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TRANSPORTED CATACLASITE, OPHIOLITE AND GRANODIORITE IN YUKON: EVIDENCE OF ARC-CONTINENT COLLISION

D.J. TEMPELMAN-KLUIT

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TRANSPORTED CATACLASITE, OPHIOLITE AND GRANODIORITE IN YUKON: EVIDENCE OF ARC-CONTINENT COLLISION

Abstract

Allochthonous Mesozoic and/or upper Paleozoic siliceous mylonite, sheared ophiolite and cataclastic granitic rocks are preserved in klippen above autochthonous, structurally imbricated Paleozoic and lower Mesozoic North American shelf strata in central Yukon. The siliceous mylonite may be a trench mélange, the ophiolite oceanic forearc floor, and the granitic rocks the roots of a northeast facing Early Mesozoic arc later accreted to North America. If so they imply that the arc system was partly thrust over the early Mesozoic North American margin. Northeast polarity of the arc suggests that it formed above southwestward subducting oceanic lithosphere and that the arc – continent suture marks a major closed ocean. This ocean may have spread in the Late Paleozoic and closed in the mid-Jurassic. Northeast obduction provides one continuous model for accreting the Early Mesozoic arc to North America, for forming the foreland fold and thrust belt, and for forming late-tectonic quartz monzonite plutons. It relates variations in the width of the fold belt to the degree of arc obduction. The duration and rates of the events are comparable to those in other mountain belts and subduction complexes

Résumé

Des mylonites siliceuses, des l'ophiolites cisaillées et des roches granitiques cataclastiques allochtones du Mésozoïque et (ou) du Paléozoïque supérieur sont préservées dans des klippes situées au-dessus de couches d'emmagasinage nord-américaines du Mésozoïque inférieur et du Paléozoïque, structuralement imbriquées et autochtones du Yukon central. Les mylonites siliceuses sont probablement un mélange de sillon, les ophiolites issues du plancher de l'avant-arc océanique et les roches granitiques les racines d'un arc du début du Mésozoïque orienté au nord-est et par la suite soudé au continent nord-américain. Si c'est le cas, il faut admettre que le système arqué a été partiellement charrié au-dessus de la lithosphère océanique à subduction vers le sud-ouest et que la suture arc-continent marque l'existence d'un vaste océan fermé. L'océan en question se serait avancé pendant la fin de Paléozoïque et refermé au milieu du Jurassique. L'existence d'une obduction nord-est fournit un modèle continu pour la soudure de l'arc du début du Mésozoïque à l'Amérique du Nord, pour la formation d'un plissement pré-continental et d'une zone de poussée ou de charriage, et pour la formation de plutons de monzonite quartzique tardi-tectoniques. L'obduction explique les variations de la largeur de la zone plissée au degré d'obduction de l'arc. La durée et les vitesses des phénomènes se comparent à celles qui sont intervenues dans d'autres zones montagneuses et d'autres complexes de subduction.

INTRODUCTION

Northern Omineca Belt (Fig. 1) is underlain by strata that were deposited on the western margin of the North American craton from Late Precambrian through Triassic time. The Intermontane Belt southwest of it includes Upper Triassic and Lower Jurassic strata juxtaposed against the ancient continental margin at about Middle Jurassic time.

Between the accreted part of North America and the older continental margin is a tectonic mélange of cataclastic rocks; although previously included with Omineca Belt these are more properly part of the Intermontane Belt. The cataclastic rocks include three assemblages: mylonitic sedimentary rocks, dismembered ophiolite and sheared plutonics. They were sheared in the Late Triassic and ?Early Jurassic and thrust northeastward over the Omineca Belt in the Early Cretaceous. The cataclastic rocks were deposited and sheared at or near the margin of the Intermontane Belt. During the Late Cretaceous 450 km of dextral strike slip movement occurred on Tintina Fault and this displaced the autochthonous Paleozoic North American facies as well as the allochthonous cataclastic rocks.

This paper is a summary of the stratigraphy and facies relations within the North American continental margin (Omineca Belt) and the adjoining Whitehorse Trough (Intermontane Belt) emphasizing their differences. Its main purpose, however, is to describe the cataclastic rocks, to detail their relations with adjoining terranes and to outline an arc – continent collision model that can explain them.

Acknowledgments

The data summarized in this paper are based on four seasons of field work (1974-77) in Quiet Lake, Finlayson Lake and Laberge map areas, but the ideas involve other areas in Yukon where I have worked during the last 17 seasons. In this time my ideas have been stimulated by many student assistants, by my colleagues at the Geological Survey in Vancouver and by exploration geologists. The individuals are too numerous to name, but I especially thank R.B. Campbell, S.P. Gordey and J.G. Abbott.

This paper has benefited from constructive criticism by R.B. Campbell, S.P. Gordey and H. Gabrielse.

AUTOCHTHONOUS ROCKS OF THE OMINECA AND INTERMONTANE BELTS

The autochthonous stratigraphy of the Omineca Belt includes four subdivisions (Fig. 2) (Tempelman-Kluit, 1976, 1977b). Oldest is an Upper Precambrian to Lower Cambrian continental terrace wedge of marine, fine grained, clastic rocks capped by carbonate and calcareous shale. This sequence is comparatively constant in facies for long distances along and across strike. The second subdivision includes Upper Cambrian to Lower Devonian rocks in which abrupt and profound facies variations occur. On the northeast in the miogeocline is a thick accumulation of shallow water carbonate strata (Mackenzie Platform) which changes facies southwestward to a thin shale and chert sequence (Selwyn Basin). Farther southwest are 1000 m of coeval volcanic rocks capped by 1500 m of shallow water carbonate and orthoquartzite (Cassiar Platform). The most distal rocks are 700 m of graphitic siltstone, fine grained quartzite and shale of the outer-shelf (Nasina) facies. The third assemblage comprises a locally thick, transgressive, upper Devonian and Mississippian marine clastic sequence eroded from faulted blocks of older rocks and deposited unconformably on them. Locally it includes extensive felsic volcanics. The fourth subdivision, locally preserved, is a thin, starved, marine sequence of fine grained clastics that range from Pennsylvanian to Triassic and which show little facies variation.

None of the Upper Proterozoic and Paleozoic strata of the Omineca Belt, even the most southwesterly now adjacent to Teslin Suture Zone, are facies that likely accumulated on the continental slope. All were probably deposited on the North American shelf or outer-shelf and the margin of the continent may have been far away.

Two stratigraphic assemblages characterize the northern Intermontane Belt (Fig. 2; Wheeler, 1961; Tempelman-Kluit, 1978a, 1978b). The older is an Upper Triassic and Lower Jurassic sequence of fanglomerate and flysch with dramatic lateral facies variations. It was probably derived from a volcanoplutonic arc presumed to have lain to the southwest. Thick, but discontinuous reefoid limestones, were formed as northeast facing barrier reefs, intercalated with the clastics at the transition from marine to nonmarine facies. The younger sequence of Whitehorse

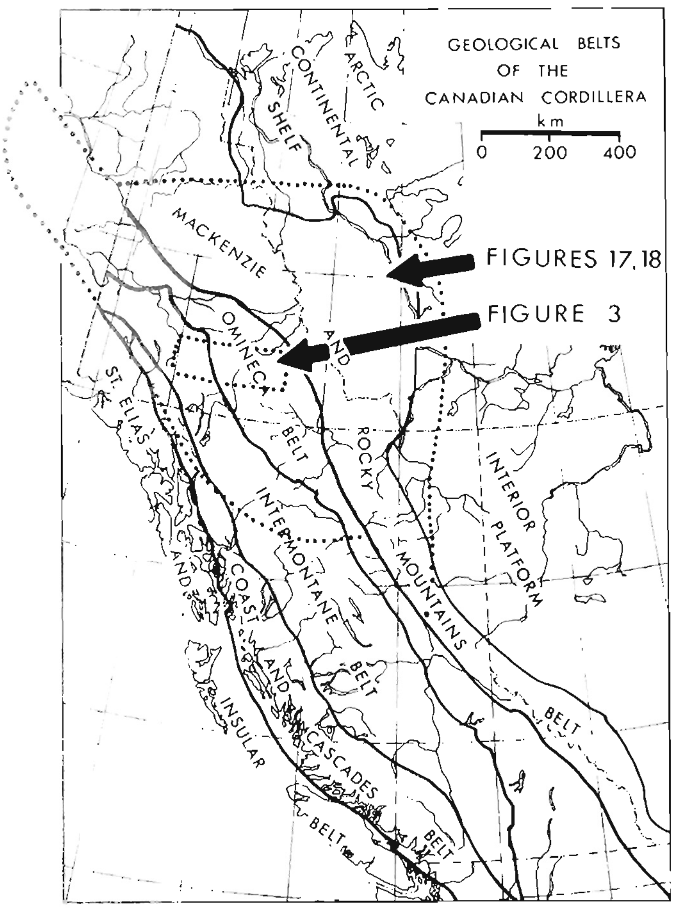


Figure 1. Fivefold subdivision of the Canadian Cordillera showing the localities of Figures 3, 17 and 18, the areas of concern.

Trough is an Upper Jurassic and/or Lower Cretaceous and possibly also Upper Cretaceous – Lower Tertiary terrestrial molasse apparently derived from the northeast, but containing mostly chert clasts for which no northeastern source is known.

ALLOCHTHONOUS (TRANSPORTED) ROCKS IN OMINECA BELT

Three cataclastic assemblages are structurally superposed on the autochthonous and parautochthonous strata in Omineca Belt (Fig. 2); (Tempelman-Kluit, 1976, 1977a, 1977b). They also occupy Teslin Suture Zone, the strip of cataclastic rocks between the Omineca and Intermontane belts. A consistent order of superposition is seen where two or more allochthonous assemblages are together. Lowest are siliceous cataclasites of the Nisutlin Allochthon that range from protoclastic, weakly metamorphosed, sedimentary and volcanic rocks to mylonite, ultramylonite, blastomylonite and schist. The siliceous cataclasites include the Klondike Schist (Tempelman-Kluit, 1976). Second in the succession is sheared ophiolite of the Anvil Allochthon. Anvil Allochthon may include the Anvil Range Group and lithologically similar rocks. The highest sheet, found only northeast of Tintina Fault (Fig. 3) contains various cataclastic granitic rocks of the Simpson Allochthon.

The Nisutlin, Anvil and Simpson allochthons are named for localities where they are well exposed. These names, those of the klippen and those of some other tectonic units are introduced herein or have been used in earlier reports (e.g. Tempelman-Kluit, 1977a, 1977b). The rock assemblages within them are referred to as the siliceous cataclasite, ophiolite cataclasite and granitic cataclasite. Erosional remnants of the allochthonous rocks are klippen named for topographic features. The klippen or outliers may include a sequence of all three allochthons or may include only one or two. No new stratigraphic names are used for the allochthonous rocks as their stratigraphy, largely obscured by cataclasis, is unknown. Depositional or intrusive relations of the allochthonous rocks to one another or to the autochthonous strata are unknown. Similarly the age of most of the allochthonous rocks is not known although Late Paleozoic and Early Mesozoic fossils were recovered from a few localities in the siliceous cataclasites.

Allochthonous rocks southwest of Tintina Fault

McNeil Klippen

Near McNeil Lake are eight klippen (Fig. 3) of siliceous mylonite whose fabric is internally folded and transposed. They overlie unmetamorphosed and largely undeformed, nearly flat-lying Paleozoic and Lower Mesozoic sedimentary strata. These klippen lie above a subhorizontal surface at an elevation about 1500 m. The klippen are muscovite-quartz and chlorite-quartz mylonite and blastomylonite with a partly recrystallized flaser structure (Fig. 4). Commonly the flaser fabric is folded and transposed on a newer, moderately southwest dipping, penetrative, closely spaced crenulation cleavage, the youngest structure in the cataclastic rocks. Only two to three hundred metres of mylonite are preserved in the klippen above the basal surface and no internal stratigraphy is recognized. The protolith for most of the cataclastic rocks in McNeil Klippen is presumed to be a feldspathic quartz arenite with interbedded slate. Arkosic rocks, though not seen in the klippen, are found in the Englishman's Group in the Thirtymile Range to the south (Mulligan, 1963 and Fig. 17) where they can be traced into siliceous cataclasite.

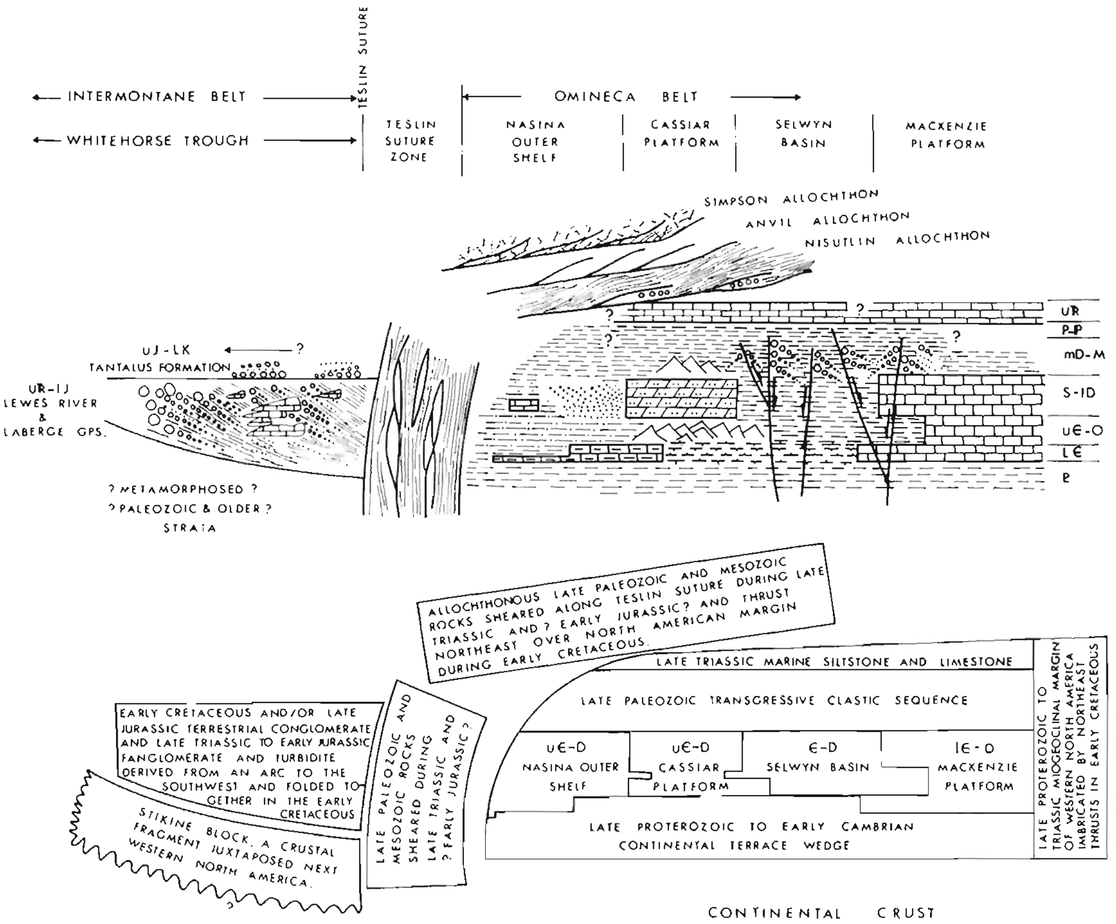


Figure 2. Structural - stratigraphic units of the Omineca and Intermontane belts.

Two of the McNeil Klippen lie directly on undeformed, fine grained clastic rocks of the autochthon but five others include about 100 m of sandstone near their base that is presumed to be synorogenic (Gordey, in prep.; Tempelman-Kluit, 1979; Fig. 5). The calcareous, fine grained clastics of the autochthon contain diverse Karnian and Norian conodont faunas collected at nine localities stratigraphically between 10 m and 200 m beneath the klippen. The presumed synorogenic greywacke contains no recognized fossils, but overlies the conodont bearing Upper Triassic strata tectonically and is itself interleaved with mylonite so that it is apparently the protolith of part of the mylonite.

The surface on which the klippen lie is poorly exposed (Fig. 5). Where seen it is abrupt with no imbrication of the underlying rocks. Strata immediately below are indistinguishable from those where no mylonite is emplaced above them and the finest details of sedimentary structures are preserved (Fig. 6). The mylonite at the fault surface is not more cataclastic than higher in the sheet. Several of the McNeil klippen are broken by steeply dipping, north trending normal? faults of small displacement.

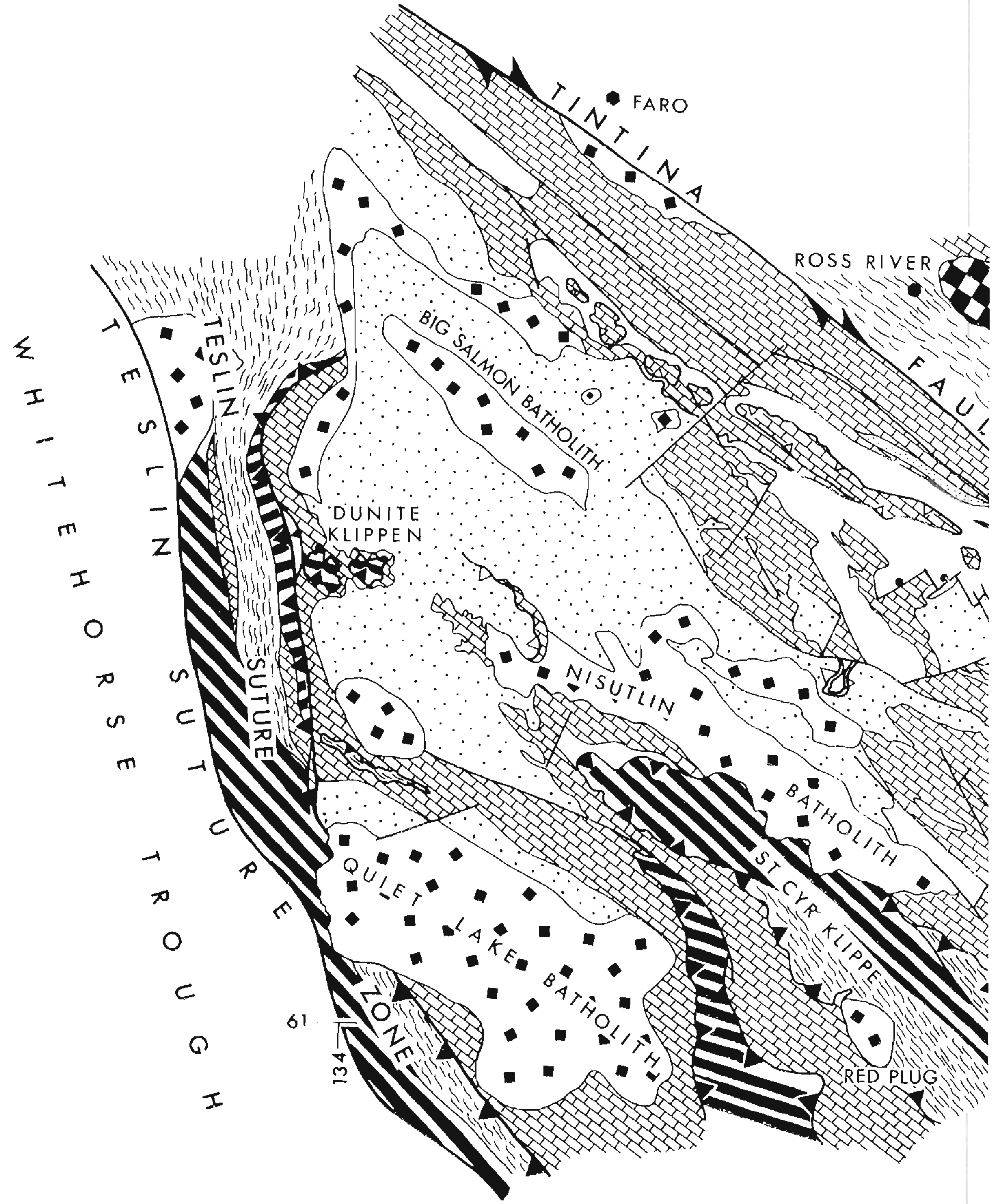
St. Cyr Klippe

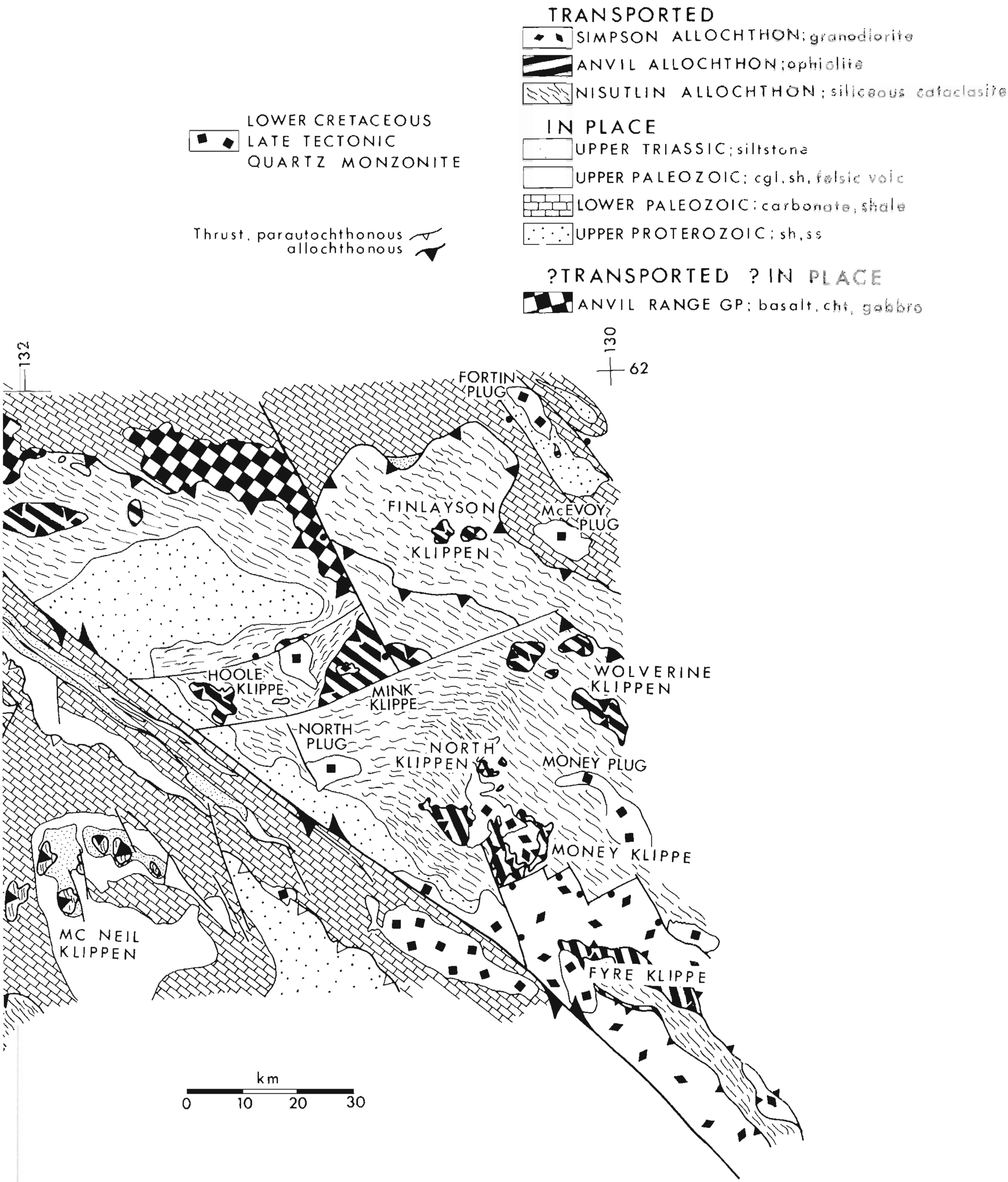
Just south of Nisutlin Lake siliceous blastomylonite lies above Siluro-Devonian orthoquartzite. The cataclastic rocks are part of the Nisutlin Allochthon and form a large erosional remnant, the St. Cyr Klippe, of which the McNeil Klippen are outliers (Fig. 3). St. Cyr Klippe is preserved in a broad, northwest trending structural depression, 150 km long, between the Quiet Lake and Nisutlin batholiths. Its cataclastic fabric dips gently into the structural depression from the northeast and southwest. The basal surface of St. Cyr klippe beneath the siliceous cataclasite was not seen, but its trace implies that it conforms with the structural depression. As in the McNeil klippen the rocks include muscovite-and chlorite-quartz mylonite and blastomylonite probably derived from siliceous sedimentary and volcanic rocks. Their flaser fabric is generally folded and transposed on a penetrative crenulation cleavage that dips southwest. On the northeast the mylonite lies above Siluro-Devonian orthoquartzite and siltstone that is not cataclastic or metamorphosed. On the southwest it rests on roughly coeval graphitic quartz siltstone (Nasina facies) with lenses of carbonate. Bedding dips gently under the klippe.

In the central part of St. Cyr Klippe the siliceous cataclasite is overlapped by a structurally higher slice of transported ophiolite and at the northwest extremity of the klippe the ophiolite lies directly above autochthonous strata. The rocks include amphibolite, sheared basalt, serpentinized peridotite and altered gabbro, part of Anvil Allochthon. Relations between the Nisutlin and Anvil allochthons are poorly exposed within St. Cyr Klippe. The siliceous and ophiolitic cataclasites generally occur separately although slivers of ophiolite 100 m thick are seen within the siliceous cataclasite near contacts with the Anvil Allochthon.

The contact between Anvil Allochthon and autochthonous rocks below is well exposed on the north side of Mount St. Cyr at the northwest end of the St. Cyr Klippe.

Figure 3. Generalized geological map of parts of Laberge, Quiet Lake and Finlayson Lake map areas showing the distribution of allochthonous rocks in relation to the main autochthonous units and to the late tectonic quartz monzonite.




TRANSPORTED
SIMPSON ALLOCHTHON; granodiorite
ANVIL ALLOCHTHON; ophiolite
NISUTLIN ALLOCHTHON; siliceous cataclasite
IN PLACE
UPPER TRIASSIC; siltstone
UPPER PALEOZOIC; cgl, sh, felsic volc
LOWER PALEOZOIC; carbonate, shale
UPPER PROTEROZOIC; sh, ss
?TRANSPORTED ?IN PLACE
ANVIL RANGE GP; basalt, cht, gabbro
LOWER CRETACEOUS
LATE TECTONIC
QUARTZ MONZONITE
Thrust, parautochthonous
allochthonous
132
130
62
FORTIN PLUG
FINLAYSON KLIPPEN
McEVOY PLUG
HOOLE KLIPPE
MINK KLIPPE
WOLVERINE KLIPPEN
NORTH PLUG
NORTH KLIPPEN
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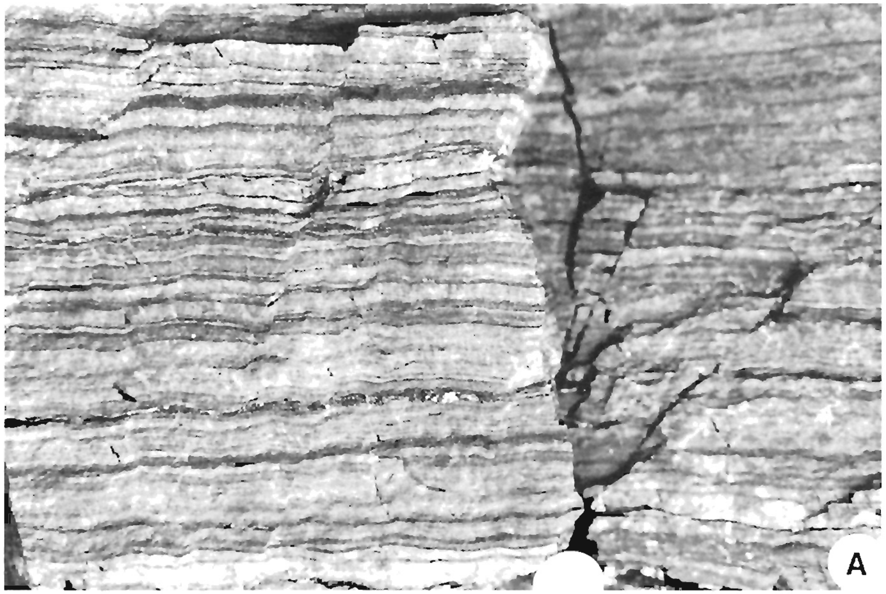
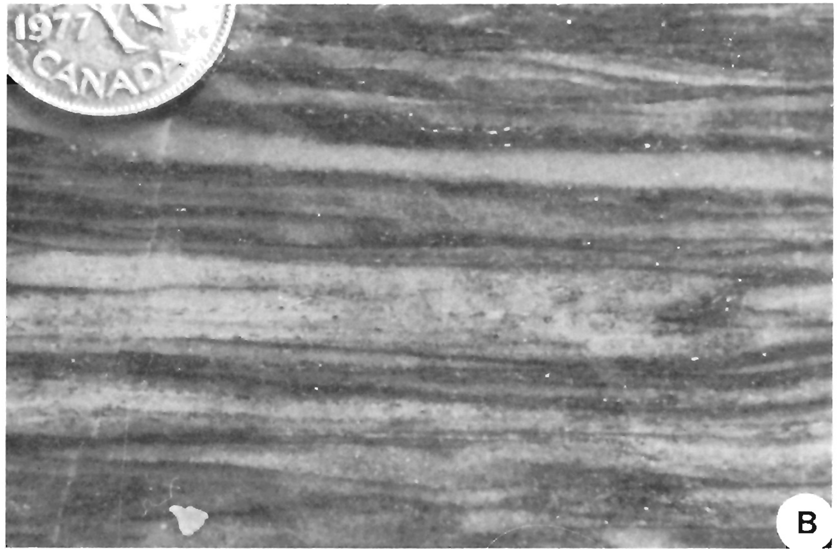
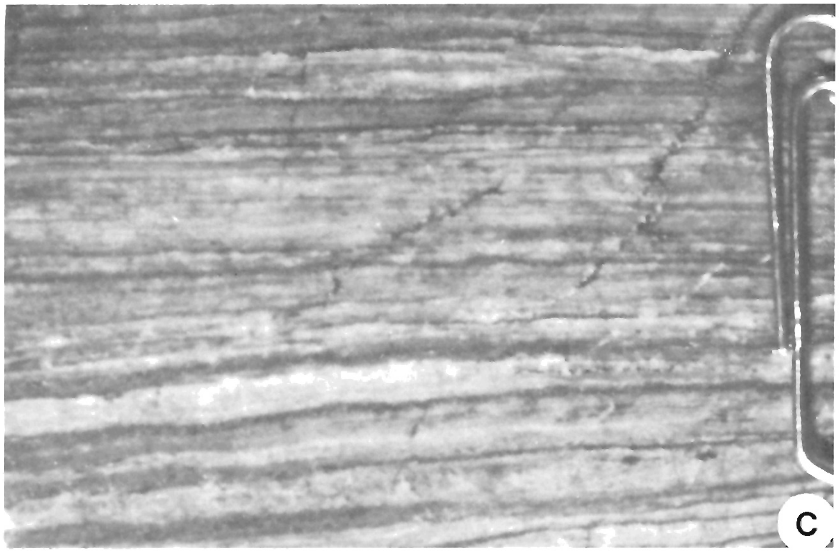


(GSC 203533)



(GSC 203533-A)



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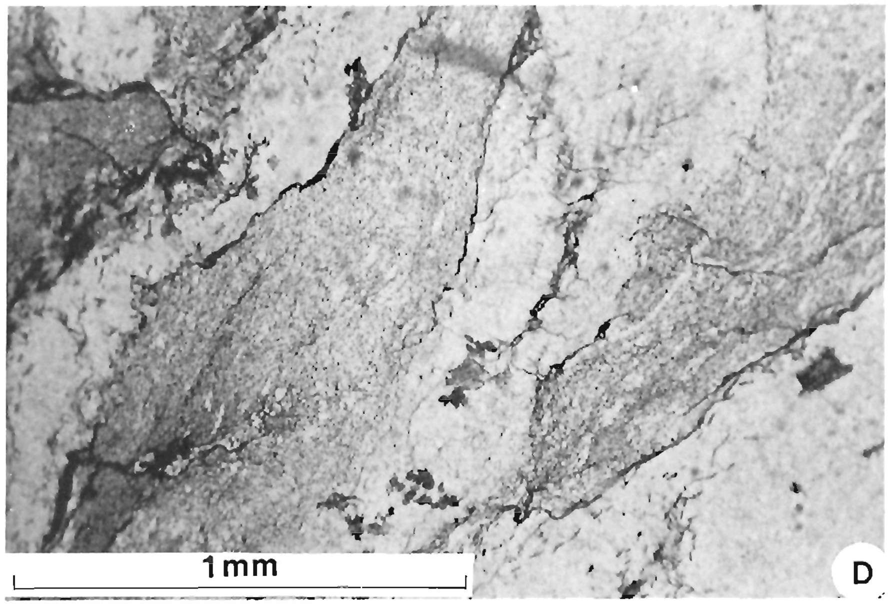

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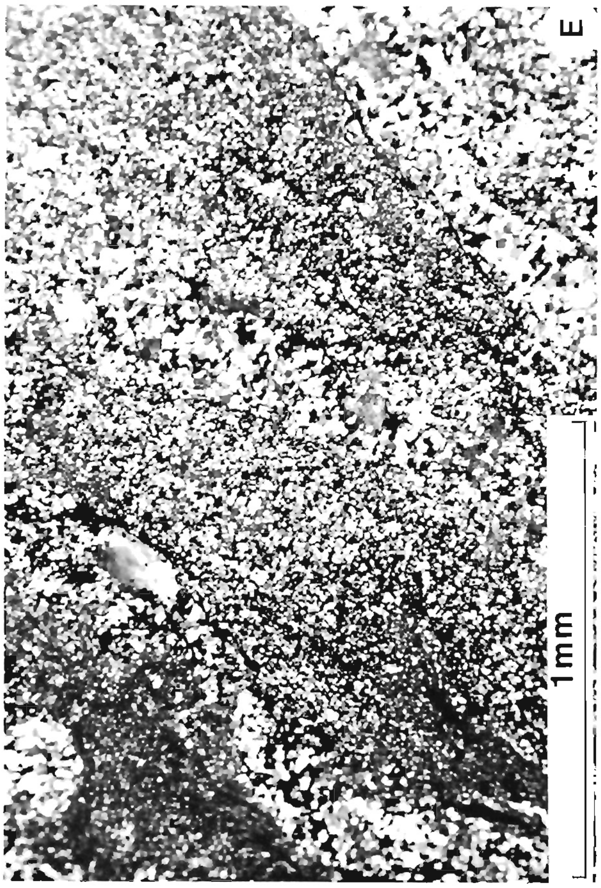


(GSC 203533-C)

Figure 4. Siliceous mylonite from various localities.

A – A natural surface of this rock in one of the McNeil Klippen.

B – A closer view of a sawn surface of the same rock.

C – A close view of a sawn surface of siliceous mylonite from under one of the North Klippen.

D,E – Photomicrographs of a thin section of C shows the fabric under plane polarized light and crossed nicols.

There the ophiolite is a flinty textured, streaky cataclasite of basaltic composition made up of fine grained amphiboles (Fig. 7) which grades laterally into amphibolite, its blastomylonitic equivalent. The preserved thickness of ophiolite cataclasite is at least 1000 m and the degree of cataclasis varies so that parts of the mass are protoclastic and others are ultramylonite. Rocks near the basal surface are not more cataclastic than those elsewhere in the klippe. Serpentinized peridotite occurs as sheets within the ophiolite; the sheets are structurally bounded and probably represent internal repetitions of Anvil Allochthon. The serpentinite is generally massive and "fish-scale" textures are rare. Devono-Mississippian slate with interbedded chert-granule grit is exposed beneath the ophiolite. These rocks are not cataclastic although the chert granules are flattened locally. In a contact zone about 50 m thick slate and cataclasite are tectonically mixed, and discontinuous lenses of the two rocks are interlayered, but otherwise no mixing was seen. Bedding in the autochthonous rocks below the contact conforms roughly with the basal surface of the ophiolite.

At the southwest margin of St. Cyr Klippe a small, undated, discordant pluton of porphyritic biotite quartz monzonite (Red Plug of Fig. 3) invades the siliceous mylonite. On the northeast margin the ophiolitic cataclasite is cut and thermally metamorphosed by Nisutlin Batholith, a homogeneous body of similar quartz monzonite whose biotite has given 84, 89 and 94 Ma K/Ar model ages.

Dunite Klippen

Northwestward along the structural depression occupied by St. Cyr Klippe are the Dunite Klippen (Fig. 3), outliers of Anvil Allochthon. These are parts of a spectacular sheet of serpentinized peridotite that cap two adjacent peaks above 800 m of autochthonous platform to outer shelf strata of Late Proterozoic to Silurian or Early Devonian age (Fig. 8). The serpentinite is a massive, brown weathering altered alpine ultramafite. The sole at the base of the ultramafic klippen lies nearly flat at an elevation of 1500 m and is marked in places by "fish-scale" serpentinite and talcose rocks that occur in a zone up to 100 m thick. Strata immediately below the contact are nearly flat lying, unsheared orthoquartzite with interbedded dolomite sandstone and graphitic calcareous siltstone (Fig. 9).

Allochthonous rocks northeast of Tintina Fault

Northeast of the Tintina Fault, a consistent structural sequence of cataclastic rocks is found above and southwest of autochthonous platform or shelf facies strata. The cataclastic and platform – shelf strata are the same sequences as those southwest of Tintina Fault, but an additional assemblage of allochthonous rocks is found. It includes mylonite and other cataclastic lithologies derived from plutonic parents and comprises Simpson Allochthon. Simpson Allochthon lies above cataclastic ophiolite of Anvil Allochthon and is the highest structural sheet of the transported rocks. Simpson Allochthon includes chloritic quartzofeldspathic mylonite and blastomylonite which grades into sheared and fractured hornblende quartz diorite and granodiorite. Locally it contains protoclastic pink quartz monzonite.

Nisutlin Allochthon

Klippen northeast of Tintina Fault include slices of Anvil and Simpson allochthons. These klippen all lie above siliceous cataclastic rocks preserved as an enormous, broadly southwest dipping terrane northeast of Tintina Fault (Fig. 3). The siliceous cataclasite is part of Nisutlin Allochthon and is found southwest of autochthonous shelf strata. Relations between the autochthonous strata and the mylonite are not exposed in the area of Figure 3 northeast of Tintina Fault. Allochthoneity of the siliceous cataclasite above the shelf strata can therefore not be demonstrated in this region. The contrast in fabric and lithology between the mylonite and shelf facies rocks, however, is the same as in the McNeil klippen and the siliceous mylonite is presumably tectonically emplaced above the autochthonous rocks.

Various autochthonous rocks occur northeast of Nisutlin Allochthon. In most places the Lower Paleozoic Nasina outer shelf facies is found, but about 15 km northwest of Finlayson klippen is a small occurrence of conodont bearing Upper Triassic strata immediately adjacent to the siliceous cataclasite (Fig. 3). East of Ross River two areas of basalt with distinctive red and green radiolarian chert and minor gabbro and serpentinite lie directly north of the siliceous cataclasite. They are lithologically like the Pennsylvanian-Permian Anvil Range Group (Tempelman-Kluit, 1972) found on Rose Mountain 60 km northwest of Rose River. Unlike Anvil Allochthon these ophiolitic rocks and those on Rose Mountain are not sheared and they may be autochthonous beneath Nisutlin Allochthon and deposited on older Paleozoic shelf strata.

Northeast of Tintina Fault Nisutlin Allochthon includes a variety of sheared sedimentary and volcanic rocks (not separated in Fig. 3). Most common are muscovite quartz blastomylonite and mylonite with interfoliated phyllonitic slate and chlorite schist. South of the Wolverine Klippen the muscovite quartz cataclasite can be traced into weakly sheared or protoclastic feldspathic quartz-granule grit and sandstone with interbedded slate. Similar granule grit, sandstone and slate is preserved as tectonic lenses elsewhere through much of the siliceous mylonite and they are thought to be the protolith for most of the siliceous cataclasite. The phyllonitic slate and chlorite schist grade into sheared dark slate with discontinuous, locally thick, sheets of fragmental volcanics of intermediate composition. Such slates and volcanics are particularly common southwest of Money and North klippen. Crinoidal limestone, mostly so strongly sheared that it is a flaser marble, is interlayered with the siliceous cataclasite as structural lenses up to 200 m thick south of the Finlayson Klippen and east of Money Klippe. Directly under the Finlayson klippen conglomerate that contains sheared and unsheared chert clasts predominates in Nisutlin Allochthon and is structurally interlayered with its highly sheared equivalents.

Near Faro, 70 km northwest of Ross River (outside the area of Fig. 3), conglomerate, sandstone, siltstone and shale are interfoliated with siliceous mylonite of Nisutlin Allochthon (Tempelman-Kluit, 1979). The clastic assemblage is texturally and compositionally immature and contains fragments of mylonite, volcanics, gabbro, peridotite, limestone, quartz, feldspar, chert, mica and granitic rocks (Fig. 10). The rocks are variably sheared, and their grain size and the proportions of clast types varies from place to place so that the sheared rocks and the coarse clastic types have been considered different suites. They are more likely part of one heterogeneous clastic suite whose depositional relations and internal stratigraphy are not yet known. The rocks probably originated as fanglomerate and turbidite deposits and they are considered equivalents of the slate, sandstone and granule grits preserved as unsheared lenses throughout Nisutlin Allochthon.

At the locality near Faro the clastic rocks are tectonically imbricated so that different depositional facies are structurally juxtaposed. Two of the slices contain Upper Triassic conodonts (Tempelman-Kluit, 1979) indicating that the clastic rocks and the protolith for much of the siliceous cataclasite of Nisutlin Allochthon is of that age.

Fyre and Money klippen

Two klippen of the granitic rocks are preserved. The most extensive, Fyre klippe, is bounded by young faults on its northern and western sides, but on the south side relations with structurally lower rocks are exposed (Fig. 3). Fyre klippe includes at least 800 m and possibly 2000 m of cataclastic rocks which range texturally from protomylonite

Figure 5. View to the southeast of the lower contact of one of the McNeil Klippen. The relief is about 500 m. The autochthonous rocks are unsheared and unmetamorphosed Upper Triassic siltstone and older rocks like those in Fig. 6 whereas the allochthonous rocks are variably sheared and metamorphosed mainly sedimentary rocks. A thin discontinuous amphibolite (Anvil Allochthon?) comprises the lowest allochthonous slice. It is overlain by a sheet of sheared immature synorogenic clastic rocks and in turn by a slice of muscovite-quartz mylonite probably derived from siliceous sedimentary rocks. The synorogenic clastics are presumed to be the protolith for some of the siliceous mylonite, but because they contain mylonite debris some cataclasis must also have preceded the deposition of the clastics. (GSC 203533-E)

Figure 6.

Thin bedded calcareous siltstone from beneath the mylonite preserves fine details of crosslamination and worm burrows right to the mylonite contact. This exposure is from the autochthon only one metre beneath one of the McNeil Klippen.(GSC 203533 F)

to ultramylonite, but which had little variation in original rock type. Where primary textures are preserved, the rock is an equigranular, medium grained, hornblende quartz diorite with subhedral, equant hornblende and bluish anhedral quartz. Locally, rounded inclusions, rich in mafic minerals, and as much as 20 cm across, are seen (Fig. 11). Variation from protomylonite to intensely cataclastic rocks (Fig. 11) takes place across the fabric in as little as 10 cm and ultramylonite grades laterally into essentially undeformed rocks in equally short distances. The mylonite is folded over an open northwest trending arch and the flaser fabric dips gently northeast and southwest conforming with the orientation of the sole surface of the klippe. The mylonite fabric is not deformed by small scale folds indicating that the arching involved brittle deformation at a shallow structural level.

Granitic cataclasite of the Fyre Klippe lies above a discontinuous sheet of serpentinite, part of the Anvil Allochthon (Fig. 3). The serpentinite, a lower structural slice of Fyre klippe, locally as much as 300 m thick, is also folded by the northwest trending arch. The serpentinite is a massive rock in which "fish-scale" textures are rare. On the south, beneath the serpentinite, are fine grained biotite muscovite granodiorite gneiss and micaceous quartzite whose foliation conforms to the tectonic boundaries of the overlying klippe. These rocks are blastomylonite of sedimentary and volcanic parentage whose cataclastic texture was overprinted and partly obliterated by younger regional metamorphism about 90 Ma ago. They represent Nisutlin Allochthon, the lowest allochthonous sheet.

Contacts between the granitic, ophiolitic and siliceous cataclasites conform with the flaser fabric where seen and no tectonic mixing of the three slices was noted. Fyre klippe is intruded and metamorphosed by a small, undated pluton of biotite quartz monzonite presumed to have cooled roughly 90 Ma ago (Fig. 3).

Money Klippe, the second in which plutonic rocks are preserved, lies in a gentle structural depression immediately north of Fyre Klippe (Fig. 3). It shows the same order of structural superposition seen in Fyre klippe so that slices of plutonic cataclasite (Simpson Allochthon) lie above serpentinite, gabbro and basalt (Anvil Allochthon) and these in turn rest on siliceous mylonite (Nisutlin Allochthon) (Fig. 12, 13). Several subslices are recognized and both the plutonic and ophiolitic rocks are more varied than in Fyre Klippe.

Figure 7. *Cherty textured basalt mylonite with wispy flaser texture. This rock makes up much of St. Cyr Klippe near Mount St. Cyr. Laterally and across strike it can be traced into basalt, greenstone and amphibolite (like that of Fig. 14). Together these rocks demonstrate a continuum of flash fabrics in Anvil Allochthon similar to that seen in Nisutlin and Simpson allochthons. (GSC 203533-G)*

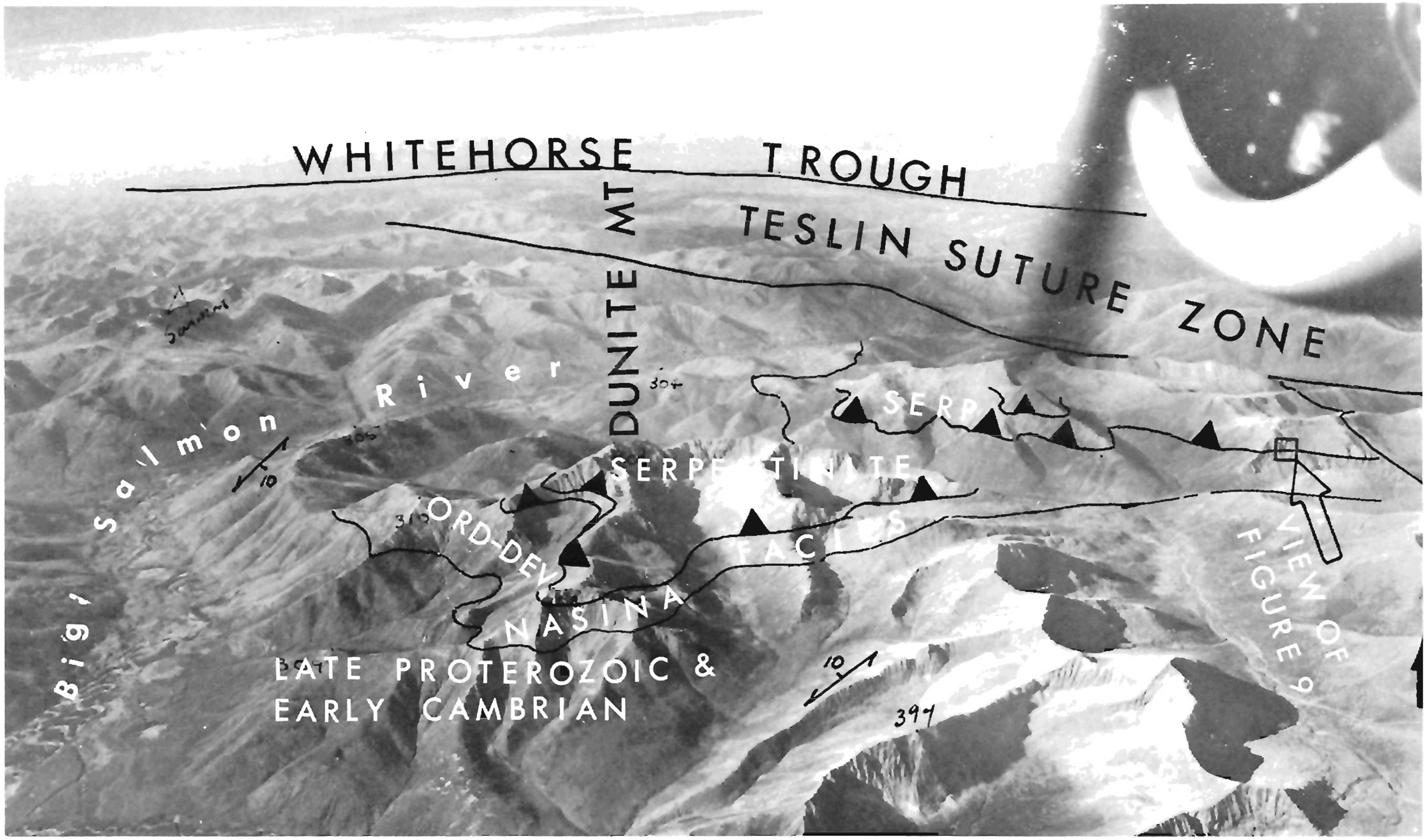


Figure 8. *Aerial view of two klippen of serpentinite and peridotite at Dunite Mountain. The view is to the southwest and Teslin Sutute Zone and Whitehorse Trough are seen in the distance. The klippen lie nearly flat above a weakly metamorphosed but noncataclastic North American outer shelf sequence that also is nearly flat lying and which includes from the base up Windermere equivalent shale and siltstone, Lower Cambrian limestone and Ordovician to Devonian graphitic siltstone with lesser intercalated orthoquartzite and limestone. The lower contact of the Ordovician to Devonian Nasina facies is picked out in this photograph.. A close view of part of the contact is seen in Fig. 9.(GSC 203533-H)*

Two discrete subslices of plutonic rocks are recognized. The upper is equigranular, medium grained quartz diorite or granodiorite like that of Fyre Klippe. The rocks are saussuritized; chlorite has replaced most hornblende, plagioclase is pink and clouded with sericite and hematite, and epidote veining is common. In many places the rocks are protoclastic, but the degree of shearing is less than in Fyre Klippe and mylonite is comparatively uncommon and restricted to zones a few metres thick. About 500 m of quartz diorite is preserved in the highest slice. A gently dipping thrust fault repeats the quartz diorite on the east side of Money Klippe (see Fig. 13).

The lower slice of granitic rocks in Money Klippe is discontinuous; it is absent in some places and as much as 500 m thick elsewhere. It includes coarsely crystalline, pink megacrystic (k-feldspar) quartz monzonite. The chief mafic mineral, biotite, is largely chloritized and the quartz has a waxy greenish appearance. Although crystals are fractured and the rocks are locally strongly sheared, intrusive textures are generally preserved. The two plutonic types appear closely related, but no intrusive relationship between them was seen. They may be parts of one dismembered plutonic complex or parts of unrelated plutons tectonically juxtaposed.

The structurally highest slice of Anvil Allochthon in Money klippe is serpentinized and sheared, locally cataclastic, medium grained gabbro with thin lenses of serpentinite and sheared basalt. The gabbro, several hundred metres thick locally, lies above a slice of altered, sheared basalt that grades to fine grained amphibolite (Fig. 14). The basalt, also discontinuous, is absent in places, but as much as 500 m thick elsewhere. The basalt slice (Fig. 15) includes lenses of serpentinite and lies above a discontinuous layer of serpentinite, locally as much as 100 m thick. Contacts between the various slices and the internal fabric of the rocks dip gently into the gentle structural depression that has preserved Money Klippe. Structural mixing of the siliceous, ophiolitic and granitic cataclasite was not seen, but repetition of lithologies at different structural levels within allochthons is common. Slivers of serpentinite in particular are seen at many levels in the Anvil Allochthon.

Money Klippe is invaded by dykes and plugs of porphyritic rocks which include pyritic quartz rhyolite and hornblende andesite in roughly equal amounts. A compound plug of these subvolcanic rocks truncates all structural slices on the north side of the klippe (Fig. 13). Though not dated at this locality the volcanics are lithologically like the South Fork Volcanics which have yielded K/Ar model ages of 117, 100 and 86 Ma at three places about 150 km to the northwest (Lowdon et al., 1963; Wanless et al., 1967). The South Fork Volcanics may be effusive equivalents of the biotite quartz monzonite intrusions which are 90 ± 10 Ma old.

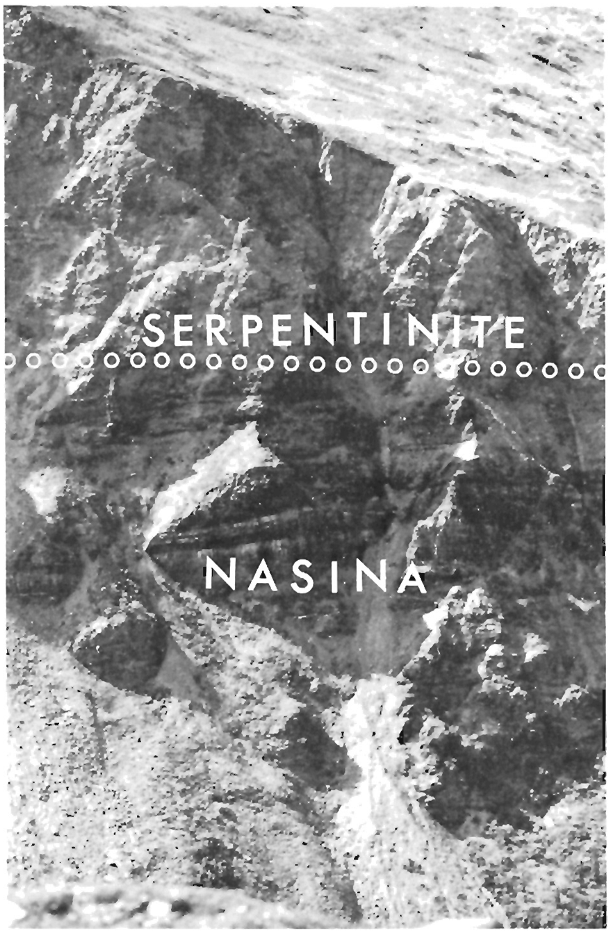
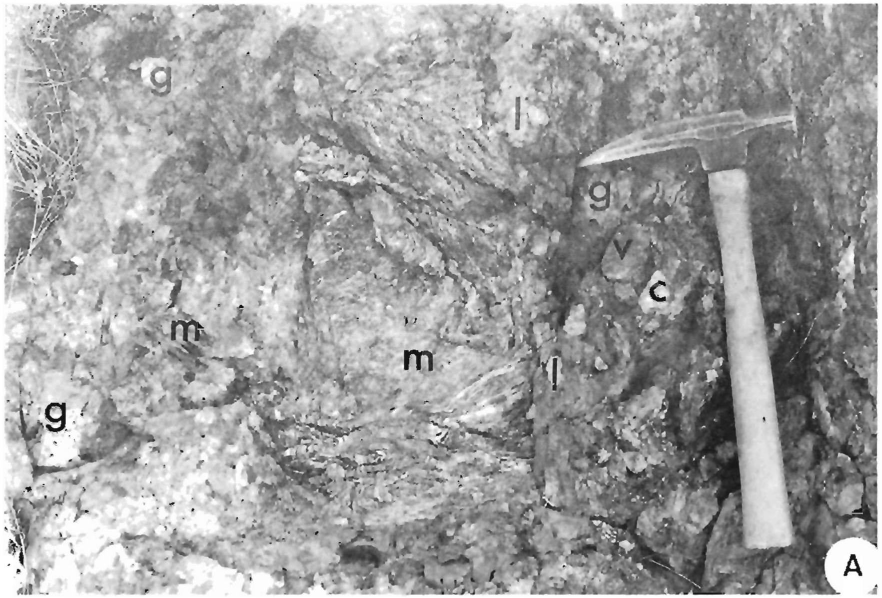


Figure 9.

Closer view of the contact between serpentinite and the autochthonous Early Paleozoic Nasina outer shelf facies beneath one of the Dunite Mountain Klippen. The location is given in Fig. 8. The serpentinite, thought thrust above the Nasina from Teslin Suture Zone, is part of Anvil Allochthon and is probably late Paleozoic. (GSC 203533-I)



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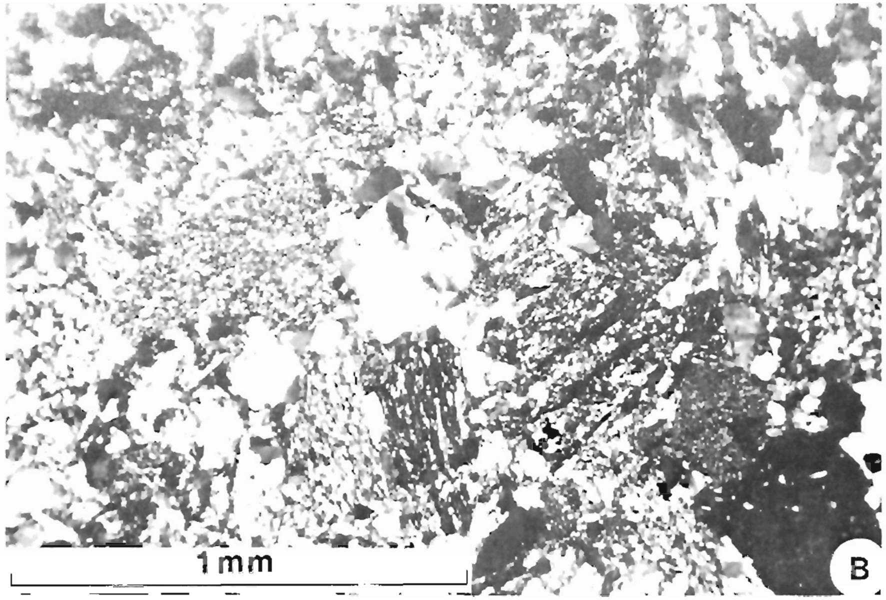

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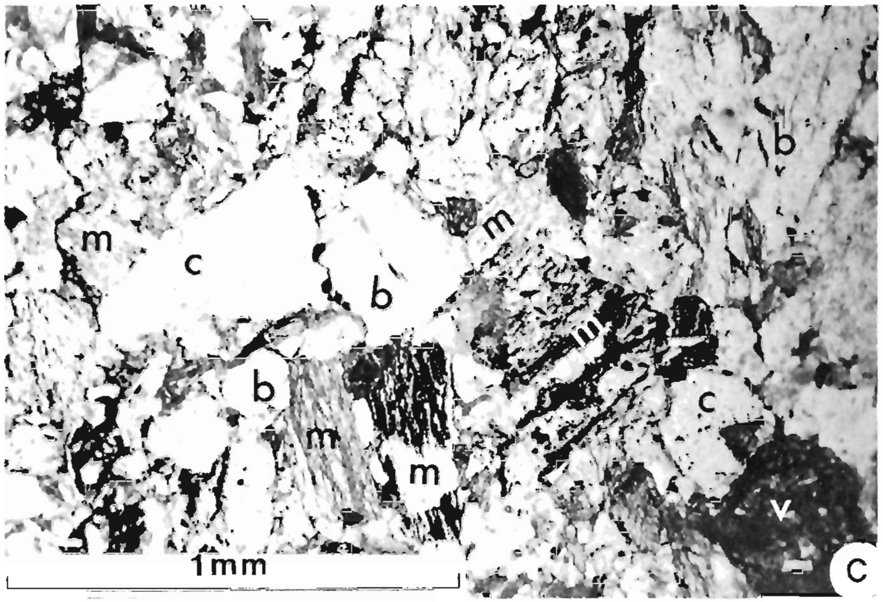
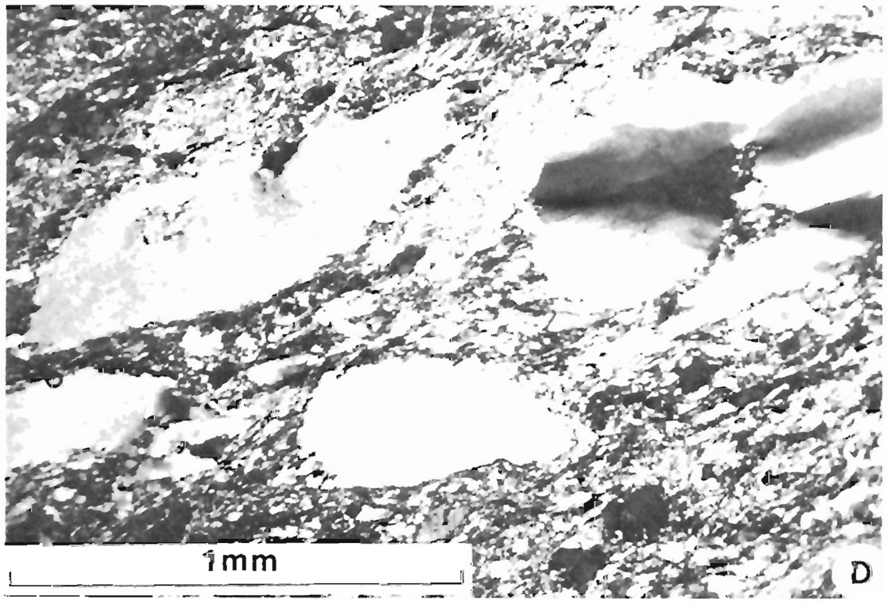


(GSC 203533-L)



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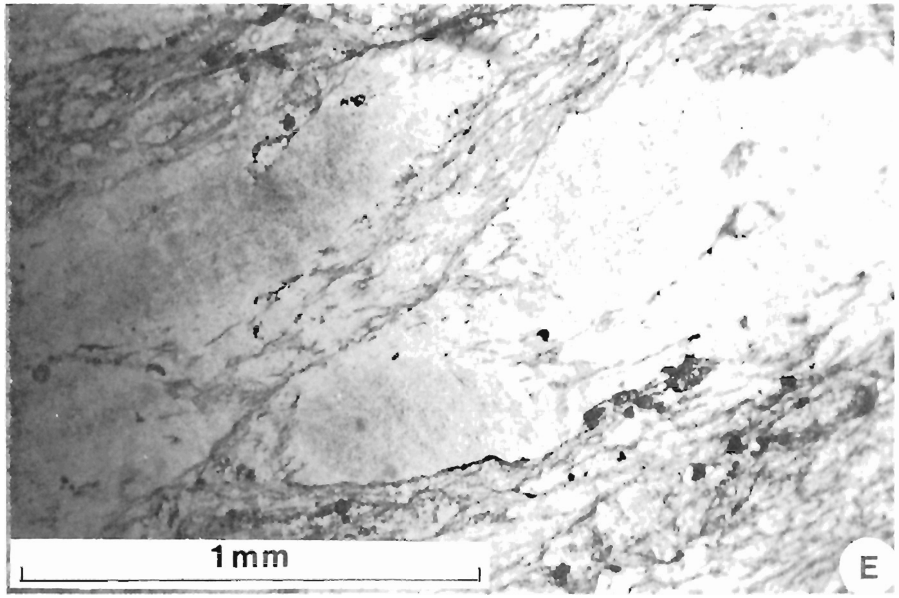


(GSC 203533-N)

Figure 10.

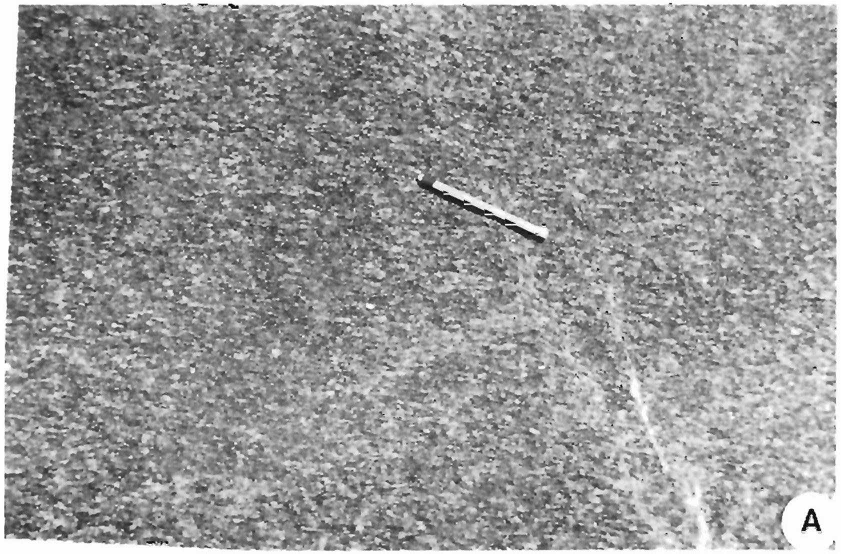
Examples of the heterogeneous synorogenic clastic suite. Generally these rocks are so strongly sheared that their depositional fabric is destroyed, but they are the protolith for much of the siliceous mylonite of Nisutlin Allochthon.

A is conglomerate from near Faro which demonstrates the textural and compositional immaturity by the range in clast size, lack of rounding and variety of clast types. The large mylonite slab has a folded flaser fabric that is transposed on a newer foliation.

B, C are photomicrographs of a finer grained variety of this rock from one of the McNeil Klippen. Note the variety of cataclastic and blastomylonitic fabrics and the varied orientation of this fabric indicating it is predepositional. The lack of rounding or sorting indicates the immaturity of this rock.

D, E are a part of the same sandstone as B and C, but in this specimen shearing has partly destroyed the depositional fabric and the larger grains are partly milled. Compare this with photomicrographs of the mylonite in Fig. 4.

The photomicrographs are with plane polarized light and under crossed nicols. (b – blastomylonite, m – mylonite, g – granitic, s – sandstone, c – chert, l – limestone, v – volcanic)



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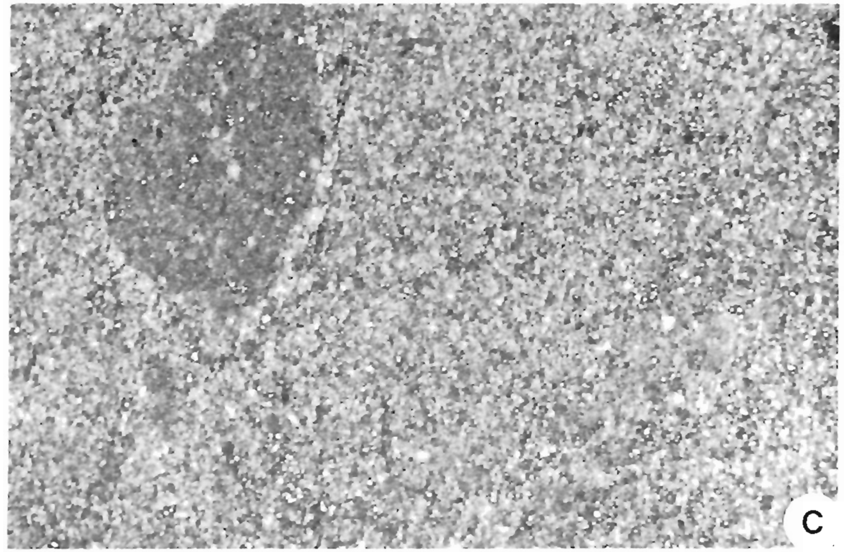
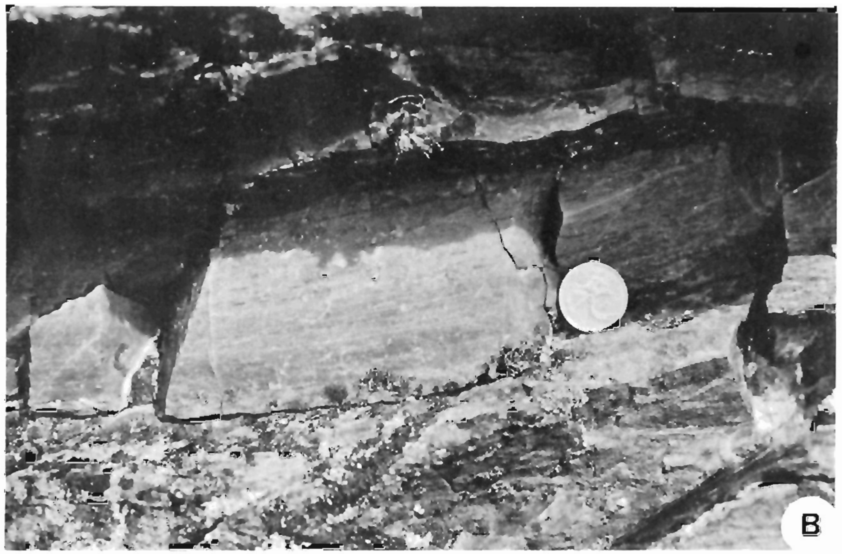


(GSC 203533-Q)



(GSC 203533-P)

Figure 11

Three photographs to illustrate the range in texture and fabric of Simpson Allochthon, the cataclastic plutonic suite. Much of the rock is biotite granodiorite gneiss (A) which in Yukon Crystalline Terrane has been included in the Pelly Gneiss. This gneissic rock is the blastomylonitic equivalent of the cherty textured chlorite mylonite in B. Locally a protoclastic hornblende granodiorite (C) is preserved in which igneous features, in this case a mafic xenolith about 8 cm long, remain. The three rocks are members of a cataclastic continuum and not only are all gradations between them seen, but they can be traced laterally or across the fabric into each other over distances less than one metre. Though texturally varied the examples represent a single plutonic type that has been strongly sheared. The strain was concentrated in certain zones while others largely escaped strain.

The three small klippen of serpentinite and serpentinized dunite southeast of the North Lakes (Fig. 3) are part of Anvil Allochthon and may have been continuous with the lower slices of Money and Fyre klippen. Roughly 400 m are preserved on the highest peak above the nearly horizontal basal surface which is at an elevation of 2000 m (Fig. 16). These three, the North klippen, lie above muscovite quartz ultramylonite and blastomylonite of the Nisutlin Allochthon which has a horizontal fabric parallel to the structural contact with the serpentinite. The siliceous mylonite is recrystallized near quartz monzonite of the Money Plug which probably cooled about 90 Ma ago.

Wolverine, Finlayson, Hoole and Mink klippen

The Wolverine Klippen are outliers of Anvil Allochthon and include basalt and its derived cataclasite, a fine grained amphibolite. The base of the sheet is an essentially horizontal surface about 1300 m above sea level and peaks between Wolverine Lake and Finlayson River above this elevation are capped by the sheared rocks. The Finlayson, Hoole and Mink klippen are outliers of Anvil Allochthon. They carry the same ophiolitic cataclasite and include slivers of serpentinite.

Teslin Suture Zone

In Laberge map area (Fig. 18) a northwest trending zone of steeply dipping cataclastic rocks 15 km wide separates the Omineca and Intermontane belts (Fig. 3; Tempelman-Kluit, 1978b). This narrow strip is named Teslin Suture Zone because it roughly follows Teslin River. The rocks include sedimentary and volcanic strata; peridotite, basalt and gabbro; and granodiorite. All exhibit a range of protoclastic, mylonite and blastomylonite fabrics. Broadly, the cataclastic sedimentary-volcanic assemblage is the siliceous mylonite of Nisutlin Allochthon and is also the Klondike Schist (Tempelman-Kluit, 1976) and a terrane herein referred to as the Yukon Cataclastic Complex (Fig. 17). The mafic rocks are like those of Anvil Allochthon; they also resemble ophiolitic rocks that are structurally interleaved with other rocks of Yukon Cataclastic Complex. The plutonic cataclasites resemble Simpson Allochthon but are also lithologically similar to the Klotassin granodiorite and pink quartz monzonite of Yukon Cataclastic Complex.

Within the suture zone the three cataclastic assemblages occupy structurally bounded lenses 3 or 4 km wide and 20 or 30 km long. In plan the zone appears as a strip crowded with long, narrow "fish" each characterized by one of the three lithologies mentioned. The three "fish" lithologies are not randomly mixed. Generally, siliceous mylonite is concentrated near the northeast margin of the zone whereas ophiolitic and granitic cataclasites are concentrated successively farther southwest.

In Laberge map area the boundaries of the suture zone are sharp and are marked by a change from steeply dipping cataclastic rocks within the zone to lithologically different rocks outside that are much less sheared and that dip gently. On the northeast boundary, in Laberge area, cataclastic rocks of the suture zone and of the flat lying, allochthonous sheets are physically discontinuous but northwest (beyond the area of Fig. 3) along the suture zone the two elements merge and the northeast edge of the suture zone becomes the leading edge of the cataclastic allochthonous sheets. Where this occurs the cataclastic fabric flattens northeastward across the suture zone. Yukon Cataclastic Complex is apparently the northwestward extension of the combined Teslin Suture Zone and allochthonous sheets of mylonite. The southwest boundary of the suture zone is difficult to extend accurately outside Laberge area from existing data and further mapping is required. Generally the boundary continues to show the sharp lithologic and fabric contrasts but younger plutonic and volcanic rocks have modified or obscured it in places.

Metamorphism of Cataclastic Rocks

Transported assemblages and the cataclastic rocks in Teslin Suture Zone are dominantly in the greenschist facies of metamorphism although parts attain amphibolite facies rank.

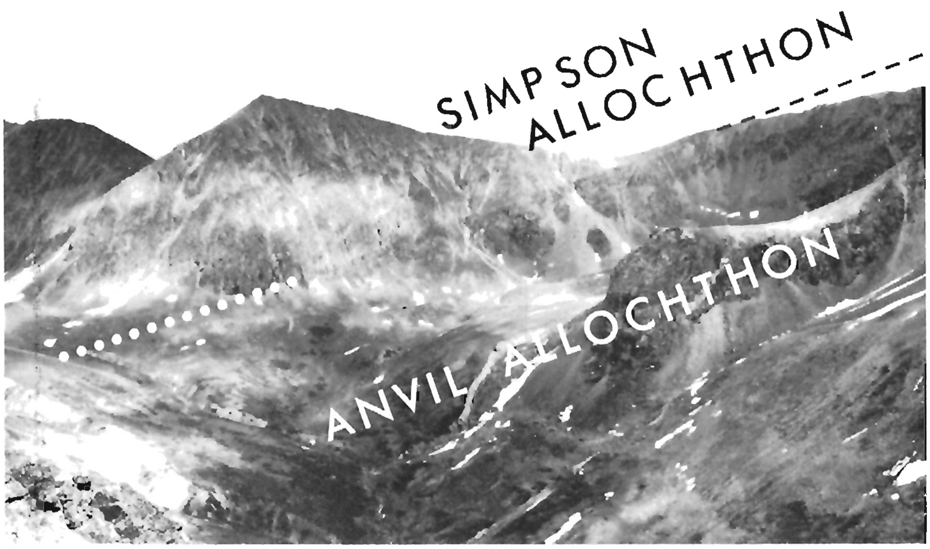


Figure 12.

View of part of the trailing (southwest) edge of Money Klippe (see Fig. 13 for location). Pink quartz monzonite, a part of Simpson Allochthon, is separated from sheared basalt with slivers of serpentinite below it by a gently dipping fault. The contact is a slickensided polished surface above which the quartz monzonite is shattered and recemented but not penetratively sheared. The basalt below is cataclastic. Other plutonic slices in Money Klippe are sheared. (GSC 203533-R)

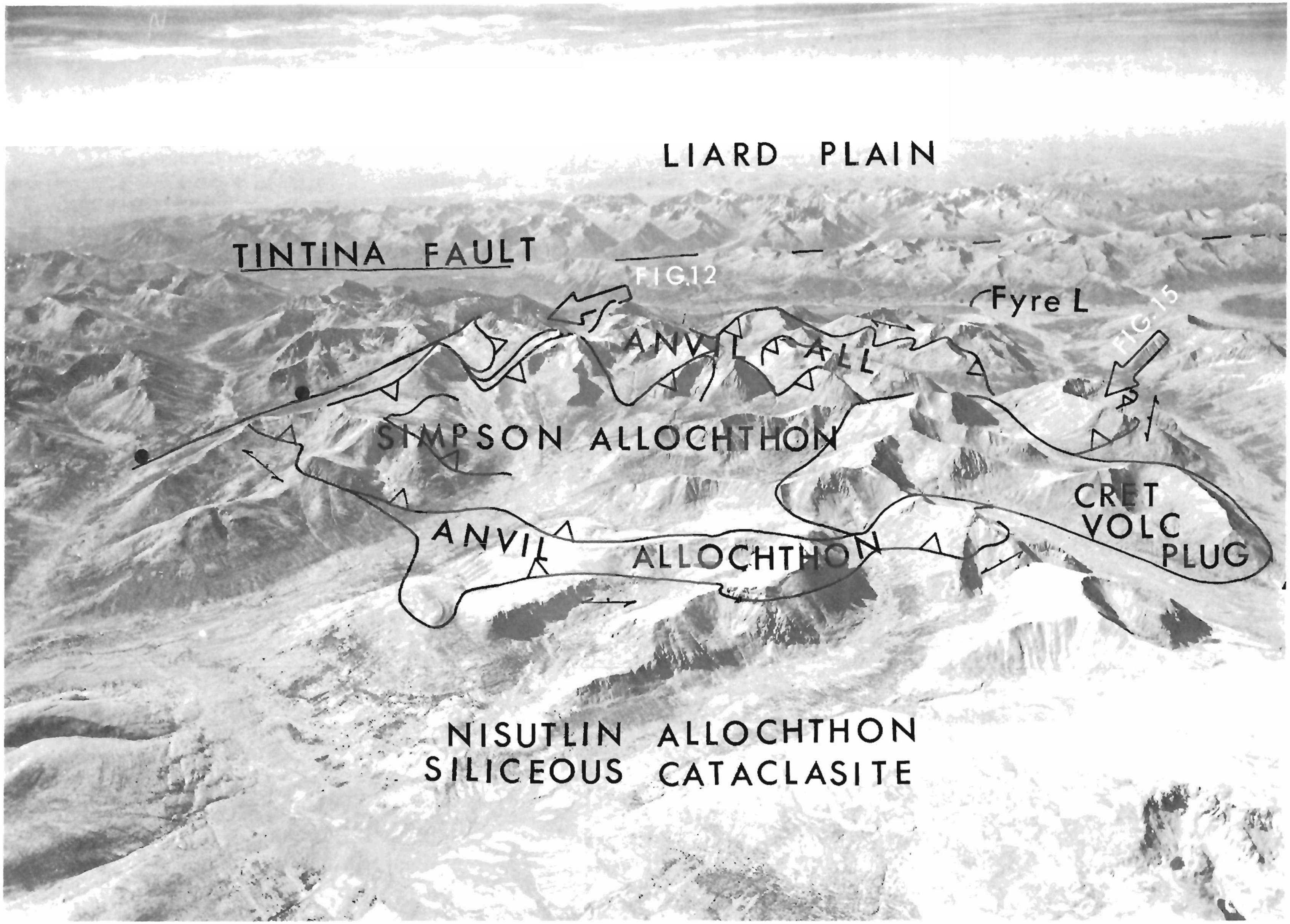


Figure 13. *Oblique aerial photograph of Money Klippe showing the structural superposition of the three allochthonous assemblages. Simpson Allochthon (granodiorite cataclasite and quartz monzonite) lies above Anvil Allochthon (cataclastic or sheared ophiolitic rocks) in turn above Nisutlin Allochthon (siliceous cataclasite). Autochthonous rocks are not seen below. Layering visible here and there is the cataclastic fabric, not bedding. The fabric is roughly parallel in each of the slices and dips gently into the structural depression that has preserved the klippe. Each of allochthons is imbricated by subsidiary faults some of which root in the sole surface but no structural mixing of slices of one allochthon in the other is seen. Note that the sheets are not continuous around the klippe and that they thin and disappear laterally. A subvolcanic plug of Late Cretaceous andesite and rhyolite cuts the klippe at its northwest side. This is a southwestward view in which Tintina Trench, the locus of the Cretaceous transcurrent fault, can be seen in the distance. The klippe is 16 km across.(GSC 203533-S)*

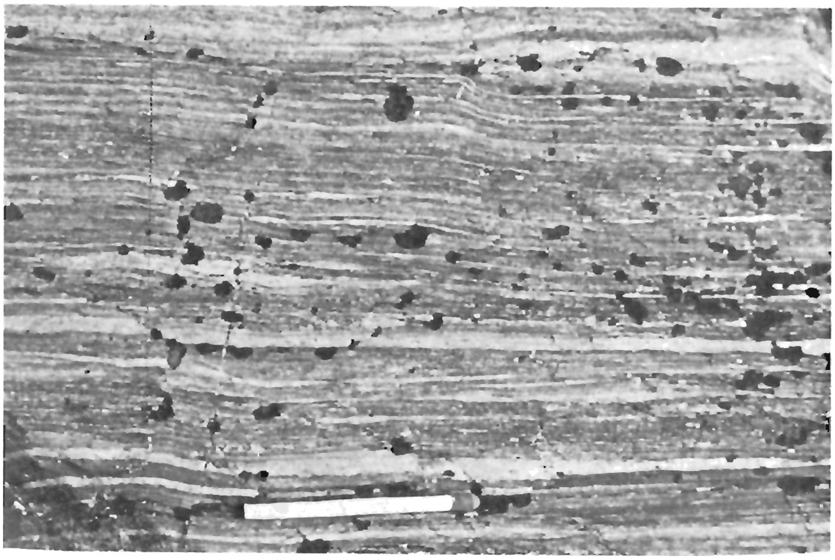


Figure 14.

Amphibolite with flaser fabric emphasized by amphibole growth and by feldspar segregation and neocrystallization. This rock is to a basalt or gabbro what a blastomylonite is to a siliceous sediment. As with the granitic cataclasite (Fig. 11) there is a complete range between this fabric and that illustrated in Fig. 6 and they can be traced into one another. This amphibolite is part of Anvil Allochthon in Money Klippe below the contact shown in Fig. 12. Generally the flaser fabric is better developed in the Simpson and Nisutlin allochthons than in Anvil Allochthon. This probably reflects the nature of the starting materials; the more siliceous the more clearly the rock shows the mylonite fabric. It does not mean that Anvil Allochthon is less sheared. The black spots are lichen. (GSC 203533-T)

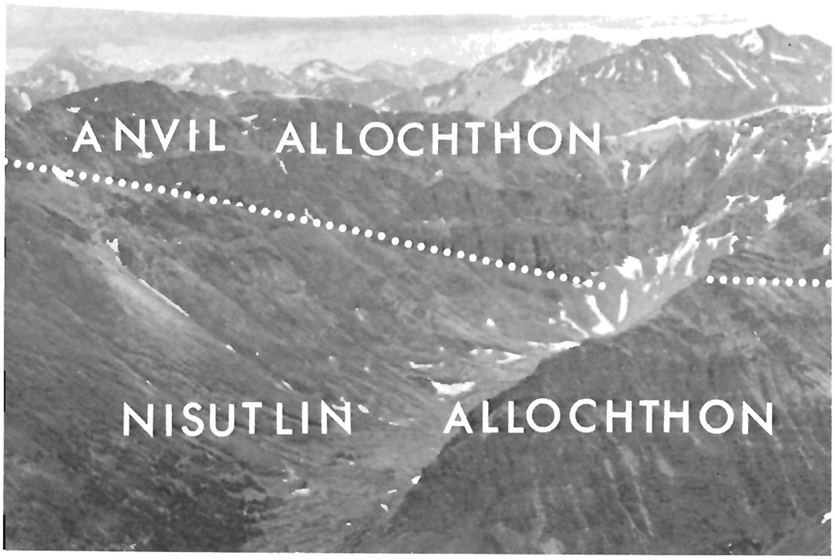


Figure 15.

Eastward view of Anvil Allochthon above Nisutlin Allochthon on the west side of Money Klippe (see Fig. 13 for location). The rocks above the prominent gently dipping contact are amphibolite like that of Fig. 14, and sheared basalt and gabbro with slices of serpentinite. Below are siliceous mylonite and blastomylonite like that of Fig. 4. Anvil Allochthon is structurally imbricated and some of its subsidiary faults, all carrying similar rocks, can be seen. In areas of poor exposure such repetition or perhaps better, such zones of strain concentration, are less obvious. (GSC 203533-U)

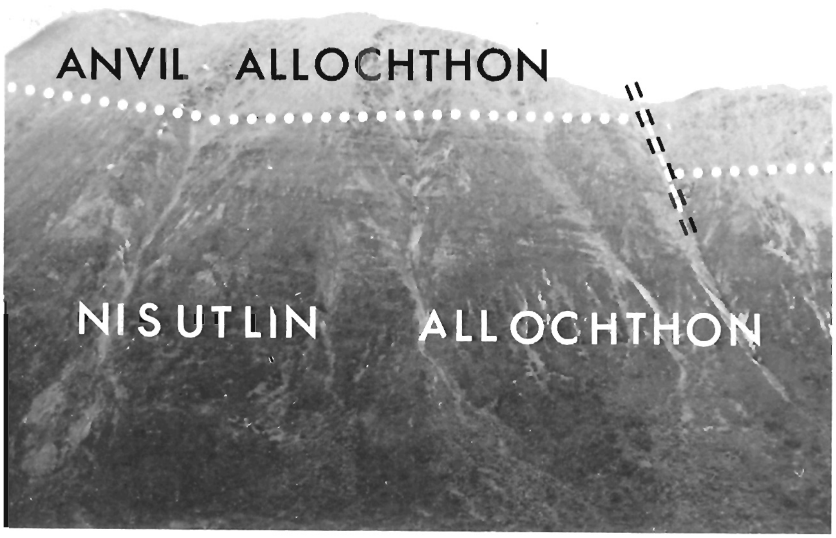


Figure 16.

View of the south side of one of the North Klippen. Brown weathering massive serpentinized peridotite, part of Anvil Allochthon, lies above siliceous mylonite and blastomylonite (Nisutlin Allochthon). The nearly horizontal layering in the lower half of the photograph is not bedding but the flaser fabric. In Nisultin Allochthon this fabric is well developed throughout and at all scales of observation and the rocks appear to be more homogeneously strained than those of Anvil Allochthon. For example, zones of concentrated strain visible in Fig. 15 are absent. (GSC 203533-V)

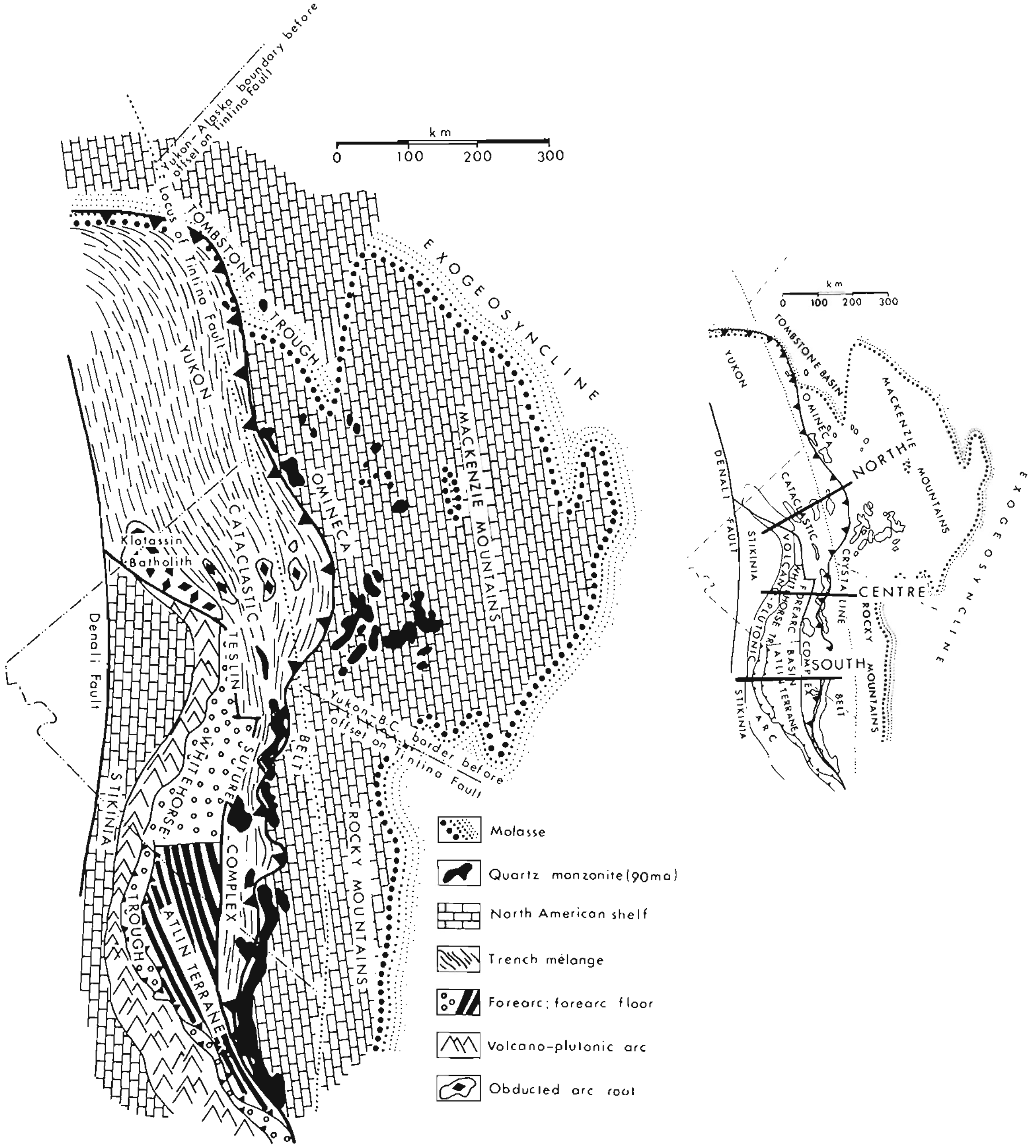


Figure 17. Reconstruction of the geology of the northern Canadian Cordillera showing the spatial relations between some of the elements before Late Cretaceous dextral strike-slip of 450 km on Tintina Fault. The line of reconstruction, shown dotted, is the Tintina Fault and the offset boundaries of Yukon are shown for reference. The diagram emphasizes the unnamed thrust front which has brought a volcano-plutonic arc assemblage, the Lewes River arc system, next to and above ancient North American shelf facies. The arc system, Late Triassic and Early Jurassic in age, includes a mélange, a forearc and a plutonic arc root with volcanic remnants. It was built immediately next to or on continental crust that may have been rifted from North America earlier (Stikinia). The arc system shows a northeast polarity which implies it was built above a southwest dipping subduction zone. This subduction zone became the locus of continental underplating or arc obduction when ocean between the arc and North America had been consumed in the mid-Jurassic. The Mackenzie and Rocky Mountain fold and thrust belts are results of this collision as are the late tectonic granitic bodies. The molasse shed northeastward from the orogenic belt accumulated in foreland basins whose axes moved away from the mountains with time. The inset locates the three cross-sections of Fig. 20F.

Mineral assemblages diagnostic of the pressure-temperature conditions of metamorphism are uncommon, but ecologite is known at several places within the siliceous calaclasite near Faro, about 70 km northeast of Ross River. Its chemistry and mineralogy are like those of ecologite of the Franciscan mélange (Tempelman-Kluit, 1970) and its presence suggests rather high pressure and comparatively low temperature environments of metamorphism. The metamorphism of the Anvil and Simpson allochthonous assemblages remains to be studied for temperature-pressure diagnostic assemblages.

Metamorphism of the cataclastic rocks was contemporaneous with their shearing which occurred in the Late Triassic and ? Early Jurassic. It is dated by conodonts recovered from clastic rocks that contain mylonite debris at the locality near Faro.

Age of Allochthonous Rocks

The three allochthonous assemblages are tectonic mélanges and the age of various lithologic units within each may differ substantially. The siliceous mylonite is thought to be largely Late Triassic and Early Jurassic and limestone enclosed by it may be Pennsylvanian. The ophiolite of Anvil Allochthon is probably Late Paleozoic and the granitic rocks of Simpson Allochthon are considered early Mesozoic.

Direct evidence for the age of the protolith of Nisutlin Allochthon comes from the two Upper Triassic conodont collections near Faro. Because some of the clastic rocks resemble the Upper Triassic to Lower Jurassic Lewes River and Laberge groups of the Whitehorse Trough the clastic rocks may range into the Early Jurassic. Some limestone

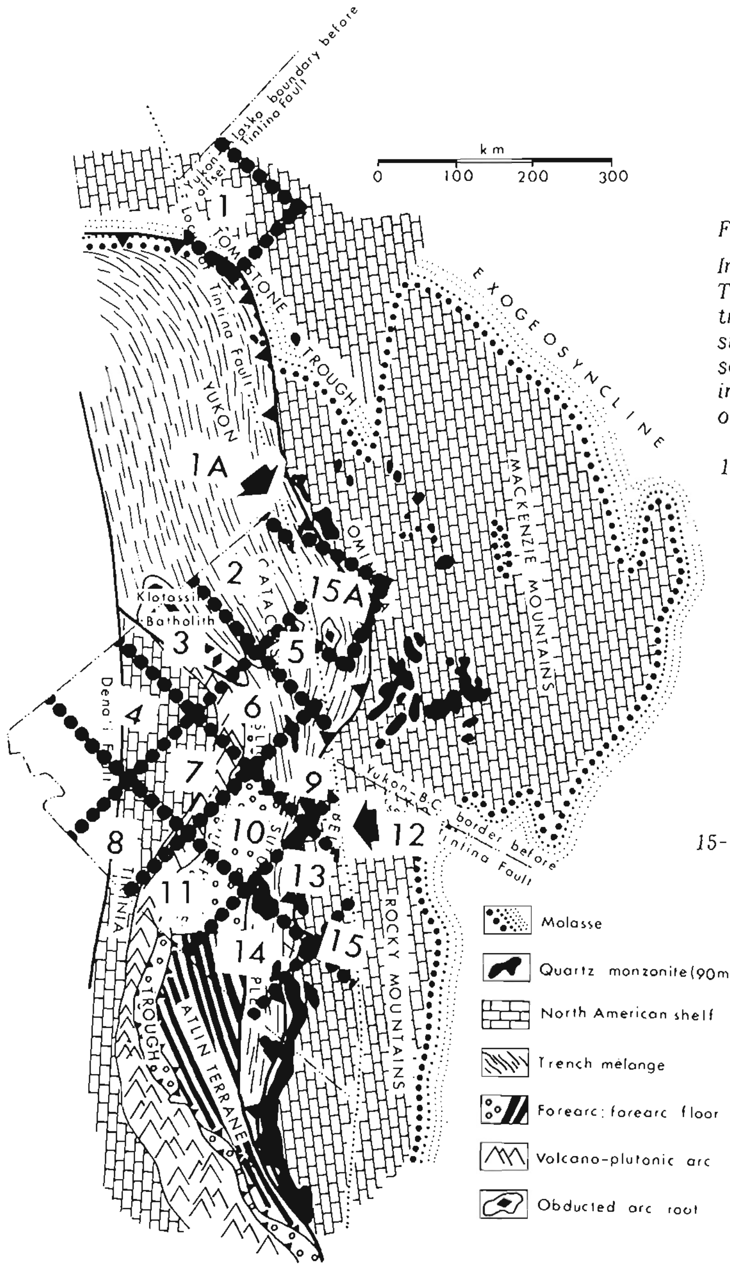


Figure 18.

Index map of some of the regional geological data sources. The base is the reconstruction of Fig. 16 before right lateral transcurrent movement on Tintina Fault. The map emphasizes that some map areas (eg. 1-1A and 15-15A) contain segments originally separated by 450 km. The area of Fig. 3 includes Finlayson Lake (15 and 15A) Quiet Lake (13) and part of Laberge (10) map areas.

1-1A	*Dawson (Green, 1972)*
2	*Stewart River (Tempelman-Kluit, 1974) and Ogilvie (Bostock, 1942)*
3	*Snag (Tempelman-Kluit, 1974)*
4	*Kluane (Muller, 1967)*
5	*McQuesten (Bostock, 1964)*
6	*Carmacks (Bostock, 1936)*
7	*Aishihik Lake (Tempelman-Kluit, 1974)*
8	*Dezadeash (Kindle, 1952)*
9	*Glenlyon (Campbell, 1967)*
10	*Laberge (Tempelman-Kluit, 1978b)*
11	*Whitehorse (Wheeler, 1961)*
12	*Tay River (Roddick and Green, 1961)*
13	*Quiet Lake (Tempelman-Kluit, 1977b)*
14	*Teslin (Mulligan, 1963)*
15-15A	*Finlayson Lake (Tempelman-Kluit, 1977b)*

clasts in the conglomerate near Faro have Upper Triassic conodonts which also indicates that Nisutlin Allochthon contains Upper Triassic or younger rocks. The volcanic rocks in Nisutlin Allochthon are more felsic than those of Anvil Allochthon and are not part of that suite. Instead they may be distal equivalents of Upper Triassic volcanic rocks included in the Lewes River Group of Whitehorse Trough, but no data are available to substantiate this.

Pennsylvanian conodonts were recovered from a lens, 15 km long, of sheared limestone enclosed by siliceous cataclasite near the Finlayson Klippen. The lens is one of a number found in a belt 150 km long, but because each is tectonically bounded their Pennsylvanian age may have no bearing on the age of the enclosing rocks and the limestone may represent a discrete stratigraphic assemblage depositionally unrelated to the siliceous cataclasite.

In Finlayson Lake area Nisutlin Allochthon grades downward into paragneiss which can be separated into two units (Tempelman-Kluit 1977b). The upper is calcareous, quartz-mica schist with marble lenses; the lower is grey, muscovite biotite granodiorite to quartz monzonite augen gneiss. Relations between the siliceous mylonite and the gneisses below are masked by mid-Cretaceous metamorphism and plutonism that postdates cataclasis and transport of Nisutlin Allochthon. It is therefore uncertain whether the schist and gneiss are autochthonous beneath the siliceous cataclasite or whether they represent a thoroughly metamorphosed and partly granitized lower part of Nisutlin Allochthon. These rocks may represent Upper Proterozoic strata or even older continental crust.

Two fossil collections were made in the Anvil district from the ophiolitic rocks of the Anvil Range Group (Tempelman-Kluit, 1972). At one locality on Rose Mountain latest Pennsylvanian or earliest Permian fusulinids and Pennsylvanian conodonts were recovered from a limestone that interfingers depositionally with red and green chert and basalt of the Anvil Range assemblage. At the other locality, near Ross River, a second limestone, thought to overlie basalt of the Anvil Range Group depositionally, contains Middle Permian fusulinids. No fossils have been discovered in the sheared ophiolite. If the Anvil Range ophiolite, which is not cataclastic and probably is not allochthonous, is the same age as the sheared ophiolite included in Anvil Allochthon the cataclastic ophiolite is Pennsylvanian-Permian otherwise its age is unknown.

No radiometric ages have so far been determined for the plutonic rocks of the Simpson Allochthon and the age of these rocks is unknown. Hornblende quartz diorite of Simpson Allochthon resembles that of the Klotassin Suite, 450 km distant, which has given K/A ages of 200-160 Ma (Tempelman-Kluit and Wanless, 1975). The Simpson Allochthon assemblage may therefore be the same age. When

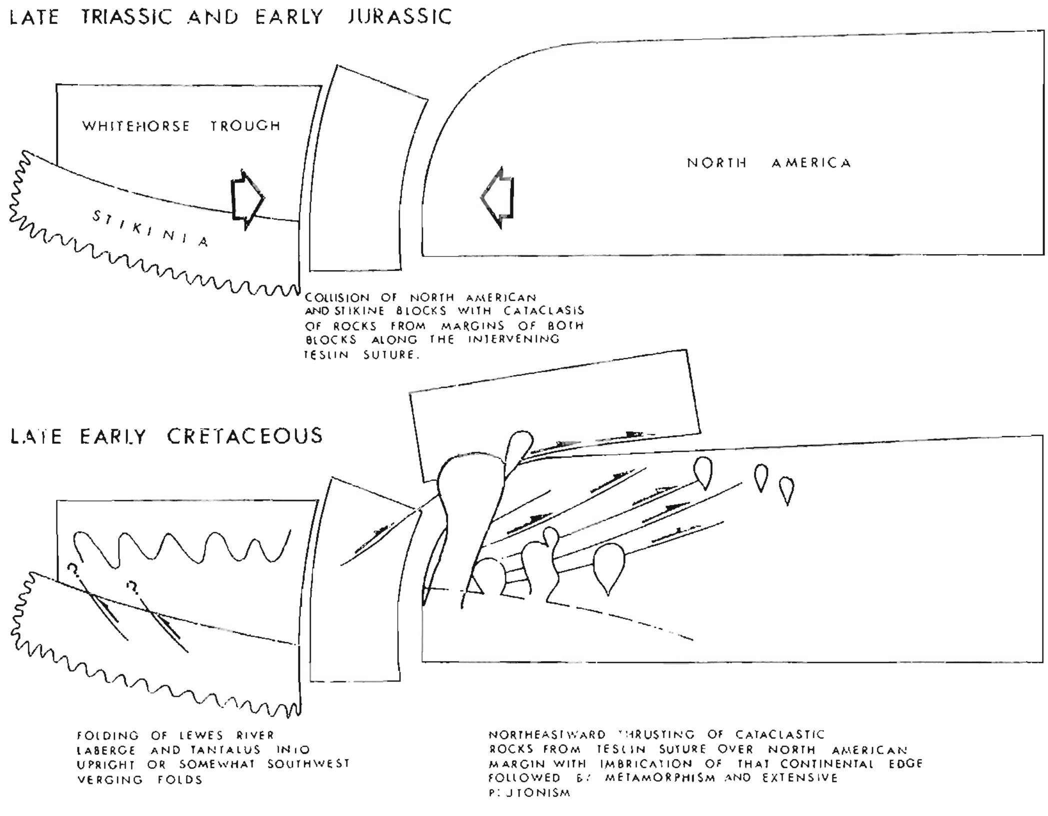


Figure 19. Schematic representation of the two tectonic events recorded in rocks across Teslin Suture Zone (compare with Fig. 2). Rocks of the suture zone and klippen are equally cataclastic and lithologically alike. The autochthon is not sheared. Cataclasis must therefore be independent of transport and most likely occurred in Teslin Suture Zone. The shearing is dated by the synorogenic clastics which contain Upper Triassic conodonts. Transport occurred in the Early Cretaceous after cataclasis and is bracketed by 90 Ma plutons that post date movement and by overridden Early Cretaceous molasse in Tombstone Basin.

the geology is restored to reflect relative positions before movement on Tintina Fault and following emplacement of the allochthons, the Fyre and Money klippen lie 150 km northeast of Klotassin Batholith.

A minimum age of 90 ± 10 Ma for the allochthonous rocks, and for allochthon transport, is given by numerous plutons and subvolcanic bodies of quartz monzonite of that age which have invaded and metamorphosed transported and autochthonous strata.

Time of cataclasis and time of transport

The cataclastic rocks of Teslin Suture Zone and those preserved as klippen and thrust sheets were probably sheared in the Late Triassic (and Early Jurassic?), but were not transported over autochthonous rocks on the ancient North American margin until the Early Cretaceous (Fig. 19).

Evidence that cataclasis and at least final transport were distinct events separated by a time interval is the marked contrast in fabric and metamorphism between allochthonous and autochthonous rocks. The allochthonous rocks are protoclastic to blastomylonitic and metamorphosed to greenschist grade whereas the autochthonous strata are unmetamorphosed, lack cataclastic fabric and preserve depositional features. The transitions from one to the other are across basal thrust surfaces that are abrupt and occur in one metre or less. The cataclastic fabric and metamorphism of the klippen is the same as that of Teslin Suture Zone and this implies that the rocks derive from Teslin Suture Zone and that they acquired their fabric and metamorphism in the zone.

The time of cataclasis is given by the unsheared parts of Nisutlin Allochthon where mylonite clasts and other cataclastic grains occur in Upper Triassic conodont bearing sedimentary strata (the Faro locality mentioned earlier). This indicates that deposition and cataclasis of Nisutlin Allochthon were synchronous so that sandstone was first deposited, then sheared and elevated to be eroded and incorporated in newer sediment in a continuous cycle.

Evidence that final transport of the cataclastic klippen was in late Early Cretaceous time comes from Dawson map area where clastic rocks, thought to be part of the synorogenic sequence because they contain mylonite debris, are thrust northward over structurally repeated Triassic, Jurassic and Lower Cretaceous strata (Tempelman-Kluit, 1979), but are intruded by mid-Cretaceous plutonic rocks. Thrust imbrication and folding of the autochthonous strata in the Pelly Mountains probably occurred while the cataclastic rocks were transported above them in the late Early Cretaceous.

Amount of transport

The marked contrast in lithology, fabric and metamorphism of allochthonous and autochthonous rocks in southwestern Omineca Belt of Yukon implies that the allochthonous rocks may be far travelled. Similarity of lithology, structure and metamorphism of the rocks in the allochthonous sheets in Teslin Suture Zone indicates that the suture zone is the root for the allochthonous slices of cataclastic rocks. The distance between the northeast margins of the klippen and of the Teslin Suture Zone is therefore a measure of the amount of overlap of the cataclastic rocks onto the autochthon and of their minimum travelled distance. Shortening following emplacement of the allochthons was accomplished by buckling the stratigraphic – structural sequence into broad, open, northwest trending culminations and depressions during posttectonic plutonism. It may amount to 10 per cent. The McNeil Klippen now lie 100 km northeast of Teslin Suture Zone and the northeast edge of St. Cyr Klippe is between 50 and 70 km from it. The Dunite klippen, only 15 km from the root zone, moved least. Reconstruction by restoring the 450 km of right lateral strike-slip on Tintina Fault shows that the Finlayson and Wolverine klippen lay about 175 km northeast of the presumed extension of Teslin Suture Zone. Money, North, Fyre and Hoole klippen were roughly 125 km from the same extension of the suture zone before Tintina movement.

SUMMARY

Three assemblages of sheared cataclastic rocks, a siliceous mylonite, a dismembered ophiolite and a sheared plutonic assemblage are found as klippen and allochthonous sheets above Upper Proterozoic, Paleozoic and lower Mesozoic autochthonous strata that were deposited near the ancient margin of North America. Together the autochthonous and transported rocks make up Omineca Belt. Southwest of this belt the Teslin Suture Zone contains cataclastic rocks lithologically like those in the klippen in Omineca Belt. Farther southwest are Lower Mesozoic fanglomerates and turbidites derived from an arc. These make up Whitehorse Trough, a part of the Intermontane Belt.

The three assemblages of sheared and cataclastic rocks in the allochthonous sheets and Teslin Suture Zone are tectonic mélanges of synorogenic sediments and remnants of crustal fragments. They were cataclastized and structurally imbricated before and/or during juxtaposition of the Intermontane and Omineca Belts in the Late Triassic and? Early Jurassic?. Omineca Belt was not overridden by these cataclastic rocks and itself imbricated by thrusts until the Early Cretaceous.

Each of the three cataclastic assemblages is a tectonically imbricated structural mélange of rocks sheared in one interval, but of diverse origin and age. Depositional relations between the assemblages are unknown. The rocks are so sheared and dismembered that their internal stratigraphy is not known. The siliceous mylonite (Nisutlin Allochthon) is a tectonic mélange that contains mainly sheared synorogenic clastics with detritus of the cataclastic rocks and volcanic debris. The clastic rocks were deposited in the Late Triassic and ?Early Jurassic. Structurally imbricated with the siliceous cataclasites and possibly depositionally interlayered are locally voluminous intermediate volcanic rocks which may be equivalents of volcanics in the Lewes River Group. Elsewhere the siliceous mylonite includes slices of sheared Pennsylvanian limestone whose depositional relations to the other rocks are not known. Slices of strongly sheared graphitic quartzite, locally an important part of Nisutlin Allochthon, are thought to be tectonically imbricated slivers of the early Paleozoic North American margin. For the most part these structural slivers, characterized by different lithologies, have not been differentiated in Nisutlin Allochthon.

The ophiolitic assemblage (Anvil Allochthon) includes basalt, gabbro and serpentinized peridotite. It is considered a slice of oceanic crustal rocks, now structurally disrupted. It presents a special problem because it is not certain that all parts of the ophiolitic rocks are allochthonous and derived from the same assemblage. In particular the Pennsylvanian and Permian Anvil Range Group on Rose Mountain (outside the area of Fig. 3) and equivalent rocks east of Ross River may not be allochthonous but may rest where they formed. If so their age gives no clue to the age of the allochthonous slices of ophiolite in the region. These latter may be younger than the Anvil Range Group.

Figure 20. Schematic diagrams of the evolution of the northern Canadian Cordillera.

A. *A shelf sequence of Windermere to Mississippian age accumulates on continental crust at the margin of North America. The edge of the continent was rifted in the Proterozoic. Not shown is a Cambro-Ordovician event that extruded alkali-basalt well aboard the continent. These volcanics may represent a fossil arc of Andean type above an east dipping subduction zone.*

B. *The North American margin is rifted as felsic volcanic rocks are extruded and continental shelf derived clastics are deposited in grabens during the Early Mississippian. In the Carboniferous or Permian tholeiitic lavas, e.g. Anvil Range Group are extruded above older shelf strata.*

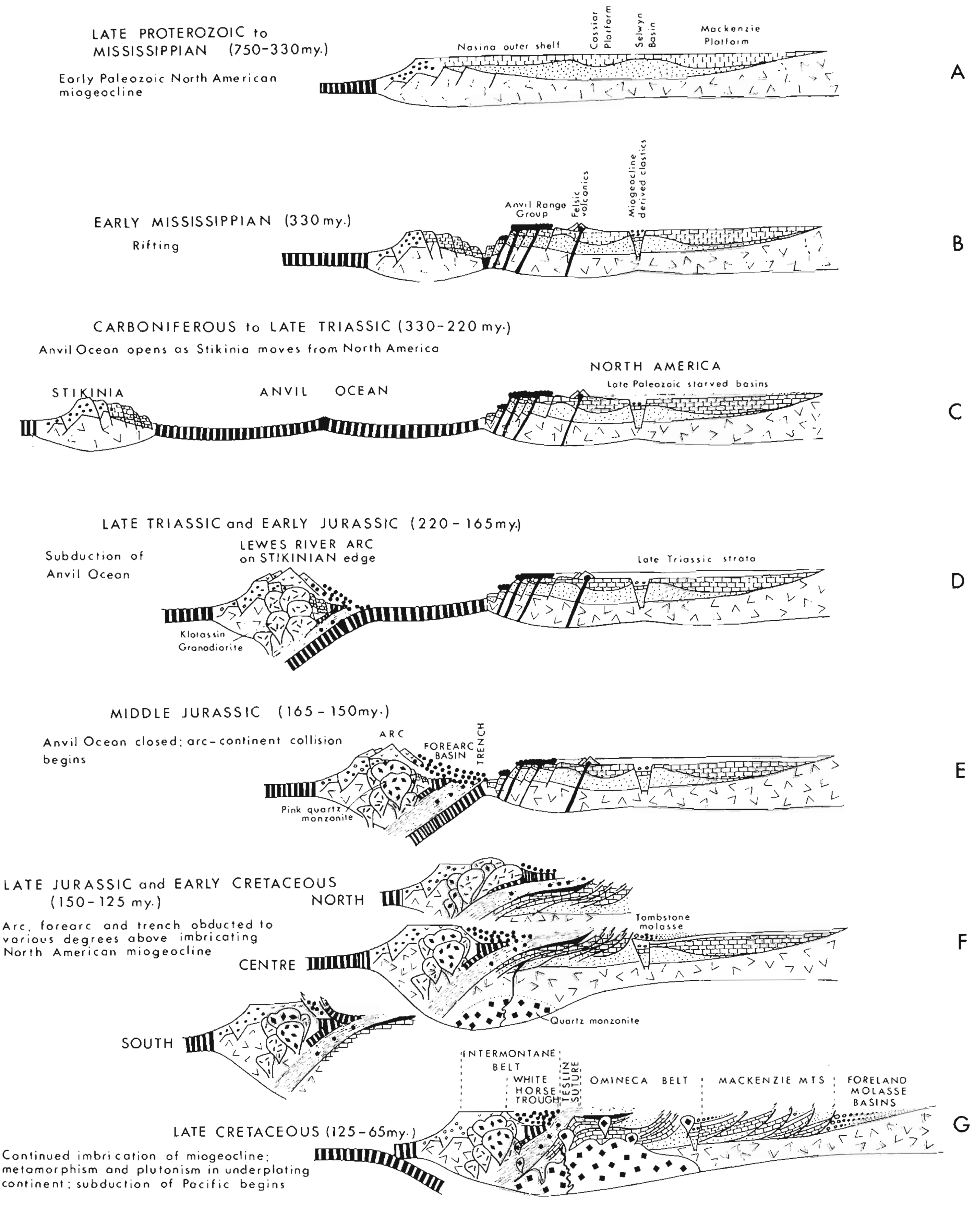
C. *The rift system graduates to the full fledged Anvil Ocean which opens as spreading continues at the rift. A condensed margin shelf sequence accumulates on North America but the history of Stikina in this interval is obscure. At average spreading rates between 1 and 5 cm/a. Anvil Ocean may have been between 1100 and 5500 km wide. Fusulinid faunas evolved away from each other on opposite sides of the ocean.*

D. *By the Late Triassic southwestward subduction of Anvil Ocean lithosphere beneath Stikinia has begun. The oldest rocks of Lewes River arc signal the event. The arc is active for 60 Ma (through the Early Jurassic) and in this interval a clastic apron develops at its front. The forearc includes the Laberge Group, the arc volcanics are the Lewes River Group and the plutonic roots of the arc is the Klotassin granodiorite suite. Clastic rocks also accumulate in the trench and are transformed into a mélange by shearing during subduction. On North America a fine clastic open marine shelf sequence accumulates. Its fauna differs from that of the coeval arc.*

E. *In the Middle Jurassic oceanic lithosphere is entirely subducted and the last arc plutons (pink quartz monzonite) rise. The arc now lies adjacent to North America but overlap has not yet begun. Shale is deposited on the North America shelf while the youngest arc sediments accumulate; their faunas differ.*

F. *The Lewes River Arc is obducted over North America during the Late Jurassic and Early Cretaceous. North American shelf strata are imbricated northeastward in the process and may be decoupled from their basement allowing the continental crust to slide under the arc independent of its cover. The leading edge of the underplating North American slab is warmed and partially melted and Omineca metamorphism begins. Molasse is shed northeastward into Tombstone basin and southwestward into Bowser Basin (see Fig. 21). The three cross sections are different transects of the orogen to depict different degrees of overlap (see inset of Fig. 17). In the north, where the arc is entirely obducted, slices of its plutonic root (Simpson Allochthon) lie on sheets of obducted forearc basin floor or undertucked Anvil Ocean (Anvil Allochthon) which in turn lie on mélange (Nisutlin Allochthon) all above imbricated North America shelf strata. In the centre cross-section mélange alone is thrust over North America but the arc system is preserved outboard. The southern section shows backthrusting of the forearc basin floor over its cover and that in turn over the arc. Backthrusting was as much a response to arc obduction as imbrication of the North American cover.*

G. *For another 60 million years North American shelf strata continue to be deformed and molasse is shed through this interval ahead of the growing mountain chain. Quartz monzonite plutons, formed by partial melting of the underplating North American edge, rise in the centre of the orogenic welt. While the structures are already formed and the metamorphic and plutonic rocks already fozen in the centre of the orogen, those toward the craton are still actively forming.*


LATE PROTEROZOIC to MISSISSIPPIAN (750-330my.)
Early Paleozoic North American miogeocline
Nasina outer shelf
Cassiar Platform
Selwyn Basin
Mackenzie Platform
A
EARLY MISSISSIPPIAN (330my.)
Rifting
Anvil Range Group
Felsic volcanics
Miogeocline derived clastics
B
CARBONIFEROUS to LATE TRIASSIC (330-220my.)
Anvil Ocean opens as Stikinia moves from North America
STIKINIA
ANVIL OCEAN
NORTH AMERICA
Late Paleozoic starved basins
C
LATE TRIASSIC and EARLY JURASSIC (220-165my.)
Subduction of Anvil Ocean
LEWES RIVER ARC on STIKINIAN edge
Late Triassic strata
Klotassin Granodiorite
D
MIDDLE JURASSIC (165-150my.)
Anvil Ocean closed; arc-continent collision begins
ARC
FOREARC BASIN
TRENCH
Pink quartz monzonite
E
LATE JURASSIC and EARLY CRETACEOUS (150-125 my.)
Arc, forearc and trench obducted to various degrees above imbricating North American miogeocline
NORTH
CENTRE
SOUTH
Tombstone molasse
Quartz monzonite
F
INTERMONTANE BELT
WHITE HORSE TROUGH
TESLIN SUTURE
OMINECA BELT
MACKENZIE MTS
FORELAND MOLASSE BASINS
LATE CRETACEOUS (125-65my.)
Continued imbrication of miogeocline; metamorphism and plutonism in underplating continent; subduction of Pacific begins
G

The granitic cataclasite (Simpson Allochthon) may be the plutonic root of a dismembered island arc. Unsheared parts resemble plutonic rocks found southwest of Whitehorse Trough and possibly related to the eroded arc thought to have lain there in the Late Triassic and Early Jurassic. Alternately they may be remnants of an intrusive complex in a metamorphic – plutonic terrane, but no metamorphic strata are associated with it. On lithologic correlation with Klotassin granodiorite and Pink quartz monzonite of Yukon Cataclastic Terrane, the granitic cataclasite is tentatively considered a suite of rocks of late Triassic or earliest Jurassic age that were sheared in Early to Middle Jurassic time.

The cataclastic rocks were thrust northeast as preassembled tectonic mélanges during the late Early Cretaceous. They moved as one or more sheets one or two kilometres in aggregate thickness above the eroded ancient margin of North America for distances in the order of 100 km. Imbrication of the cataclastic rocks may have occurred during the thrusting. During transport the rocks were not sheared, but their flaser fabric was folded and locally transposed on a gently southwest dipping crenulation foliation. Autochthonous strata were also thrust northeast during transport of the cataclastic rocks. Their deformation involved folding and northeast movement on discrete, widely spaced thrusts beneath the allochthonous slices. Facies overlap of 10 or 20 km was achieved locally.

Synorogenic clastic rocks, structurally interleaved with the siliceous mylonite, were turbidites and related strata deposited synchronously with the Lewes River - Laberge groups of Whitehorse Trough and with Late Triassic fine clastic rocks in the Omineca Belt. They were derived from the southwest partly from the arc that supplied detritus to Whitehorse Trough and from elevated areas of rocks sheared in Teslin Suture Zone. The basin in which the clastic rocks accumulated was wider during deposition than the roughly 100 km that now separate Whitehorse Trough from preserved Triassic strata in Omineca Belt.

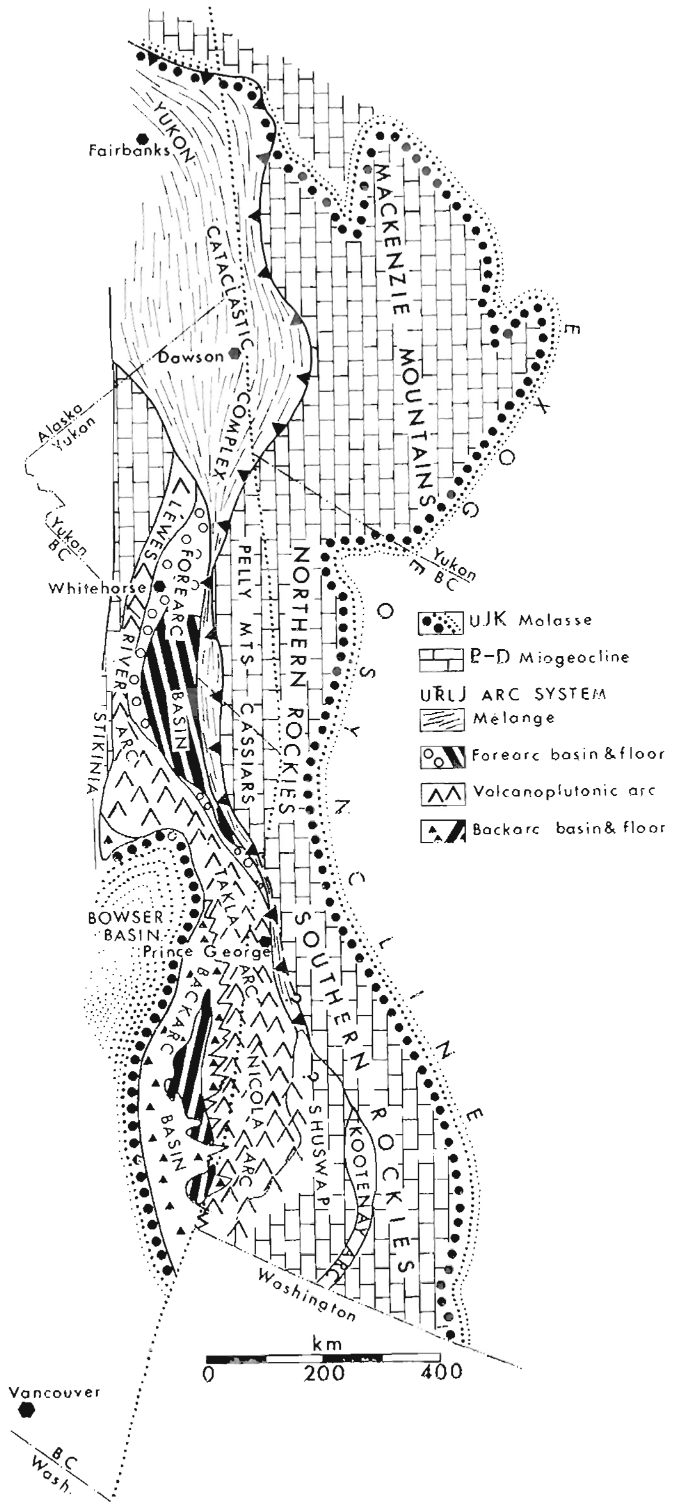


Figure 21.

Reconstruction of the Canadian Cordillera by restoring 450 km of right lateral slip on the Tintina - northern Rocky Mountain faults and extending this displacement across Intermontane Belt to the Fraser or Pasayten Faults. In assuming southward continuation of the model the diagram shows the obducted Lewes River - Nicola - Takla as one arc system on the underplated edge of North America. The restoration emphasizes that the wide parts of the foreland fold and thrust belt i.e. Mackenzie and southern Rocky Mountains formed opposite the two zones of greatest arc obduction and that the orogenic welt is narrowest where the entire arc system is preserved and presumably least obducted. The map shows the Bowser-Tantalus molasse southwest of the orogen. It is interesting that the Lewes River arc lies immediately on or next Stikinia in the north (Sumatra type arc) but that the Takla and Nicola extension is well outboard of Stikinia in the south and presumably founded on oceanic crust there (Japan type arc). If the model applies the basal contact of the obducted arc system must continue into the Shuswap terrane and be involved in its latest metamorphism and deformation.

No isotopic ages have so far been obtained from cataclastic rocks in Quiet Lake and Finlayson Lake areas. However, K/Ar ages were determined for these rocks from adjacent parts of Yukon Cataclastic Complex (Tempelman-Kluit and Wanless, 1975). Equivalents of the siliceous mylonite, and the granitic cataclasite, there included in the Klondike Schist, Pelly Gneiss and Klotassin granodiorite, have given cooling ages of 170-160 Ma and the post-cataclastic Pink quartz monzonite cooled 160 Ma age. These ages are reinterpreted as the time of cooling following cataclasis. They therefore show that the cataclasis, which was active in the Late Triassic and Early Jurassic in Teslin Suture Zone, ceased by the Middle Jurassic.

AN ARC – CONTINENT COLLISION MODEL

Most of the elements described herein fit the concept that Teslin Suture Zone was a subduction complex formed at an arc-ocean collision boundary in Late Triassic and Early Jurassic time and that the boundary graduated to an arc continent collision margin in the late Jurassic when the ocean was finally closed (Fig. 20). In this interpretation Whitehorse Trough rocks are an arc-trench sequence deposited on a forearc terrace northeast of its accompanying volcanic arc (Fig. 20 d, e). This arc is now represented mainly by its deeply eroded plutonic roots in Whitehorse, Aishihik and Dezadeash areas (Fig. 18). Northeast of the arc and its trench lay the open sea with North America beyond (Fig. 20 c). The arc grew above a southwestward dipping subduction zone where oceanic floor was consumed (Fig. 20 d) and it probably formed on a continental margin rather than as an intraoceanic arc; its plutonic rocks have yielded initial ratios above .706 (Le Couteur and Tempelman-Kluit, 1976). Metamorphic rocks southwest of the arc may be remnants of this continent, "Stikinia"*, although they suggest affinities with the North American block. In Aishihik Lake area they are separated into a lower garnet mica schist, a marble, and a graphitic quartzite which together resemble Upper Proterozoic, Lower Cambrian and Siluro-Devonian strata at the edge of the North American block.

Other evidence suggests that Stikinia may have been rifted from North America. The most southwesterly preserved Lower Paleozoic strata of the old North American block (those immediately northeast of Teslin suture) are shelf facies that accumulated at least some distance northeast of the then continental margin. The Stikinian block may be the old continental margin of North America on which the Early Paleozoic slope facies may be preserved. The rifting probably occurred in the Carboniferous. Evidence that implies Carboniferous extension of the crust in this region is the continental shelf derived Mississippian conglomerate deposited in grabens that are most likely also Mississippian (S.P. Gordey pers. comm., 1978). Early Mississippian (Viséan) alkalic volcanics, extruded as submarine plug domes in the Pelly Mountains coincide in time with the possible extension event.

Assuming that rifting occurred in the Early Mississippian (Fig. 20 b, c) the Anvil Ocean grew for about 110 Ma through Pennsylvanian, Permian and Early Triassic time. At reasonable spreading rates it must have attained substantial size. Rates between 2 and 10 cm/a** translate to widths of 2200 km and 11 000 km. The observation of Monger and Ross (1971) that profoundly different fusulinid faunas occur in the Canadian Cordillera in three belts can support the concept of a major closed ocean. Their Eastern Belt of Schwagerinid faunas is found in the Anvil Range Group and equivalent rocks extruded on the ancient North American margin in this model, but their Central Belt of Verbeekinid faunas is confined to the accreted arc system of the Intermontane Belt. In Late Triassic and Early Jurassic time, while the Anvil Ocean was subducted under Stikinia and while the Lewes River Arc was active, the marked difference in faunas between North America and the arc continued. Tozer (1958) who studied the Triassic faunas referred to them as Eastern and Western Assemblages respectively and H.W. Tipper (pers. comm., 1978) considers that the Early Jurassic (Pliensbachian) of ancient North America has Boreal affinities and that of the arc, Mediterranean characteristics.

The Lewes River arc system (Intermontane Belt), formed during westward subduction of the Anvil Ocean includes, from northeast to southwest, the 10 to 100 km wide trench mélange (Yukon Cataclastic Complex and Teslin Suture Zone), the forearc basin (Whitehorse Trough) and forearc basin floor (Atlin Terrane) up to 150 km wide as well as the plutonic arc root with volcanic remnants, which is an unnamed 50 – 100 km wide segment of the Intermontane Belt. Behind (southwest of) this arc are the metamorphosed remnants of Stikinia. The widths of the arc elements are similar to those of other fossil and active arcs as summarized by Dickinson (1974).

The cataclastic rocks of Teslin Suture Zone and the allochthons are a mélange and presumably were trench sediments sheared during subduction and imbricated tectonically with slabs of oceanic crust and parts of the arc at the face of the arc system (Fig. 20 d, e). The presence of eclogite in the cataclasite and its occurrence in equivalent rocks on trend near Fairbanks (Forbes et. al, 1968) supports the interpretation of these rocks as subduction related mélange. Parts of the mélange were sufficiently uplifted by oceanic underplating that cataclastic rocks became exposed to erosion and detritus from them was incorporated in newer mélange. By the Middle Jurassic the ocean between Stikinia and North America had shrunk and the two continents, the first with its Sumatran type arc, the second unadorned, collided (Fig. 21). Now (Bajocian and Callovian: Middle Jurassic) the ammonite faunas of the arc and North America show many common forms (H.W. Tipper pers. comm., 1978). The west edge of the newly accreted Stikine block become the west edge of the new North America. Teslin Suture with its tectonic mélange remained to mark the closed ocean. Although in contact, the two continental blocks continued to be driven toward each other, and in the Late Jurassic a Himalayan-type collision orogen, took over from the arc-ocean system (Fig. 20 f). The late Paleozoic-early Mesozoic North American margin began underplating the Lewes River arc on the Stikine block. Thrusts transported cataclastic mélange sheets from Teslin Suture Zone and slices from the old North American edge northeastward above the underplating block for as much as two hundred kilometres. A molasse formed on the depressed North American margin in front of the advancing obducted sheets.

The degree of obduction of the arc evidently varied along the length of the belt. In the north the arc system terminates (Fig. 17), presumably because it is thrust over the ancient North American edge in its entirety and largely eroded. Only the mélange with large klippen of granodiorite remains as an enormous flap above the old North American edge. Klotassin Batholith, as an example, may be a 200 km long klippe of the arc's root. In the south the whole arc system is preserved outboard of ancient North America. There transcurrent movement may have dominated relative motion between the arc and the old continent.

In plan the great bulge of the Mackenzie Mountains lies opposite the region of maximum overlap of the arc on the old North American margin (Fig. 17). This may point to a cause and effect relationship. Mackenzie bulge may represent the foreshortened North American miogeoclincal wedge in front of, and beneath, the entirely obducted arc system of the Intermontane Belt. Southward where obduction was less the fold and thrust belt narrows.

* The names Stikine Block and Stikinia are inventions of J.W. Monger. He has used the former but not the latter in his publications.

** a is the SI abbreviation for years.

Molasse accumulated in foreland basins now preserved mainly in the exogeosyncline east of the Rocky and Mackenzie mountains. In the north the molasse probably includes the Lower Schist – Keno Hill Quartzite, a sequence of marine Upper Jurassic shale overlain by Lower Cretaceous paralic sandstone and siltstone as well as their offset equivalents on the southwest side of Tintina Fault northwest of Fairbanks (Fig. 17). These strata, now preserved as a thrust wedge, accumulated in the Tombstone Basin, an intermontane depocentre 200 km nearer the orogenic core than the main preserved molasse basins (Fig. 17; 20 f, g). Tombstone Basin may have been connected to the main foreland troughs east of the Mackenzie-Rocky Mountains as shown in Figure 17 or it may have been entirely separate.

Northeastward thrusting of allochthonous rocks over the continental margin and its cover of molasse continued through the Cretaceous (Fig. 20, f, g), but in central Yukon, 300 km from the present mountain front, deformation ceased by mid-Cretaceous. At that time the strata well back from the fold belt front, including the Early Cretaceous molasse, were metamorphosed and invaded by quartz monzonite (Fig. 20 f, g). Metamorphism and plutonism resulted from warming of the overridden North American crust when it was depressed beneath the obducted arc. Warming probably began at the base and leading edge of the underplating North American slab in the Late Jurassic and progressed northeastward and up into the slab through the Early Cretaceous. The plutonic-metamorphic culmination ended early in the Late Cretaceous (about 90 Ma ago) and its main exposures are just northeast of the obducted trench mélange (Fig. 17). Some plutons invaded the obducted cataclastic rocks of the trench mélange but few are known in the forearc and arc.

The right lateral shear that marks the Pacific-North American interface to the present evidently began in the Late Cretaceous. About this time, following cooling of the plutonic and metamorphic rocks 90 Ma ago, dextral strike-slip started on Tintina Fault. The fault broke across old depositional trends and major structural boundaries and when it became inactive in the Early Tertiary displacement amounted to 450 km (Fig. 17). Right lateral movement probably then jumped outboard to a new locus, the Denali Fault.

When the arc – continent collision across Teslin Suture Zone was completed during the late Cretaceous northeastward subduction of oceanic lithosphere probably began anew on the southwest side of the freshly consolidated Stikine and North American blocks (as shown in Fig. 20 g). This led to development of a fresh southwest facing arc on the Stikine block. The Coast Plutonic Belt marks the site of that arc.

The tectonic evolution of the northern Cordillera proposed here is based on initial reconnaissance mapping with little detailed or follow up study. The story is far from being final or understood in detail but these very imperfections should stimulate further study. This report may also serve to help focus future work on the nature, age and history of the transported rocks.

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