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Abstract

It is proposed that all strata underlying the Atan Group in Cassiar and Omineca mountains of north-central British Columbia be included in the Ingenika Group (restricted) of the Windermere Supergroup. The Ingenika Group is subdivided into four formations which are, from the base upwards: Swannell, Tsaydiz, Espee and Stelkuz. These can be correlated, using lithostratigraphic criteria, with homotaxial strata in Cariboo Mountains, comprising the Kaza, Isaac, Cunningham and Yankee Belle formations.

In general, the Ingenika Group represents a change in depositional environment similar to that evident elsewhere along the length of the Canadian Cordillera, from deep water clastic sedimentation, in the lower and thickest part, to shallow water clastic and carbonate sedimentation in the upper part. The data seem to be compatible with a concept of a sedimentary wedge constructed along the cratonal margin during late Proterozoic time.

Résumé

On propose que toutes les couches sous-jacentes du groupe d'Atan dans la chaîne des Cassiars et les chaînons Omineca du nord de la région centrale de la Colombie-Britannique soient incluses dans le groupe d'Ingenika (restreint) du supergroupe de Windermere. Le groupe d'Ingenika est subdivisé en quatre formations qui sont, à partir du niveau inférieur: Swannell, Tsaydiz, Espee et Stelkuz. Trois d'entre elles peuvent être mises en corrélation si l'on tient compte des critères lithostratigraphiques et des couches homotaxiques des chaînons Cariboo, incluant les formations de Kaza, d'Isaac, de Cunningham et de Yankee Belle.

En général, le groupe d'Ingenika est représentatif d'un changement dans le milieu sédimentaire, semblable au changement qui se manifeste ailleurs le long de la Cordillère canadienne, depuis la sédimentation clastique en eau profonde, dans la partie inférieure la plus épaisse, jusqu'à la sédimentation clastique et carbonatée en eau peu profonde, dans la partie supérieure. Les données semblent être compatibles avec la théorie du coin de sédimentation formé le long de la marge de l'aire continentale à la fin du Protérozoïque.

INTRODUCTION

Strata of the Upper Proterozoic Windermere Supergroup (Young et al., 1973), are almost continuously exposed the full length of the Canadian Cordillera (Gabrielse, 1972; see Figs. 1 and 2). The supergroup is characterized by a great thickness (commonly more than 3000 m) of impure gritty clastic sediments with numerous quartz- and feldspar-pebble conglomerate units, diamictite that locally forms a basal formation but elsewhere may occur higher in the assemblage, fine grained clastics and, generally in the upper parts, carbonate and minor clean sandstone. Except in southeastern British Columbia where an unconformity with underlying strata of the Purcell (Belt) Supergroup is exposed, the base of the Windermere Supergroup is generally not observable. Commonly, strata immediately overlying the supergroup are orthoquartzites assigned to the Lower Cambrian but in some areas, where basal Lower Cambrian strata are fine grained and argillaceous, a Proterozoic-Paleozoic boundary is difficult or impossible to establish.

Almost invariably Upper Proterozoic rocks are the oldest exposed in the metamorphic culmination of the Omineca Crystalline Belt. There, the metamorphic facies range from low greenschist to amphibolite.

The Windermere Supergroup is of critical importance in the evolution of the North American continent. Similar, homotaxial strata are present in the western United States (Crittenden et al., 1971), and comprise a fundamental element of the depositional record in the southern Appalachian Mountains (King, 1970). Clearly, extensive areas of Pre-Cambrian basement with considerable relief were present along the margins of the craton during deposition of the lower part of the Upper Proterozoic assemblages.

Study of the Winderemere Supergroup in Omineca Mountains was carried out by Mansy from 1970 to 1975 (see Mansy, 1972a, 1972b, 1975). Regional mapping by Gabrielse (1962a, 1962b, 1963) provided data on the stratigraphy and distribution of the rocks in Cassiar Mountains.

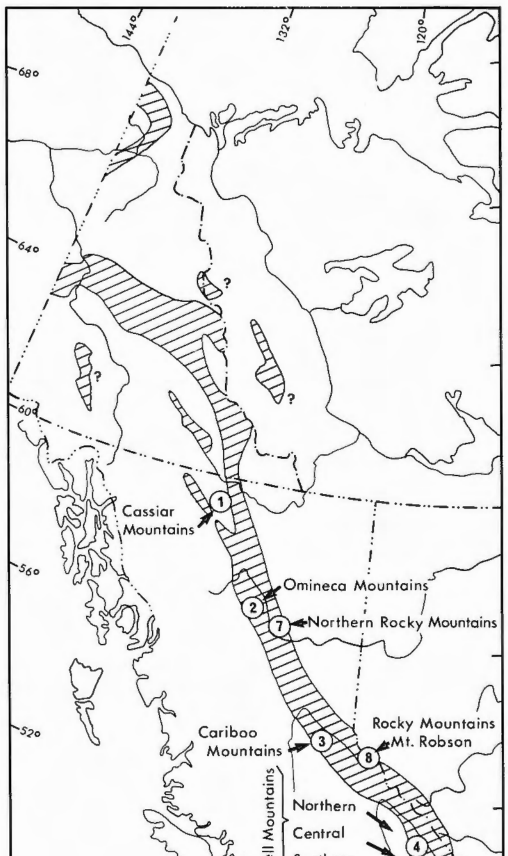


Figure 1. General distribution of the Upper Proterozoic Windermere Supergroup in the Canadian Cordillera.

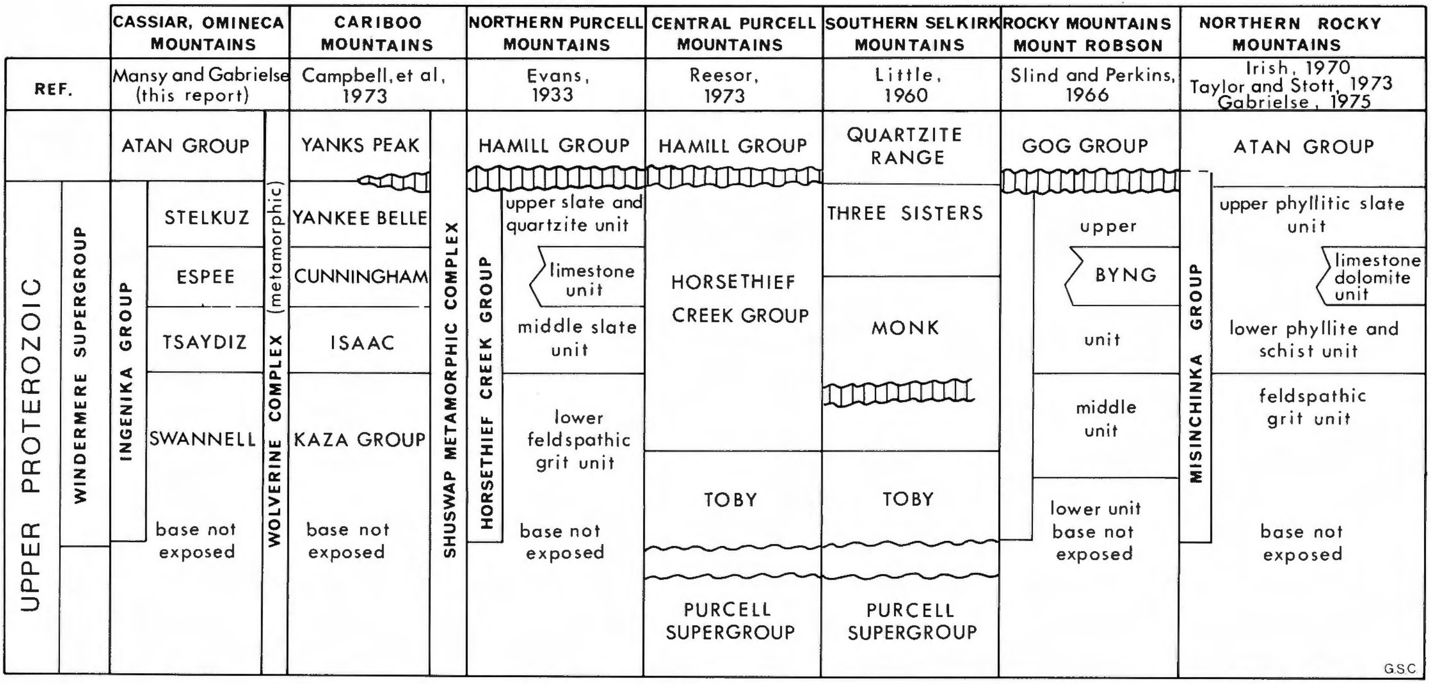


Figure 2. Current and proposed stratigraphic terminology and correlation of the Windermere Supergroup (data in part from Young, Campbell and Poulton, 1973).

PREVIOUS TERMINOLOGY

In the Omineca Mountains, Upper Proterozoic strata have been included in the Ingenika and Tenakihi groups (Roots, 1954), and their highly metamorphosed and granitized equivalents in the Wolverine Complex (Armstrong and Thurber, 1945). Upper Proterozoic strata in northern Cassiar Mountains (Gabrielse, 1963), were assigned to the Good Hope Group. In McDame map-area, Cassiar Mountains, highly metamorphosed strata of probable Late Proterozoic age form the lower part of the Horseranch Group. The Misinchinka Group (Dawson, 1881), east of Northern Rocky Mountain Trench, is at least in part correlative with the Ingenika Group.

PROPOSED TERMINOLOGY

Regional mapping has demonstrated the close similarity in all aspects of Upper Proterozoic stratigraphy throughout Cassiar and Omineca mountains. For this reason it is useful to adopt a consistent regional terminology before local studies result in a proliferation of stratigraphic names.

It is proposed that the name 'Ingenika Group' be retained but redefined. Overlying rocks, formerly included in the group are herein assigned to the Atan and Kechika groups (see Gabrielse, 1963). For mapping purposes, the Tenakihi Group cannot be uniquely defined and is generally indistinguishable from the Ingenika Group, therefore it seems best to abandon the name and include the strata defined as Tenakihi Group by Roots (1954) in the Ingenika Group. The name 'Good Hope Group' should be abandoned also, because in its type area it includes parts of the two upper formations of the Upper Proterozoic assemblage neither of which has been clearly defined. As redefined herein the Ingenika Group, consisting of four formations, comprises all strata underlying the Atan Group in Cassiar and Omineca mountains.

The best and most complete exposures of Upper Proterozoic rocks known in Cassiar and Omineca mountains are in Swannell and Russel ranges between Finlay and Ingenika rivers (see Fig. 3). There, four distinct lithostratigraphic formations have been recognized and can be easily correlated with formations previously mapped in Cassiar Mountains. The formations described and named herein, from oldest to youngest, as the Swannell, Tsaydiz, Espee and Stelkuz formations, comprise the Ingenika Group. It is clear that the terminology used in the type area (Ingenika Group and its constituent formations) can be applied throughout Cassiar and Omineca mountains. Correlations on a larger scale indicate that the assemblage can be readily referred to the Windermere Supergroup overlying rocks of the Purcell (Belt) Supergroup in the Cordillera.

STRATIGRAPHY

Swannell Formation

The oldest recognized formation of the Ingenika Group is named the Swannell Formation after the ranges in which the rocks are best exposed and most extensively developed. The rocks are generally resistant (Fig. 4a) and commonly comprise thick sequences of well bedded but monotonous lithologies. In Swannell Ranges the formation occupies a broad anticlinorium much complicated by several phases of folding and faulting. It is difficult, therefore, to measure a complete section and even an estimate of minimum thickness is suspect. Despite structural complications, however, it seems clear that the rocks are at least 2000 m thick (and may be much thicker), with the base unexposed. A sequence on the northeast limb of the Swannell anticlinorium north of Bower Creek is more than 1100 m thick and comprises three members. The lowest member, 350 m thick, consists of slightly recessive mica schist, impure quartzite, and minor thin carbonate beds, all regionally metamorphosed to garnet grade. An approximate section of the lowest member is given opposite.

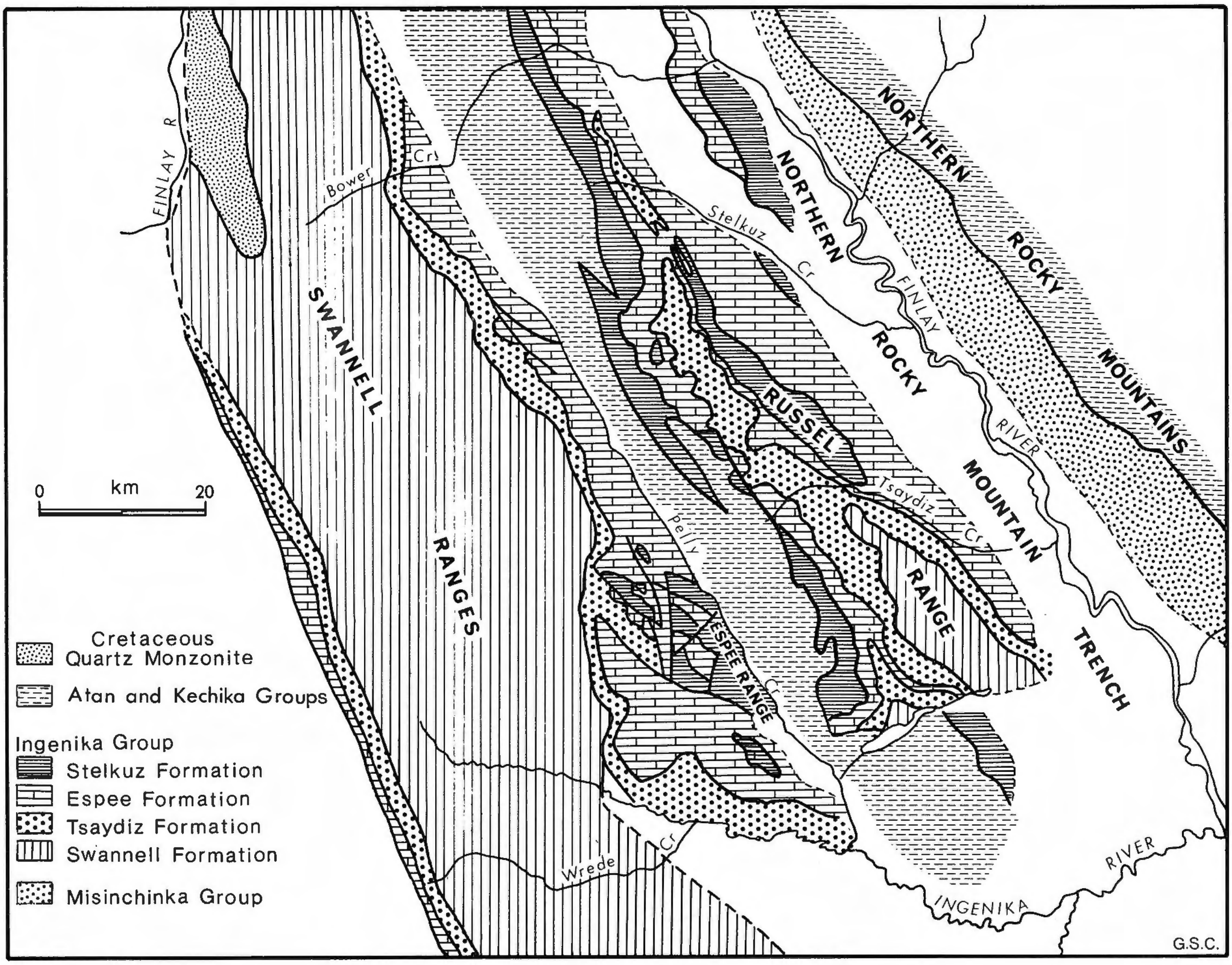


Figure 3. Distribution of Ingenika Group in Swannell and Russel ranges.

Unit	Description	Thickness (metres)	Total from Base (metres)
8	Alternating massive beds (5-6 m) of feldspathic grit and phyllitic schist; feldspar grains are mainly perthite with a maximum length of about 1 mm	100	350
7	Alternating beds of feldspathic grit and muscovite schist; muscovite is tightly crinkled; feldspar includes perthite and plagioclase	150	250
6	Feldspathic grit with calcareous cement	20	100
5	Dolomite, reddish weathering in places	10	80
4	Feldspathic grit	30	70
3	Schist with thin, dark weathering beds of crystalline limestone	10	40
2	Chlorite schist	10	30
1	Schistose crystalline limestone	20	20

Figure 4a

Typical well-bedded monotonous assemblage of Swannell Formation in Swannell Ranges.

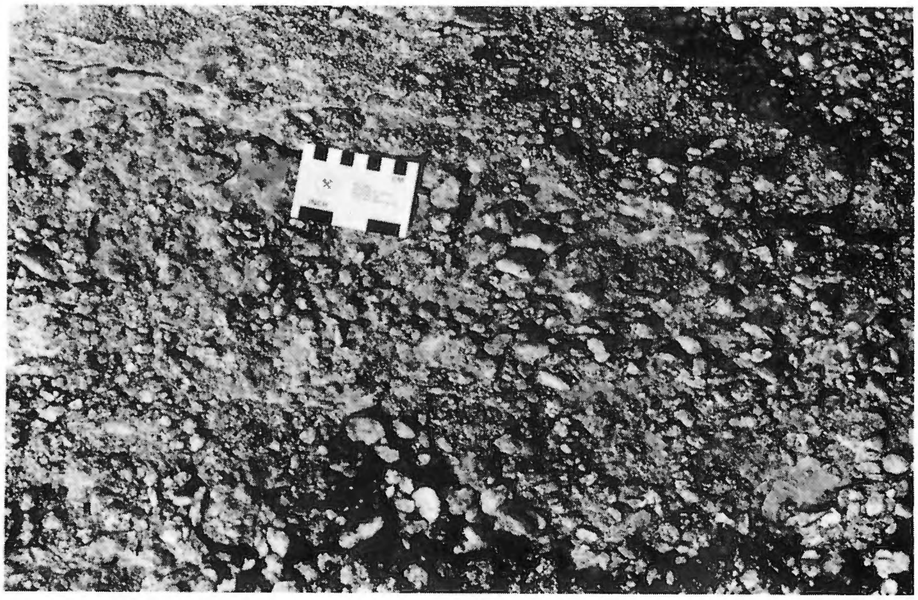


Figure 4b

Microconglomerate in Swannell Formation, Russel Range.

In general, the upper part of the member is more competent than the lower because of a higher proportion of feldspathic grit.

The middle member, about 300 m thick, includes three alternating lithological assemblages. The most abundant is thick-bedded feldspar-quartz pebble conglomerate and conglomeratic sandstone or grit (Fig. 4b). About 70 per cent of the rock consists of opalescent blue quartz grains or pebbles averaging 3 mm in diameter. Perthitic feldspar of about the same grain size comprises 20-25 per cent. Commonly the quartz and feldspar grains are surrounded by a phyllitic matrix imparting a reticulated texture (Michot, 1958) to the rock. Another assemblage consists mainly of green phyllite with quartz grains generally less than 0.1 mm in diameter in a fine grained chloritic and micaceous matrix. The phyllite is strongly cleaved and crenulated. The third and least abundant lithology is crystalline limestone in beds 4 to 5 m thick. Detrital, very fine grained quartz and feldspar are fairly common. The calcite crystals are generally bladed with length to width ratios reaching 5:1. The bladed calcite and muscovite with common orientation result in a well defined schistosity.

The uppermost member of the Swannell Formation, transitional with underlying strata, is a succession of grey quartzite, phyllite and minor limestone about 400 m thick. The quartzite is mainly impure and has a phyllitic or calcareous matrix. Feldspar constitutes less than 5 per cent of the rock and tourmaline is an abundant accessory mineral. Grey and green crenulated phyllite interbedded with quartzite, contains variable amounts of quartz and feldspar. Laminae of quartz grains are commonly present in limestone beds.

In the southern Swannell Ranges metamorphism locally reaches kyanite grade, and elsewhere, as in Wolverine Range, pegmatite is abundant. Where metamorphism has been so intense that the original lithology and stratigraphy is in doubt, the rocks are assigned to the Wolverine Complex.

In Russel Range only the upper part of the Swannell Formation is exposed. There, a conglomeratic facies contains clasts of well rounded quartzite and argillaceous limestone as much as 7 cm long. Roots (1954) described conglomerate in Russel Ranges with clasts of quartzite more than 10 cm in diameter. The coarsest conglomerate yet noted was described by Roots (1954) and occurs in Swannell Ranges south of Ingenika River. The clasts include rounded boulders of coarse grained, foliated granitic rock of acidic to intermediate composition up to 20 cm in diameter.

The general character of the Swannell Formation suggests derivation from an eastern cratonal crystalline basement. Sedimentary structures are not abundant but ripple marks and cross-beds indicate southwesterly and westerly transport (see Fig. 5). Some of the coarser beds show graded bedding and perhaps they may have been deposited by turbidity currents. Relatively deep water deposition, at least below wave base, is suggested by the poor sorting of most units. The origin of the thin limestone units is not clear because original textures have been completely masked by recrystallization. Most likely, however, they represent detrital beds derived from an easterly shelf or platform source. The presence of detrital quartz and feldspar as thin laminae in the limestones supports this contention.

Correlation. On the basis of lithology and stratigraphic position, the Swannell Formation can be correlated with the lower part of the Horsethief Creek Group in northern Purcell Mountains, the Kaza Group in northern Cariboo Mountains, and the middle unit of the Miette Group in Rocky Mountains (Young et al., 1973; see Fig. 2). To the north in Cassiar Mountains, the formation outcrops at least as far north as northwestern Kechika map-area (Gabrielse, 1962a). Just southeast of Moodie Creek (Fig. 6), bluish quartz-pebble conglomerate and quartzite with clasts of opalescent quartz to 7 cm long, comprise a member about 35 m thick. In contrast to the Swannell Ranges localities, the conglomerate is enclosed in a much more calcareous assemblage that includes members of well bedded crystalline limestone, generally micaceous, as much as 50 m thick. Correlative strata may be present in northernmost Cassiar Mountains in south-central Yukon Territory (Tempelman-Kluit, pers. comm., 1975).

Tsaydiz Formation

This formation derives its name from the creek along which the rocks are best exposed in the core of Russel Range. It is also well exposed on the northeast of Swannell Ranges west of Pelly Creek. The rocks are dominantly strongly crenulated and cleaved, thin bedded, sericitic, glossy, grey phyllites (Fig. 7) with minor beds of limestone and fine grained quartzitic grit containing lenses of black limestone as much as 4 or 5 cm long. Generally the upper part is more calcareous than the lower, and platy, thin bedded limestone grades into overlying carbonates of the Espee Formation. Locally, interbedded thin beds of limestone and phyllite impart a distinctive striped appearance to the rock (Fig. 8). The Tsaydiz Formation is gradational with the underlying Swannell Formation and the mapped boundary between them is drawn at the top of the uppermost resistant beds of the Swannell Formation.

Typically, strata of the Tsaydiz Formation are highly deformed, and this characteristic combined with recessive weathering makes it difficult to measure stratigraphic sections. Estimates of total thickness range up to 185 metres.

The Tsaydiz Formation was deposited in a quiet environment, below wave base and remote from significant sources of coarse detritus. In view of the character of the overlying rocks (shallow water carbonate), the Tsaydiz interval represents one of major decrease in relief of the source area, as well as one of decreasing water depth in the depositional basin within Cassiar and Omineca mountains.

Correlation. Exposures of the Tsaydiz Formation are fairly widespread in the south-central part of Kechika map-area. Southwest of Kechika Ranges the rocks are regionally metamorphosed to sericitic and muscovitic phyllite and schist. In Kechika Ranges, however, little metamorphosed greenish grey to brown, locally sandy, phyllitic shale, in part calcareous and interbedded with grey, fine grained limestone beds 2 to 5 cm thick, is exposed in the core of an anticline extending southeasterly from Frog River. In places, limestone comprises about half of sequences as much as 8 m thick. The calcareous shales in the Kechika area appear to grade upward into thicker bedded carbonates of the overlying Espee Formation.

As with the underlying Swannell Formation, Tsaydiz strata southeast of Moodie Creek in Kechika Ranges (Fig. 6), seem to be much more calcareous than those noted in the type area. Near Moodie Creek, silver-grey, crenulated, calcareous phyllitic schist and micaceous and chloritic crystalline limestone are dominant lithologies. No other significant outcrops are known farther northwest in Cassiar Mountains.

The Tsaydiz Formation is a lithostratigraphic correlative of the Isaac Formation in Cariboo Mountains, and part of the upper Miette Group in Rocky Mountains (Young et al., 1973).

Espee Formation

The Espee Formation is the oldest distinctive carbonate unit exposed in the miogeoclinal assemblage west of northern Rocky Mountain Trench. The name is derived from the Espee Range, a small mountain block along the northeast side of Swannell Ranges. There the formation is best exposed (Fig. 9) although facies contrasts with other areas preclude any particular locality from being considered typical. Excellent sections can also be studied in many places in Russel Range. Contacts with the underlying Tsaydiz Formation and the overlying Stelkuz Formation are generally gradational but locally sharp.

In general, the Espee Formation is a resistant, thick bedded limestone assemblage underlying relatively high topography compared to the markedly recessive weathering, underlying Tsaydiz Formation and the less resistant overlying Stelkuz Formation. Pisoliths and ferrodolomite particles are abundant in many beds of the formation throughout the Cassiar — Omineca region. Several measured sections in Espee and Russel ranges illustrate the main characteristics and variations of lithology (see Figs. 10a and 10b).

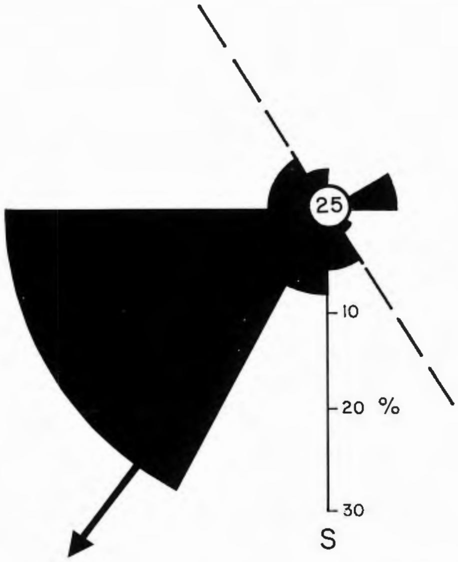


Figure 5. *Rose diagram showing paleocurrent directions derived from cross-beds in the Swannell Formation. Dashed line represents average trend of ripple marks at three localities.*

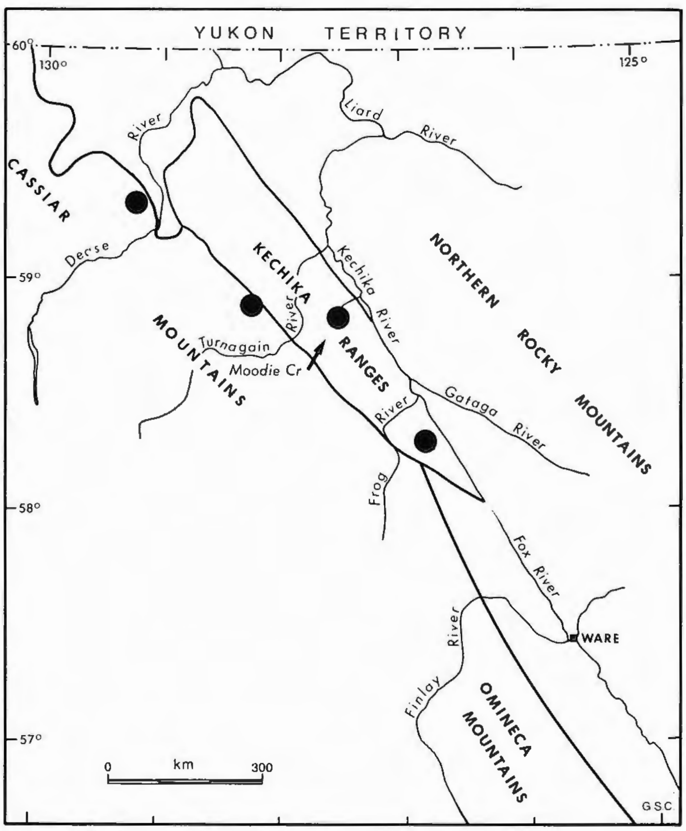


Figure 6. *Index map showing locations of well exposed strata of Ingenika Group (circles) in Cassiar Mountains, British Columbia.*

Figure 7. *Tightly folded shale of Tsaydiz Formation.*

Figure 8. *Striped, thin-bedded phyllite and limestone (light colour) in uppermost part of Tsaydiz Formation near Pivot Peak.*

Section in Espee Range conformably overlying Tsaydiz Formation (Fig. 10a, section 2)

Unit	Description	Thickness (metres)	Total from Base (metres)
12	Limestone, detrital, oolitic, strongly recrystallized; detrital clasts flattened and have a dark rim with grains less than 0.02 mm thick and a core with a grain size 0.05 to 0.08 mm in diameter; matrix is microsparite	60	408
11	Limestone, grey; recessive, micritic with microcrystalline intraclasts to 0.4 mm in places corroded by the matrix	50	348
10	Limestone, massive microsparite, detrital fraction corroded by calcite matrix	8	298
9	Limestone, recessive, oolitic and recrystallized	5	290
8	Limestone, blue-grey weathering, massive	5	285
7	Limestone, yellow-buff weathering, recessive; intraclasts of limestone locally oxidized in a microsparite matrix	10	280
6	Limestone, massive to medium bedded and mauve weathering; micrite and microsparite matrix; intraclasts of limestone common	45	270
5	Limestone, recessive and yellow weathering, medium bedded; clasts of limestone to 3 mm in a micritic and sparite matrix; clasts outlined by a thin oxidized film	25	225
4	Limestone, massive, violet weathering; beds 0.6 to 0.8 m; contains little if any detrital material	30	200
3	Limestone, recessive, weathers with tints of yellow and maroon; beds range from 0.6 to 0.8 m.	70	170
2	Limestone, massive, ivory weathering; micritic matrix mainly recrystallized to microsparite and sparite; some rounded limestone clasts	40	100
1	Limestone, recessive and yellow weathering; beds 0.8 to 1 m; clasts of limestone (microsparite) to 2 and 3 mm in diameter	60	60

The assemblage described above is considerably thicker than that observed east of Pelly Creek in the Russel Range. Ooliths and detrital intraclasts of limestone are particularly abundant in the Espee Range section. In addition, the presence of yellow weathering recessive members in Espee Range is distinctive. A well exposed section of the Espee Formation in Russel Range (Fig. 10b) was measured north of Russel Creek and is given below (Fig. 10a, section 8):

Unit	Description	Thickness (metres)	Total from Base (metres)
10	Limestone and green phyllite in sharp contact with overlying Stelkuz Formation	10	134
9	Dolomite, lenticular assemblage of reddish dolomite ranging from 0-15 m	15 (max.)	124
8	Phyllite, green	5	109
7	Limestone, cryptalgal (Aitken, 1966); grey weathering with reddish bedding surfaces; local dolomitization with euhedral dolomite crystals 0.6 to 1.5 mm	15	104
6	Phyllite, green	3	89
5	Limestone, blue-grey weathering; with undulating discontinuous, nonparallel laminae; ovoid bodies 2 to 3 mm in diameter deform the laminae (possibly organic?)	5	86
4	Phyllite, green and beige quartzite	50	81
3	Limestone, blue-grey weathering and thinly bedded	15	31
2	Limestone, blue-grey weathering; stromatolitic, stromatolites consist of undulating laminae forming rectangular structure about 10 cm across (Fig. 12)	6	16
1	Limestone, beds 2 to 8 cm; interbedded with minor silvery phyllite	10	10
	Conformably overlies Tsaydiz Formation		

A stratigraphic section near Pivot Peak in eastern Russel Range shows further variations in thickness and lithology of the Espee Formation (Figs. 10b, 10a, section 7):

Unit	Description	Thickness (metres)	Total from Base (metres)
	Overlain conformably by Stelkuz Formation		
9	Limestone, blue-grey weathering in beds averaging about 5 cm	60	291
8	Limestone, yellow weathering; interbedded with green phyllite	25	231
7	Limestone, blue-grey weathering; beds 7 to 10 cm thick with many thinner beds; contains very little detrital material	30	206
6	Phyllite, green feldspathic; feldspar grains corroded by calcite	10	176
5	Limestone, blue-grey in beds 10-20 cm thick; recrystallization has produced a lamellar schistosity; locally quartz in subarkose displays a polygonal texture characteristic of the triple point (Spry, 1969) showing the extent of recrystallization; the grains range in length to width ratio from 1 to 10; recrystallization has left only minor inclusions of the original calcitic matrix	55	166
4	Phyllite, green with subarkose; perthitic feldspar and albite much altered; ankerite is common and corrodes grains of quartz	6	111
3	Limestone, blue-grey weathering, massive and contains detrital quartz and feldspar; near middle of units beds 2 or 3 cm thick consist of subarkose in a calcite matrix	50	105
2	Limestone, yellow weathering, massive; fairly abundant fine grained quartz and feldspar detritus; muscovite occurs on planes of schistosity	40	55
1	Limestone, coarse grained; detrital grains of quartz and feldspar comprise as much as 10 per cent; euhedral, authigenic feldspar present locally	15	15

The thickness of the Espee Range assemblage and its abundant oolites and intraclasts suggest a more rapidly subsiding carbonate shelf than the condensed stromatolitic and dolomitic carbonate in the Russel Creek locality. Further variations in facies of the Espee Formation have been noted northeast of Russel Range and at localities farther southeast, just west of northern Rocky Mountain Trench. There, carbonate of the Espee Formation is entirely dolomite, in part laminated and orange-buff to cream weathering. Thus, in a southwesterly direction, the strata change facies from dolomite and stromatolitic dolomite to limestone and sandy limestone to oolitic and coarsely detrital limestone (see Fig. 14). On this evidence it can be postulated that the Espee Formation in Russel and Espee ranges was deposited on a southwesterly inclined paleoslope.

Near the north end of a narrow belt of carbonate rocks on the west-southwest side of Swannell Ranges a lower unit about 35 m thick of blue-grey weathering limestone overlies about 35 m of fairly massive dolomite. The rocks are recrystallized and deformed so that useful sedimentary features have been mainly obliterated. The assemblage seems to be much thinner than that to the east. Farther south but still north of Ingenika River the following sequence was measured:

Unit	Description	Thickness (metres)	Total from Base (metres)
	Fault contact with Upper Paleozoic or Triassic rocks		
6	Limestone, white, dolomitic; reddish where dolomitized; dolomite markedly transgressive to bedding	50+	65+
5	Limestone, thin bedded, maroon	1	15
4	Limestone, pale blue-grey	2	14
3	Shale, grey, pyritic	5	12
2	Limestone, fine grained	4	7
1	Quartzite, bright maroon weathering	3	3
	Transitional contact with Tsaydiz Formation		

Figure 9. Thick- and thin-bedded limestone of Espee Formation in Espee Range overlain by dark weathering Stelkuz Formation on extreme left.

South of Ingenika River on the southwest side of Russel Ranges the Espee Formation locally appears to be about 100 m thick. The uppermost carbonate assemblage, in fault contact with Upper Paleozoic or Triassic rocks, comprises between 50 and 60 m of blue-grey limestone in beds 5 to 20 cm thick overlying 10 m of thin bedded strongly recrystallized limestone. The lower part of the sequence includes highly folded grey limestones with as much as 50 per cent detrital quartz and feldspar. Phyllitic beds are conspicuous in the lower part and interbedded limestone and shale, with a quartzite unit 3 m thick, forms a transitional sequence with the underlying Tsaydiz Formation.

Another section, southeast of the one described above, is dominated by calcareous shale and includes about 35 m of limestone in an assemblage 95 m thick. Thus, in comparison with correlative sequences farther east and north the Espee strata on the west flank of Swannell Ranges south of Ingenika River are much thinner and more argillaceous. These data suggest somewhat deeper water to the southwest during at least part of the period during which the strata were deposited and are consistent with the concept of a generally westerly to southwesterly inclined paleoslope indicated by lithological variation in Russel and Espee ranges.

Correlation. In south-central Kechika map-area (see Fig. 6), carbonate strata of the Espee Formation are similar to those in the type area. A section in southeastern Kechika Ranges is apparently more than 300 m thick. It contains the distinctive mauve, cryptograined limestone of the Espee section. In addition, buff-orange weathering particles of ferrodolomite are ubiquitous.

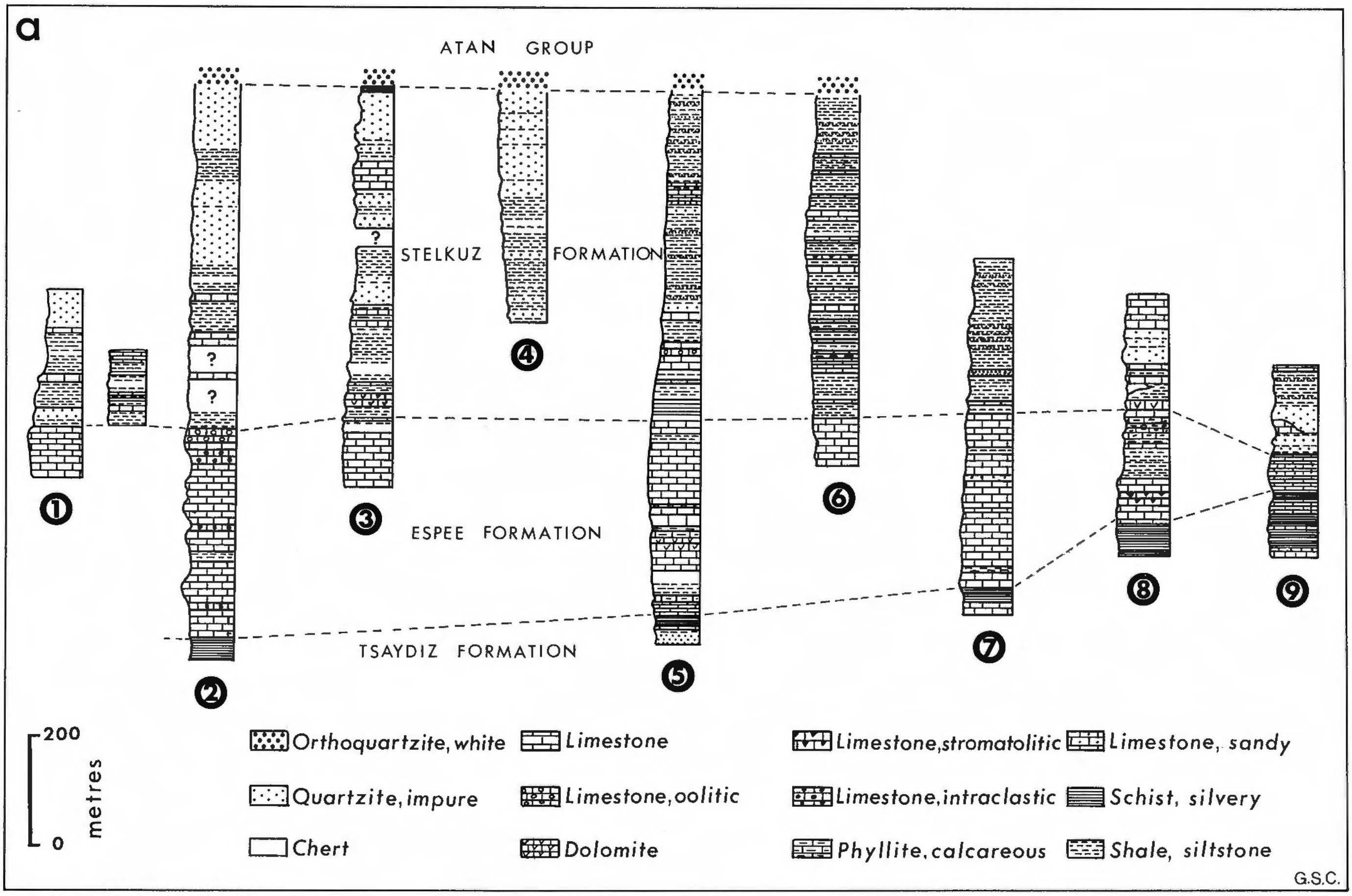
In the McDame area north of Dease River in Cassiar Mountains, the Espee Formation is well developed (see Gabrielse, 1963), and was included in the lower part of the Good Hope Group, a name which should be abandoned. Characteristic lithologies include well bedded limestone with abundant specks of ferrodolomite. Pisolitic and oolitic limestone is particularly widespread.

Coarsely crystalline limestone considered to be correlative with the Espee Formation is included in a metamorphic assemblage north of Turnagain River, in northeastern Cry Lake map-area (Gabrielse, 1962a). In north-central Kechika map-area near Moodie Creek about 185 m of grey-white, fine- to medium-grained crystalline limestone and minor dolomite of the Espee Formation is interbedded with much less abundant calcareous shale and phyllitic slate.

The Espee Formation is a lithostratigraphic correlative of the Cunningham Formation in Cariboo Mountains (Campbell et al., 1973). There, facies changes from dolomite to limestone, and greater thickness to the west (ranging from 150 to about 600 m) represent a polarity of sedimentation similar to that in Omineca Mountains. Correlation with the Byng Formation in Rocky Mountains seems probable (Young et al., 1973).

Stelkuz Formation

This formation, the youngest of the Precambrian assemblages in Cassiar and Omineca mountains, derives its name from Stelkuz Creek in Russel Range where the rocks are typically developed. The formation is characterized by a wide variety of varicoloured lithologies including distinctive green and maroon members, which alternate more or less regularly in vertical sequence (see Figs. 10a, 13, 15). Generally three units of unequal thickness can be recognized. The first and lowest can be subdivided into members consisting mainly of limestone, pelite, and sandstone; the second consists essentially of pelite and lenses of fine grained sandstone in places capped by a fairly thick limestone member; the third comprises pelite and sandstone, the latter more abundant upwards in the succession. The Stelkuz Formation is in sharp contact with the basal sandstone of the overlying Atan Group and is in gradational and, locally in sharp contact with limestone of the underlying Espee Formation.



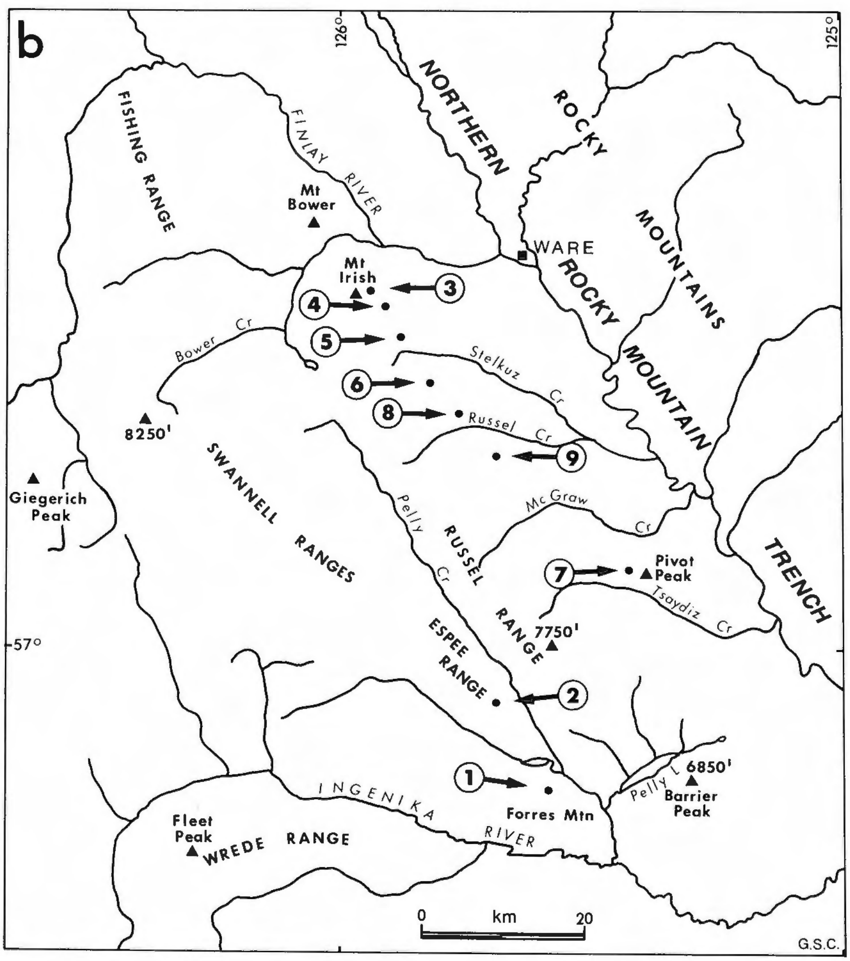


Figure 10

a. *Columnar sections of Espee and Stelkuz formations in Swannell and Russel ranges.*

b. *Location of columnar sections in (a).*

The type section of the Stelkuz Formation just north of the headwaters of Stelkuz Creek is described below with the three units subdivided into members (Fig. 10a, section 5).

Unit		Description	Thickness (metres)	Total from Base (metres)
		Overlain by clean white quartzitic sandstone assigned to the Atan Group		
C.	2	Shale, green, interbedded with numerous beds of white to maroon weathering fine grained sandstone and siltstone up to 0.5 m thick; quartz is strongly recrystallized	20	284
	1	Shale, green, interbedded with minor fine grained sandstone and siltstone; matrix of the clastics is either phyllite or carbonate; cleavage folds are present in shales but do not involve sandstone beds	70	264
B.	5	Dolomicrosparite, contains faintly outlined particles of micritic dolomite	1	194
	4	Limestone, recrystallized with sparitic texture, interbedded with green shale	11	193
	3	Shale, green and quartzitic siltstone	20	182
	2	Shale, distinctive grey to green containing quartz grains; siltstone, violet, containing quartz grains to 0.01 mm; siltstone, grey-green with flattened limestone grains	25	162
	1	Sandstone and green shale interbedded; sandstone is fine grained and subarkosic, clasts corroded in calcareous matrix	20	137
A.	21	Limestone, detrital	4	117
	20	Sandstone, shale, siltstone, green weathering and interbedded with grey limestone; beds are less than 50 cm	20	113
	19	Limestone (sparite), includes detrital quartz (15 per cent) and feldspar (7 per cent)	10	93
	18	Limestone, well bedded, contains numerous ankeritic intraclasts; intraclasts are commonly moulded by sparitic matrix	10	83
	17	Limestone (microsparite), includes about 40 per cent fresh detrital quartz and feldspar grains to 1.5 mm in upper part	3	73
	16	Sandstone, quartzitic; quartz grains (1 mm) surrounded by microcrystalline quartz	4	70
	15	Shale, green	4	66
	14	Sandstone, fine grained	2	62
	13	Shale, basal part distinctive grey-green	3	60
	12	Shale and sandstone, yellow	2	57
	11	Sandstone, quartzitic and well bedded	2	55
	10	Limestone, sparitic matrix, contains about 30 per cent detrital quartz and feldspar commonly corroded by calcite; minor shale in upper part	6	53
	9	Sandstone, maroon	1	47
	8	Limestone, blue-grey	2	46
	7	Shale and sandstone	3	44
	6	Limestone, blue-grey	3	41
	5	Sandstone, calcareous	2	38
	4	Limestone (microsparite) contains minor detrital quartz and numerous intraclasts of ankerite	20	36
	3	Shale and sandstone	4	16
	2	Limestone, blue-grey, upper part includes much detrital sand interbedded with shale	10	12
	1	Shale and sandstone, green	2	2
		Conformable(?) contact with Espee Formation		

Two sections were measured in basal parts of the Stelkuz Formation near Russel Creek at localities where the underlying Espee Formation is relatively thin and generally of shallow water facies (see Fig. 10a, sections 8, 9). South of Russel Creek, a sequence 78 m thick comprises about 40 m of green and white weathering sandstone. The remainder is mainly interbedded green shale and sandstone with about 5 m of recrystallized limestone. North of Russel Creek a basal assemblage of shale about 10 m thick is overlain by a sequence including 23 m of blue-grey limestone, much of which has cryptalgal structure; 40 m of quartzitic sandstone, in part calcareous and maroon weathering with well developed cross-bedding locally; 20 m of green shale and quartzitic sandstone and 10 m of interbedded shale and carbonate. Many of the sandstone beds are lenticular.

The two basal sequences described above contrast markedly with the basal part in the type area. In particular, the relative abundance of sandstone displaying lenticular units, cross-bedding, and abrupt contact with underlying Espee Formation characterize the Russel Creek sections.

Further lithological variations in the lower part of the Stelkuz Formation are illustrated by the section near Pivot Peak (Fig. 10a, section 7).

Unit	Description	Thickness (metres)	Total from Base (metres)
	Top of sequence eroded		
10	Shale, green; a few interbeds of quartzite	35	284
9	Siltstone, quartz and feldspar grains; slightly calcareous phyllite; interbedded with 20 per cent green shale	20	249
8	Shale, green	50	229
7	Quartzite, green; includes 15 per cent markedly schistose phyllite; strongly recrystallized imparting a texture indicative of a triple point (Spry, 1969)	30	179
6	Shale and siltstone, green; minor quartzite; markedly schistose	40	149
5	Shale and siltstone, bright green; much chlorite and strongly schistose	25	109
4	Quartzite	4	84
3	Shale and siltstone, green	55	80
2	Limestone, yellow	5	25
1	Shale, green; minor quartzite	20	20
	Conformable with Espee Formation		

A very thick assemblage of the Stelkuz Formation overlies a thick section of the Espee Formation in Espee Range. Each of the three units noted in the type area can be recognized. A generalized section is given below (Fig. 10a, section 2).

Unit	Description	Thickness (metres)	Total from Base (metres)
C. 8	Quartzite, white and maroon, minor interbedded phyllite; recrystallized with polygonal textures indicating a triple point (Spry, 1969); arbitrary contact (conformable) with overlying white quartzitic sandstone assigned to the Atan Group	130	633
7	Shale, green with silty sandstone	70	503
6	Quartzite, medium grained, in part feldspathic; matrix is phyllitic; minor beds of phyllite; contains bifurcating burrows about 1 cm in diameter	90	433
5	Quartzite, thick bedded; coarse grained sandstone with calcite matrix; grain-size of quartz between 1 and 2 mm; mono or polycrystalline quartz characterized by recrystallization of periphery; sparitic matrix is oxidized and contains a great number of broken oolites	10	343
4	Dolosparite, oolitic; only outer shell of oolites can be distinguished; consists of dolomicrite; some structures appear to be oncolites	3	343
3	Quartzite, in part subarkosic, locally with carbonate matrix or microcrystalline quartz	50	330

Unit	Description	Thickness (metres)	Total from Base (metres)
2	Quartzite, beds 5 to 40 cm thick interbedded with shale and siltstone	40	280
1	Shale, green, upper part contains much orthoquartzite	25	240
2	Limestone, blue-grey at the base and violet near the top, very well bedded; locally oolitic; textures micritic to microsparitic	15	215
1	Phyllite, bright green and purple; abundant fine grained quartz, form a distinctive member throughout the region; upper part is green shale with minor fine grained siltstone	70	200
2	Limestone, interbedded with shale and quartzite; ranges from intraclastic cryptagal to detrital, and from thin to thick bedded; in part distinctive purple and green beds 2 to 10 cm thick	30	130
1	Siltstones, green, in beds 10 to 30 cm thick interbedded with limestone and bluish sandstone in beds several cm thick; sandstone is subarkosic and fine to very fine grained with reticulated texture and a sparitic matrix; rhythmic sequences comprise quartzite-impure limestone-siltstone; rocks are highly recrystallized with calcitic matrix in grains 0.5 to 0.6 mm; detrital clasts rarely exceed 0.1 mm	100	100

The Espee Range section with its abundance of oolitic beds, oncolites and coarse, locally conglomeratic detrital limestone indicates a high energy environment of deposition in shallow water. Some of the limestone units have a pseudonodular lithofacies (Cayeux, 1935; Lombard, 1972), which prior to deformation may have consisted of rose, micritic material, interbedded with bright red argillaceous laminae. Deformation of this assemblage has resulted in the present nodular structure. Striae on slip planes, locally noted on phyllitic laminae, support this hypothesis.

In the distinctly coloured red and green limestones the transition from one colour to another is generally sharp, although in places there is a bleached transitional zone. In thin section no notable differences can be detected in the transitional rock. Lienhardt (1963) and Perriaux (1974) have shown that the colour does not depend on the total content of iron but on the value of the coefficient of oxidation-reduction. Thus, a red coloration reflects a relatively high coefficient and not necessarily an exceptionally high total iron content. If, as Lienhardt and Perriaux believe, the red pigment is derived from the source area, the red sediments did not encounter a reducing environment during transport or deposition, and the coloration should be traceable from the source area to the outcrops seen today. Interestingly, west of Pelly Creek (and elsewhere in Cassiar Mountains), red and green phyllite and carbonate are present, whereas east of the creek, beds of phyllite have the same colours. The colorations maintain a remarkable similar stratigraphic level.

Summary. The Stelkuz Formation in Omineca and Cassiar mountains can be readily subdivided into three major units. The greatest diversity is present in the basal assemblage with three main types as follows (see Fig. 16):

1. Basal, thick bedded, locally lenticular, coarse grained, green quartzitic sandstone with lenticular units of limestone, dolomite and green shales – exemplified by Russel Creek sections.

2. Well bedded (beds on a scale of centimetres) interbedded green shale, siltstone, fine- to medium-grained sandstone, and limestone, locally sandy and, in places, intraclastic – best seen in the type area near Stelkuz Creek.

3. Interbedded siltstone, shale and sandstone – near Pivot Peak.

Less variation is noted in the middle assemblage. It consists essentially of green shales interbedded with beds of purple and grey-green siltstone. The upper unit comprises shale, siltstone and limestone, the relative amounts of which vary from place to place. Near Mount Irish shale and siltstone predominate, whereas sandstone is more important in the central and southern parts of Finlay Ranges.

The general character of the Stelkuz Formation indicates mainly shallow marine to possibly fluvial environments of deposition. Carbonate in the formation locally resembles that in the Espee Formation but generally contains more detrital quartz and feldspar. The influx of quartz and feldspar during Stelkuz time is in contrast with the dominantly shale and carbonate deposition that formed the Tsaydiz and Espee formations, respectively, and heralds the voluminous introduction of sand that constitutes the lower part of the overlying Atan Group.

Paleocurrent data (Fig. 17) and the predominance of quartzite and dolomite to the northeast suggest a north-easterly source direction. This is in accord with conclusions presented on source areas for the Swannell and Espee formations.

Correlation. Red beds of the Stelkuz Formation constitute an excellent marker in the Cassiar Mountains. Near Dease River in McDame map-area (Gabrielse, 1963), red, rose and green limestone, slate and laminated siltstone from 60 to 80 m thick contain chip breccias and mudcracks, and locally have a pseudonodular texture. The red beds can be followed discontinuously to the southeast as far as Kechika River in Kechika map-area (Gabrielse, 1962b). Red and green shales and phyllite at about the same stratigraphic level are widespread in areas underlain by the Windermere Supergroup in northern Rocky Mountains and east of Tintina Trench in southeastern Yukon Territory (Gabrielse, 1972). Throughout the region the remainder of the Stelkuz Formation is similar to that in the Espee Range assemblage in Omineca Mountains. Southeast of Frog River pisolitic carbonates are common and in several places sandy limestone displays well developed cross-bedding on a scale of up to 10 cm. There, also, platy, well bedded to laminated green siltstone and fine grained sandstone is abundant.

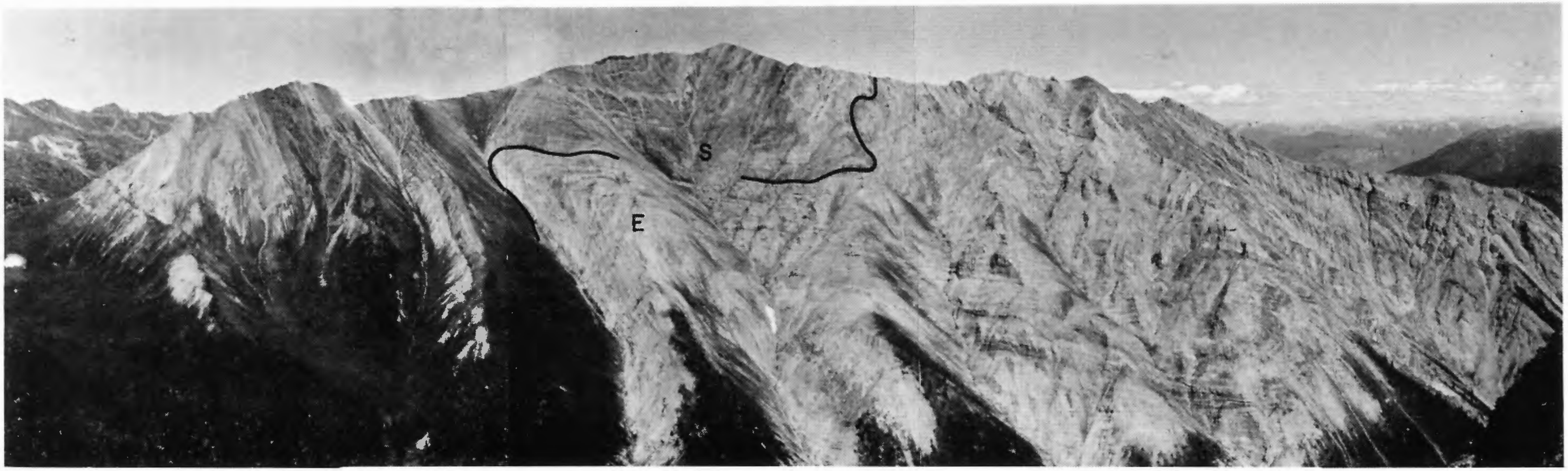


Figure 11. View northerly to Espee (E) and Stelkuz (S) formations north of Stelkuz Creek in Russel Creek.

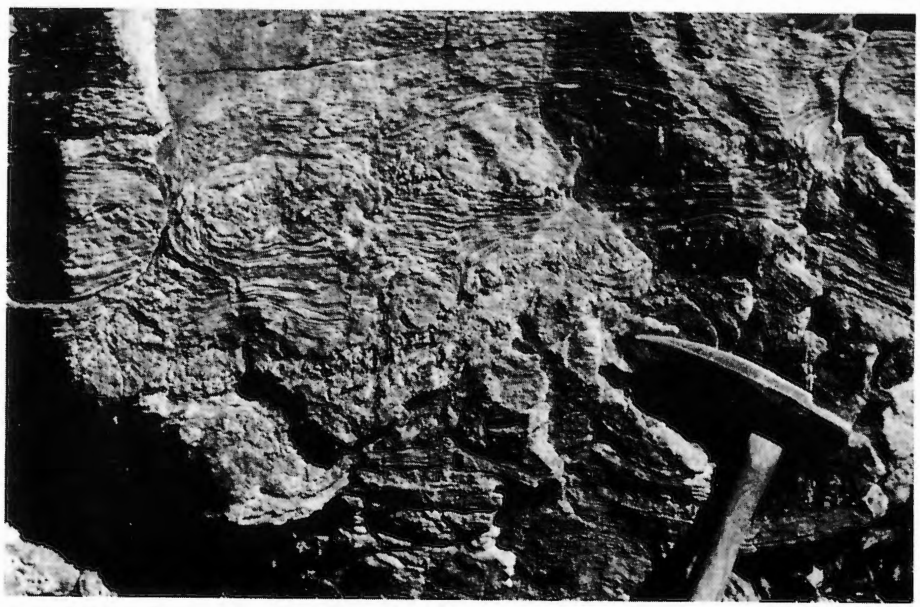


Figure 12

Algal structures in limestone of Espee Formation north of Russel Creek.

Figure 13

Cyclical sandstone, shale and limestone beds in lower part of Stelkuz Formation, northern Russel Range.

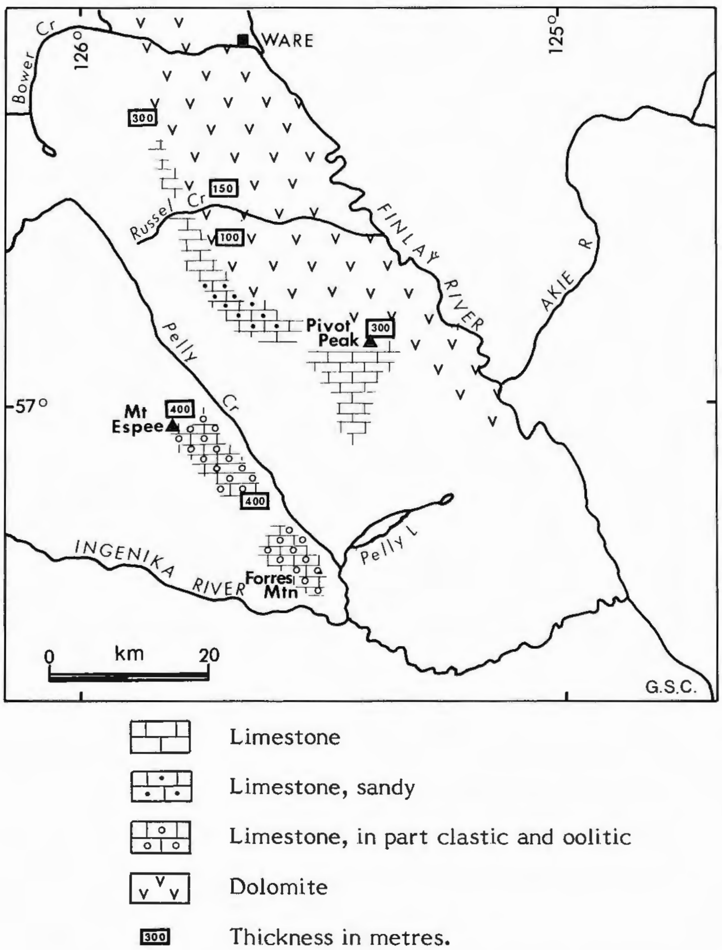


Figure 14. Facies and thicknesses of the Espee Formation.

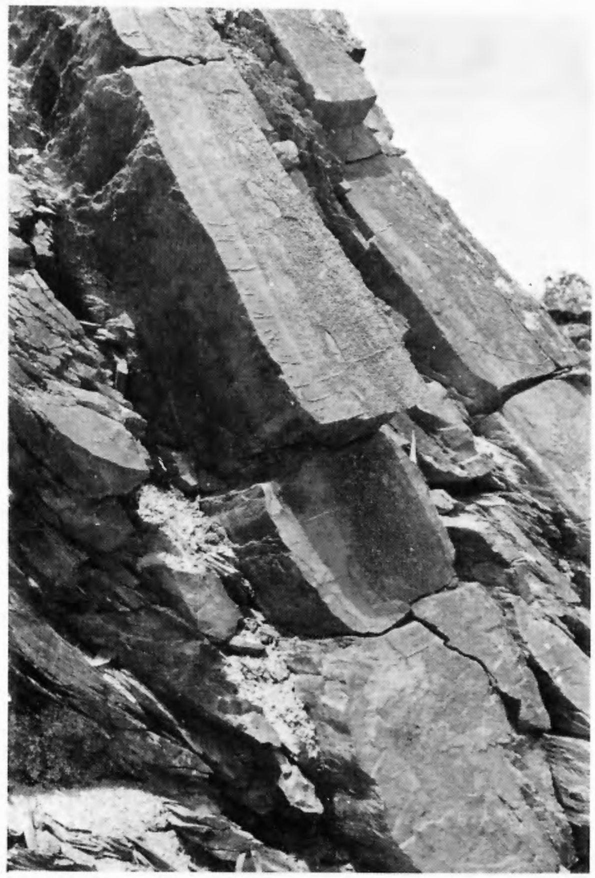


Figure 15. Blue-grey limestone clasts in locally cross-bedded calcareous sandstone, Stelkuz Formation.

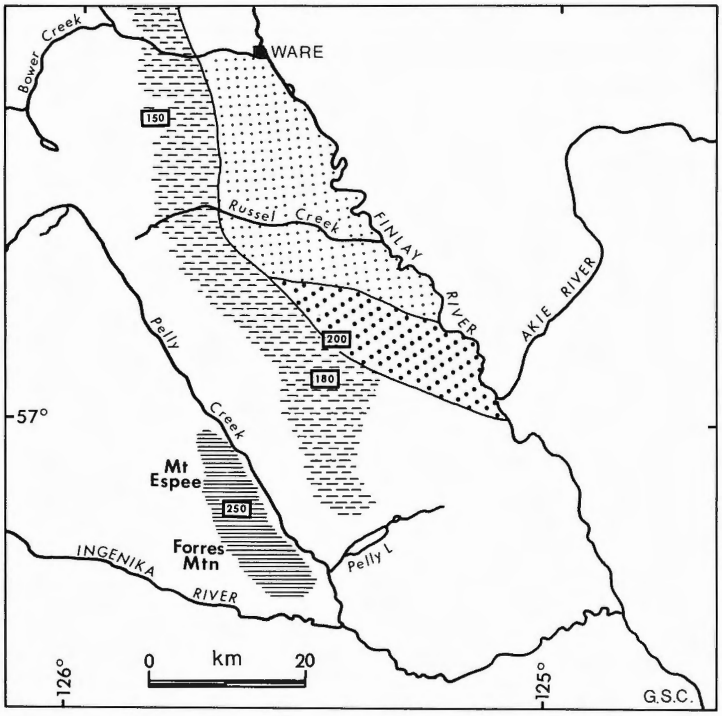


Figure 16.
Facies and thicknesses of the basal unit of the Stelkuz Formation.

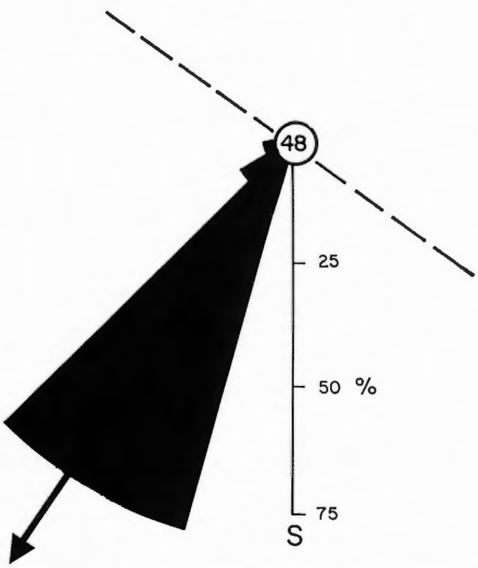


Figure 17. *Rose diagram showing paleocurrent directions derived from cross-beds in the Stelkuz Formation. Dashed line represents average trend of ripple marks in five localities.*

Three units have been recognized in the Yankee Belle Formation in the Black Stuart area of Cariboo Mountains (Mansy, 1970). The basal sequence, about 150 m thick, comprises interbedded green phyllite (60 per cent) and subarkose overlain by 100 m of limestone with ferrodolomite particles, ovoid bodies and pellets interbedded with subarkose and phyllite. The second unit includes black and green phyllite capped by an intraclastic limestone. The uppermost unit is about 200 m thick and comprises phyllite and impure maroon sandstone. Limestone is absent.

According to Campbell et al. (1973), the basal part of the Yankee Belle Formation in northeast Cariboo Mountains is represented by a wedge of coarse sandstone and red shale which thickens towards the Rocky Mountain Trench. Farther west the sandstone intertongues with limestone and shale.

CONCLUSIONS

Subdivision of the Ingenika Group (restricted) in Omineca and Cassiar mountains facilitates lithostratigraphic correlation with Upper Proterozoic formations in Cariboo Mountains and emphasizes strong similarities with strata farther south in Central Purcell Mountains (Reesor, 1973), and Northern Purcell Mountains (Evans, 1933). Less well defined but at least general similarities are evident also with Upper Proterozoic rocks of the Windermere Supergroup in central and northern Rocky Mountains and in southeastern and central Yukon Territory.

The regional lithostratigraphic correlations imply that depositional environments of like character extended throughout much of the western Cordillera during particular intervals of the Late Proterozoic and shows that these environments changed in the same way during deposition of the Windermere Supergroup. Price and Lis (1975) have demonstrated the presence of major faults transverse to the trend of the Cordilleran Geosyncline in southeastern British Columbia which profoundly influenced sedimentation during Windermere time. Doubtless other such structures will be documented elsewhere but judging from the correlations outlined above they must represent second order features relative to the entire Cordilleran depositional basin.

In a general way the lower part of the Windermere Supergroup west of Rocky Mountain Trench indicates deposition in relatively deep water of a very thick, poorly sorted clastic sequence derived from an easterly source.

During sedimentation of the upper part of the Tsaydiz Formation in Cassiar and Omineca mountains (Isaac Formation in Cariboo Mountains), a transition to shallow water environment was effected, and this persisted throughout the remainder of Late Proterozoic time. This history seems consistent with the concept of a clastic wedge building out along the margin of a Precambrian craton (Gabrielse, 1972).

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