STRUCTURE OF AN AREA ALONG THE BOUNDARY OF THE LETITIA LAKE GROUP AND SEAL LAKE GROUP, CENTRAL LABRADOR

by

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INTRODUCTION

Detailed structural analysis was carried out in a small area (62°14'W, 54°15'N) north of Letitia Lake in central Labrador. The area is situated along the boundary of the Letitia Lake Group and the Seal Lake Group (Thomas, 1979) along the northern margin of the Grenville Province. The purpose of the project is threefold: (1) to establish the structural geometry of the rock sequences; (2) to determine and compare the deformation histories of the rocks of the two groups, paying special attention to the relationships between deformation and metamorphism; (3) to develop a kinematic model for the structural evolution of the terrain. Microstructural observations have yielded some preliminary data on the operative deformation mechanisms. The study attempts to resolve some of the problems concerning the position and nature of the Grenville Front Zone in central Labrador. It may also provide information about the structural controls of the setting of mineral deposits elsewhere in the zone.

Aspects of the regional geology of the Letitia Lake area have been discussed by Brummer and Mann (1961), Marten (1979) and Thomas (1979). In this study the lithostratigraphic subdivision proposed by Thomas (1979) has been followed with the exception that the slates and metapsammites overlying the regolith are included in the Letitia Lake Group. This change is based on two observations. First, the regolith appears to grade locally into slates and metapsammites which are discontinuously exposed along the contact between the two groups. It is believed that these features are depositional in nature and that the unit represents localized deposits formed during the weathering process. Contacts between these rocks and the basal members of the Seal Lake Group, on the other hand, are always sharp and tectonic in nature. Secondly, it is found that the conglomerates and quartzites of the Seal Lake Group grade laterally into one another and that both rock types may be underlain by the slates and metapsammites. The latter rocks also occur as pebbles in the conglomerate. The unconformity between the two groups is apparently of a complex nature, but it may be more consistently drawn at the base of the conglomerate - quartzite units.

Previous workers have recognized two deformation events which have affected both the Seal Lake Group and the Letitia Lake Group. D_1 produced east - west trending, horizontal to gently plunging folds whose limbs dip moderately to steeply towards the south. These folds define the structural grain of the area. D_2 produced local shear zones and thrusts, and gave rise to the development of folds with related crenulation cleavages. No attempts were made to date the regional metamorphism with respect to the deformation events. This paper presents a major revision of the deformation history outlined for the area.

STRUCTURAL ANALYSIS

North of Letitia Lake three isolated occurrences of conglomerate and quartzite are found along the boundary of the Letitia Lake and Seal Lake Groups

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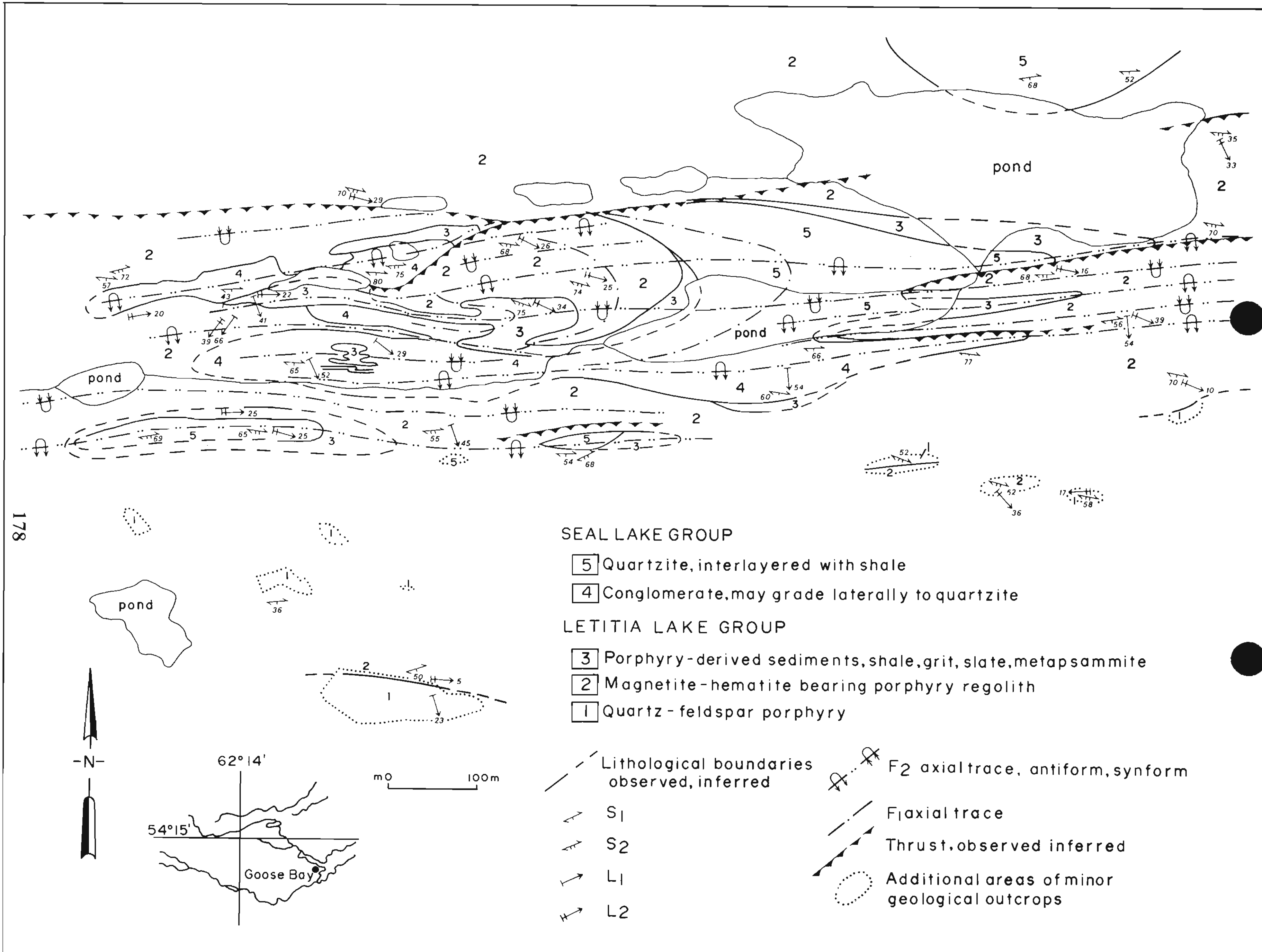
pond
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SEAL LAKE GROUP
5 Quartzite, interlayered with shale
4 Conglomerate, may grade laterally to quartzite
LETITIA LAKE GROUP
3 Porphyry-derived sediments, shale, grit, slate, metapsammite
2 Magnetite-hematite bearing porphyry regolith
1 Quartz - feldspar porphyry
Lithological boundaries observed, inferred
S1
S2
L1
L2
F2 axial trace, antiform, synform
F1 axial trace
Thrust, observed inferred
Additional areas of minor geological outcrops
-N-
62° 14'
54°15'
Goose Bay
m0
100m

the folds. In the slates and metapsammites the foliation has the morphology of a differentiated layering which can be easily mistaken for bedding. An irregular crenulation lineation (L_2) is developed parallel to F_2 fold axes. The linear elements are horizontal or gently plunging towards east or west, but they show a weak tendency to rotate in the S_2-plane towards transverse positions. Large scale F_2 synforms and antiforms are easily observed in outcrop or they can be inferred on the basis of asymmetry of small scale folds. In the field the axial traces can be readily mapped due to the fact that the fold hinges show abundant quartz veining. The large F_2 folds define the structural grain of the area. These folds have been referred to by previous workers as F_1 structures. In many localities, however, they can be seen to overprint F_1 folds.

Microstructures related to the second deformation event show evidence for cold working accompanied by minor recovery; recrysallization is subordinate. On the other hand, the occurrence of differentiated layering and quartz veining indicate that fluid-assisted diffusion processes may also have operated. It is probable that the deformation occurred under waning conditions of metamorphism in the ductile field.

Faults

Thrust and high-angle reverse faults break the continuity of the F_1 and F_2 fold structures. These faults are usually developed parallel to the limbs of macroscopic F_2 folds, but they do not show any preference, at this scale of mapping, to cut off either synformal or antiformal closures as has been suggested by previous workers. Faults are also developed parallel to major lithological contacts where a large competency contrast between the adjacent rocks exists. Displacements along the faults appear to be relatively small. Movement directions inferred on the basis of slickensides and the style of minor drag folds indicate transport towards the north. The fault zones are often extensively chloritized.

INTERPRETATION OF GEOMETRY AND A KINEMATIC MODEL

The most important features of the map in terms of its structural geometry are: (1) the closed outcrop pattern of the younger rocks of the Seal Lake Group, which occupy the core of a large scale refolded fold; (2) the inverted nature of the stratigraphy in the southern and central part of the area and along a short segment of the northern boundary of the conglomerate - quartzite sequence, which is interpreted to be due to F_2 folding; (3) the contrasting orientation patterns of the F_1 and F_2 folds. The kinematic model explaining the structural geometry and evolution of the area must be consistent with the above features.

The closed outcrop pattern of the Seal Lake Group suggests the presence of a doubly plunging fold. The overall eastward plunge of F_2 fold axes over the structure, however, rules out the possibility that the geometry of the fold is due to an interference pattern between F_1 and F_2 folds. It is therefore reasonable to assume that the F_1 structure was internally closed prior to F_2 folding.

Tubular or sheet folds provide the geometry required by the field data. These structures develop by rotation of fold axes, which are originally at a high angle to the X direction of the mean strain ellipsoid, towards X during progressive deformation at highs strains in both pure and simple shear. Initially the fold axes may be subparallel to the intermediate axis of the strain ellipsoid, for example in the case of simple shear. In the final state the long axis of the tube will be parallel to X and signifies the tectonic transport direction. Such structures are

(Thomas, 1979). The outcrops of the bodies are elliptical in shape with the longest dimension parallel to the east - west regional structural trend. Aspect ratios of the outcrop areas of the bodies range up to 10:1. The bodies are situated at different structural levels as measured with respect to a penetrative axial plane foliation developed in the area. Each of the bodies is completely surrounded by outcrop of the older regolith.

The central body has almost continuous exposure and was selected for surface mapping and analysis of small scale structures. Three generations of structures have been recognized on the basis of overprinting criteria and of relationships between deformation and metamorphism using microstructural criteria. The deformation sequence comprises the development of two generations of fold structures (F_1 and F_2) on various scales and a younger faulting event. The deformation history is described below, followed by a discussion of the large scale structural geometry of the area.

F_1 structures

F_1 structures are penetratively developed in all rock units in the area. A well developed axial plane foliation (S_1) is observed which varies in morphology for different rock types. In most cases it is an anastomosing type of slaty cleavage defined by an alignment of layer silicates and preferred dimensional orientation of minerals such as quartz and feldspar. In fine grained rocks a mineral elongation lineation (L_1) is developed in the S-plane; it is particularly common in the quartzites. The conglomerates show a L>S fabric defined by slightly flattened but extremely elongated pebbles. In most cases the foliation is parallel to the primary compositional layering, but in a few conglomerate localities a small angle between the S-planes has been observed. F_1 folds are common in most multilayered sequences, but they are extremely difficult to recognize. They range usually from microscopic to mesoscopic, and are asymmetric, tight to isoclinal and reclined. Fold axes are parallel to the mineral lineation. Large scale F_1 folds have not been observed, but they can be inferred on the basis of bedding/cleavage relationships, asymmetry of small scale folds and lithostratigraphic criteria. The axial traces of a number of F_1 folds have been determined in the central and eastern part of the conglomerate - quartzite outcrop. In the western part of the outcrop the position of these traces is uncertain.

The F_1 structures show a very constant orientation pattern. S_1 planes dip moderately to steeply towards the south. Fold axes and L_1 have a pitch of 70° from east in the S-plane; they constitute a transverse linear element with respect to the regional structural trend.

Microstructures related to the first deformation event show evidence for dynamic recrystallization of muscovite and quartz. Pressure solution features have been observed in the conglomerates and in detrital quartz grains in quartzite. The deformation is almost entirely of a ductile nature, and probably occurred at the peak of metamorphism.

F_2 structures

F_2 structures are found in all rock units in the area, but their intensity of development is less than observed for the F_1 structures. In the conglomerates evidence is found that the amount of strain related to F_2 folding is comparatively small. F_2 folds ranging from microscopic crenulations to large scale, close to tight folds with short wavelengths and large amplitudes are common. They are steeply inclined with axial planes dipping southwards and they usually have S-shaped asymmetry when viewed down plunge towards the east. A crenulation cleavage is commonly developed parallel to the axial plane of common in mylonite zones (Bell, 1978) and in ductile thrust nappes (Williams and Zwart, 1977).

In the studied area, sheet folds have not been observed on a small scale, but many other features are consistent with the proposed geometry. F_1 deformation is associated with high strains. The F_1 axes are parallel to a stretching lineation which defines the X direction and which is transverse to the trend of the Grenville Front Zone. The inversion of the stratigraphy, the northwards facing nature of the F_1 structures, and on a larger scale, the metamorphic zonation (Thomas, personal communication 1979) all indicate that older and more deep-seated rocks have been transported northwards over younger, higher level rocks. In this context it seems probable that L_1 signifies the transport direction.

The geometry of the F_2 folds is not necessarily in conflict with the movement pattern proposed for F_1 deformation. The fold axes may have developed close to parallel with the Y axis of the mean strain ellipsoid. The tendency of the axes to rotate towards transverse postions in conjunction with the northwards vergence of the folds indicates that a similar movement path was followed, but that much lower strains were attained during F_2. A possible explanation for this point may be that a transition from predominantly ductile to brittle deformation conditions occurred with decreasing temperature. The faults which are geometrically strongly related to the F_2 folds may have developed during the late stages of F_2 deformation.

An elegant kinematic model for the development of ductile thrust belts involves progressive simple shear (for example, see Escher and Watterson, 1974). The structural style of the studied area is consistent with all aspects of this kinematic model, but other more complex movement patterns may be equally valid. Notwithstanding possible kinematic complexities, it can be concluded that the studied area is part of a ductile thrust belt in which large strains were obtained during Grenvillian deformation. The structural style of the area resembles that of many other segments of the Grenville Front.

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