PRELIMINARY RESULTS OF MAPPING IN THE RAMAH GROUP AND ADJACENT GNEISSES SOUTH OF SAGLEK FIORD, NORTHERN LABRADOR

by

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Abstract

The predominantly metasedimentary Aphebian Ramah Group, which lies along the junction of the Nain and Churchill Provinces in northern Labrador, is transected by the north trending Hudsonian Front. In the east, rocks of the Ramah Group are autochthonous and lie undeformed on Archean gneisses, whereas in the west they are variably deformed and metamorphosed, and were transported eastward during Hudsonian thermotectonism.

Metamorphic grade in the Ramah Group increases from greenschist facies in the east to amphibolite facies in the west and south, and from north to south there is a significant increase in structural complexity. The westerly increase in metamorphic grade reflects the Hudsonian metamorphic zonation, subsequently telescoped by west dipping thrust faults which carried higher grade rocks on top of lower grade rocks. The southerly increase in metamorphic grade and structural complexity is believed to be a result of crustal tilting.

Early subhorizontal thrusting was probably synchronous with the development of the regional S_1 fabric, and both S_1 and D_1 thrusts were refolded during D_2 into north trending folds with gently north or south plunging axes and vertical to west dipping axial planes. Later thrusting along west dipping surfaces truncated F_2 folds. Locally a D_3 event produced northwest trending folds with subhorizontal axes. These F_3 structures may be related to subhorizontal transcurrent shearing along the Hudsonian Front, as indicated by the penetrative subhorizontal linear fabric in mylonitized rocks west of the Ramah Group. The peak of metamorphism was probably reached during D_2.

Introduction

This report presents preliminary results of field observations and mapping in the area south of Saglek Fiord (Figure 1). Efforts were concentrated on the Aphebian Ramah Group and to a lesser extent on the adjacent gneisses.

The general aim of this study is to establish the nature and extent of Hudsonian deformation and metamorphism along the boundary of the Nain and Churchill Provinces as recorded by the Ramah Group and adjacent gneisses. Work in 1984 will concentrate on the Hudsonian effects on the Archean gneisses and the early Proterozoic dike swarm (2300-2400 Ma; Fahrig, 1970; Taylor, 1974; Ryan et al., 1983) that occur on both sides of the Ramah Group.

Geological Setting

Rocks of the Ramah Group are dominantly of sedimentary origin (Morgan, 1975; Knight and Morgan, 1981) and occupy a north trending fold belt in northern Labrador (Figure 1). To the east the group unconformably overlies Archean gneisses with along and complex pre-Ramah history (Morgan, 1975; Bridgwater et al., 1975; Collerson et al., 1976; Collerson and Bridgwater, 1979; Ryan et al., 1983, 1984 in this volume). Gneisses west of the Ramah Group belong to the Churchill Province and are chiefly rocks of Archean age, reworked during the Hudsonian Orogeny (Bridgwater et al., 1975; Morgan, 1975; Ryan et al., 1983, 1984 in this volume; Wardle, 1983).

The Ramah Group was variably deformed and metamorphosed during the Hudsonian Orogeny. In the present study area gradients of increasing deformation and metamorphism have been reported from east to west and from north to south (Morgan, 1975; Ryan et al., 1983, 1984 in this volume).

Description of Rock Units

Basement Rocks in Nain Province, East of Ramah Group

In the northern area (Figure 2) the Archean basement comprises banded gneisses of granitic to tonalitic composition, mafic

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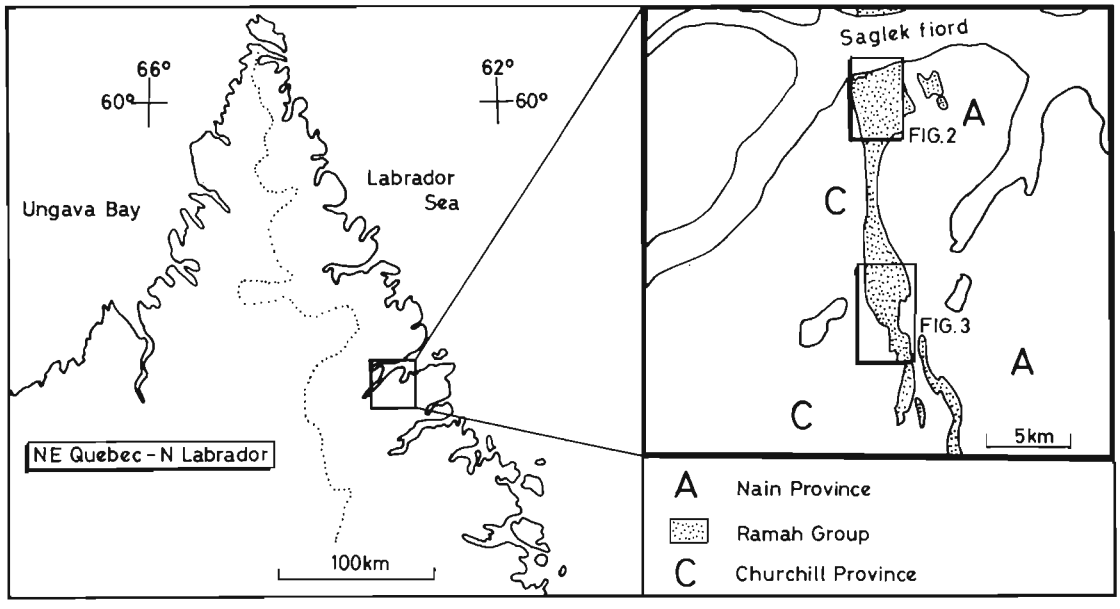

Figure 1: *Sketch map of northern Labrador showing the location of the study area. The extent of the Ramah Group is from Ryan et al. (1983).*

granulites and granitoids. In the southern area (Figure 3) the basement gneisses are well layered and predominantly of granodioritic to dioritic composition. In both the northern and southern area the observed contacts with the Ramah Group are tectonic, and the original unconformity was not recognized.

Banded gneisses. This is a compositionally variable unit, being predominantly granitic to tonalitic in the northern area, and granodioritic to dioritic in the southern area. The gneisses possess a millimetre to centimetre scale compositional layering defined by alternating felsic and mafic layers, which is parallel to a foliation defined by the parallel alignment of biotite grains.

In the southern area the gneisses are more strongly tectonized, especially in the region of the contact with the Ramah Group where they are darker in color, strongly mylonitized and schistose, and amphibolites within the gneisses are converted to hornblende schists.

Inclusions within the gneisses include minor pegmatitic and mafic components; a small talc-serpentine outcrop is believed to be an altered ultrabasic lens. Recognizable mafic metadikes are completely recrystallized and contain hornblende, plagioclase and minor sulfides. These amphibolites frequently contain centimetre scale lensoid augen, presumably plagioclase, and are believed to belong to the early Proterozoic dike swarm.

The *mafic granulite* unit comprises fine to medium grained rocks consisting of hornblende, plagioclase, garnet and quartz. Pegmatoid sweats frequently contain large garnets (10 to 20 mm) and brown clots thought to be relict orthopyroxene. These rocks are seen to be cut in one place by a pegmatitic gray gneiss identical to the tonalitic gneiss described above. Microstructurally these mafic rocks vary from isotropic to well layered on a millimetre to centimetre scale. Where sheared, the rocks are fine grained and display a fine laminar banding.

The *granite (sensu lato)* varies in composition from alkali granite to granite, the mafics never exceeding 1% (biotite). The rock is medium grained and isotropic.

The *granodiorite (sensu lato)* varies from granodiorite to tonalite in composition, and is composed of quartz, plagioclase, hornblende and minor alkali feldspar. Veins of granodiorite cut the mafic granulite, but boundaries are not sharp, indicating that both units underwent postinjection recrystallization. The boundary is cut by mafic metadikes with white lensoid augen and recognizable plagioclase

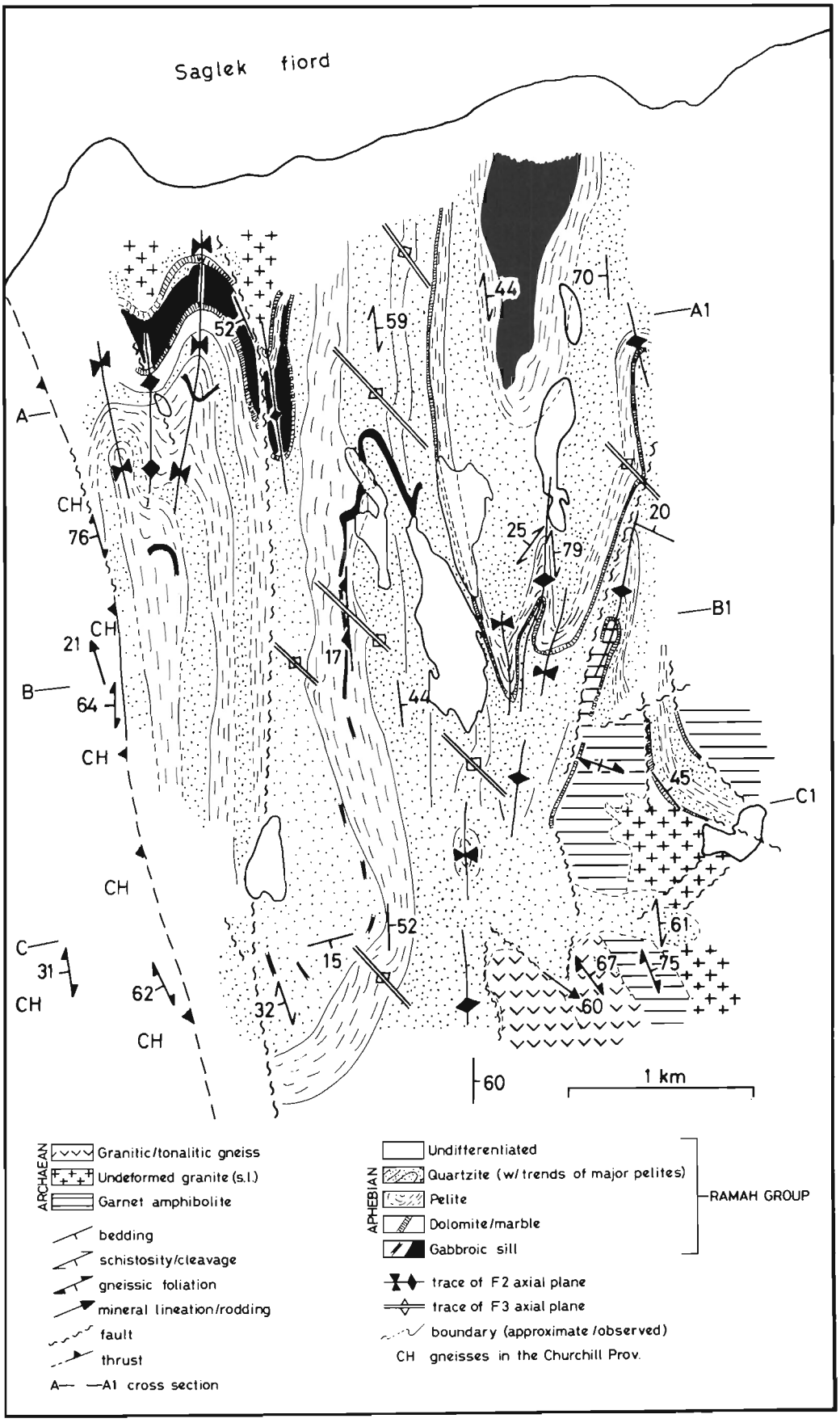

Figure 2: *Generalized geological map of the northern area (see Figure 1 for location). Minor pelite layers have been omitted in the quartzites. Cross-sections (Figure 4) are indicated by A-A1, etc..*

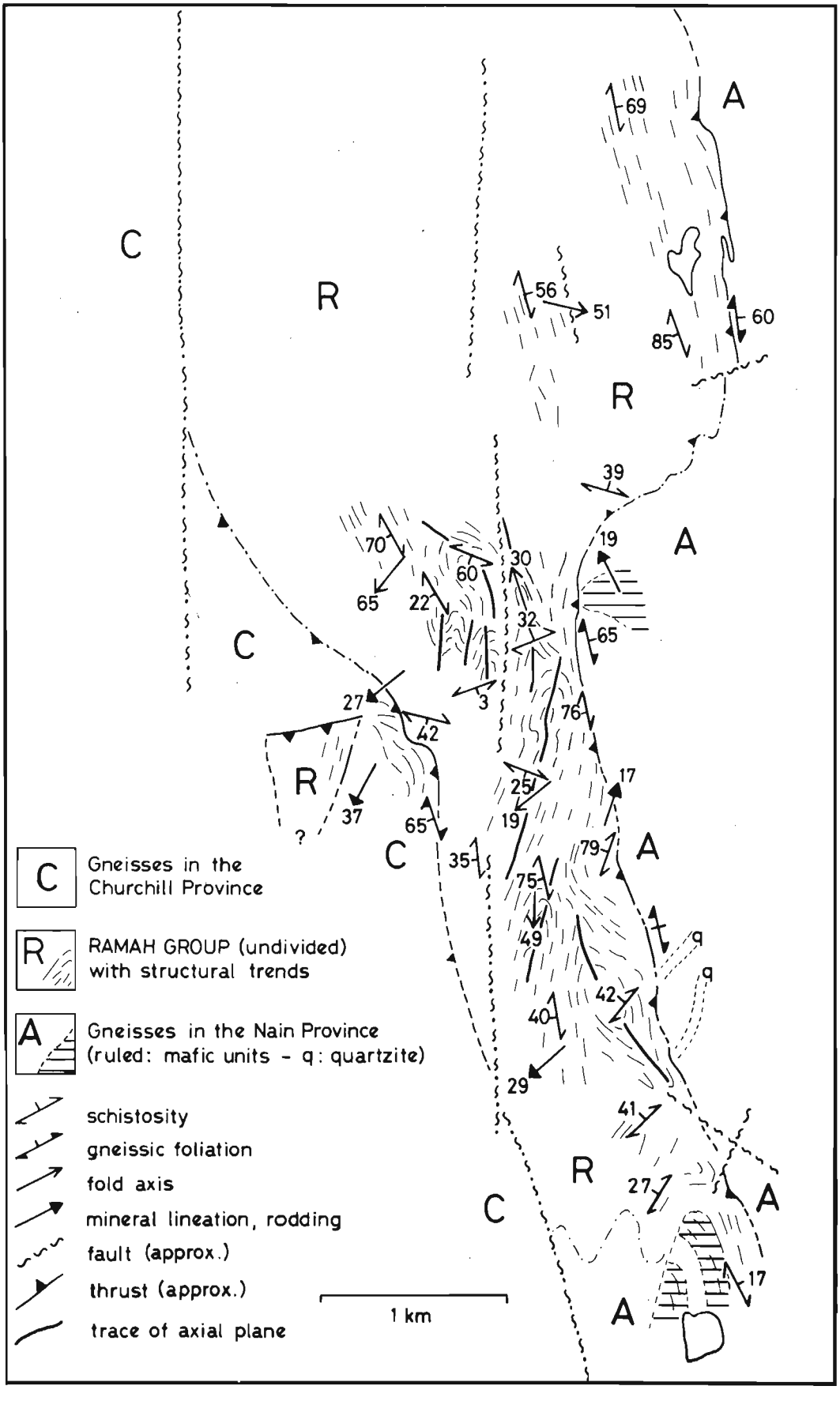

Figure 3: *Generalized structural map of the southern area (see Figure 1 for location). Structural trends are mainly from pelites. All symbols of the dash-dot type are from Ryan et al. (1983).*

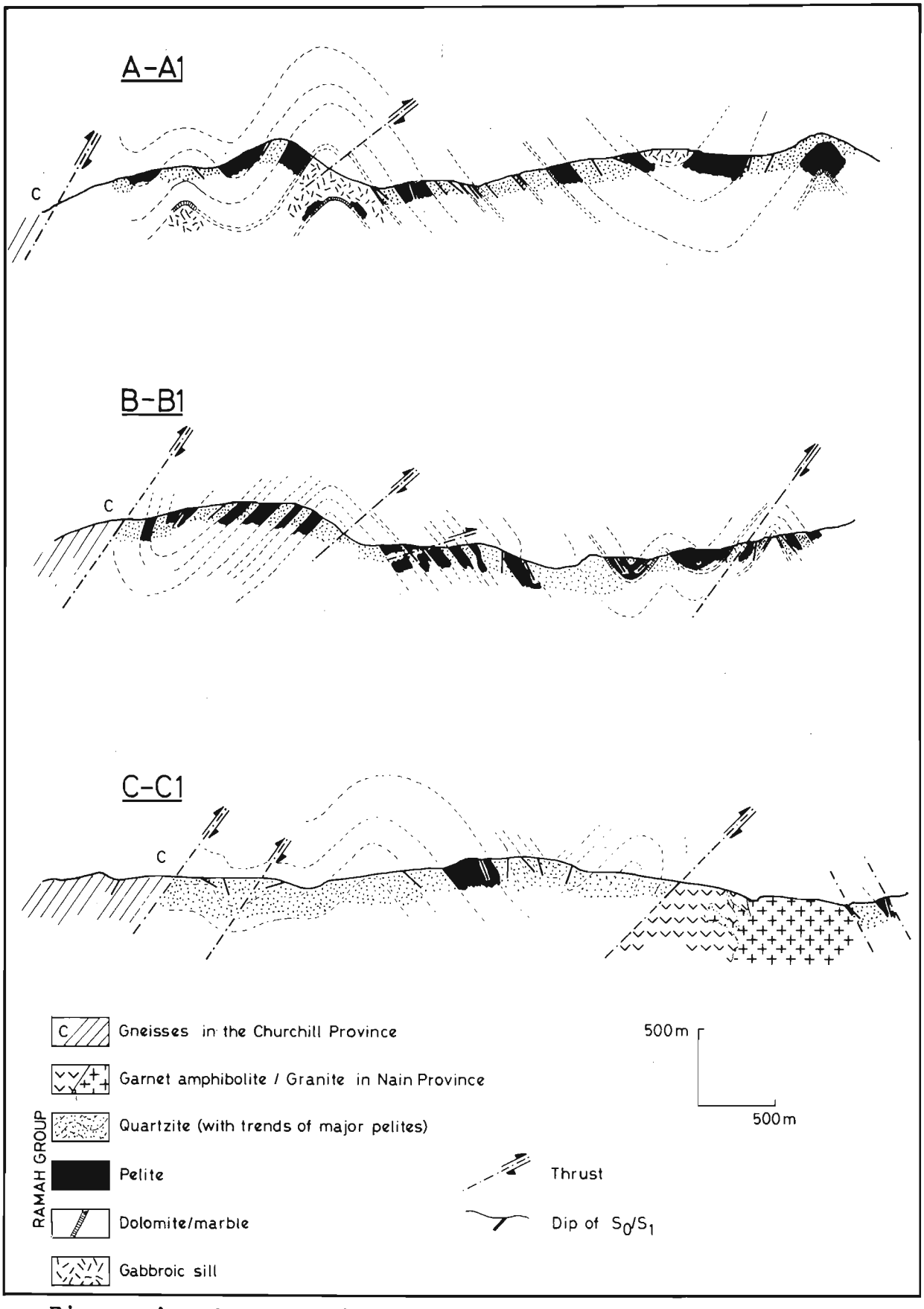

Figure 4: *Structural cross-sections of the Ramah Group in the area (Figure 2). Note the change in lithological symbols from Figure 2. Several of the pelites displayed in B-B1 are not distinguished on the map (Figure 2).*

laths. These dikes presumably belong to the early Proterozoic dike swarm.

Gneisses in Churchill Province

Gneisses in the Churchill Province are broadly similar to those in the Nain Province, but underwent an additional tectonothermal event of Hudsonian age in amphibolite to granulite facies.

They are gray biotite gneisses of granitic to tonalitic composition, with millimetre to centimetre scale compositional layering. Mafic metadikes in the gneisses are garnet amphibolites, in many cases with hornblende mantling orthopyroxene, indicating that the rocks experienced retrogression after a granulite facies metamorphic event. The metadikes may represent deformed and metamorphosed Saglek dikes (3000 to 3600 Ma; Bridgwater et al., 1975) but are probably metamorphosed members of the early Proterozoic dike swarm.

Near the tectonic contact with the Ramah Group, the biotite gneisses are strongly deformed and locally mylonitic. Well developed mineral lineations and rodding with shallow plunges are contained in the west-southwest dipping sheared contact. The lineations are compatible with transcurrent movements in the Hudsonian front zone. The implications of this will be discussed in a later section.

Ramah Group

Sedimentological and stratigraphic aspects have been treated in great detail by Morgan (1975) and Knight and Morgan (1981). They subdivided the ca. 1700 m sediments into six formations, of which only the lower three are represented in the study area. The Rowsell Harbour and Reddick Bight Formations comprise quartzite, pelite and dolostone of shallow shelf facies, recording several transgressive/regressive events. Following rapid subsidence, the deep water basinal Nullataktok Formation, composed mainly of black shales, was deposited. Locally a gabbroic sill intrudes the sedimentary pile at this level. The following sequence, found in the northeastern part of the study area, is thought to represent the transition from Reddick Bight to Nullataktok Formations: carbonate-cemented quartzite - black slate - Fe-sulfide-rich horizon - gabbroic sill. The large region with quartz-veined mica schist in the southern area (not distinguished on Figure 3, but see Ryan et al. (1983), Figure 41.3) is likewise thought to represent the Nullataktok Formation, but complex folding elsewhere in the southern area renders stratigraphic correlation tenuous.

Metamorphism

Earlier workers in the area (Morgan, 1975; Ryan et al., 1983, 1984 in this volume) have suggested that there is an increase in metamorphic grade both from east to west and from north to south in the area. Preliminary results of this study seem to confirm this zonation. In the northern area, microstructural changes in the gabbroic sill record the transition from well preserved ophitic igneous microstructure with recognizable plagioclase and clinopyroxene to an amphibolite with hornblende and recrystallized plagioclase. The presence of unmetamorphosed gabbroic dikes in the central part of the northern area strongly suggests postmetamorphic intrusion. Gabbroic rocks are not recognized in the southern area.

Metamorphic development is spectacular in the carbonate units. In the east, quartz and calcite-dolomite are in stable coexistence, and talc is only developed locally, indicating the reaction:

dolomite + quartz + H_2O = talc + calcite + CO_2

(Winkler, 1974, page 111 *ff*). In the west tremolite is developed, and a reaction such as

quartz + dolomite + talc = tremolite + CO_2

(Winkler, 1974, page 111 *ff*) is likely to have occurred. In the southern area talc is believed to be present in the east, whereas diopside occurs further west, suggesting that carbonates reacted with tremolite and quartz to form diopside and a fluid phase (Winkler, 1974, page 111 *ff*).

Details of metamorphic reactions occurring in the pelites are at present being studied, but generally the highest grade recorded by the pelites is represented by kyanite and staurolite (identified in thin section) and andalusite (identified in hand specimen) in the western part of the area. To the east the pelites may contain biotite and/or muscovite with chlorite. These preliminary observations suggest a change from greenschist facies in the east to amphibolite facies in the west. Judging from distribution of the mineral assemblages, the metamorphic grade changes rather rapidly in the central part of the area; these abrupt changes may indicate the presence of thrust faults.

In the southern area, garnet (with muscovite and biotite) is present in all

pelites, the only indication of a metamorphic gradient being the presence of talc in the carbonates to the east.

Structures

Northern Area

S_o is recognizable throughout and occurs as compositional or laminar bedding or as color differences, and current bedding and ripple marks are preserved. D_1 produced a regional S_1 parallel to S_o. D_1 has been interpreted from results of regional mapping as an episode of extensive eastward subhorizontal thrusting producing a regional S_1 (Ryan, personal communication, 1983). F_1 would thus likely be preserved as asymmetrical intrafolial folds, but these and other evidence supporting the above interpretation (e.g. strong L_1 lineations) were not observed. S_1 may be described as a slaty or phyllitic cleavage in the lower grade rocks, and a schistosity in the mica schists.

During D_2, mesoscopic and macroscopic north striking F_2 folds (Figure 4) with vertical to west dipping axial planes were developed. F_2 fold axes are gently north or south plunging. D_2 also produced small scale crenulations giving rise to pronounced D_2 crenulation lineations, small fold axes, mineral lineations and rodding. All L_2's are parallel to F_2 fold axes. S_2 is locally, but not extensively developed. D_3 formed local mesoscopic asymmetrical northwest trending folds with subhorizontal axes, open antiforms and tight synforms (See Figure 2). D_3 clearly folded structures produced by D_2. L_3 is seen as small folds and crenulation lineations. S_3 is only sporadically developed. A significant population of north-northeast to northeast plunging crenulation lineations and small fold axes may represent a D_4 episode, but may also be L_2's rotated during D_3.

D_2 structures are believed to have formed in response to the eastward movement of the rocks west of the Ramah Group. This orientation of the stress field is in accordance with eastward directed thrusting (Figure 4).

The eastward thrusting occurred late in the D_2 since several D_2 structures are truncated. Linear fabrics compatible with eastward thrusting are not preserved, and the subhorizontal lineations observed in the Churchill-Ramah boundary provide evidence for transcurrent movements postdating the thrusting. Formation of the D_3 structures is in accordance with transcurrent (dextral?) movement along the Hudsonian front.

At least two episodes of gabbro intrusion can be documented. In the northern area, the minimum 10 m thick sill is subhorizontal and more or less parallel to stratification. The rock is metamorphosed, and the primary minerals are now converted to hornblende, recrystallized plagioclase, epidote and chlorite. The sill was probably emplaced pre- or syn-D_1. Further west and southwest the gabbroic dikes are 1 to 10 m wide and have variable orientation. The dikes cut across S_1 but are folded by D_2, so intrusion must be pre- or syn-D_2. Preliminary observations indicate that these dikes are unaffected by metamorphism, thus suggesting that penetrative metamorphism and deformation ceased sometime during D_2.

Southern Area

The structures in this area (Figure 3) have not been investigated in detail, but a few general statements can be made.

All boundaries between the Ramah Group and adjacent gneisses are tectonic, and structural data suggest that they have been modified by later folding and thrusting. Along the western margin of the Ramah Group, mineral lineations and rodding plunge systematically southwest in accordance with northeast directed thrusting. At the time of writing it is not known whether this is part of the main thrusting event (and thus comparable with the eastward thrusting recorded in the northern area) or represents a later kinematic episode. The latter hypothesis is favored by the roughly north trend of axial planes: structures of this orientation are unlikely to have formed contemporaneously with northeast directed thrusting. The general north trend of axial planes is comparable to the D_2 structures in the northern area, and suggests that the southern area also experienced a period of folding with north trending axial planes possibly followed by eastward thrusting.

Discussion

The following general observations have been made:

(1) structural complexity increases from north to south;

(2) metamorphic grade increases from east to west and from north to south.

Figure 5 shows a schematic cross-section of the Nain-Churchill boundary and the overlying Ramah Group. The section X-X represents the structural level presently exposed immediately south of Saglek Fiord (compare with cross-sections, Figure 4) and

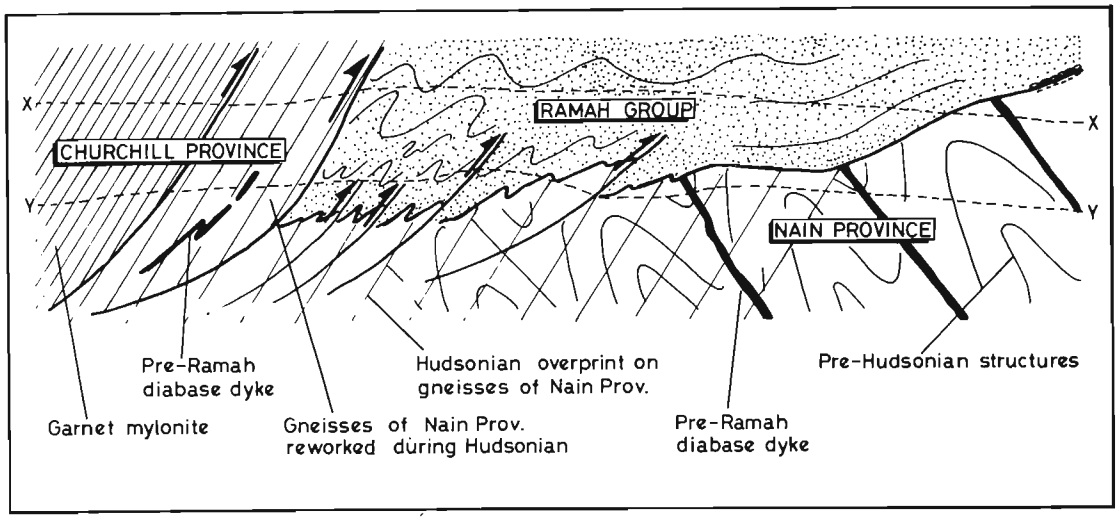

Figure 5: *Schematic cross-section of the Nain-Churchill boundary and the overlying Ramah Group illustrating the structural and metamorphic changes recorded from the northern area (level X-X) to the southern area (level Y-Y). The unconformity between the Ramah Group and the Archean basement is indicated in the top right hand corner. Trend lines in the Ramah Group are S_1. Thrusts postdate S_1. Based partly on Ryan et al. (1983) and Wardle (1983).*

the deeper level Y-Y is believed to represent the more complex southern area. Post-Hudsonian crustal tilting, exposing deeper levels in the southern area, can explain the above general observations, and is also in accordance with the drastic thinning and eventual disappearance of the Ramah Group further south towards Hebron Fiord (Ryan et al., 1984 in this volume).

Economic Geology

Near the base of the Nullataktok Formation, a sulfide horizon occurs where the gabbroic sill intrudes the black slate. The horizon was described by Knight and Morgan (1981), Ryan et al. (1983) and Wardle (1983), and comprises a massive to bedded fine grained pyrite-pyrrhotite horizon with pebbles of quartzite, chert and slate. The occurrence is not of economic importance in itself, but does indicate the presence of sulfide-generating processes in the Ramah basin at the time of deposition.

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Field work was carried out in co-operation with a regional mapping program in the Saglek-Hebron area (see Ryan et al., 1984 in this volume, for details).

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