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19.

EARLY PROTEROZOIC SEQUENCES IN LABRADOR

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Abstract

Early Proterozoic (Aphebian) sedimentary and volcanic rocks in Labrador are described from two tectonic belts: the Churchill Province of western Labrador, and the Makkovik Subprovince of eastern Labrador.

The Aphebian in the Churchill Province is represented mainly by the Labrador Trough (Kaniapiskau Supergroup) but also in the Laporte Group, Lake Harbour Formation and Petscapiskau Group. The Labrador Trough is the most completely exposed of these sequences and displays a transition from shelf sedimentation in the west, to deeper water basinal conditions in the east. Rifting along the eastern margin of the Labrador Trough may have produced a narrow proto-oceanic rift during this stage.

Aphebian sequences in the Makkovik Subprovince are represented by the Moran Lake and Aillik groups. The Moran Lake and lower Aillik groups were deposited in environments broadly similar to those of the Churchill Province and in approximately the same time. The upper Aillik Group (1750-1670 Ma) represents a younger assemblage dominated by felsic volcanics intricately intruded by granites and may indicate the onset of radically different tectonic conditions towards the end of Aphebian time.

Résumé

La présente étude décrit les roches sédimentaires et volcaniques du Protérozoique récent (Aphébien), provenant de deux zones orogéniques au Labrador, soit la province de Churchill dans le Labrador occidental et la sous-province de Makkovik dans le Labrador oriental.

Dans la province de Churchill, l'Aphébien est surtout représenté par la fosse du Labrador (supergroupe de Kaniapiskau) mais aussi par le groupe de Laporte, la formation de Lake Harbour et le groupe de Petscapiskau. La fosse du Labrador est la mieux exposée de ces séquences; les sédiments représentent une transition d'une plate-forme dans l'ouest à un bassin plus profond dans l'est. Durant cette période, la formation de fissures le long de la marge orientale de la fosse aurait produit un fossé proto-océanique étroit.

Dans la sous-province de Makkovik, les groupes de Moran Lake et d'Aillik représentent les séquences aphébiennes. les sédiments des groupes de Moran Lake et d'Aillik inférieur ont été déposés à peu près en même temps que ceux de la province de Churchill et dans des environnements plus ou moins semblables. Le groupe d'Aillik supérieur (1750-1670 Ma) représente un assemblage plus récent, dominé par des sédiments volcaniques felsiques pénétrés par des granites; il pourrait indiquer la création, vers la fin de l'Aphébien, de conditions tectoniques très différentes.

GENERAL STATEMENT

Early Proterozoic (Aphebian) supracrustal sequences occur in a variety of metamorphic states in all tectonic provinces of Labrador and adjacent New Quebec. The most completely preserved sequences occur in the Churchill and Nain provinces, and in the Makkovik Subprovince (Fig. 19.1). This paper is concerned predominantly with those sequences of the Churchill Province, in particular the Labrador Trough, and the Makkovik Subprovince. Those of the Nain Province have been treated by Knight and Morgan (1981) and by Smyth and Knight (1978). Extensive areas of Aphebian supracrustal rocks are also present in the Grenville Province, but in general their complexly deformed and metamorphosed state precludes detailed stratigraphic analysis. The Churchill Province (R. Wardle) and Makkovik Subprovince (D. Bailey) are discussed separately in Parts 1 and 2 of this paper. In the Churchill Province, emphasis has been placed on the Labrador Trough, which provides the best preserved Aphebian sequence in Labrador and provides the most insight into Early Proterozoic basinal processes in this area.

At present, insufficient information is available to allow development of a comprehensive tectonic model unifying the Churchill Province and Makkovik Subprovince. Models for each region, therefore, are discussed individually.

PART I – EARLY PROTEROZOIC OF THE CHURCHILL PROVINCE: THE LABRADOR TROUGH

Introduction

The Churchill Province of Labrador-New Quebec is a mobile belt of Hudsonian age (1750-1800 Ma; Stockwell, 1972), forming a southern splay off the main Churchill Province of western Canada and the Arctic Islands. The belt is bounded to the east and west by the stable Archean cratons of the Nain and Superior provinces. Aphebian sequences of the Churchill Province are shown in Figure 19.1. The principal area of sedimentary and volcanic rocks occurs in the Circum-Ungava Foldbelt or Geosyncline (Dimroth et al., 1970), which forms the western margin of the Churchill Province and lies unconformably on the rim of the Superior Province. The southeastern part of this belt is termed the

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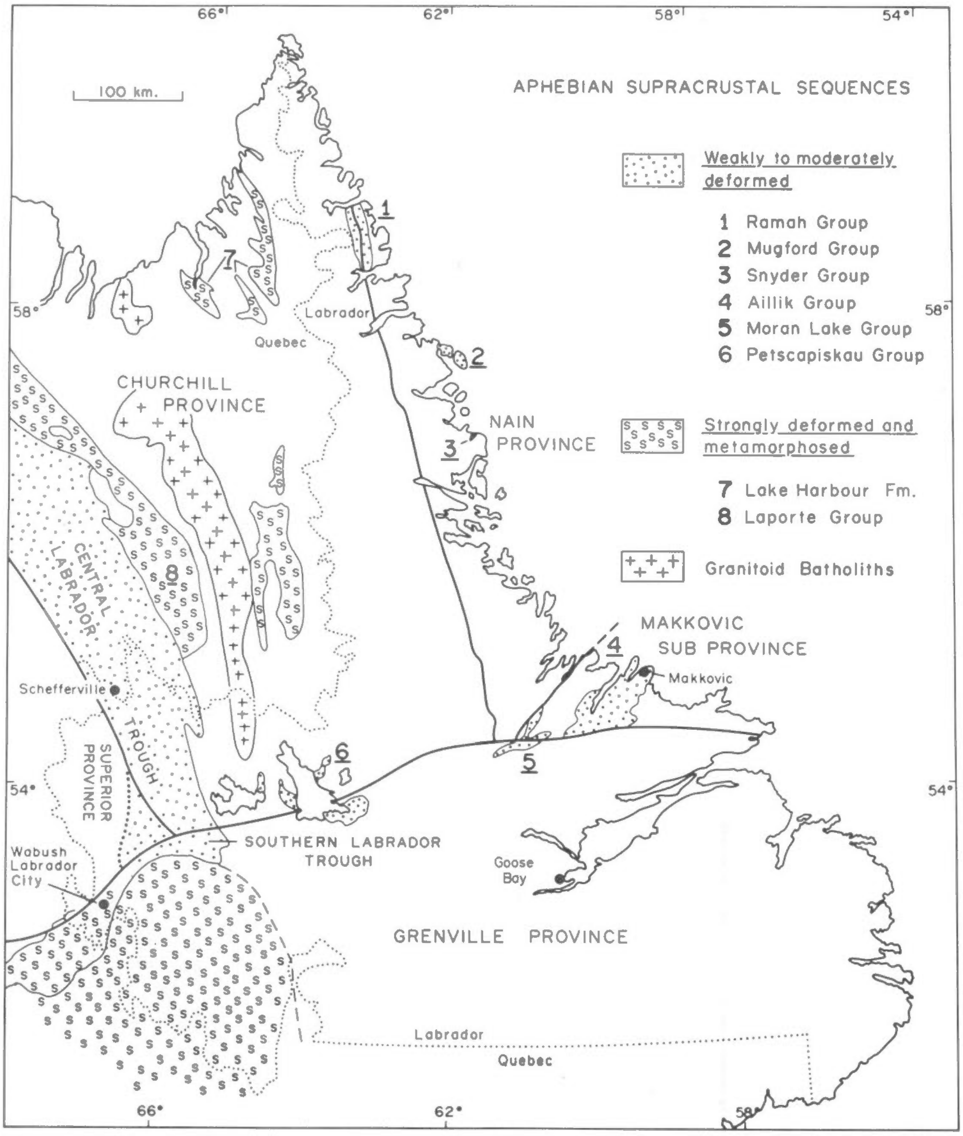


Figure 19.1. *Early Proterozoic (Aphebian) sequences of Labrador and adjacent New Quebec.*

Labrador Trough. An extensive sequence of more highly metamorphosed supracrustal rocks occurs in the Laporte Group adjacent to the eastern margin of the Trough.

Small units of highly metamorphosed supracrustal rocks (marble, metaquartzite, calc-silicate, amphibolite and pelitic gneiss) occur scattered throughout the central Churchill Province, some of which in northeastern New Quebec have been correlated with the Lake Harbour Group of Baffin Island (Jackson and Taylor, 1972) and named the Lake Harbour Formation (Taylor, 1979). A small sequence of pelitic schist at the southern end of the province is known as the Petscapiskau Group (Emslie, 1970).

Clastic and local mafic volcanic rocks also comprise the Ramah Group which lies largely in the Nain Province of eastern Labrador (Knight and Morgan, 1981). The eastern margin of this group, however, has been affected by Hudsonian deformation and therefore lies in the Churchill Province.

Structural trends within the Churchill Province are dominantly northwest-southeast. The western margin is characterized by steep, easterly-dipping thrust faults, and folds overturned to the west. A mirror image of these structures is present in the Ramah Group on the eastern margin of the Churchill Province where the direction of thrusting and overturning was eastwards, onto the Nain Province craton. The interior of the Churchill is largely underlain by granitic gneisses with diverse structural trends defining basinal and domical structures. The age of these rocks is largely unknown; in large part they probably represent remobilized Archean basement (e.g. Dimroth, 1964; Dimroth et al., 1970; Wardle, 1979a). Undoubtedly though, they also include some highly metamorphosed and migmatized Aphebian granites and supracrustals (e.g. Taylor, 1979). Where exposed along the eastern margin of the Labrador Trough the Archean gneisses are grouped in the Wheeler Complex (Dimroth, 1978) and Eastern Basement Complex (Wardle, 1979a).

A further important feature of the Churchill Province is a belt of late kinematic granitoid batholiths (Taylor, 1979) which form an axial zone 450 km long (Fig. 19.1).

The following discussion is concerned largely with the stratigraphy and basinal development of the Labrador Trough and Laporte Group. The other sequences of the Churchill Province are, in general, too highly deformed and poorly known to permit detailed analysis.

Labrador Trough (Including Laporte Group)

The Labrador Trough (2150 Ga – 1800 Ga; Dimroth, 1972; Fryer, 1972) has been divided into three geographic segments by Dimroth et al. (1970): the Northern Trough, north of 57°N; the Central Trough between 57°N and the Grenville Front; and the Southern Trough, south of the Grenville Front.

The stratigraphy of the Trough is most completely developed in the central segment, and it is with this region that the following discussion is concerned. The northern part of this area, referred to as the North-Central Trough (Fig. 19.2) has been extensively described by Dimroth (1968, 1970, 1971a, b, 1972, 1978) and Dimroth et al. (1970). The regional geology of the South-Central segment (that part south of 55°15'N) has been established by Frarey (1961), Baragar (1967), Wynne-Edwards (1960, 1961) and Fahrig (1967) and, more recently, by Wardle (1979a), Evans (1978), and Ware and Wardle (1979).

The Labrador Trough comprises a succession of sedimentary and mafic volcanic rocks, the Kaniapiskau Supergroup, which is intruded by a sequence of gabbro and ultramafic sills, approximately 6000 m thick, of the Montagnais Group (Frarey and Duffell, 1964; Baragar, 1967). The Kaniapiskau Supergroup (Fig. 19.2) is divided into two distinct, lithic assemblages: a western, predominantly sedimentary succession, the Knob Lake Group (6500 + m), and an eastern, predominantly mafic volcanic unit, the Doublet

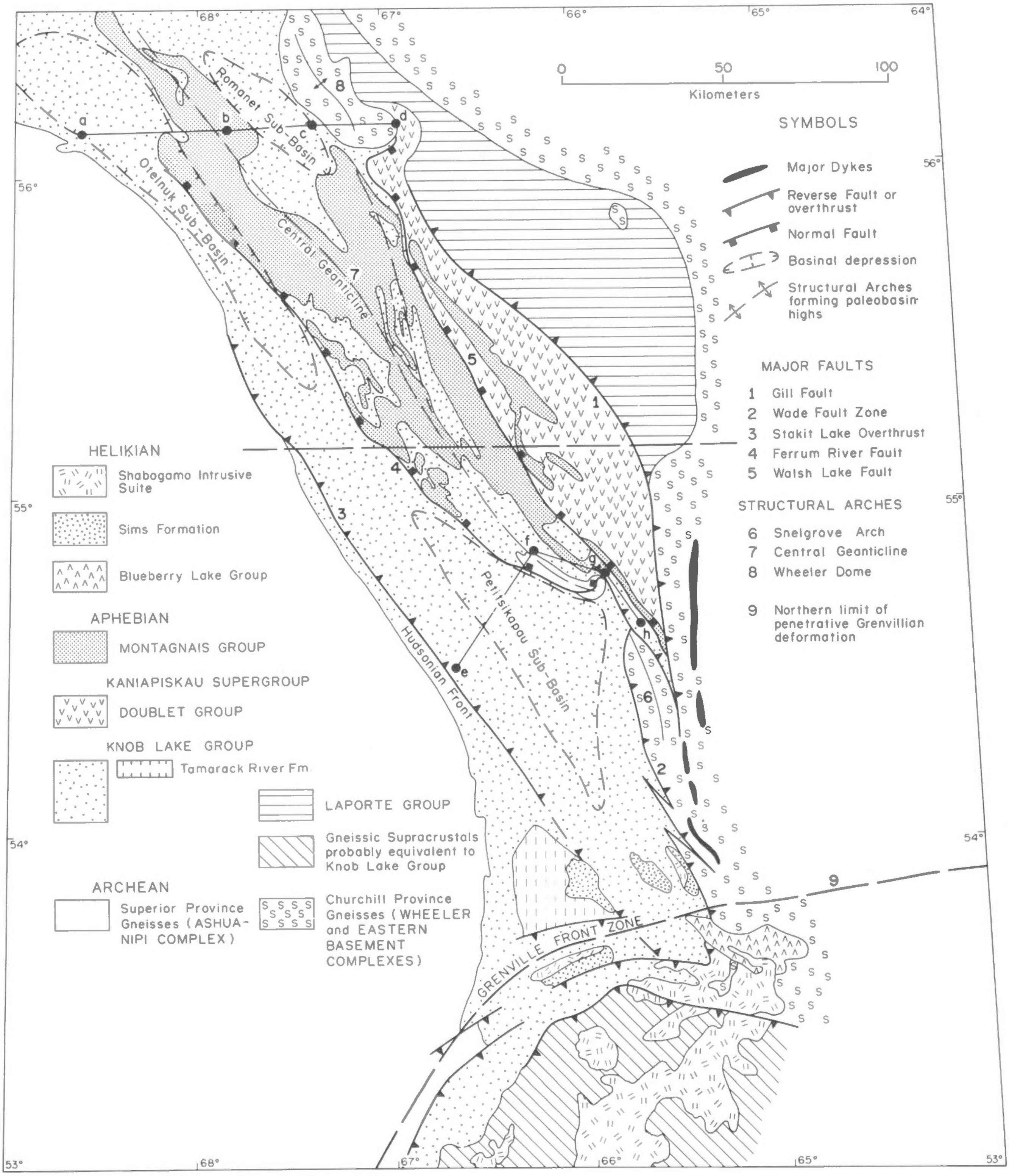


Figure 19.2. *General geology of the Central Labrador Trough. Dashed line divides north-central and south-central parts.*

Group (5000 + m). The Knob Lake Group may in turn be divided into a western zone containing predominantly shallow water sediments, and an eastern zone dominated by deep-water sediments and abundant mafic volcanics. The Doublet Group locally conformably overlies the Knob Lake Group on the eastern margin of the Trough but the two are generally in tectonic contact along the Walsh Lake Fault (Fig. 19.2). A thick succession of pelitic to semi-pelitic schist and amphibolite, termed the Laporte Group, is in overthrust contact with the eastern margin of the Doublet Group. Dimroth et al. (1970), did not consider the group to be part of the Labrador Trough, largely because of its uncertain stratigraphic position. Dimroth (1978), however, has recently demonstrated the group to be laterally equivalent to the major part of the Knob Lake Group, and it is evident that it should be considered as an integral component of the Labrador Trough.

The Labrador Trough has often been considered as a miogeosynclinal-eugeosynclinal couple (e.g. Harrison et al., 1972) with the western part of the Knob Lake Group representing a shallow shelf and the eastern part of the Knob Lake Group and the Doublet Group an offshore basinal equivalent. It is now clear, however, that this concept has to be modified since it is the Laporte rather than the Doublet Group which forms the offshore component. The Doublet Group is a younger sequence developed across the Knob Lake – Laporte Group transition.

In the following sections, the basinal evolution of the Trough is divided into several stages, each of which represents a distinct lithofacies assemblage and tectonic environment. Emphasis throughout is placed on facies patterns rather than formal stratigraphic division. Stages 1-9 deal with the evolution of the shelf (Knob Lake Group) and its transition into deeper water lithologies to the east (Laporte Group). Stage 10 concerns the development of the Doublet Group. Each stage is summarized in facies maps and palinspastic sections.

The Shelf Sequence (Knob Lake Group)

The stratigraphy of the Knob Lake Group is summarized in Figure 19.3. Terminology for the South-Central Trough is that of Frarey and Duffell (1964) modified by Wardle (1979a), Evans (1978), and Ware and Wardle (1979); that for the North-Central Trough is from Dimroth (1978).

As proposed by Dimroth et al. (1970), the Knob Lake Group is informally divided into two segments, here termed the upper and lower Knob Lake group. Both begin with fluviatile or intertidal terrigenous clastics, pass through an interval of shallow marine shales, carbonates, or chemical precipitates and culminate with deep water turbidites.

Deposition of the lower Knob Lake Group was followed by broad regional warping. While sedimentation was continuous in the axial region of the Trough, uplift and erosion occurred at the margins. As a result, the upper Knob Lake Group disconformably oversteps earlier units and locally rests directly on basement at the Trough margins.

Deposition of both segments was strongly influenced by uplift of two major basement structures which acted as intermittent basin arches. The most important of these structures is a linear arch located along the eastern margin of the Knob Lake Group. The basement gneisses underlying this structure are exposed in two culminations of the arch referred to as the Wheeler Dome and Snelgrove Arch (Fig. 19.2). West of these structures, the entire Knob Lake Group is dominated by shallow water clastics, shale, carbonate and chemical precipitates. These structures define the eastward limit of this environment and were themselves the site of shallow water environments. East of the structures, the Knob Lake Group is largely buried beneath thick Doublet Group cover, but where exposed east of the Snelgrove Arch, it consists of a thick shale-siltstone succession apparently deposited in moderately deep water. The arch, therefore, marks the break between shallow water shelf deposition in the west and basinal or basin slope deposition to the east.

The other intrabasinal arch, termed the Central Geanticline (Dimroth, 1968), was more short-lived and aerially restricted to the North-Central Trough. The structure is discordant to the general trend of the Trough and merges with the Snelgrove Arch (Fig. 19.2). The structure was first an active source area during the early stages of the Knob Lake Group and was covered during later transgression.

The basinal evolution of the Knob Lake Group shelf sequence is discussed under the following 9 stages.

Stage 1 – Continental Rifting (Lower Seward Subgroup)

Development of the Knob Lake Group began with deposition of a thick (1500-3000 m) continental clastic sequence throughout the Central Trough. In the north, the sequence is known as the Chakonipau Formation (Dimroth, 1968) and in the south as the "Discovery Lake and Snelgrove Lake formations" (new terms proposed by Wardle in a manuscript in preparation).

In both north and south, the rocks are very similar and consist of red and grey crossbedded arkoses, quartz granule conglomerates, and local pebble-boulder conglomerates. Most clasts are derived from adjacent basement terranes. Locally, andesite clasts in the North-Central Trough indicate a contemporaneous volcanic source (Fig. 19.4a, b). Baragar (1967) has also described trachyandesites and alkaline trachybasalt flows interbedded with the Chakonipau Formation.

Festoon and planar crossbedding are abundant in sandstones and conglomerates in the south-central area. Unimodal paleocurrents and the lack of typical point bar cycles have been used to infer deposition in a gravelly, braided fluviatile regime (Wardle, 1979a). Scarce interbeds of mudcracked shale and dolomite concretions (caliche?) provide evidence of local flood plain deposition, or filling of abandoned channels. Granule conglomerate beds within the sequence are probably longitudinal gravel bars. A similar braided fluviatile depositional environment has been inferred for the Chakonipau Formation in the north-central area (Dimroth, 1978). In this same area, a thick fanglomerate sequence developed as an alluvial fan on the northern scarp of an inferred east-west fault (Dimroth et al., 1970). The fault defines the southern margin of a structure known as the Castignon Lake graben (Fig. 19.4a), which funneled detritus into the Trough from the west (Dimroth et al., 1970).

Paleocurrent data (Wardle, 1979a) in the south-central area suggest a source area for trough-filling sediments near the present southern end of the Trough (Fig. 19.4a), an interpretation which is strengthened by the presence of cobble conglomerates in this area and the absence of the Seward Subgroup to the south.

The thickness of the clastic sequences, and their apparent restriction to the axial region of the Trough, suggest deposition in a north-northwest trending rift valley, an interpretation strengthened by the presence of synsedimentary alkaline volcanics. The valley was probably fed from both northern and southern ends by a system of braided alluvial fans. The east-west Castignon Lake graben at the north end probably represents a subsidiary rift, similar to those in modern rift systems (e.g. East African Rift). However, there is no evidence to suggest the graben was an aulacogen or failed arm, as suggested by Burke and Dewey (1973).

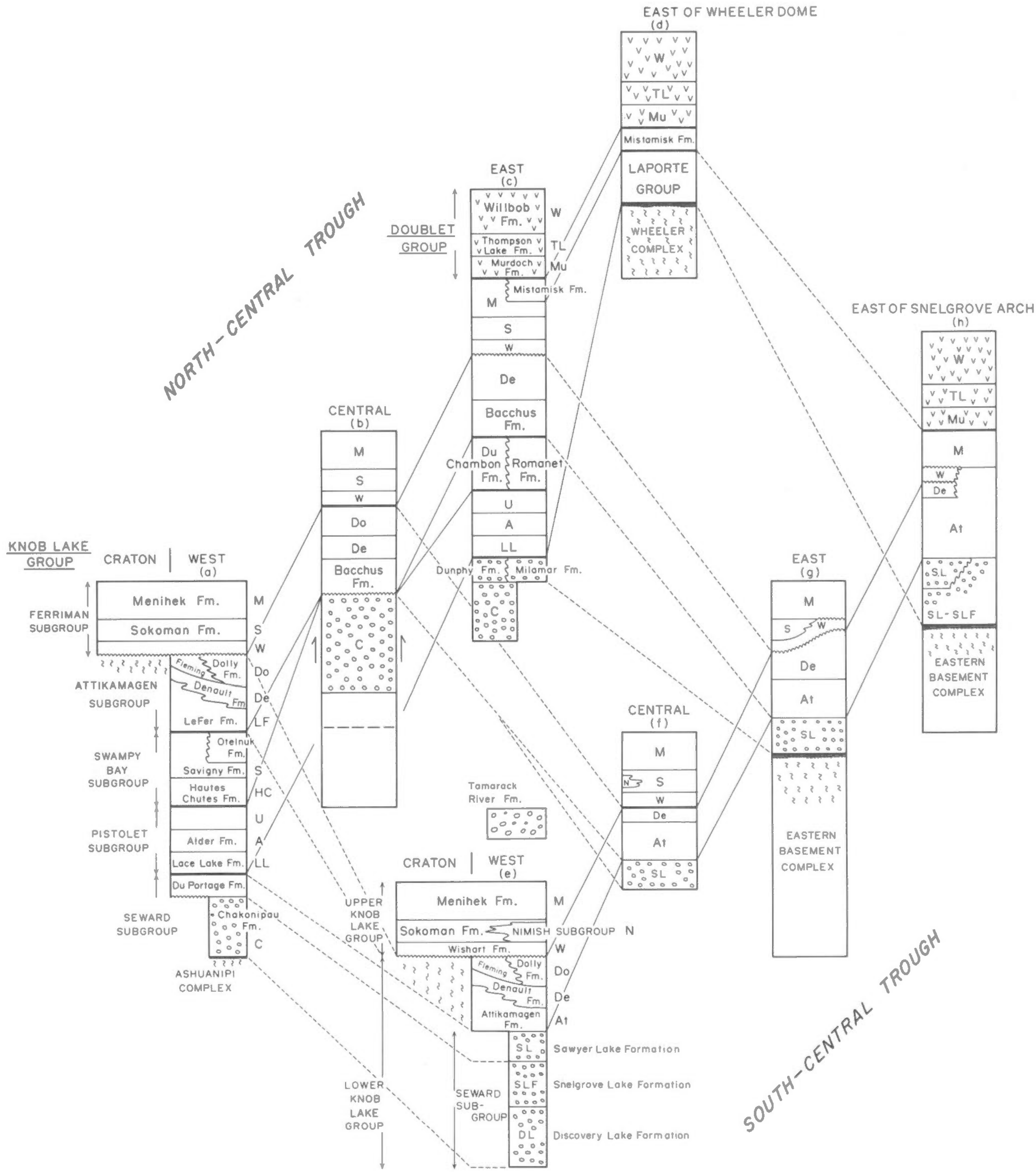
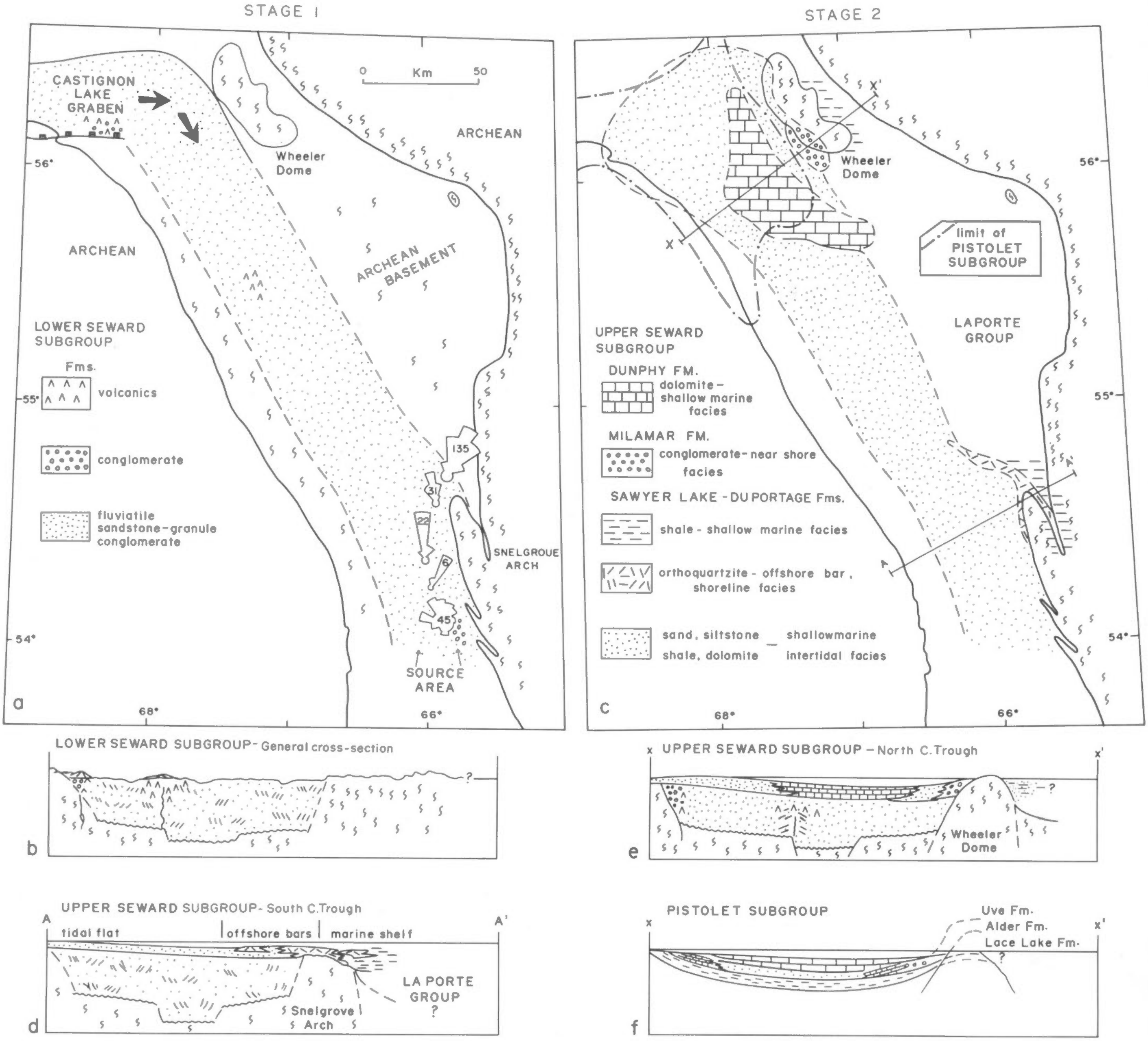


Figure 19.3. *Stratigraphic correlations: North-Central and South-Central Labrador Trough. Letters in brackets refer to section lines in Figure 19.2.*



a,b) Stage 1: *Lower Seward Subgroup. Deposition in braided fluviatile system. Paleocurrent directions measured on crossbedding (Wardle, 1979a).*

c,d,e) Stage 2: *Upper Seward Subgroup (Du Portage, Dunphy and Milamar formations, in North-Central Trough; and Sawyer Lake Formation in South-Central Trough). Note transition from intertidal to shallow marine deposition in south and presence of shallow marine carbonate basin in north.*

c,f) *Pistolet Subgroup (Lace Lake, Alder and Uve formations). Deposition restricted to shallow marine carbonate-clastic basin in North-Central Trough.*

Figure 19.4. *Lithofacies distribution and palinspastic cross-sections, Labrador Trough.*

Stage 2 – Marine Transgression and Development of Shelf Environment (Upper Seward Subgroup and Pistolet Subgroup)

This stage marks the filling of the rift valley and the beginning of a shallow marine transgression across the Trough.

In the South-Central Trough (Wardle, 1979a), this stage is represented by the "Sawyer Lake formation" (new term proposed by Wardle in a manuscript in preparation), a lithologically variable unit consisting of a 300 m thick red and purple shale-siltstone facies in the west; a 300-500 m thick sandstone-orthoquartzite facies around the Snelgrove Arch; and a shale-phyllite-siltstone sequence over 800 m thick east of the arch. The transition is interpreted as a progression from tidal flat deposition in the west, through a system of offshore sandbars or strand line deposits around the Snelgrove Arch, into a basinal environment in the east (Fig. 19.4c, d).

In the North-Central Trough, this stage is represented by a more complex sequence comprising the upper Seward Subgroup and the Pistolet Subgroup, both deposited in a minor basin with a depocentre located west of the Wheeler Dome (Fig. 19.4c, e). The upper Seward Subgroup consists of a western sequence of sandstones and stromatolitic dolomite (Dunphy Formation) which passes eastwards into fine grained arkoses (Du Portage Formation), and then into arkoses, conglomerates and quartzites (Milamar Formation). These sequences accumulated in environments ranging from shoreline in the west and east, to shallow marine in the basin centre. Wind-borne sand in the western shoreline facies (Dimroth, 1968) indicates the probable existence of terrestrial environments west of this area.

Upper Seward Subgroup formations are overlain by the Pistolet Subgroup (700 m, Dimroth, 1978), which is restricted to the North-Central Trough (Fig. 19.4e, f). Deposition commenced with shallow water shales (Lace Lake Formation) followed by accumulation of stromatolitic dolomite, dolomitic sandstone and quartzite (Alder Formation), then by dark, massive dolomite (Uve Formation). Sedimentation in the basin centre was dominated by a shallow marine-intertidal carbonate environment, interfingering towards the basin margins with near shore and shoreline clastics (Fig. 19.4f).

The Wheeler Dome and Snelgrove Arch probably acted as locally emergent highs during this stage and separated shallow water – shoreline environments in the west from deep-water conditions in the east. Deep-water deposits are apparently represented by the thick metashale – siltstone sequence (Sawyer Lake Formation) east of the Snelgrove Arch and by pelitic schists of the equivalent Laporte Group east of the Wheeler Dome (Fig. 19.4c, d, e).

Stage 3 – First Stage of Subbasin Development on Shelf (Swampy Bay Subgroup)

This stage was also restricted to the North-Central Trough. Uplift of a central block or arch, termed the Central Geanticline (Dimroth et al., 1970) was accompanied by subsidence in the marginal Otelnuk and Romanet subbasins (Fig. 19.5a).

Deposition in both subbasins was dominated by rhythmically bedded shale, siltstone and quartz wacke turbidites, but conglomerates are locally present on the eastern side of the Romanet Subbasin. Turbidites of the central zones of the subbasins laterally interfinger with shallow water sandstones, shales and conglomerates towards the margins (Dimroth, 1978; Fig. 19.5b).

The Otelnuk and Romanet subbasins were later, as now, separated by uplifted Chakonipau Formation. The source of the Swampy Bay sediments was therefore probably upper Seward and Pistolet subgroups. We speculate that development of these structures was fault-controlled and related to accelerated rifting on the shelf.

Stage 4 – First Collapse of Shelf (Attikamagen, Bacchus and Le Fer formations)

This stage signifies a temporary halt to shallow-water clastic – carbonate deposition and the prograding incursion of shales and deep-water mafic volcanics, concomitant with shelf collapse.

In the South-Central Trough, this stage is represented by the Attikamagen Formation and is divisible into two distinct depositional lithofacies: a western sequence of grey, yellow and green shales and siltstones; and an eastern sequence of grey shale, siltstone and greywacke interbedded with mafic pyroclastics and thick basaltic lavas (Fig. 19.5a). Limited data suggest that the formation thickens from about 500-1000 m in the west to about 2000-3000 m in the east.

The western sequence is characteristically thinly bedded with abundant ripple cross-lamination and was deposited in shallow to moderate water depths. The eastern facies contains greywacke and siltstone turbidites deposited in a considerably deeper-water environment (Fig. 19.5d).

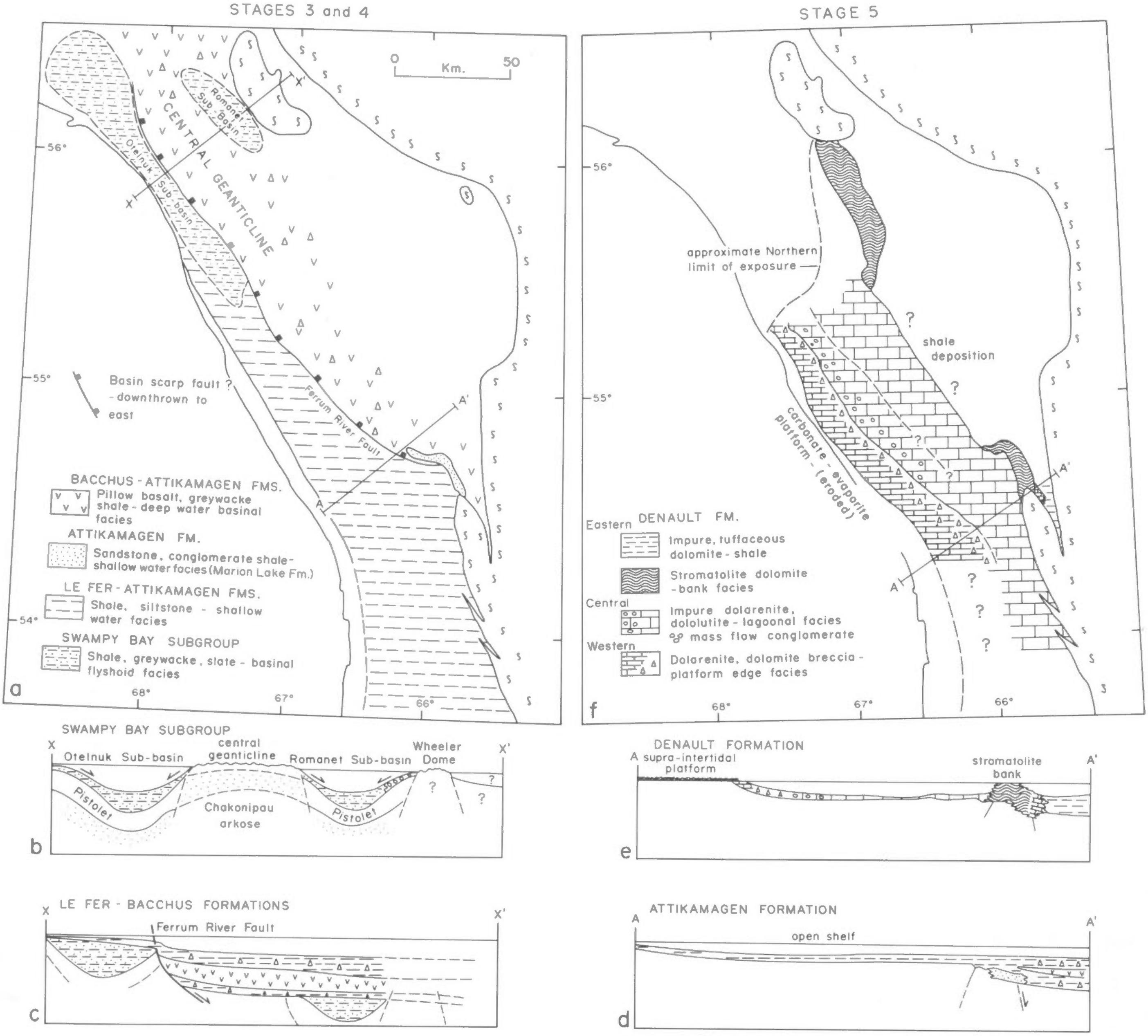
Eastern facies volcanics occur as a single unit of tholeiitic flows about 400 m thick. The flows are predominantly massive but are locally pillowed. Pillows are typically nonvesicular and show little internal structure in the form of radial joints, variolites, cavities, etc. Comparisons with textures seen in modern pillow basalt (e.g. Wells et al., 1979) suggest that they formed in intermediate water depths below 1000 m. The massive nature of many of the flows is not incompatible with deposition in this environment and probably indicates rapid eruption (Dimroth et al., 1978).

The flows and overlying sediments have been intruded by numerous basalt, diabase and fine grained gabbro sills assigned to the Montagnais Group. These are petrographically and chemically similar to the lavas and are generally interpreted as comagmatic (Baragar, 1967; Dimroth; 1971a; R.A. Doherty, personal communication). The general fine grained nature of the sills and the lack, or restricted nature, of contact metamorphism in the host sediments suggest intrusion at very high levels.

A unique sedimentary facies developed around the northern edge of the Snelgrove Arch (Fig. 19.5a) has previously been termed the Marion Lake Formation (Donaldson, 1966). The facies is a thick sequence (approximately 1000 m) which occurs in the middle Attikamagen Formation and comprises shallow water impure sandstones, conglomerates and shales. The sequence is interpreted as a local nearshore deposit developed around the margin(s) of the Snelgrove Arch as it subsided. East of the arch, the Attikamagen Formation consists of a "normal" thick sequence of shale, siltstone (turbidites?) and mafic volcanics (Fig. 19.5a, d).

The division between the western shallow water facies and the eastern basinal facies is abrupt and is defined by the steep, easterly dipping, Ferrum River Fault (Fig. 19.5a), a structure which also marks the westward limit of Montagnais Group gabbro sills. The abrupt facies change across the fault suggests that it may have been active as a syndepositional basin scarp fault, with downthrow to the east (Fig. 19.5d). The fault was subsequently modified to a reverse fault during deformation.

Similar facies relationships occur in the North-Central Trough (Fig. 19.5a, c), where the intermittently-exposed, shallow-water western facies, termed the Le Fer Formation (Dimroth, 1978) is transitional eastward into the thick Bacchus Formation slates, sandstones, tuffs, hyaloclastites



a,b) ***Stage 3:*** *Swampy Bay Subgroup. Restricted to two flysch basins in North-Central Trough: the Otelnuk Subbasin (Hautes Chutes, Savigny and Otelnuk formations) in the west and the Romanet Subbasin (Du Chambon and Romanet formations) in the east. Subbasins separated by Central Geanticline source area.*

c,d) ***Stage 4:*** *LeFer, Bacchus and Attikamagen formations. Ferrum River Fault interpreted as basin scarp fault separating shallow water shale environment in west from deep water shale – greywacke – mafic volcanic environment to east.*

e,f) ***Stage 5:*** *Denault Formation. Shallow basin containing impure, muddy carbonates is bounded to east by intertidal, stromatolite bank; and to west by an inferred supra-intertidal, carbonate-evaporite platform. Edge of platform marked by slump breccias and debris flows.*

Figure 19.5. *Lithofacies distribution and palinspastic cross-sections, Labrador Trough.*

and massive to pillowed basaltic lavas (Dimroth, 1978). The Bacchus lies unconformably across the Central Geanticline but may be conformable with parts of the Swampy Bay Subgroup in the Romanet and Otelnuk subbasins. Dimroth (1978) has shown the Le Fer and Bacchus formations to be separated by a reverse fault. In Figures 19.2 and 19.5a, c, the fault is inferred to be the northern continuation of the Ferrum River Fault.

Both the Bacchus and Attikamagen formations appear to pass eastwards into the pelitic-amphibolitic schists of the Laporte Group. It is inferred, therefore, that the Snelgrove Arch and Wheeler Dome were largely passive features at this time and only locally influenced sedimentation.

Stage 5 – Shelf Re-established as Shallow Carbonate Environment (Denault Formation)

The Denault Formation dolomite marks the re-establishment of shallow water environments across the shelf and provides an excellent picture of the basinal geometry of the Trough at this stage. The Denault is best developed in the South-Central Trough and pinches out between 55° and 56°N (Fig. 19.5f). The formation is divisible into western, central, and eastern depositional facies; a fourth facies is also inferred to have existed west of the present limit of the Trough (Fig. 19.5e, f).

Western Facies. The western facies (500-600 m) is composed of thin-bedded, rarely graded, dolarenites with incomplete Bouma sequences, interbedded with lensoid units of coarse dolomite breccia 1 to 10 m thick. Clasts in the breccias were derived from a variety of dolarenites and vary from angular in the west to subangular and subrounded in the east. The dolomite-breccias are interpreted to have formed by slumping (debris flows) on a steep, easterly dipping slope, adjacent to a supra-intertidal platform associated with evaporites. Evidence for the existence of this platformal facies is derived from the overlying Fleming Formation and is discussed further below.

Central Facies. The central facies (200 m) comprises brown, muddy, commonly crossbedded and slump folded dolomites, interbedded with massive diagenetic dolomite. The thickness of the central facies is highly variable, however, and the formation locally pinches out between underlying and overlying shale. The facies is interpreted as having formed in shallow basinal conditions (Fig. 19.5e).

Eastern Facies. The eastern facies is a thick (1000-3000 m) accumulation of stromatolitic dolomite which formed a discontinuous carbonate bank along the eastern margin of the Trough. Tepee structures, pisolite and oolite horizons, and intraclastic rip-up breccias of algal laminite, indicate deposition in an intertidal-supertidal environment, subject to storm agitation (Donaldson, 1963, 1966; Dimroth, 1971b; Wardle, 1979a). Interbedded units of crossbedded dolarenite probably represent channel sequences within this environment.

The stromatolite banks extend out from the Wheeler Dome and the Snelgrove Arch. These areas may have been partially emergent at this time. Whether the banks were connected is uncertain, since faulting has removed much of the intervening Denault Formation. Small scattered exposures of thin-bedded, non-algal, dolomite, however, indicate that the two banks were probably separated by deeper water, subtidal regions.

East of the Snelgrove Arch the stromatolitic dolomite is transitional into a discontinuous sequence (50-700 m thick) of impure dolomite interbedded with mafic tuff. The Denault Formation is not recognized east of the Wheeler Dome but marble and calc-silicate units in the Laporte Group to the east may be its lateral equivalents. Some of the shales assigned to the Attikamagen Formation east of the Snelgrove Arch may also in fact be equivalents of the Denault (Fig. 19.5e)

The thick stromatolitic facies was probably developed over a subsident zone which may have marked the shelf-basin slope break at this time. It separated a shallow shelf-lagoon environment in the west from a deeper-water basinal environment in the east. Stromatolite growth was apparently able to keep pace with subsidence and continuously maintained an intertidal environment.

Stage 6 – Second stage of Subbasin Development on Shelf; Broad Warping, Uplift and Erosion (Dolly and Fleming formations)

Carbonate deposition was followed by warping of the shelf in the South-Central Trough into a major central subbasin (Petitsikapau Subbasin) in which the Dolly Formation accumulated (Fig. 19.6a, b); and a minor western subbasin in which the Fleming Formation was deposited.

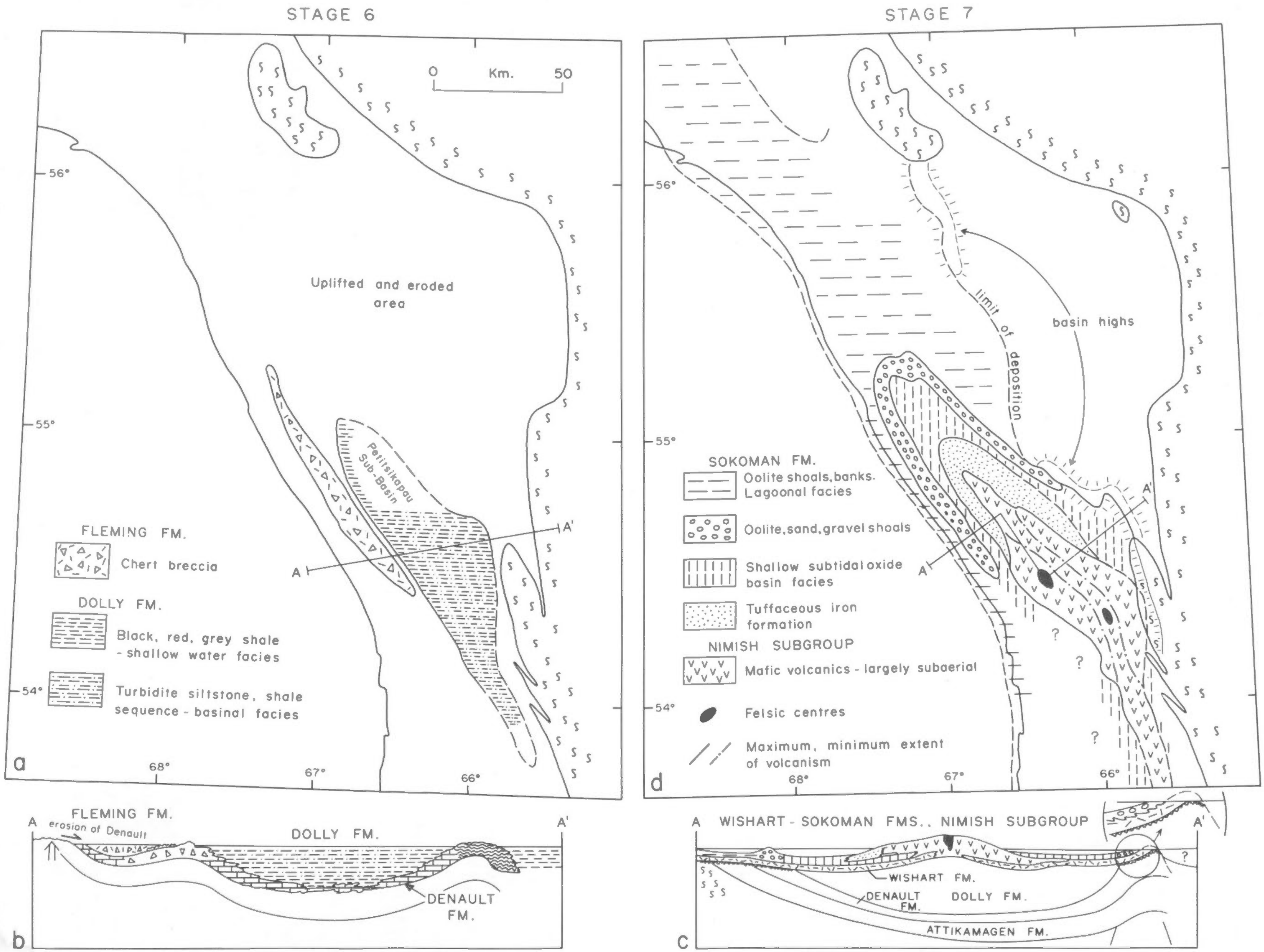
Dolly Formation. The Dolly Formation (Harrison et al., 1972; Dimroth, 1978) has been recognized over a large area (Wardle, 1979a) and defines an area termed the Petitsikapau Subbasin (Fig. 19.6a). At the subbasin margins, predominantly crosslaminated red, green and black shales and minor siltstone accumulated in a shallow-water environment. Toward the basin centre, their equivalents are rhythmically-bedded grey shale and siltstone of turbidite origin (Fig. 19.6b). In many respects, the Dolly Formation is similar to the Swampy Bay Subgroup.

Fleming Formation. The Fleming Formation is a distinctive chert breccia unit restricted to the western margin of the South-Central Trough, and occupies a stratigraphic position equivalent to the Dolly Formation. However, the two formations do not interfinger and we interpret the Fleming to be slightly younger than the Dolly Formation.

In central and western areas, the Fleming consists of massive to thick-bedded chert breccia of pebble- to boulder-sized clasts of colloform chert and drusy quartz set in an impure quartzite-chert matrix. Slabs of colloform chert up to several metres long have also been noted (Wardle, 1979b). In eastern exposures the formation consists of well-defined (1-2 m) breccia beds interbedded with quartzite and siltstone. All chert clasts are clearly void-fill structures derived from a pre-existing terrain.

Previously, the Fleming has been interpreted both as a residual karstic breccia formed by erosion of silicified Denault Formation (in Harrison, 1952) and as a submarine breccia produced by collapse and subsequent silicification of an interbedded sequence of siliciclastics and carbonates (Howell, 1954; Dimroth, 1971b). Dimroth (1978) recognized length-slow chalcedony in the clasts and proposed a replaced evaporite origin for the sequence (Pittman and Folk, 1971). Brecciation was proposed to have resulted from a combination of solution collapse and slumping. The authors agree with an evaporitic origin for at least part of the sequence and propose that the source must have been a western facies of the Denault Formation which was eroded during upwarp of the western margin of the Trough and whose representatives occur only as clasts in the Fleming Formation. However, the chaotic nature of the sequence is believed to be the result of large scale slumping, possibly as an olistostrome sheet, rather than solution collapse. The necessary slope instability required by this mechanism would have been provided by the

Figure 19.6


STAGE 6
0 Km. 50
Uplifted and eroded area
Petitsikapau Sub-Basin
56°
55°
54°
68°
67°
66°
A
A'
FLEMING FM.
Chert breccia
DOLLY FM.
Black, red, grey shale - shallow water facies
Turbidite siltstone, shale sequence - basinal facies
a
A
FLEMING FM.
erosion of Denault
DOLLY FM.
DENAULT FM.
b
STAGE 7
limit of deposition
basin highs
SOKOMAN FM.
Oolite shoals, banks. Lagoonal facies
Oolite, sand, gravel shoals
Shallow subtidal oxide basin facies
Tuffaceous iron formation
NIMISH SUBGROUP
Mafic volcanics - largely subaerial
Felsic centres
Maximum, minimum extent of volcanism
d
WISHART - SOKOMAN FMS., NIMISH SUBGROUP
WISHART FM.
DENAULT FM.
DOLLY FM.
ATTIKAMAGEN FM.
c

***a,b) Stage 6:** Fleming and Dolly formations. Fleming Formation interpreted to be derived by erosion of silicified Denault carbonate-evaporite platform. Dolly Formation restricted to Petitsikapau Subbasin, locally interdigitates with Denault Formation.*

***c,d) Stage 7:** Wishart and Sokoman Formations; Nimish Subgroup. Wishart forms a transgressive sandstone-siltstone blanket of littoral-shallow marine origin, and lies disconformably upon most older units. Sokoman Formation facies show a concentric deepening towards the Nimish volcanics. Volcanics are largely subaerial and developed over the previous Petitsikapau Subbasin. Centre of volcanism moved westward during Sokoman deposition.*

***Figure 19.6.** Lithofacies distribution and palinspastic cross-sections, Labrador Trough.*

broad warping which apparently initiated development of the Fleming and Petitsikapau subbasins, and then continued to deform the Trough into broad basins and arches (Fig. 19.6b). Deposition continued in the basinal areas but erosion occurred on the arches and on the margins of the Trough. This period of deformation defines the break between the lower and upper parts of the Knob Lake Group.

The cause of this period of broad warping is not obvious, but may be related to deep-seated, fault-block adjustment on the shelf. Sedimentation on the eastern margin of the Trough was continuous during this period and dominated by shale-siltstone deposition (Laporte Group and shale succession east of Snelgrove Arch, Fig. 19.6b).

Stage 7 – Transgression Across Shelf; Shallow Water Clastic and Chemical Precipitate Deposition (Wishart and Sokoman formations and subaerial volcanism (Nimish Subgroup)

The Wishart and Sokoman formations occur together over most of the Central Trough; the Nimish Subgroup, however, is restricted to the area of the Petitsikapau Subbasin in the South-Central Trough (Fig. 19.6d). The Wishart Formation marks the beginning of a new transgressive cycle which progressively overstepped older units from east to west. On the margins of the Trough it disconformably overlies earlier units (Fig. 19.6c).

Wishart Formation. The Wishart is composed of quartzite, siltstone and shale, and varies in thickness from 50 m in the west to 300 m in the east. The well sorted, mature nature of most of the formation and abundant small scale cross-stratification indicates deposition in a near shore, shallow, shelf environment. Thick, highly mature, orthoquartzite units, up to 70 m thick, occur in eastern parts of the formation near the Snelgrove Arch and may represent offshore sand bar complexes.

East of the Snelgrove Arch, the formation pinches out into shales of the Attikamagen and Menihek formations. The Wishart Formation is not exposed near the Wheeler Dome, therefore, it is impossible to ascertain what effect, if any, this structure had on lithofacies development.

Sokoman Formation. The Sokoman Formation is a cherty iron formation, and for economic reasons is the most widely studied unit of the Labrador Trough. The unit is a typical Superior-type iron formation (Gross, 1970) and is comparable with similar formations found throughout the Circum-Ungava Belt (Dimroth et al., 1970) and Southern Province (Sims, 1976). The formation varies from 120 to 500 m thick and is generally thickest in the area of the Petitsikapau Subbasin, where it is intimately interbedded with the Nimish Subgroup volcanics (Fig. 19.6d, c). The cherty iron formation is usually underlain by Ruth Formation black ferruginous shale-lean chert. Following the suggestion of Zajac (1974), this has been included in the Sokoman Formation. The cherty iron formation is generally divisible into three stratigraphic units: a lower silicate-carbonate member; a middle oxide member; and an upper silicate-carbonate member. However, this is frequently complicated by local facies changes.

The silicate-carbonate iron formation is typically thinly plane-laminated and is inferred to have formed in quiescent, albeit shallow, lagoonal environments. The oxide iron formation, however, shows a variety of features such as oolitic-pisolithic texture, intraclastic breccia and conglomerate, ripple marks and cross-stratification, which indicate deposition in a variety of shallow water, turbulent environments.

Based on these sedimentary textures, Chauvel and Dimroth (1974), Zajac (1974), and Wardle (1979c) define paleogeographic and facies models for separate parts of the Trough. These correlate remarkably well and are summarized in Figure 19.6d.

The north-central part of the Trough formed in a complex environment dominated by oolite shoals and intraclastic (sand) banks, separated by lagoons (thinly laminated silicate-carbonate iron formation) and tidal channels. This was fringed to the southeast by a horseshoe-shaped ring of oolite shoals and coarse, intraclastic sand and gravel bars deposited in turbulent intertidal conditions. To the southeast, this complex was transitional into a basin around the volcanics of the Nimish Subgroup. The periphery of this basin is dominated by fine grained, oxide iron formation formed in shallow, subtidal conditions, and thinly laminated silicate-carbonate iron formation. Around the Nimish volcanic pile these lithologies pass into tuffaceous, silicate- rich iron formation, and interfinger with mafic flows and tuffs.

The eastern limit of the Sokoman Formation is delineated by the Snelgrove Arch and by the stromatolite banks of the Denault Formation. The formation may, however, have extended to the east through gaps between these barrier structures. Iron formation does not occur in the Laporte Group, however, and cannot have extended far beyond the barrier system. The barrier system probably separated a protected and restricted shallow shelf in the west from a deeper water, open sea in the east.

Nimish Subgroup. The Nimish Subgroup (Evans, 1978) is a sequence of mafic volcanics, varying between several metres and 1000 m in thickness, interbedded with various levels of the Wishart and Sokoman formations. The subgroup extends into the Southern Trough where it is interbedded with the Denault Formation in addition to other units (Noel and Rivers, 1980).

The Nimish volcanic complex consists of a central pile of vesicular, largely subaerial mafic lavas, interbedded with thin basaltic conglomerates and breccias. Many of these are interpreted to be laharic; some, however, show evidence of a shallow marine or fluviatile origin. Two volcanic centres have been identified (Fig. 19.6d) and are characterized by rhyolite- and comendite- bearing fanglomerates, trachytes and rhyodacites of alkaline affinity (Evans, J.L., 1978, 1980). The width of the pile varied considerably during its formation, as shown in Figure 19.6d.

The subaerial pile passes laterally into aprons of pillow breccia, hyaloclastite and bedded tuff which interfinger basinward with tuffaceous, cherty iron formation.

Stage 8 – Second Collapse of the Shelf (Menihek – Mistamisk formations)

The Menihek Formation occurs throughout the Central Trough and marks the beginning of a major transgression within the Knob Lake Group and the collapse of the shallow shelf environment characteristic of the underlying formations.

Two major facies have been recognized in the formation. In the western area of the Knob Lake Group the formation consists of grey, rhythmically bedded, turbidite siltstones and shales (Harrison et al., 1972; Wardle, 1979b). In the eastern area of the Knob Lake Group the formation is a black shale-siltstone-greywacke turbidite sequence interbedded with mafic tuffs, breccias and tuffaceous greywackes (Fig. 19.7a). In the extreme eastern part of the area, adjacent to the Doublet Group, the sequence contains massive and rarely pillowed, basaltic flows. Minimum thickness of the formation varies from about 1000 m in the west to 1500 m in the east.

The upper Menihek Formation facies in the vicinity of the Snelgrove Arch is atypical and consists of crossbedded, clean, quartz rich sandstones and siltstones, which accumulated in shallow water environments and reflect the local influence of the Snelgrove Arch as a basin high in upper Menihek time (Fig. 19.7a, b).

The Menihek Formation also occurs around the Wheeler Dome but it appears that this structure exerted little influence on depositional facies. The formation is probably transitional eastward into pelitic schists of the Laporte Group.

The Menihek has been intruded by numerous sills of the Montagnais Group and distinctions between fine grained intrusions and flows are difficult. Thin black graphitic shale sandwiched between the flows commonly contain lenses of syngenetic, massive pyrite-pyrrhotite, apparently formed by submarine, synvolcanic, exhalative activity.

Immediately north of the Snelgrove Arch, the eastern and western facies of the Menihek Formation are separated by the Ferrum River Fault. Further north, however, the two facies are separated by a large area of uplifted older rocks. Development of the two facies in the South-Central Trough may have been controlled by reactivation of the Ferrum River Fault as a basin escarpment (Fig. 19.2, 19.7a, b). This relationship may have extended into the North-Central Trough.

The Mistamisk Formation is a series of basalts disconformably overlying earlier units in the North-Central Trough (Fig. 19.7a). Dimroth (1978) has proposed the formation to be in part equivalent to the upper Menihek Formation. Its stratigraphic position would also suggest a possible correlation with the lower Doublet Group which overlies the Menihek Formation to the east (Fig. 19.7d).

Stage 9 – Local Uplift and Erosion of Shelf; Red Bed Deposition (Tamarack River Formation)

This unit, recently recognized from the South Central Trough, was previously mapped as part of the Menihek Formation (Fahrig, 1967). The unit has not yet been formally incorporated into the Knob Lake Group, but for the purposes of this paper, it is included as such.

The formation generally consists of red, crossbedded arkose, frequently dolomitic; red pisolithic dolomite, green-red argillites and siltstones (Ware and Wardle, 1979; Ware, 1980). The general depositional environment fluctuated between fluviatile and shallow marine or possibly lacustrine. Paleocurrents indicate derivation from a westerly source area (Fig. 19.7c, e).

The lower contact of the formation is not exposed but is presumed to be a disconformity as arkoses within the unit contain clasts typical of the upper Knob Lake Group. The lithological character of the formation indicates derivation by uplift and erosion of at least the western part of the shelf. This uplift may represent an early phase of the Hudsonian Orogeny. As such, it resembles the Loaf Formation of the Belcher Islands (Dimroth et al., 1970; Ricketts and Donaldson, 1981), a molasse facies overlying similar rocks to the Knob Lake Group in the western part of the Circum-Ungava Belt.

This formation completes the shelf sequence in the Central Trough. Another sequence of post-Menihek age occurs in the northern Trough where it consists of shallow shelf dolomites, iron formation and shale (Abner, and Larch River formations; Dimroth et al., 1970; Clark, 1978) which conformably overlie Menihek equivalents. These may be broadly equivalent in age to the Tamarack River Formation.

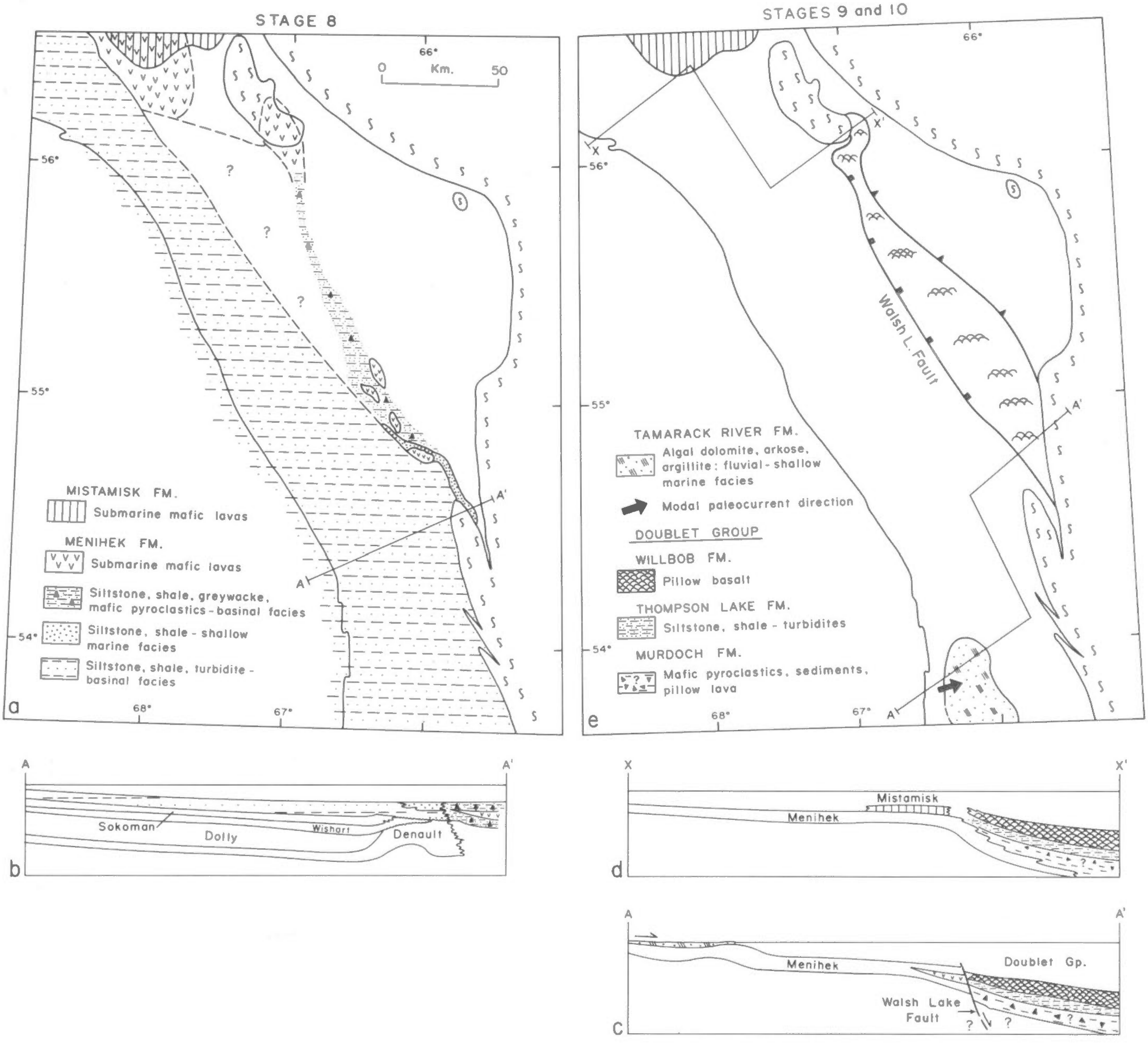
Igneous Activity on the Shelf. Volcanic rocks and comagmatic intrusives (dominantly sills) of the shelf sequence occur in two divisions: a western division comprising subaerial-shallow water volcanics of the Seward and Nimish Subgroups (Stages 1 and 7); and an eastern division of deep-water volcanics associated with shelf collapse and flysch incursion in the Attikamagen and Menihek formations (Stages 4 and 8).

The Seward Subgroup lavas are largely of trachybasalt-trachyandesite composition, show a strong alkaline affinity, and were apparently associated with rifting and graben formation during the initial stage of Trough development. Volcanics in the Castignon Lake Graben were apparently formed along active graben faults (Dimroth et al., 1970).

The Nimish Subgroup is a predominantly basaltic suite of subalkaline-alkaline affinity (Fig. 19.8), (Evans, J.L., 1978, 1980) with local trachyte, trachyandesite, comendite and rhyolite. J.L. Evans (1980) has noted the strong similarity between these rocks and those of the Little Aden Suite (Cox et al., 1970) developed on the margin of the Red Sea Rift. The volcanics are locally affected by strong potash metasomatism which is largely responsible for the pronounced alkaline trend in Figure 19.8.

A suite of kimberlites, carbonatites and melilitite tuffs (Dressler, 1975) has been recognized in the North-Central Trough and may be of approximately the same age as the Nimish Subgroup, indicating a northerly extension of this alkaline environment. Dimroth (1970), however, has proposed a post Kaniapiskau age for these rocks.

Basaltic volcanics in the Attikamagen, Menihek and Mistamisk formations are tholeiitic and chemically identical to the associated sills of the Montagnais Group, and younger volcanics of the Doublet Group. The petrology and chemistry of these rocks in the North-Central Trough have been described by Baragar (1960, 1967), Dimroth (1971b), and Dimroth et al. (1970) and are only summarized here. Recent analyses from the South-Central Trough (Fig. 19.9, from unpublished information by R.A. Doherty and R.J. Wardle) show general similarity with the volcanics to the north. The basalts and associated sills are all low-K tholeiites with



a,b) Stage 8: *Menihek and Mistamisk formations. The Menihek Formation shows a transition from non-volcanic flysch deposition in the west to a volcanic-flysch association in the east. The facies change may be controlled by reactivation of the Ferrum River Fault as a basin scarp fault.*

c,d,e) Stages 9 *and* ***10:*** *Stage 9. Tamarack River Formation arkoses and dolomite represent uplift and erosion of western shelf. Stage 10. Doublet Group (Murdoch, Thompson Lake and Willbob formations). Deposition in South-Central Trough is inferred to have been controlled by a basin scarp fault, the Walsh Lake Fault. This fault dies out to the north where the Doublet Group is in conformable contact with the Menihek Formation. The Doublet Group is inferred to be in part a lateral equivalent of the upper Menihek and the Mistamisk formations. It may possibly also be equivalent to Tamarack River Formation.*

Figure 19.7. *Lithofacies distribution and palinspastic cross-section, Labrador Trough.*

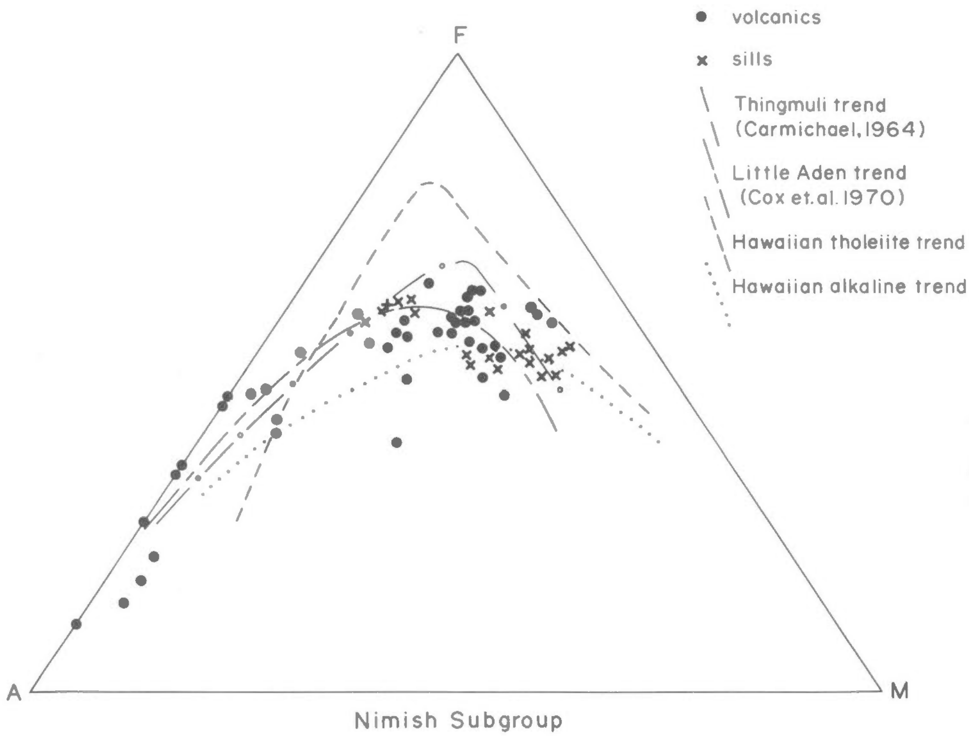


Figure 19.8

AFM plot for Nimish Subgroup volcanics compared to differentiation trends from recent volcanic series.

typical iron enrichment differentiation trends (Fig. 19a, b; Baragar, 1967), and fall largely into the oceanic tholeiite field (Engel et al., 1965). This is also borne out by the K_2O-TiO_2-P_2O_5 diagram (Fig. 19.9c) of Pearce et al. (1975).

The Basinal Sequence

The Laporte Group

The Laporte Group (Harrison, 1952), also known as the Younger Complex (Baragar, 1967), is a poorly defined unit which includes most of the recognizable metasedimentary and metavolcanic rocks that occur along the eastern margin of the Trough (Fig. 19.2).

The contact with the Trough is generally an easterly dipping overthrust. However, in the vicinity of the Wheeler Dome, Dimroth (1978) has recognized the group as a lateral equivalent to that part of the Knob Lake Group above the lower Seward Subgroup. The Laporte Group is also interpreted as a distal, lateral correlative of the shale-siltstone sequence which characterizes the Knob Lake Group east of the Snelgrove Arch. Much of the group has only been mapped on reconnaissance scale; consequently, no stratigraphic subdivisions have been made and only the general nature of the sequence is known.

Over much of its outcrop area, the Laporte Group comprises monotonous biotite schists and gneisses (Fahrig, 1964) of a pelitic - semi-pelitic composition for which Baragar (1967) has recognized a shale-greywacke protolith.

From the considerable extent and generally monotonous pelitic nature of these rocks, it is inferred that they were deposited in a deep water, basin slope-basinal environment. Intercalated within the pelitic metasediments are units of meta-igneous rocks including amphibolites (metavolcanics) and talc-tremolite-fosterite schists (meta-peridotite sills?). Also present are local units of metaquartzite, meta-arkose, dolomite, marble and calc silicate (Taylor, 1979); all apparently representing periods of shallowing within the Laporte basin.

Stage 10 – Rapid Rifting and Submarine Volcanism on Eastern Margin (The Doublet Group)

The Doublet Group is a dominantly mafic volcanic sequence divided into the Murdoch, Thompson Lake, and Willbob formations. The group has a minimum thickness of 5000 m of which 3000 m is formed by the pillow basalts of the Willbob Formation. The Murdoch and Thompson Lake formations have been intruded by numerous gabbro and peridotite sills of the Montagnais Group, which generally appear comagmatic with the volcanics. The Doublet Group occurs in a synclinorium overturned to the west. The eastern margin of this structure is overthrust by Laporte Group and reworked Archean basement rocks. The western limit, where the group is in contact with the Knob Lake Group, is generally the Walsh Lake Fault (Fig. 19.2). However, in the vicinity of the Snelgrove Arch and Wheeler Dome this fault dies out and the Murdoch Formation conformably overlies the Menihek Formation. In diagramatically reconstructed sections across the Trough, Dimroth et al. (1970) suggested the lower Doublet Group interfingers with the Menihek Formation (cf. Fig. 19.7d), suggesting that the Walsh Lake Fault is not, therefore, a particularly profound structure. The normal movement on the fault (downthrow to the east) may indicate that it was an active syndepositional basin scarp fault as proposed for the South-Central Trough (Fig. 19.7c). A 5 km long sliver of rhyolite located along the fault (Frarey, 1961) that may have been the source of similar rhyolite clasts in the Murdoch conglomerates supports this interpretation. The rhyolite may have been intruded during early development of the fault and exposed along the scarp during later movement.

Murdoch Formation

The Murdoch Formation is the most varied unit of the Doublet Group and consists of fine grained, schistose mafic pyroclastics (chlorite phyllites), tuffaceous siltstones, pillow lava and minor conglomerate (Frarey, 1967). Deformation has obscured primary textures and the environment of deposition is unknown. The relatively fine grained nature of most of the formation suggests that it represents the distal products of explosive volcanism, the locus of which presumably lay somewhere to the east.

Baragar (1967) reported a local, discontinuous, iron formation approximately 200 m thick, at the Murdoch-Thompson Lake Formation contact. The unit is thinly bedded and consists of chert-oxide and chert-carbonate-silicate assemblages. The depositional environment of the unit is unknown.

Thompson Lake Formation

The Thompson Lake Formation is a relatively thin unit (500-700 m) composed of rhythmically bedded siltstone, slate and argillite. Although the primary character of the unit is metamorphically obscured, the rhythmic alternation of slate and siltstone suggests a distal turbidite environment.

Willbob Formation

The Willbob Formation is the most prominent unit of the Doublet Group and is composed entirely of tholeiitic flows interbedded with thin units of pillow breccia and hyaloclastite. Willbob flows are predominantly pillowed in contrast to those of the Knob Lake Group. Pillow morphology and texture is similar to that of the Attikamagen Formation.

Volcanic rocks of the Willbob Formation and associated Montagnais sills are also low-K oceanic tholeiites, chemically identical to those of the Attikamagen and Menihek formations with which they are plotted in Figure 19.9a, b, c.

Also shown in Figure 19.9a, b, c are plots for analyses from large amphibolite and metagabbro dykes which occur in the Eastern Basement Complex adjacent to the South-Central Trough (Fig. 19.2). These were once interpreted to be Archean (Wardle, 1979a), but on the basis of their chemical similarity to the Montagnais Group are now interpreted as feeders for the overlying volcanic-sill complexes of the Knob Lake and Doublet groups.

The Doublet Group represents a renewal of submarine rifting activity. This was initiated by a period of explosive volcanism (Murdoch Formation), passed through a period of relative quiescence (Thompson Lake Formation), and culminated in voluminous lava eruption in a deep water environment (Willbob Formation). This is interpreted as the precursor of rapid crustal rifting.

Summary of Basinal Development

The restored stratigraphy of the Labrador Trough, approximately corrected for about 100 km of Hudsonian shortening, is shown in Figure 19.10. Stages in the evolution of this system are illustrated in Figure 19.11 and summarized below.

The Central Trough west of the Wheeler Dome-Snelgrove Arch developed initially in a continental rift environment (Stage 1), then evolved into a shallow marine shelf for the greater part of its existence (Stages 2 to 9). The shelf was subjected to broad warping and possibly block faulting on two occasions: the first (Stage 3) resulted in formation of the Central Geanticline and the flyschoid deposits of the Swampy Bay Subgroup; the second (Stage 6) saw the formation of the Petitsikapau Subbasin and accumulation of the Fleming and Dolly formations. Both periods of broad warping were probably the result of block faulting in the basement in response to rifting activity on the eastern margin.

The shelf was also subjected to two periods of partial or complete inundation during which the shelf-basin slope break moved well to the west. The first period occurred with collapse of the shelf east of the Ferrum River Fault (Stage 4) and incursion of Attikamagen and Bacchus Formation flysch and mafic volcanics. The second inundation occurred during deposition of Menihek and Mistamisk formations (Stage 8) when the entire shelf was drowned and covered by flysch. During both incursions the shelf edge is believed to have been defined by a basin escarpment (listric?) fault. The final stage seen in the evolution of the shelf, at least in the Central Trough, was uplift, local erosion and deposition of Tamarack River Formation redbeds (Stage 9).

Volcanic activity on the shelf was predominantly alkaline, and occurred largely in a terrestrial environment. The eastern margin of the shelf during periods of normal shallow water sedimentation was defined by the Wheeler Dome - Snelgrove Arch line. This line may have consisted of upwarped arches, upfaulted blocks or fault scarps at various stages in its history. Eventually, they were deformed and upthrust into their present position during the Hudsonian Orogeny.

East of the Wheeler Dome-Snelgrove Arch line, the shelf environment was transitional into deeper-water basin slope and basinal environments in which the Laporte and eastern Knob Lake groups were deposited. The chemistry of the volcanics in these units and their association with active synsedimentary faulting indicate that this was an area of intermittent rifting activity through the evolution of the Trough. Incursions of flysch and mafic volcanics from this environment onto the shelf (Stages 4 and 8) were probably the result of periods of increased rifting activity and widespread subsidence east of the Trough.

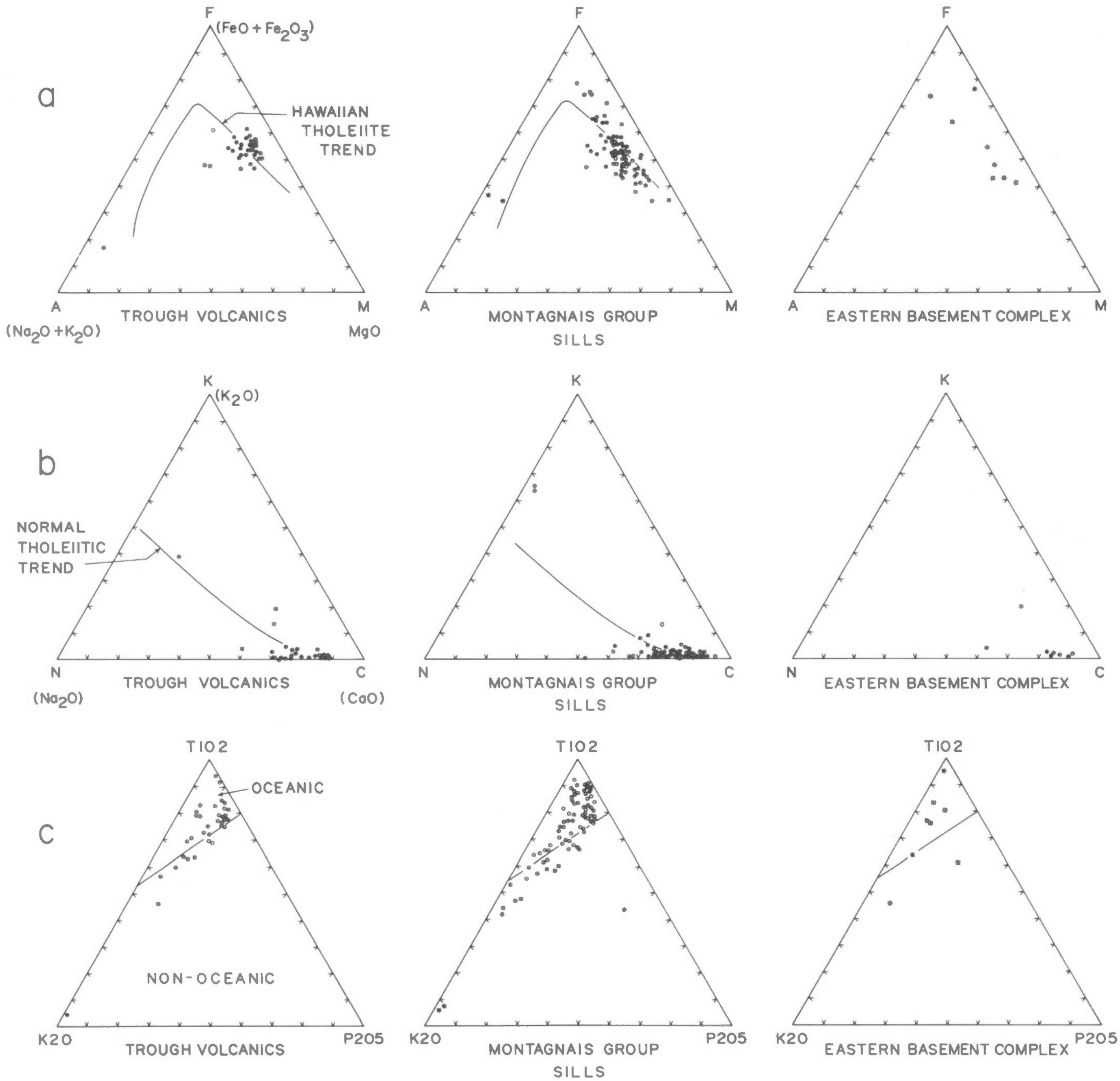
The Doublet Group (Stage 10) represents a renewed period of rifting activity and it spread across the earlier shelf-basin slope break. The massive pillow lava eruption forming the end of this stage (Willbob Formation) is interpreted as the result of rapid rifting at the end of Trough evolution.

The original eastern extent of the Doublet Group is unknown. The western limit is believed to have been a major basin escarpment (Walsh Lake Fault). Shelf equivalents of the Doublet Group west of this structure have not been definitely identified. Conceivably, however, they could be the Tamarack River Formation or the post-Menihek succession in the Northern Trough.

Speculation on Tectonic Setting

In the preceeding sections, the Labrador Trough has been established as a shelf-basin slope-basin system whose evolution was controlled by crustal rifting. The locus of rifting originally lay under what was to become the shelf and then moved to a deep water environment on the eastern margin of the Trough where it was associated with voluminous mafic volcanism. In plate tectonic terms, the most obvious interpretation of this system is that the Trough represents an ancient continental shelf-slope-rise system developed on the passive margin of an oceanic rift system, as suggested by Wilson (1968), Burke and Dewey (1973), and Dewey and Burke (1973).

In this respect, the profiles in Figure 19.10 and 19.11 are similar to those derived for the North Atlantic margin (Drake et al., 1959; Rabinowitz, 1974) where offshore fault horsts (cf the Snelgrove Arch) form prominent subsurface ridges. Burke (1968) and Talwani and Eldholm (1972) have suggested that similar ridges form at the line about which the



a) AFM plots of volcanics, Montagnais Group sills and Eastern Basement Complex amphibolites.

b) NKC plots for above groups.

c) K_2O-TiO_2-P_2O_5 plot (Pearce et al., 1975) for above groups.

Figure 19.9. *Chemistry of Labrador Trough magmatic rocks.*

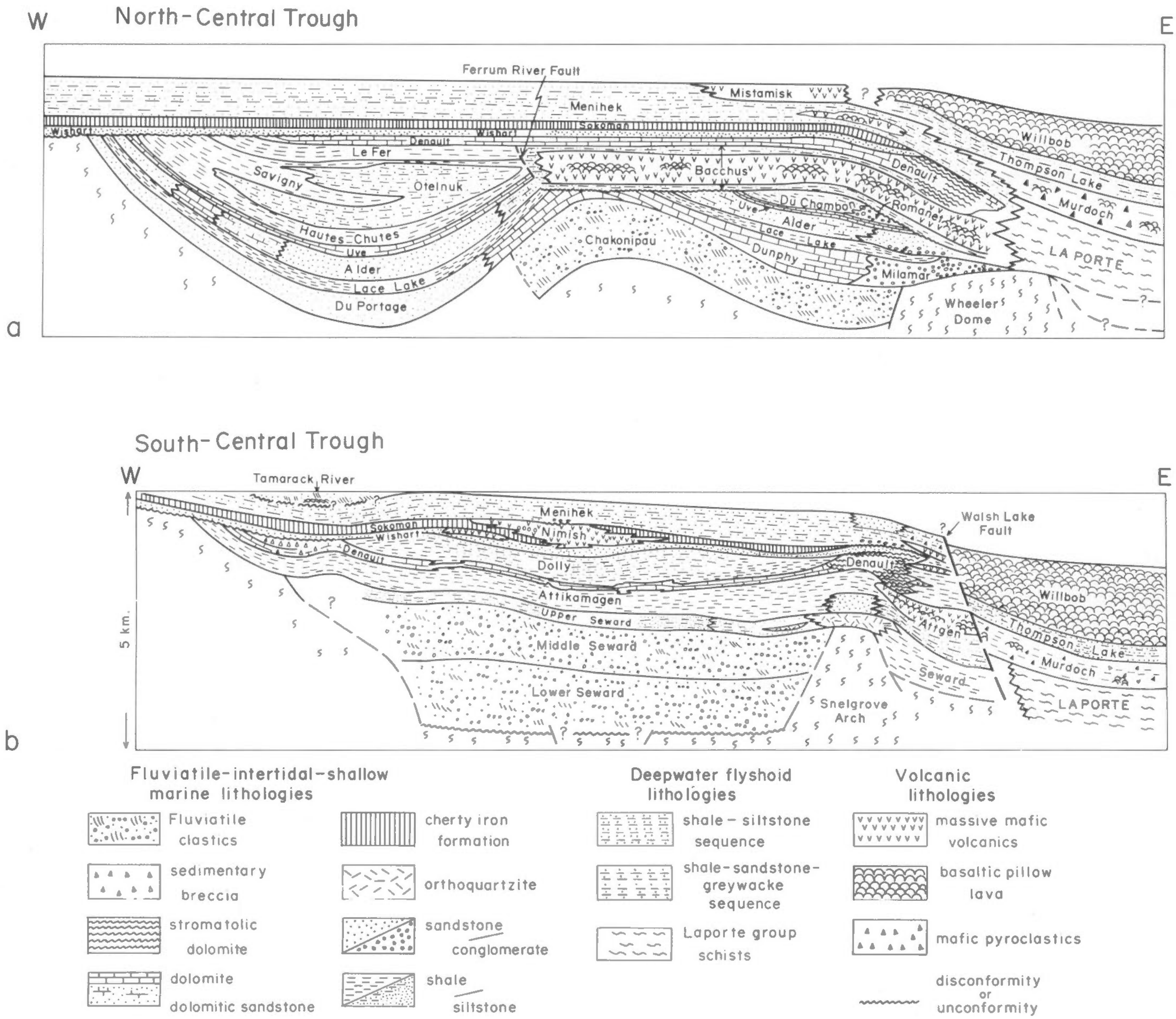


Figure 19.10. *Summary of stratigraphic development of: a) North-Central Trough (modified after Dimroth et al., 1970); and b) South-Central Trough. The Wheeler Dome-Snelgrove Arch line represents the eastern limit of shallow water clastic and chemical precipitate deposition on the shelf. East of this line deposition is dominated by shales, siltstones and mafic volcanics of deep water origin, which correlate with the pelitic schists of the Laporte Group.*

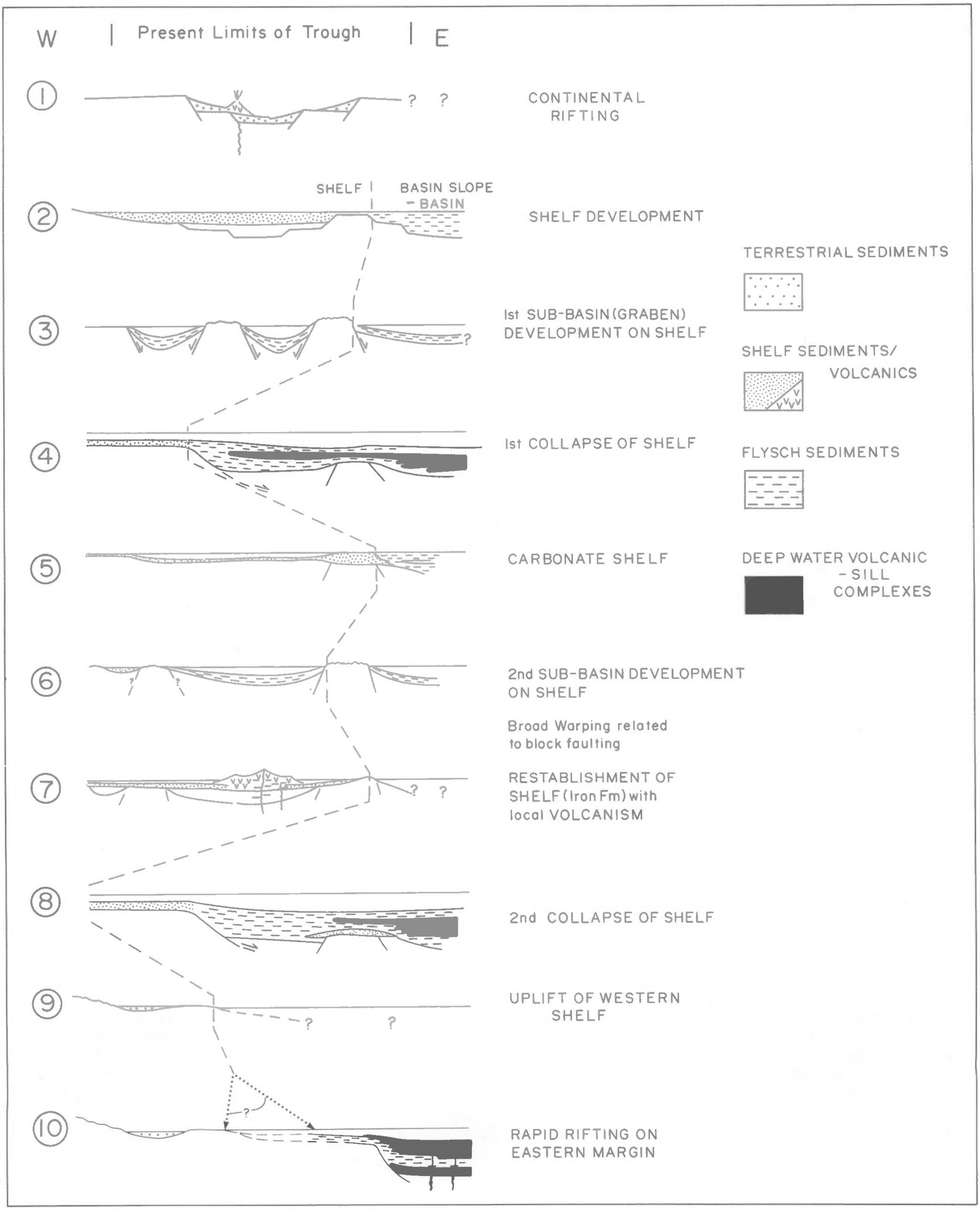


Figure 19.11. *Diagramatic summary of basinal evolution of Labrador Trough. Individual stages are described in text.*

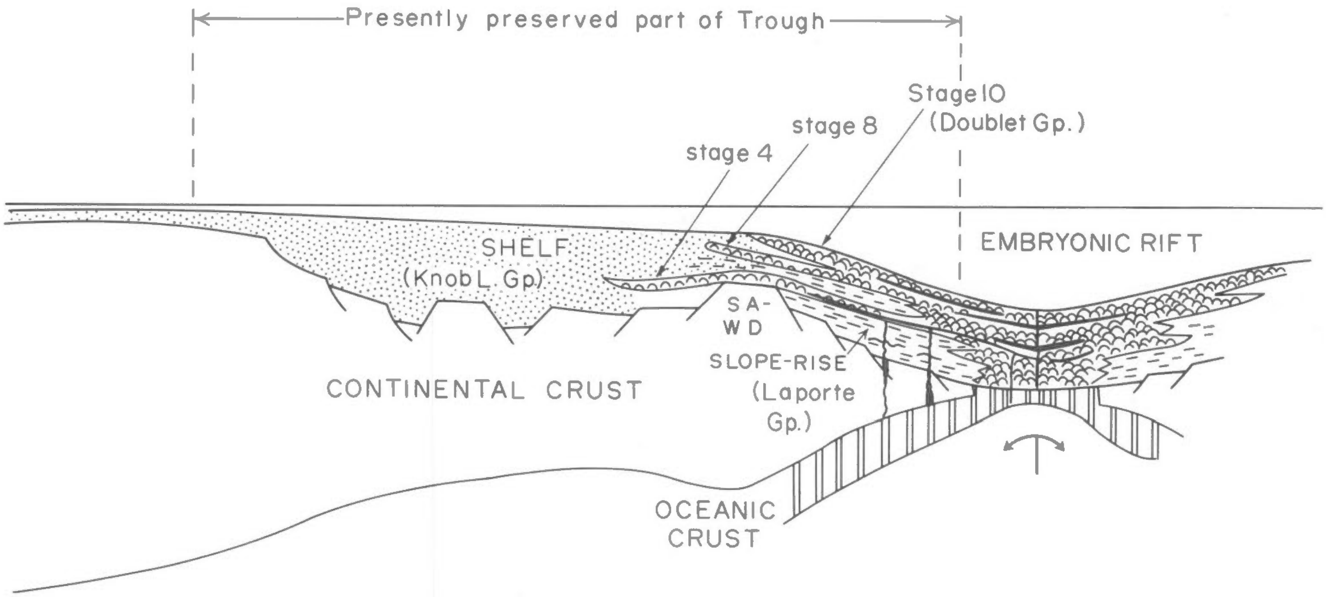


Figure 19.12. *Schematic model for embryonic ocean rift development on eastern margin of Trough.*

continental slope and rise hinge downwards during early oceanic rifting. The ridges subsequently come to mark the shelf-slope break. Lorenz (1981) has also suggested a similar origin for the Sweetgrass Arch marking the offshore margin of the Williston Basin.

It is probable, therefore, that structures such as the Snelgrove Arch originated as horsts during continental rifting and that subsident structures such as the various subbasins originated as grabens.

However, there are no preserved remnants of oceanic crust, either in situ, or obducted, to confirm the original presence of oceanic crust to the east. The flysch- volcanic-sill swarm complexes of the eastern Trough have been described as ophiolitic (Baragar, 1967; Dimroth, 1972) using the term in its classical sense (Steinmann, 1905). However, whilst the chemistry of these rocks is characteristic of ophiolite, they clearly do not display the sequence and structure required in the more modern definition of ophiolite as fragmented oceanic crust (Dietz, 1963; Moores and Vine, 1971). However, recent studies in the Gulf of California – (Einsele et al., 1980) a narrow embryonic oceanic rift – have shown that during the initial stages of opening the turbidite fill of the rift was intruded by numerous sills generated over the developing spreading ridge. Sill formation, accompanied by sea floor eruption of pillow lava, in this case apparently took place at the expense of construction of normally layered crust. In this situation, it is apparent that rapid flysch deposition will keep burying the ridge, particularly if spreading rate is low, and prevent formation of the pillow lava-sheeted dyke system typical of mature ocean basins (e.g. Le Pichon, 1969; Christensen, 1970). The rift, therefore, will develop an interstratified assemblage of continentally-derived flysch, sill swarms and pillow lava, a situation analogous to the eastern margin of the Trough. A schematic evolution for the eastern Trough utilizing this concept is shown in Fig. 19.12.

Basement to this rift would consist of continental crust on the margins and a primitive two-layer (gabbro-peridotite) oceanic crust in the centre. It is evident that the entire eastern margin of the Trough is underlain by Archean continental crust and, therefore, can represent only the eastern half of such a paleo-rift zone.

From Figure 19.11, however, it is apparent that rift-related volcanism was intermittently active on the eastern margin of the Trough throughout practically the whole history of the shelf sequence. This situation would not be expected if rifting had been rapid and resulted in early plate separation and removal of the oceanic ridge axis well to the east. Rather, it is speculated that rifting during evolution of most of the shelf sequence was slow and intermittent and did not result in the formation of anything more than a very narrow oceanic rift.

The complete drowning of the shelf during Menihek Formation deposition, and ensuing voluminous volcanism of the Doublet Group, however, may indicate the onset of rapid rifting and ocean basin formation.

If the remainder of the rift did develop as an ocean basin, the oceanic crust must have been subsequently removed during plate closure – either by obduction to the west, or subduction to the east under an approaching Nain plate. A model for such a system, which accounts for deformation of the Churchill Province by plate closure and subsequent collision, has recently been proposed by Thomas and Kearey (1980). There is at present little evidence (e.g. island arc volcanics, obducted ophiolite) to confirm a plate closing event, but this could be a function of deep erosion levels. It should be noted that Thomas and Kearey interpreted the Labrador Trough as a trench complex – presumably developed at the leading edge of a Nain plate. The Labrador Trough, however, shows none of the characteristics of an accretionary trench prism (e.g. mélange, ophiolite slices, telescoped stratigraphy) and clearly formed on the passive margin of the Superior craton. This does not, however, invalidate the rest of their model which remains a good working model for the evolution of the eastern Churchill Province.

In summary, it is speculated that the Labrador Trough formed as a continental shelf-slope-rise system on the western edge of a proto-oceanic rift system. Whether this system evolved into a large ocean basin or remained as a narrow rift is unknown and must await more detailed work in the interior of the Churchill Province.

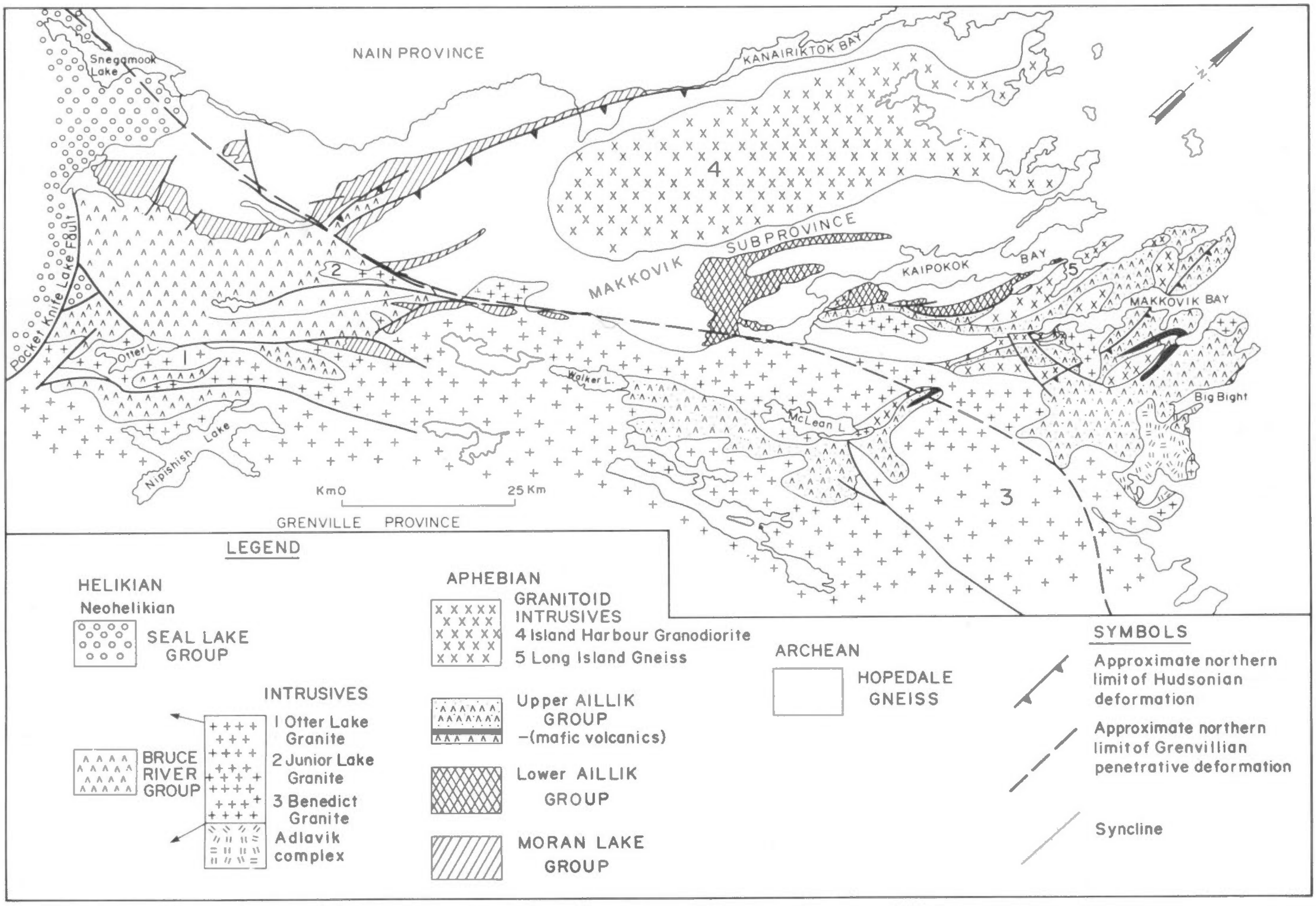


Figure 19.13. *General Geology of the Makkovik Sub-Province. Modified after Marten (1977), Smyth et al. (1978) and Bailey (1979).*

PART II – EARLY PROTEROZOIC OF THE MAKKOVIK SUBPROVINCE

Introduction

Following Taylor's (1971) proposal, the Makkovik Subprovince is defined as that area of the southern Nain Province which has been affected by deformation of approximately Hudsonian age. The northern and southern limits of the subprovince (Fig. 19.13) are defined as the northern limits of significant penetrative Hudsonian and Grenvillian deformation respectively. The subprovince is separated from the Churchill Province by Helikian rocks, but is presumed to have once been contiguous. It also forms a westerly extension of the Ketilidian Mobile Belt of southern westerly Greenland (Sutton et al., 1972).

The oldest rocks in the subprovince are the Archean gneisses of the Hopedale Complex (Sutton et al., 1971) and are unconformably overlain by two major Aphebian sequences: the Moran Lake Group in the west (Smyth et al., 1978; B. Ryan, personal communication) and the Aillik Group in the east (Ghandi et al., 1969; Marten, 1977; Bailey, 1979; Clark, 1979).

The Moran Lake Group is unconformably overlain by Paleohelikian felsic volcanic rocks of the Bruce River Group which are in turn overlain unconformably by the Neohelikian Seal Lake Group (Smyth et al., 1978; Ryan, 1981).

Within the Makkovik Subprovince, the Moran Lake and Aillik groups have been variably deformed, and metamorphosed during an event, approximately equivalent to the Hudsonian Orogeny of the Churchill Province. The Aillik Group was also intruded by a number of pre-, syn- and post-tectonic plutons. Initial K-Ar dating of rocks of the Aillik Group gave ages of 1728 to 1600 Ma (Gandhi et al., 1969). However, recent Pb-Pb and Rb-Sr dating (Kontak, 1980; Brooks, 1979) indicates that older ages may predominate in the deformed granitoid plutons and Aillik Group rocks and may more closely correspond to Hudsonian dates in the Churchill Province (Stockwell, 1972). Younger ages, which predominate in undeformed plutons intruding the Aillik Group (Gandhi et al., 1969; Archibald and Farrar, 1979), document a Paleohelikian magmatic event which post-dates Hudsonian orogenesis.

Much of the area of the Makkovic Subprovince has been metamorphosed at greenschist facies conditions and displays a relatively simple style of deformation consisting of northeast-southwest trending folds, faults and cleavage in the supracrustal rocks; and refoliation and cataclasis in the basement gneisses. In localized zones, particularly in the area of Kaipokok Bay, the main phase of metamorphism occurred at middle and upper amphibolite facies conditions and was accompanied by intense polyphase deformation.

The Moran Lake Group

This group originally comprised the lower part of the Croteau Group (Fahrig, 1959; Williams, 1970; Roy and Fahrig, 1973). However, Smyth et al. (1975, 1978) recognized the presence of a major internal unconformity within the Croteau Group and proposed a new subdivision into the Moran Lake Group (Aphebian) and the Bruce River Group (Helikian).

The group is estimated to have a minimum thickness of 1600 m and has been subdivided into a number of informally defined units (Smyth et al., 1978). This stratigraphy is summarized in Figure 19.14.

In the area of the southwestern part of the group, basement granites are unconformably overlain by moderately sorted, grey-white sandstones and quartzites which become interbedded with purple and grey laminites towards the top of the unit. These are locally overlain by a thinly bedded chert-oxide iron formation less than 10 m thick.

To the northeast, the basal sandstones and quartzites are inferred to be overlain by a middle unit comprising a succession of black shale, dolomite and greywacke. The greywackes are in turn overlain by a thick (800-1000 m) sequence of massive and pillowed mafic volcanics (Fig. 19.14). The greywackes and shales onlap over the older units of the group and indicate northerly transgression onto the Nain craton.

The environment in which the group was deposited appears to have evolved from one of shallow water, near-shore, deposition at the base of the group, through a shallow marine, shelf environment, into deep-water basinal conditions associated with greywacke turbidite deposition and submarine basaltic volcanism.

Nonvesicular pillows in the submarine flows suggest that the basalts were extruded into relatively deep water, perhaps in a similar environment to that of the Labrador Trough basalts. The maximum basin depth is indicated by chert-carbonate interbeds which suggest extrusion at depths less than the carbonate compensation depth of approximately 5000 m.

The stratigraphic sequence of the Moran Lake Group is strongly reminiscent of the upper Knob Lake Group. In particular, the sequence of sandstone-quartzite-iron formation-black shale is practically identical to that of the Wishart, Sokoman and Menihek formations sequence (Fig. 19.14). The upper part of the Moran Lake Group, comprising greywacke and pillow lava, could also be favourably compared to the upper Menihek Formation on the eastern margin of the Trough. The intermediate unit of the Moran Lake Group, comprising shallow water shales and dolomite, may represent a shallow water facies equivalent to the lower Menihek Formation.

The Moran Lake Group iron formation appears to be of particular significance with respect to comparisons between the two groups. From its mineralogy and its association with shallow water clastics and shales, it would appear to be of Superior type (Gross, 1970). Evidence accumulated to date suggests that most Early Proterozoic iron formations of this type in the Canadian Shield (e.g. Biwabik and Gunflint iron formations of the Lake Superior region; the Temiscamie Formation of the Mistassini Group; the Sokoman Formation and Kipula Formation of the Circum-Ungava Belt) are all of approximately the same age (Goldrich, 1973), i.e. 1900-2000 Ma. Thus, the occurrence of a unit of Superior type iron formation, albeit thin and poorly exposed, may be highly significant in long-range comparisons between the Labrador Trough and Makkovik Subprovince. It should be noted, however, that if the Nain and Superior cratons were once separated by an ocean, then the Knob Lake and Moran Lake Group cannot be directly correlated.

Regardless of whether direct correlations are possible it is evident that both groups show similar patterns of stratigraphic development and formed in similar basinal settings.

Aillik Group

The Aillik Group (Stevenson, 1970) initially known as the Aillik Series (Kranck, 1939; King, 1963; Gandhi et al., 1969) is a heterogeneous sequence comprising a lower unit of mafic volcanics and metasediments, and an upper unit of felsic volcanic and volcaniclastic rocks.

Total thickness of the group has been estimated at between 7620 m (Gandhi et al., 1969) and 8500 m (Clark, 1974). In view of the locally highly deformed state of parts of the Aillik Group, these figures must be interpreted as speculative.

Rb-Sr whole rock determinations on the felsic volcanics have yielded ages of 1676 ± 8 Ma, (Watson-White, 1976) and 1767 ± 4 Ma (Kontak, 1980). These dates are younger than the 1812 Ma Rb-Sr age proposed by Stockwell (1972) for the Aphebian-Helikian boundary. The Aillik Group, however, has been deformed in an event correlated with the Hudsonian Orogeny and must therefore be regarded as Aphebian. The dates on the felsic volcanics, however, indicate that volcanism either immediately preceeded, or was synchronous with orogeny.

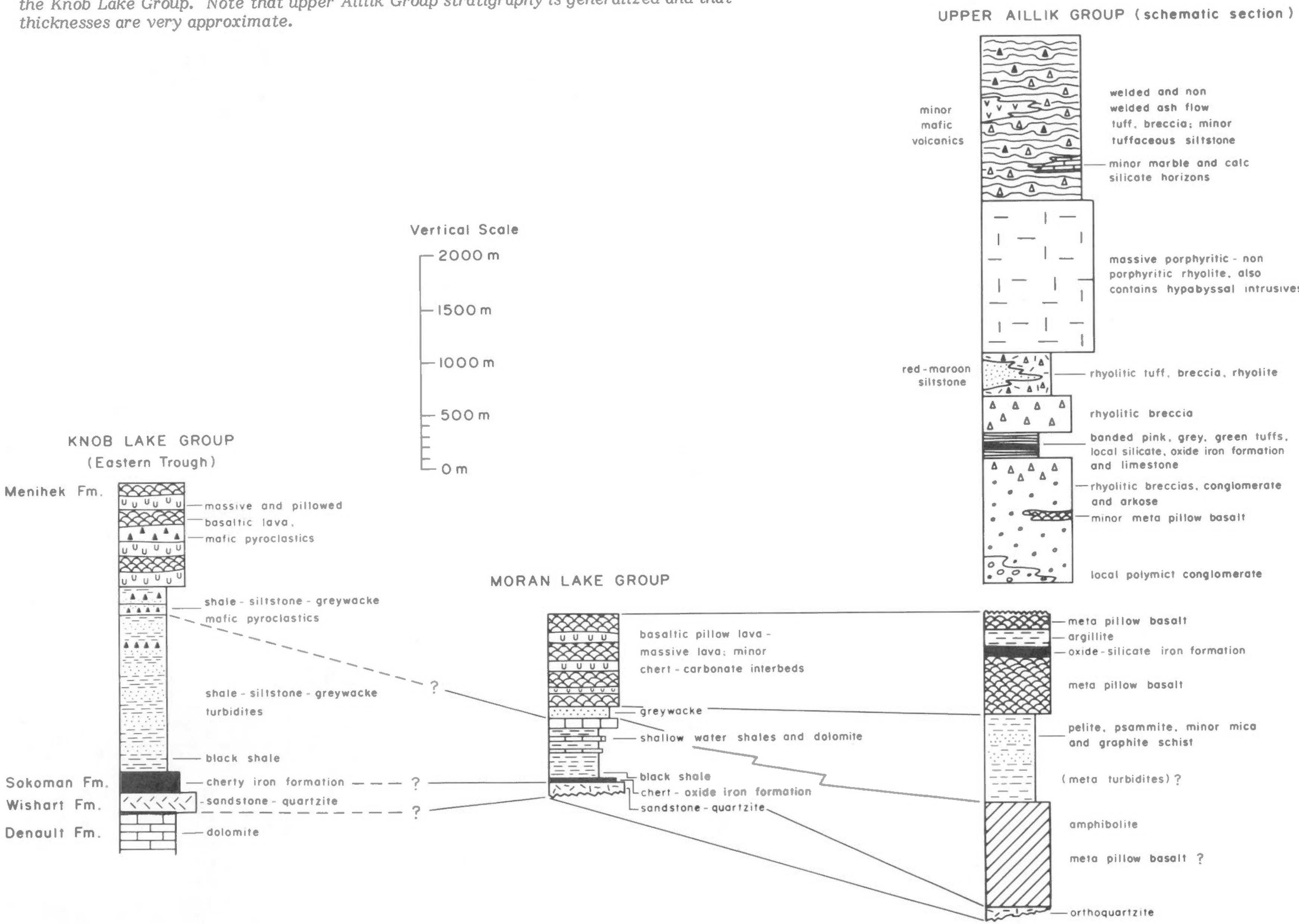
The upper Aillik Group exhibits a relatively simple structural style and low grade of metamorphism in comparison to the intense polyphase deformation and high grade metamorphism characteristic of the lower Aillik Group, suggesting the presence of an angular unconformity. The contact, however, is a zone of strong cataclasis and the depositional contact has nowhere been found, despite detailed mapping (Marten, 1977). Sutton et al. (1971) and Marten (1977), have attributed the deformation in the Aillik Group to a single orogenic event, and suggested that the marked structural contrast between upper and lower parts of the group is due to inhomogeneous deformation and metamorphism concentrated within the lower Aillik Group. Marten (1977), however, has recognized the local development of a polymict conglomerate unit at the lower- upper Aillik contact, which he believes may indicate a disconformity.

Lower Aillik Group

The lower Aillik Group is restricted in lateral extent to the area around the western and eastern shores of Kaipokok Bay (Fig. 19.13). West of the bay, the lower Aillik consists of intensely deformed basaltic pillow lavas, largely converted to actinolite phyllite, with minor pelitic units (Sutton, 1972). Towards the southern end of Kaipokok Bay the volcanics are structurally underlain by a white orthoquartzite (Ryan, 1979). Intense deformation has produced tectonic interleaving of the lower Aillik rocks with refoliated Hopedale gneisses. However, on the basis of structural evidence, Sutton (1972) has inferred the contact to be a tectonized unconformity.

On the eastern side of Kaipokok Bay, Marten (1977) recognized a sequence of amphibolite, (consisting largely of metamorphosed mafic volcanics) metasiltstones and sandstones, and metabasaltic pillows lavas associated with silicate-oxide iron formation and tuffaceous metasandstone approximately 2700 m thick (Fig. 19.14). Marten (1977) has

Figure 19.14. *Stratigraphy of the Aillik and Moran Lake Groups and comparison with the Knob Lake Group. Note that upper Aillik Group stratigraphy is generalized and that thicknesses are very approximate.*



recognized occasional relict pillow textures in the amphibolite but the origin of the remainder of the unit is uncertain. These units have been severely deformed and interleaved with refoliated basement gneiss in a similar manner to that seen west of Kaipokok Bay.

A depositional environment for the lower Aillik Group can only be generally inferred. The transition from orthoquartzite to thick sequences of pillow lava is similar to that seen in the Moran Lake Group and would likewise suggest a progression from shallow water, nearshore to deeper water, basinal conditions.

A correlation has been suggested by Sutton et al. (1972) and Marten (1977) between the lower Aillik and Moran Lake groups and has been reinforced by the recent mapping of Ryan (1979; personal communication). The meta-pillow basalts occupying the upper part of the lower Aillik Group may be correlative with the pillow lavas of the upper Moran Lake Group (Fig. 19.14). The pelites and psammites, which form the middle unit of the lower Aillik, have been inferred by Marten (1977) to be metaturbidites and are probably equivalent to the greywacke turbidites occurring below the pillow lavas of the Moran Lake Group. The lower amphibolite unit of the Aillik Group, which may represent meta-pillow basalt does not have a correlative in the Moran Lake Group. The white orthoquartzite found on the west side of Kaipokok Bay, however, may be correlative with the basal Moran Lake sandstones. An overall comparison between the two units suggests that the lower Aillik Group represents a deep water, more basinal facies equivalent to the Moran Lake Group. This is consistent with its more southeasterly location.

Upper Aillik Group

The upper Aillik Group comprises a thick sequence of felsic volcanics and associated volcaniclastics with minor intervals of mafic volcanics. Figure 19.14 illustrates a generalized stratigraphic scheme for the unit which may be recognized in both the northeastern belt near Makkovik, and in the inland belt between Walker and MacLean lakes (Bailey, 1979). This stratigraphy cannot, however, be uniformly applied throughout the sections, largely because of the laterally discontinuous nature of the volcanic units. However, a distinctive banded tuff unit is traceable from the southwestern to the northeastern part of the belt (Bailey, in press).

The apparent base of the upper Aillik is seen on the eastern side of Kaipokok Bay where mafic volcanics of the lower Aillik are overlain by grey-white and pink arkoses interbedded with rhyolitic tuff and tuffaceous sandstone. Marten (1977) has also described a localized polymictic conglomerate, containing clasts of granite, felsic volcanics and hyperabyssal felsic intrusives which possibly marks a disconformity surface with the lower Aillik Group (Fig. 19.14).

The arkoses and conglomerates pass up into a thick sequence of conglomerate, arkose and rhyolitic breccia, then into a thin sequence of banded tuffs containing minor units of silicate-oxide iron formation and limestone. The iron formation is poorly described but would appear to be of exhalative origin and related to volcanic-hydrothermal processes. The tuffs pass up into a sequence of rhyolitic breccias, tuffs and minor rhyolite flows; then into a thick unit of massive rhyolite flows and associated hypabyssal intrusives. The uppermost unit of the group is a thick succession of welded and nonwelded ash flow tuffs interstratified with various rhyolitic breccias of monolithologic and heterolithologic nature. The monolithologic breccias are composed predominantly of rhyolite clasts and are interpreted to have formed by explosive volcanism. The heterolithologic breccias consist of rhyolite clasts of varying texture and origin, and are interpreted as laharic breccias similar to those described by Fisher (1960). Small amounts of mafic tuff and lava occur in the sequence.

In the southwestern belt of the upper Aillik Group, which occurs between Walker and MacLean lakes (Fig. 19.13), the ash flow tuffs are underlain by red sandstones interbedded with ash fall tuffs. In the northeast, however, the redbeds are absent and the tuffs contain minor intercalations of limestone and calc-silicate.

The limestone, iron formation and crossbedded sandstone and conglomerate in the lower, volcaniclastic part of the upper Aillik Group indicate deposition in a shallow marine environment. The upper part of the sequence, containing the massive rhyolite and ash flow tuffs, was evidently formed largely under subaerial conditions. The thin limestone and calc-silicate horizons in the ash flow tuffs of the northeastern part of the area indicate that this area was subject to shallow marine or lacustrine incursions.

Plutonic Rocks of the Makkovik Subprovince

The Aillik Group has been intruded by numerous granitoid plutons of varying composition. In general, they can be divided into late Aphebian plutons, intruded during the Hudsonian Orogeny; and Paleohelikian plutons mainly intruded in the period 1600-1400 Ma. The Aphebian granites vary from strongly foliated to gneissic and are generally small, with the exception of the Island Harbour granodiorite (Fig. 19.13) located north of Kaipokok Bay. Plutons of Helikian age (e.g. Benedict and Otter Lake granites) are unaffected by Hudsonian deformation and form a large batholith extending between the coast and Nipishish Lake (Fig. 19.13). Locally, some of these plutons show synvolcanic relationships to the upper Aillik volcanics, suggesting that batholith development began in very late Aphebian time, during or immediately following the Hudsonian Orogeny, and continued into the Paleohelikian.

Chemistry of the Upper Aillik Group

In terms of overall composition, the upper Aillik Group is a bimodal suite composed predominantly of rhyolite with minor basalt. The limited information available on the chemical composition of the volcanic rocks suggests that the felsic volcanics are dominantly of rhyolitic composition (Watson-White, 1976; Bailey, 1979; Evans, D.F., 1980). Compared to modern rhyolites (e.g. Ewart and Stipp, 1968; Lowder and Carmichael, 1970) from island arc environments, rhyolite of the Aillik Group is slightly more potassic but is comparable to rhyolite of comenditic composition (e.g. Nicholls and Carmichael, 1969). However, the typical anorthoclase of comendite is lacking from the Aillik Group rhyolites which also show trace element contents similar to those of calc-alkaline suites (Bailey, 1979).

Plots of total alkalies against silica (Fig. 19.15a) show that most of the upper Aillik volcanic rocks fall into the sub-alkaline field as defined by Irvine and Baragar (1971). Similarly, on Na-K-Ca diagram (Fig. 19.15b), the few analyses available suggest a calc-alkaline trend (Irvine and Baragar, 1971), a suggestion also made by Evans, D.F. (1980). White and Marten (1980), however, have proposed a marginally sub-alkaline character for the rhyolites and note that they have locally been subjected to a strong peralkaline autometasomatism which has completely altered the original character of the rocks. They suggested that the apparent calc-alkaline character of the rhyolites may be due to

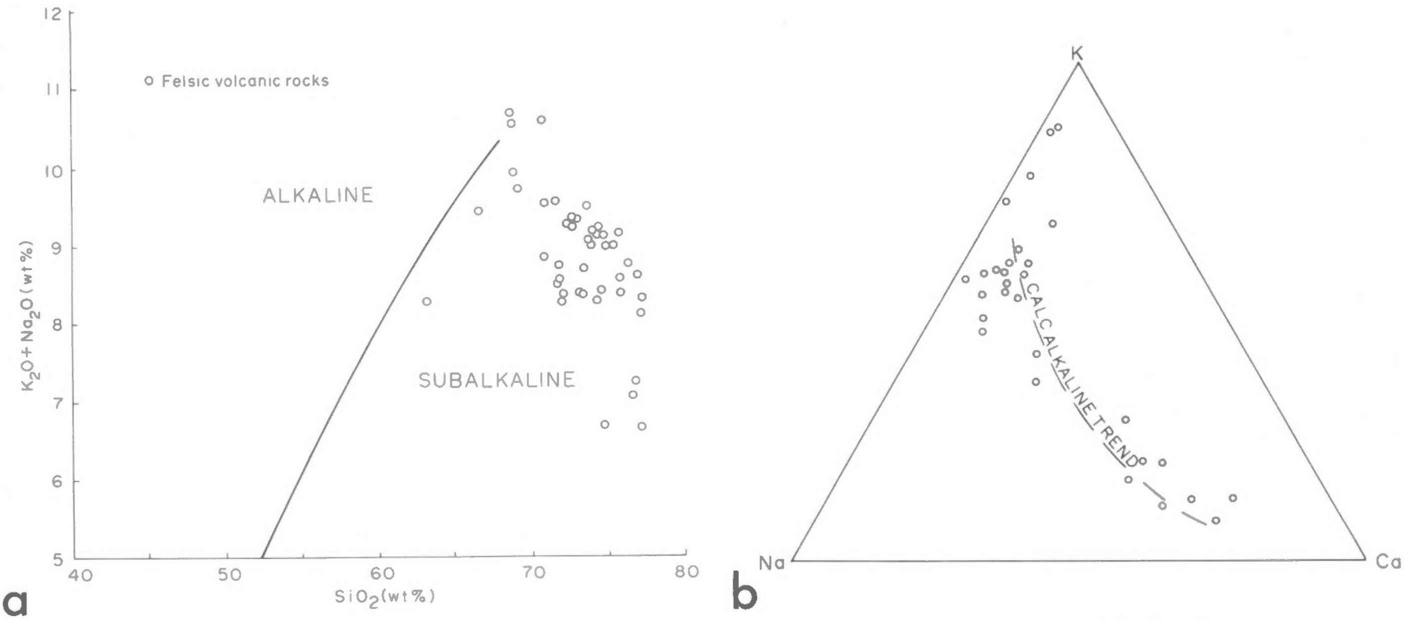


Figure 19.15. a) Alkali-silica plot and b) NKC plot of upper Aillik Group Volcanics. Dividing lines are those suggested by Irvine and Baragar (1971).

metasomatic alteration. At this stage, however, insufficient data exist to allow firm conclusions as to classification of the volcanic rocks. Certainly, the greenschist mineralogies of the Aillik volcanics suggest considerable chemical exchange may have taken place during metamorphism and thus present chemical compositions may not accurately reflect those of the unaltered rocks. The work of Kontak (1980) and White and Martin (1980) also indicates that autometasomatism may locally have strongly modified the original chemistry of these rocks.

Strontium isotope analyses have given slightly different initial Sr^{87}/Sr^{86} ratios of 0.704 (Watson-White, 1976) and 0.7022 (Kontak, 1980). Whereas Watson-White has proposed a mantle origin for the Aillik Group on these grounds, Kontak favoured a crustal origin. Both origins are possible. Low initial ratios may result from mantle partial melting and basaltic liquid differentiation, although current models of strontium evolution (Faure and Powel, 1972) suggest that initial ratios of rhyolites formed by this method should be somewhat lower than the results obtained (0.700-.702). On the other hand, the low initial strontium ratios could have resulted by melting of very old (3.5 Ga) sialic crust with low initial Sr ratios such as is exposed in the northern Nain Province (Collerson and Fryer, 1978), and which could also be present in the Hopedale Complex basement. This latter possibility, however, requires single-stage strontium evolution, a requirement which is unlikely at best (Carmichael et al., 1974; Faure and Powell, 1972), and which is almost certainly not the case in an open system such as a sialic crustal environment subjected to several periods of metamorphism and attendant metasomatism.

Speculation On Tectonic Setting

The Moran Lake and lower Aillik groups developed in a similar basinal setting to that of the Labrador Trough. A shallow-water shelf around the southern end of the Nain craton was transitional southwards into a deeper-water environment dominated by submarine rifting and tholeiitic volcanism.

The change to felsic volcanism in the upper Aillik Group suggests a fundamental change in the tectonic setting of the basin for which four possible models may be proposed:

1. Ensialic arc: the upper Aillik volcanics developed in response to northward subduction under a Nain "plate". If this is the case, however, the volcanics should be largely pre-orogenic, whereas in fact they appear to be practically synorogenic. The lack of andesites also detracts from the model, since these form important components of Phanerozoic ensialic arcs (e.g. Andean chain of Peru, Taupo Zone of New Zealand).
2. Collisional products: the volcanics were developed on the overriding plate in a continent-continent collision, such as has been proposed for the dacite-andesite volcanics of the Tibetan Plateau (Dewey and Burke, 1973) and the early Proterozoic Bear Province (Hoffman, 1980). This model is compatible with the synorogenic nature of the volcanics but again suffers from the lack of andesites, generally held to be volumetrically important in collisional orogeny (e.g. Burke and Kidd, 1980).
3. Strike-slip fault: a variation on the collisional model has been proposed by Clark (1979) who suggested that the upper Aillik volcanics were produced over a strike-slip fault zone following collision of two crustal blocks. However, most of the major faults in the Aillik Group appear to have originated as normal faults active during sedimentation and volcanism (Bailey, 1979), and were later modified into reverse faults during the Hudsonian Orogeny.
4. Rift environment: the volcanics represent a continuation of the rifting environment evident in the preceding shelf-mafic volcanic sequence, but with added partial melting of sialic crust. This model is compatible with the bulk composition of the upper Aillik volcanics (Evans, D.F., 1980; White and Martin, 1980), in particular their slight bimodal nature, and analogies could be drawn with the late Cenozoic Rio Grande Rift (Chapin and Seager, 1975) and the late Proterozoic volcanics of eastern Newfoundland (Strong, 1979). The apparent synorogenic timing of volcanism is a problem in this respect, however.

On the basis of present evidence, it is difficult to adequately discriminate between these models. On the basis of bulk volcanic composition alone, a rift origin is favoured (e.g. White and Martin, 1980) and a sequence could be invoked which began with development of a mantle plume and melting of mantle to produce lower Aillik volcanics, then evolved to melt sialic crust and produce upper Aillik felsic volcanics. With time, this plume may have migrated southwards producing increasingly greater amounts of crustal melt which eventually crystallized as the late Aphebian-Paleohelikian batholith terrane.

If radiometric dates on the Aillik Group are taken at face value, the apparent synorogenic timing of volcanism presents a problem. A possible explanation may be that rifting in the Aillik area occurred contemporaneously with deformation and metamorphism south of the Makkovik Subprovince. Deformation and metamorphism may then have advanced north and overprinted the Aillik Group immediately following the cessation of rifting. The precision of radiometric dating techniques is probably not sufficient to separate the rifting and deformational events. Crystallization of the granite batholiths presumably outlasted deformation, hence their posttectonic nature.

This hypothesis is clearly tentative, however, and open to revision pending work in progress south of the Makkovik Subprovince.

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