite in appearance and composition. The various phases grade into one another, but aplite syenite cuts the monzonite phase and holds large masses of it as inclusions. The rocks are probably hybrid; quartz-deficient facies are perhaps a result of desilication of a fluid magma by limestone.

Internal and External Structure

The granitic plutons of the area, excepting possibly the series extending through Big Salmon Range, are definitely intrusive types without gneissic or migmatitic phases, and cut discordantly across fold structure. Contact metamorphic effects are generally very limited in intensity and range.

Those of Big Salmon Range on the other hand show a considerable tendency to concordance, especially in the area between Canol road and Nisutlin Bay. There gneissic phases are common, the rocks grading into gneisses that are considered to be of typically metamorphic origin.

Age and Correlation

As all the granitic bodies are generally similar, and some cut rocks probably of lower Jurassic age, they are provisionally considered to be related to the main Coast and Cassiar intrusions, of presumed Middle to Upper Cretaceous age. However, because of evidence of older granites in Coast Range areas the possibility cannot be ruled out that pre-Cretaceous granitic rocks are present in the area.

Unit 14

This unit is an assortment of relatively young distinctive volcanic rocks and of dyke rocks that superficially resemble them. The dykes are considered to be in part related to the volcanic rocks but may be in part younger. The volcanic rocks occupy two limited areas that just touch the map-boundaries, one in the northwest corner, the other at the southern boundary 4 miles west of Teslin Lake. Elsewhere within the map-area the unit is represented by sills, dykes, and irregular bodies, mostly too small to represent accurately on the map. They are most numerous on the ridge east of Nisutlin Bay (*see* note on map). The volcanic body on the southern boundary is flanked on the east by similar dykes that also resemble the volcanic rocks. The area of volcanic rocks touching the northwest corner of the map-area and a dyke crossing the northern map-boundary on Slate Mountain, both mapped by Lees, are included in this unit although their relationships to each other and to other members of the unit are not known.

Unmapped aplite or rhyolite dykes that outcrop west of Teslin Lake, north of the Alaska Highway near the west map-boundary, and in various other places, may be related to some of the dykes.

Lithology

Unit 14 consists of porphyritic and felsitic dykes and porphyritic, fragmental, and amygdaloidal volcanic rocks.

The porphyritic dykes are characterized by euhedral, white feldspar phenocrysts up to half an inch long, with or without quartz or hornblende, in a fine-grained, grey, greenish or purplish groundmass. The phenocrysts are, as a rule, closely spaced; where widely scattered the rock becomes a felsite that resembles the groundmass of the porphyries. Outcrops of the dyke rocks generally have a light coloured, weathered appearance.

The feldspar phenocrysts where fresh enough to determine were found to be andesine, An_{30} to An_{40}. Most sections contain quartz, in rounded, resorbed phenocrysts. The ferromagnesian minerals are chloritized; some appear to be pseudomorphs after hornblende, some after biotite. The groundmass varies from a fine, felted mass of alteration products to an almost aphanitic felsite. A faint fluidal structure is discernible in some specimens. Potassic feldspar may be present in some dykes, and granophyric or myrmekitic intergrowths of feldspar and quartz are prominent in the groundmass in a section from east of Nisutlin Bay, where felsitic dykes are most abundant.

The volcanic rocks south of the map-boundary have fewer and smaller phenocrysts than the dykes in general, and groundmass colours vary more commonly to purple, green, and black. They are mostly fragmental. Some angular fragments are distinguishable only on the weathered surface; others, of fine, less porphyritic purple rock, show distinctly on fresh surfaces. In thin section fragment boundaries are distinguishable only by difference in texture. The fresh feldspar phenocrysts are andesine. Quartz was noted in one of four sections. Most sections revealed amygdaloidal structures, the vesicle-fillings being chlorite, calcite, and quartz. Probably the rocks are mostly andesite and dacite.

The volcanic rocks touching the northwest corner are, according to Lees (1936, p. 21), dense, purplish to chocolate-brown dacites with occasional quartz amygdules. A thin section is cryptocrystalline, apparently composed of feldspar, quartz, and carbonate that is probably pseudomorphous after hornblende. The mass contains, in its base, a few pebbles of granite containing bleached biotite. It forms a veneer on the valley side, outcropping over a vertical range of 2,000 feet. Probably related basalt farther north is somewhat sheared, though unaltered.

The mapped dyke at Slate Mountain is one of a group described by Lees as "granite porphyry and felsite". It is white or cream, with pale feldspar, quartz and occasional biotite phenocrysts in a cream-coloured felsitic groundmass.

Structural Relationships, Age, and Correlation

The volcanic rocks at the south border have gentle dips and occur only on the upper ridges of the isolated mountain massif (Dawson Peaks) lying mainly south of the border. Thus they apparently overlie, with angular unconformity, the surrounding, steep-dipping rocks of unit 4. Dykes similar to the volcanic rocks cut the latter. The volcanic rocks are invaded by a granite stock south of the map-boundary (Aitken, 1960), and on this basis are probably not younger than Middle or Late Cretaceous. As they are apparently post-deformational, the writer would correlate them tentatively with the Hutshi Group of Whitehorse and Laberge map-areas, of post-Lower Cretaceous, pre-Upper Cretaceous age.

The volcanic rocks in the northwest corner were tentatively correlated by Lees with the Carmacks volcanics, of Tertiary age, but placed in the Cretaceous Hutshi Group (Wheeler, 1952) in Whitehorse map-area.

The dykes associated with the volcanic rocks at the south boundary are probably contemporaneous with them. Others may be roughly contemporaneous with the granite, or may be of distinctly younger, possibly of early Tertiary age.

Unconsolidated Deposits (Unit 15)

A small patch of gravel, whose pebbles are cemented together and to bedrock by iron oxide, is exposed by placer workings on Iron Creek. Other unconsolidated gravels with rotted, water-worn granite boulders lie below blue glacial till. These deposits are probably of pre-Glacial age.

Glacial, fluvioglacial and glacio-lacustrine deposits occur in abundance throughout the map-area, filling the valleys and mantling the upper slopes. They include till, consisting of blue sticky clay with scattered pebbles or boulders, glacio-fluvial sand and gravel, occasionally bedded and crossbedded, and fine, light, thin-bedded silts, in deposits scores of feet thick. Their characteristic forms and distribution are described in some detail under *Physical Features and Geomorphology*.

Various fluvioglacial and glacial deposits occur also high on the valley-walls in places, and even on the upland surfaces. Much of these upland surfaces and the slopes leading to them are soil-covered, and exposures of bedrock commonly consist of frost-heaved felsenmeer and talus.

Recent sands and gravels along the rivers and streams and in their restricted flood plains are mainly re-washed glacial deposits. Some of the lacustrine deposits may also be of recent origin. Recent soil covers the greater part of most upland areas and slopes leading to them.

An intermittent layer of white volcanic ash, 2 to 4 inches thick, occurs on some terraces along Teslin River and Nisutlin River, as low as 3½ feet above high-water mark, but is absent from lower terraces (Lees, 1936, p. 22). It is covered by up to 2½ feet of sand and soil and commonly underlain by a brown layer of dead vegetation, locally with stumps and undecomposed plant remains (Porsild, 1951). Similar ash occurs elsewhere in the Yukon and Alaska (Bostock, 1952). Adjacent to White River, it has been estimated by Capps (1931) to be 1,400 years old.

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Chapter IV

STRUCTURAL GEOLOGY

The internal structures peculiar to each rock unit, and their immediate interrelationships, were discussed in the preceding chapter. This chapter is devoted mainly to features that involve several units, but is an attempt to review and correlate the broad structural features of the map-area regardless of the number of units involved.

Folds

With the possible exception of the volcanic rocks of unit 14, all the bedded rocks are folded. The trend of fold axes is generally northwest parallel with the regional trend of formations, but local deviations are common. The degree of deformation is highly variable; in some parts broad open folds are prevalent, elsewhere tight, possible isoclinal, folds, some probably overturned, are indicated.

A southeasterly plunging anticline in the southeast corner is indicated by the distribution, attitude, and lineation of limestone and associated rocks of unit 1. Rocks of the Englishmans Group (units 2 and 3) overlie those of unit 1 on the east flank of this structure and apparently swing around the nose of it in Wolf Lake area. They may be represented by limestone and associated rocks just east of Teslin Lake at the southern map-boundary. If so, they would establish the southwest limb of the same major structure, but part of the intervening ground is covered and other possibilities must be taken into account. In this connection a major limestone member of the metamorphic Oblique Creek Formation of Tuya-Teslin map-area (Watson and Mathews, 1944, p. 15) extends in northwesterly direction almost to latitude 59°30′, longitude 130°50′. The above-mentioned anticline appears to extend as the basic structural feature north-northwest to the vicinity of Wolf River, beyond which the limestone marker apparently closes on itself and the structure becomes unrecognizable. What may be the same limestone and greenstone reappear farther northwest in the valley of Sidney Creek, but the structure is uncertain. Elsewhere, although small-scale structures may be readily outlined, no reliable interpretation of major structures can be made in the area underlain by unit 1.

In the Englishmans Range, the distribution and attitude of exposed limestone (unit 3c) around Mount McCleery outline a shallow syncline, but the stratified rocks of Englishmans Range are excessively faulted and structures are complex.

In Thirtymile Range the trend of strikes and fold axes swings from northwest to north to northeast in the area north of Thirtymile Lake, the dips east of about the longitude of Thirtymile Creek being rather consistently eastward. This may indicate that the major structure of Thirtymile Range is a faulted syncline, plunging gently to moderately southward at its northern fringe. On the southwest fringe of the range west of Wolf River the strata of the Englishmans Group appear with some sharp local inconsistencies to be nearly flat lying. Broad open folding seems to prevail along and west of the lower part of Thirtymile Creek. Some more or less hypothetical fold axes have been delineated in this northwestern part of the range but to the north, west of Thirtymile Creek, the structure becomes increasingly complex, involving intense crumpling and dynamic metamorphism of the folded and faulted rocks.

In the southwestern part of the map-area late Palæozoic and Mesozoic rocks trend rather constantly northwest along the valley of Teslin Lake and Teslin River. Southwest of the valley extending through Squanga Lake, however, attitudes form no consistent pattern. Strikes in unit 4 south of the Alaska Highway, and in units 7 and 9 north of it, are generally northeastward. The overall arcuate trend combines with the regional distribution of late Palæozoic and Mesozoic groups to produce the concept of a broken north-northwest trending anticline, plunging northward and bringing up successively younger rocks on the flanks and at the nose. Within the map-area the concept is an attempt to rationalize the broad distribution of rock types in terms of folding. It is in apparent conflict with observed attitudes in several places (*see* under description of units) and must be regarded as hypothetical. In particular, a fault along the cross-trench followed by the Alaska Highway southwest of Squanga Lake may be the main structure forming the northward limit of the late Palæozoic assemblage.

Towards the northwest corner an anticlinal axis may, as stated by Lees, coincide approximately with Teslin River but the structure in unit 9 is complex and this may not be a dominant feature.

Faults

Faulting has evidently taken place to a greater or lesser extent in most parts of the map-area. Only a rather arbitrary few of the faults have been mapped because, although they have probably been the prime factors in determining the local distribution and attitudes of the rocks, their relative importance in the major scheme can rarely be ascertained. In most places where important faulting is suspected, aerial photographs reveal a complex network of lineaments striking in various directions and only a subjective generalization can be achieved on a map of this scale.

No important low-angle thrust faults have been recognized, although several hypothetical ones may be discussed. One assumed fault or fault-zone that may be an overthrust involves the main geological boundary of the map-area, that separating unit 1 on the northeast from units 9 and 10 on the southwest. This boundary in most places coincides with a through-going drift-floored trench but the separation is incomplete in two places (*see* under *Unit 1*) where an assumed fault is indicated on the map. At the locality northwest of Cone Mountain evidence suggestive both of unconformity and of faulting is present. At that east of the outlet of Teslin Lake the contact involves a complex network of faults, perhaps related to an unrevealed major fault in the northwesterly striking drift-floored trench. The sinuous trend of the boundary suggests a complex zone of faults, along some of which the contact may be offset in various places. A purely hypothetical thrust fault involves the contact between the Cache Creek, and unit 7 west of Teslin Lake and is discussed under *Unit 5*. It is unsupported by direct evidence but would provide a possible explanation of cross-faults and structural complexities, ultramafic intrusion, and assumed overfolding. Another hypothetical thrust fault in the Englishmans Range is mentioned under *Unit 3*.

A fault-contact between unit 4 and unit 5 south of the Alaska Highway west of Squanga Lake is marked by a quartz stockwork but its extent and nature are not known. A hypothetical fault along the valley followed by the highway is supported by physiographic evidence and would be co-extensive with a major fault assumed in Whitehorse map-area. The two faults may intersect, enclosing the limestone mass of Mount White in a wedge-shaped horst structure. The possible disruptive effects of the above hypothetical fault are not marked east of the Summit Lake area but it might be pointed out, as a matter of pure speculation, that an extension of such a fault northeastward across Big Salmon Range and through Thirtymile Lake would coincide with several minor geological boundaries and rather sharp breaks in structural trends.

Steep strike faults break the limestone bands in the Englishmans Range and many similar faults are visible in the highly complex structures seen in cirque walls in Big Salmon Range. Large, conspicuous quartz veins or dykes follow the strike of contorted rocks in the mountains between Thirtymile Creek and Nisutlin River and northward. Several of these are represented on the map as assumed faults. One pronounced topographic lineament in the area of unit 9 west of Teslin River that makes a small angle with the bedding in adjoining rocks is shown as an assumed fault.

Numerous oblique and cross-faults are present throughout the map-area. In most instances the structural complexity is such that their true courses can only be guessed at. A few of the more obvious ones are indicated in a generalized way on the map, but it should not be inferred that these are the only or necessarily the most important faults in any particular area.

The conspicuous, almost straight topographic lineament that extends through Teslin Lake and Teslin River for at least 150 miles has been shown on some large-scale structural maps as a fault. There is no positive evidence of faulting anywhere along this lineament in Teslin map-area. Teslin Lake covers one major geological boundary (that between unit 1 and unit 4 at the southern map-boundary). Also, several minor boundaries lie within or cross the trench under the lake, and no doubt some faults do likewise. However, along Teslin River below 100 Mile Creek, where bedrock is exposed at or close to the river on both sides, there is nothing to suggest the existence of a fault along the valley.

Unconformities

Postulated regional unconformities of which some expression might be expected in Teslin map-area are, in chronological order:

1. Between early to mid-Mississippian and Permian.
2. Between Permian and Upper Triassic.
3. Between Upper Triassic and Jurassic.
4. Between Jurassic sedimentary and Cretaceous volcanic rocks.

The evidence for one or more intra-Mississippian breaks is discussed under *Unit 3*. The contact between Mississippian or older, and Pennsylvanian (?)-Permian, assemblages at the southern map-boundary is concealed beneath Teslin Lake. An unconformity is suggested by the pronounced contrast in metamorphism between the units—a contrast which applies also to the relationship between unit 6 and unit 3A near the northeast corner of the map-area. The contact between presumably Mississippian or older and Mesozoic rocks northeast of Teslin River is marked at one point by conglomerate that may be the expression of the profound unconformity to be expected between these groups (*see* under *Unit 1* and *Unit 9*).

Known Upper Triassic rocks are restricted to a small area near the western map-boundary and are not in contact with known Permian. The intervening rocks are mainly volcanic. The possibility that some of these may overlie different members of the Permian assemblage disconformably is discussed under the Cache Creek Group.

The limestone-rich conglomerate of unit 9 is taken to be the base of the Jurassic in Whitehorse map-area (Wheeler, 1961) where it is considered to lie with local disconformity on uppermost Triassic strata. In Teslin area, unit 9 is in exposed contact with volcanic rocks of unit 7 at one point, the contact taking the form of a rather gradual transition from volcanic to conglomerate and other sedimentary rocks.

Volcanic rocks (unit 14), correlated with the Cretaceous Hutshi Group of Whitehorse and Laberge areas, overlie folded Permian strata with pronounced angular unconformity.

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Chapter V

ECONOMIC GEOLOGY

No commercial mineral deposits have yet been found in Teslin area, and only on the Iron Creek placer property has exploitation been attempted on a commercial scale. Prospecting for placer and lode deposits was apparently fairly active in the northwestern part of the area, as it was in Boswell River valley just to the north, prior to about 1935 when Lees (1936) mapped that part of the area. Elsewhere, signs of prospecting are virtually absent and the only minerals that have received noteworthy attention in late years are minor occurrences of asbestos.

Placer Deposits

The Iron Creek placer property was in operation at the time of Lees' visit. His report is now out of print and his description is herewith reproduced verbatim (Lees, 1936, pp. 25, 26):

> The Iron Creek placer deposits were discovered about 1905 and the creek was staked along its lower 3 miles. About this time the neighbouring tributaries and Sidney creek were also staked. Work was carried on by hand and it is reported that some operators recovered $70 to $80 a month. About 1915 Blick, now of Telegraph Creek, brought in a crew of five men and put in one-half mile of ditch and flume. His workings consist of two cuts or ditches 1½ miles up stream from the present camp. No records of the results are available, and after two years he allowed his claims to lapse. About 1921 Bonebreak and his associates bought all existing claims and commenced operations at the present site with a crew of ten to twelve men. A small monitor, a sawmill, and, later, a caterpillar tractor were brought in, and a ditch and flume 1 mile long were built. After some prospecting one small pit was hydraulicked across the creek from the present by-wash dam; the recovery is unknown. Subsequently, the claims were allowed to lapse. In 1932 the Inca Mining Corporation staked the lower 3 miles and had five men prospecting. They put in an open-cut and several shafts, continuing the work in 1933. In 1934, under the management of L. W. Staples, they brought in a crew of twenty-two men with about 40 tons of equipment. A summer tractor road was built from Nisutlin river, 13 miles distant, using parts of a former winter tractor road. The old flume and ditches were enlarged, three monitors installed, and, to date, 18,000 cubic yards of gravel have been washed. The values from the washings were mostly obtained from near the present creek. The recovery was not high and at the time of visit the crew had been reduced to four and a drill was being brought in to search for an old channel.
>
> The lower reaches of the creek lie between glacial terraces 250 feet high with rim rock of argillite and schists. Below the lowest workings the creek cuts a canyon through the rock. The workings have been concentrated along the gravels of the present creek. Some booming done from the flume on the south side of the creek, and several exposures above the workings on the north side of the creek, show the unconsolidated deposits to include rotted pre-Glacial gravels at the bottom, overlain by glacial till, with interbeds of glaciofluvial sand and gravel. The glacial till consists of blue clay with scattered pebbles.

The property was evidently abandoned soon after Lees' visit. A wing dam and sluice boxes still mark the site of the most recent pit. What is probably an earlier pit is mostly covered by a mud slide. Old workings were seen on some other tributaries to Sidney Creek farther upstream. Lees also reported work by L. Sarilla on Cottonwood Creek; south of Quiet Lake in 1934 and 1935, stating that "nothing of commercial value is yet reported".

A placer digging just about at the west boundary on the northernmost mapped creek was reported in Lees' field notes.

A small placer digging, thought to be the work of a David Hammond, was found near the head of a canyon due west of Mount McCleery in Englishmans Range. Some fine gold is reported to have been recovered from bars on Teslin River and Nisutlin River, and the creek south of Cone Mountain is said to be gold-bearing. A little panning was done in creek gravels near several campsites but no colours were seen and no serious attempt to test any of the streams was made.

The greatest obstacle to placer prospecting in this area is the heavy deposit of drift and alluvial material which floors most of the creek valleys. Here and there throughout the map-area rock canyons occur and a careful search in the vicinity of these might well reveal suitable ground and conditions for placer prospecting. The present drainage is widely disorganized as a result of damming by ice and glacial deposits and the locations of preglacial stream channels may be deduced with some confidence. These would be favourable places to prospect especially where cut by present stream courses.

The most favourable source rocks should be those of unit 1 in Big Salmon Range, and the most favourable creeks those transverse to the direction of movement of ice in the main valleys, where they would have some protection from its erosive effects.

Lode Deposits

No important lode deposits were seen in the course of mapping, although samples of iron-stained quartz from many parts of the area showed small amounts of base metals and traces of gold and silver. Galena-bearing quartz at the 'Moose Hill' Group near the creek just south of Cone Mountain was reported by Lees to be covered by twenty-five to thirty mineral claims but the extent of mineralization is apparently negligible. Some pyrite-impregnated rotten schist was found near the head of the creek, and calamine was identified among secondary minerals in this material. Copper-stained float was found near the head of Sidney Creek and a cupriferous occurrence has been reported on a small creek flowing into Rosy Lake. Most metallic mineral deposits seen (all small) were associated with limestone skarns near the contacts with granite bodies in Englishmans and Big Salmon Ranges. Most of these limestone bodies are outlined on the map. Such places are particularly favourable for prospecting.

Also favourable are the mapped faults, a few of which showed signs of mineralization, although none was seen in the large quartz veins west of Thirtymile Creek and to northward. Several of these are shown on the map as assumed faults. No attempt was made during the mapping to search any of these favourable zones. It is therefore possible that thorough investigation might turn up valuable orebodies. Indeed no part of the area, except perhaps the interior of large granitic bodies, can be considered unfavourable on geological grounds.

A radioactive occurrence in the southwestern part of Teslin map-area is shown on a recent map of the Metallogenic Series published by the Geological Survey of Canada. The location is given as Lincoln Creek. That is the local name for a creek that flows into Gladys Lake some miles south of the map-boundary, and the location shown is believed to be in error.

Non-Metallic Mineral Deposits

Cross-fibre veins of chrysotile asbestos up to an inch across were seen by the writer on Hayes Peak but were few and scattered and were not noted elsewhere. A concentration of heavy minerals from specimens of peridotite from that locality showed only small amounts of chromium. Some prospecting has been carried out recently in the ultrabasic rocks, but nothing commercial has been reported.

A block of ground extending northwest for about 4 miles from Hayes Peak (Claim Map 105 C/5) is reported to be held by Conwest Explorations, Ltd., and blocks north of the Alaska Highway towards the west map-boundary by Conwest and Prospectors Airways.

In 1953, a discovery of asbestos south of the pass east of Cone Mountain led to widespread staking in that area. Snow prevented examination of the deposit by the writer. The rocks are partly serpentinized, hornblende-gneiss (unit A). A sample of asbestos reported to have come from the deposit was proved by X-ray methods to be tremolite.

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PLATES I TO X

PLATE I. Big Salmon Range, looking south. Iron Creek (in foreground) joins Sidney Creek, (across centre). Showing biscuit-board topography and old cirques rounded and scoured by westward-flowing continental ice-sheet. (*Photo by U.S. Army Air Force; F19AL52.*)

PLATE II. Thirtymile Range, looking south; bend of Wolf River at lat. 60°30′ in upper left corner. Showing sharply incised young cirques in contrast with old cirques rounded and scoured by continental glaciation; note also morainal ridges lying across stream valleys. (*Photo by U.S. Army Air Force; F14 L60.*)

PLATE III. Englishmans Range, looking south from a point east of Fish Lake. Crag-and-tail topography resulting from continental glaciation (foreground and upper right) contrasts with alpine cirque topography of higher country in upper centre. (*Photo by U.S. Army Air Force; F14 L51.*)

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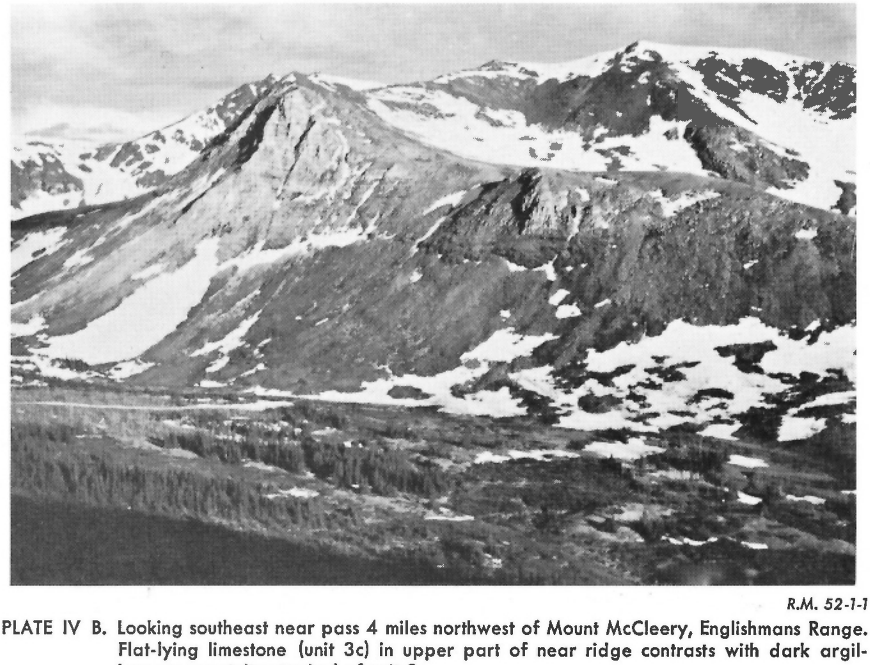
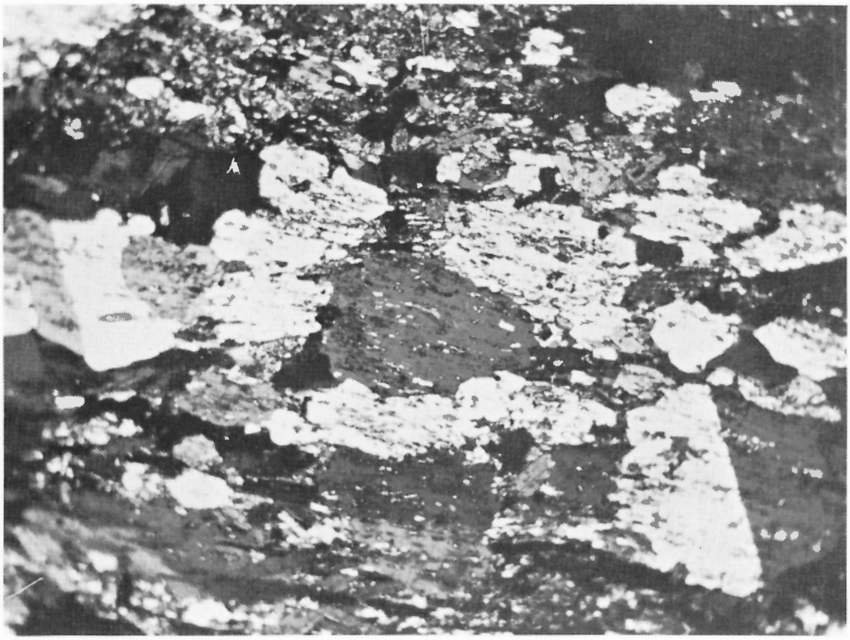
R.M. 50-1-10

PLATE IV A. Looking west from ridge 5 miles southwest of Squanga Lake. Peneplain remnant at about 5,000 feet elevation forms flat summit of Mount White (left). Note also typical sprawling growth of alpine fir near timber-line.



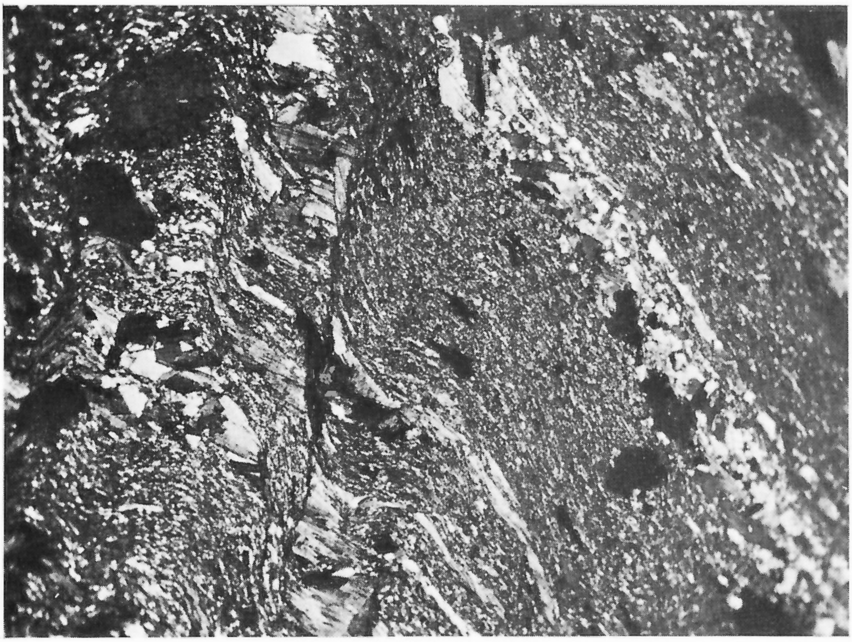
R.M. 52-1-1

PLATE IV B. Looking southeast near pass 4 miles northwest of Mount McCleery, Englishmans Range. Flat-lying limestone (unit 3c) in upper part of near ridge contrasts with dark argillaceous quartzites typical of unit 3.



M 300

PLATE V A. Albite-gneiss, unit 1e. Note twinned albite porphyroblasts and trains of inclusions parallel to trace of foliation. Crossed nicols, X27.



M 660

PLATE V B. Crenulated biotite-gneiss, unit 1d. Note porphyroblastic nature of biotite flakes, and trains of inclusions parallel with crenulated banding. Crossed nicols, X27.

M 655

PLATE VI A. Crenulated quartz-sericite schist, unit 1a. Showing crenulations of first and part of second order of magnitude. Plane-polarized, X27.

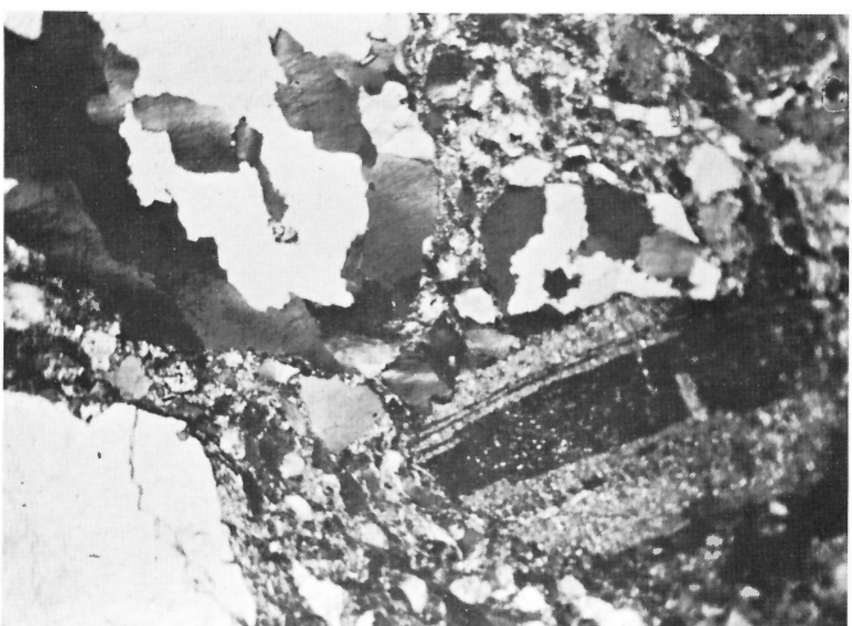


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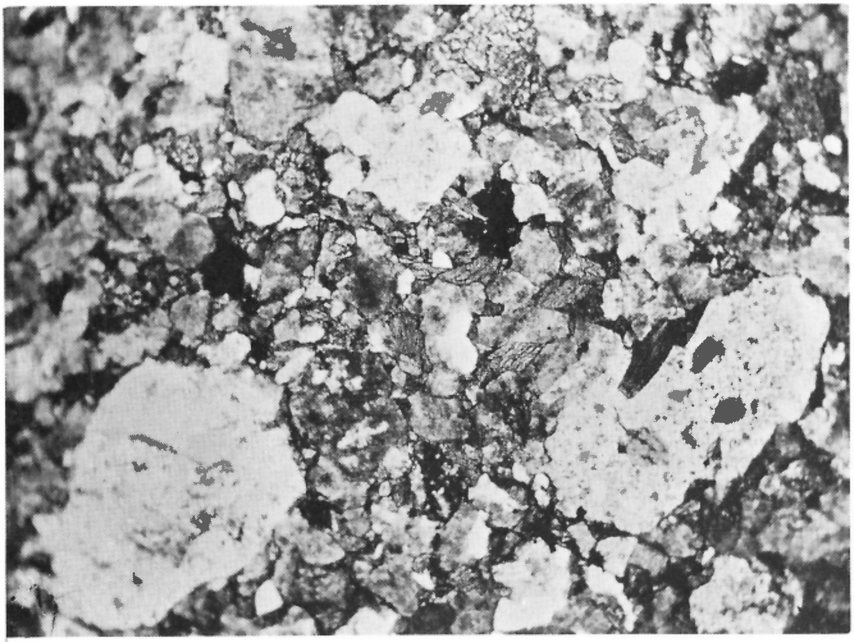
PLATE VI B. Coarse arkose, unit 3. Note composite detrital quartzite grains, and partly altered feldspar. Crossed nicols, X27.

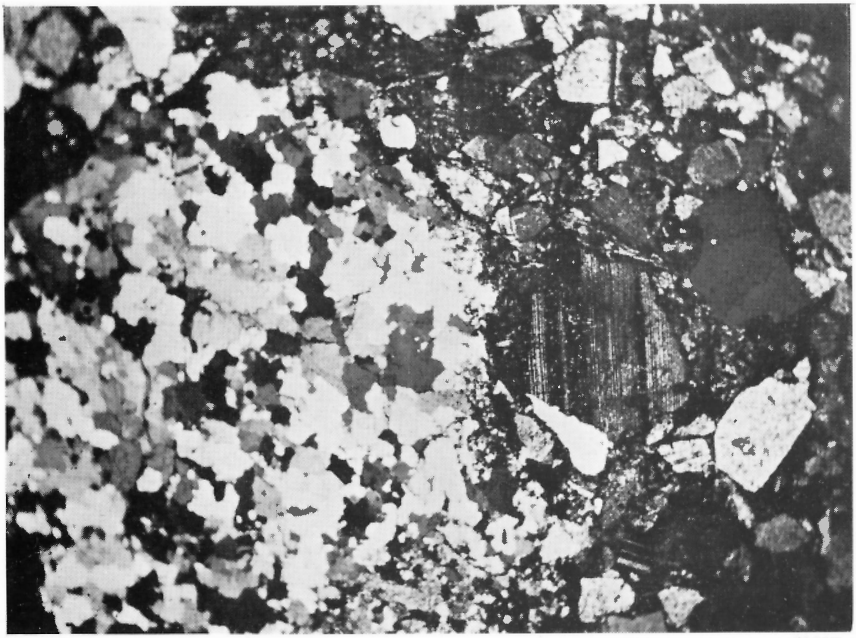


B 147

PLATE VII A. Greywacke of unit 4. Abundant hornblende and lithic fragments. Large grain at upper right is fine granitic feldspar-quartz porphyry. Plane-polarized, X27.

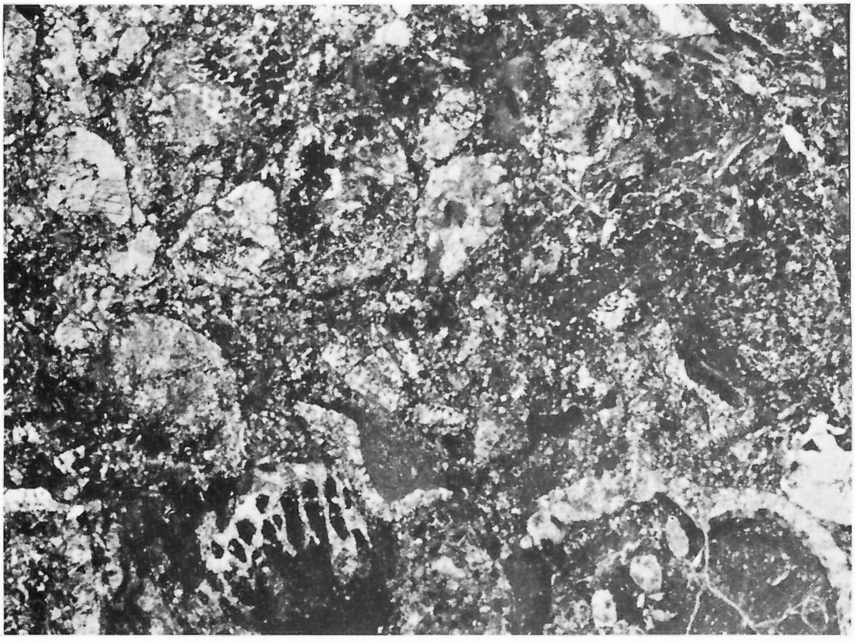
M 121

PLATE VII B. Greywacke of unit 9. Abundant fresh augite and lithic fragments, with quartz, feldspar, and carbonate. Grain at right of centre is quartzitic gneiss. Plane-polarized, X27.



M 137

PLATE VIII A. Arkosic greywacke of unit 9. Note feldspar and quartz fragments and large quartzite grain shown in part at left. Crossed nicols, X27.

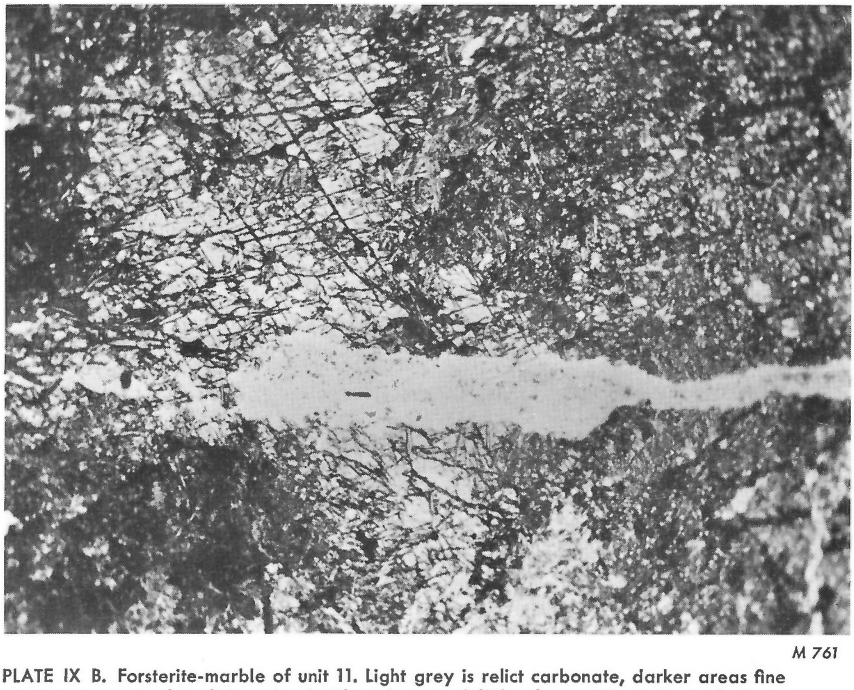


M 759

PLATE VIII B. Calcarenite of unit 9 showing rounded composite carbonate grains. Unpolarized light, X7.

M 13

PLATE IX A. Peridotite, unit 11. Fresh olivine (irregular cracks), and lamellar structure of broken, distorted enstatite grains. Plane-polarized, X27.



M 761

PLATE IX B. Forsterite-marble of unit 11. Light grey is relict carbonate, darker areas fine granular olivine mixed with carbonate. A little of serpentine-talc matrix shows at right of bottom centre. Plane-polarized, X27.

A. Unpolarized, X7.

PLATE X

Chrysotile asbestos vein in peridotite of unit 11. Note sheared fresh olivine among fibres, and bladed antigorite at contact and in diagonal stringer.

M 12

B. Crossed nicols, X27.

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