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ET MINÉRALE

STUKELY AREA

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STUKELY AREA

Electoral Districts of Shefford and Stanstead

by

J.I. Sharpe

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(1000 pieds au pouce)

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by John I. Sharpe

INTRODUCTION

General Statement

The Stukely area is a part of the Sutton range of the Appalachian Uplands in the Eastern Townships of Quebec. It is located within the "Serpentine Belt".

This "belt" has been long known as a favourable local for a diversity of economic minerals and has received considerable attention in the past 100 years.

An economic copper deposit (Quebec Copper Mine) occurs ~~five miles~~ south of the map area. In hope of acquiring further information of economic importance, a detailed mapping project was undertaken in 1956 by the Mineral Deposits Branch of the Quebec Department of Mines. The present area is a continuation of this project.

The sedimentary and volcanic rocks of the Stukely area are believed to be early Paleozoic in age. They include the Sutton assemblage of highly contorted schists, mainly of sedimentary origin, which are overlain by the Caldwell group. The latter consist of interbedded impure sandstones, slates and acid to basic volcanic rocks.

A considerable number of serpentinized ultrabasic sills and dykes intrude the above rocks and are themselves intruded by extensive tracts of gabbroic, dioritic and granitic rocks.

All the non-intrusive rocks are sheared and folded to some extent. The dominant structure is an anticlinorium whose axial zone appears to transect the northwestern corner of the area. A major strike-fault may in part separate the Caldwell and Sutton rocks and there are indications of several cross faults.

Minor disseminations and local concentrations of chromite, copper, talc and asbestos were discovered. None of these appear to be of economic quantity. However, the wide variety of rock types, possible structural controls and a position within a known mineralized belt are encouraging features for further exploration.

Location and Access

The Stukely area is located in the Eastern townships of Quebec, 72 miles east of Montreal, and is bounded by latitudes 45°20' and 45°25' and longitudes 72°13' and 72°20'. This area of approximately 33 square miles includes portions of Stukely and Orford townships and Mount Orford Provincial Park, in the electoral districts of Shefford and Stanstead.

Access to the area is provided by secondary roads which connect with provincial highway No. 1, some two and one half miles to the south. A north-south branch of the Canadian Pacific Railway Co. transects the western part of the area and a main line to Montreal, of the same railway, passes through the village of Eastman, two miles to the south.

Travel within the map area is facilitated by gravel and dirt roads and Stukely lake provides a water route. The southeast part of the area is best attained by canoeing along the flooded portion of the Cherry river, from the end of the road that leaves highway No. 1 near the tip of Lake Memphremagog.

Field work

The Stukely area was mapped in the summer of 1958 as a continuation of the mapping done to the south by De Romer (1957, 1958).

The method of survey was by pace and compass traverses spaced at approximately 500 foot intervals and controlled by a system of chained baselines less then 4000 feet apart. Closer spacing of traverses was made in areas of poor outcropping. Vertical air photographs also were used for control.

Few of the lot and range lines established by the old township survey may be followed on the ground.

The base map for that part of the area within Stukely township was prepared by A.E. Simpson Ltd. The remainder of the map is an enlarged version of published government maps supplemented by details from vertical air photographs and ground surveys.

Acknowledgment

C. Paré, a graduate of Laval University acted as senior assistant. J.P. Morin and Guy Dallaire were student assistants and Guy Bastien general assistant.

All performed their duties in an efficient and conscientious manner.

Previous Work

Systematic geologic mapping of the Eastern townships commenced shortly after the organization of the Geological Survey# in 1842 and was implimented in part by the demand for copper in the years 1859 to 1886.

The folded nature and distribution of the Sutton Schists were indicated by Sir William Logan (1863) and the rocks assigned to the "Quebec Group" believed equivalent to the less disturbed Paleozoic rocks of the St-Lawrence Lowlands. Subsequently Hunt (1890) and Selwyn (1878) demonstrated that the Sutton rocks were arranged in an anticlinal structure rather than the

#For a more complete discussion of the progress, the accomplishments and the controversies, the reader is referred to Dresser and Denis (1944, pp. 372-447).

"synclinal" indicated by Logan. Selwyn's suggestion (1883) and Adams' (1883) confirmation that the serpentine rocks and sheared chloritic rocks were igneous rather than sedimentary in origin (per Logan's uniformatarianism viewpoint), and other advances in the sciences necessitated a revision of the geology of the Eastern townships. R.W. Ells, of the Geological Survey, remapped most of the Eastern townships and his report for 1894 includes the Stukely area. Ells' conclusions were generally in accord with the views of Selwyn. Of particular interest are the description of lower Trenton graptolites immediately southeast of the Stukely area and the recognition that the Sutton anticlinal axis passed through the northwest corner of present area. Ells regarded the Sutton rocks as mainly Precambrian rather than Paleozoic in age.

Observations in the Stukely area are incorporated in Dresser's reports for the Geological Survey (1901, 1906, ~~1907~~, 1910-11). Dresser's work is of particular interest as he appears to be the first to recognize igneous rocks within the "Sutton series". He also demonstrated that at least some of the "Sutton series" is post-Precambrian and suggests that all the rocks of the series are altered parts of the "Quebec Group" thus reverting toward the older classification of Logan. The serpentine of the igneous complex of Mount Orford was also recognized as older than the gabbroic rocks.

Harvie (1911) studied the Sutton range south of the Stukely area and assigned the schists and graywacke provisionally to the Precambrian and Cambrain systems respectively.

More recent publications pertaining to the Stukely area are Clark's (1934) general discussion of the structure and stratigraphy of the Eastern townships; Fortier's (1945) preliminary map of the Orford area, ~~and~~ Cooke's (1950) compilation of the geology of the Eastern townships and De Romer's (1957, 1958) work on adjoining areas.

DESCRIPTION OF AREA

Settlement and Resources

The area is lightly populated; the only village being Notre Dame de Bonsecours (or North Stukely). The northern and northwestern parts, and elsewhere, have been utilized for pasturage, truck gardens and a few seed and root crops. The remainder is mainly covered by hardwood and coniferous forest except for occasional patches of "cut-over" and heavy underbrush mixed with raspberry bushes.

Stukely and Bowker lakes and the surrounding hills provide pleasant scenery and have a considerable influx of tourists in the summer.

The rolling land surface is strewn with glacial debris and the soil difficult to work agriculturally as attested by the numerous stone fences.

A moderate amount of softwood timber (outside Mount Orford Park) remains uncut and good stands of maple are common and produce considerable syrup.

Physiography

The Stukely area lies within the Appalachian Uplands. It is a part of a series of hills, designated the Sutton range, which extend from the Green Mountains of Vermont northeast through the Eastern townships. The minimum and maximum elevations, within the present area, are 725 feet and 2490 feet in the northwest and southeast corners respectively.

The general physiography is mainly the imprint of continental glaciation, controlled to some extent by the pre-glaciation landforms and subdued by accumulations of glacial debris. The minor features reflect variations of the nature of the bedrock and outcroppings of the quartzose schists, sedimentary rocks and basic volcanics rocks are generally abundant.

The topographic elements of the area may be crudely divided threefold into: A depressed area in the central part; an enclosing upland; and the north slope of Orford mountain and subsidiary hills.

The depressed area is irregular in shape, entering from the northwest along the brook and railroad track. The boundary is marked approximately at the north by the east-west road through Bonsecours; at the west by the railroad track and at the east by the road west of Stukely lake. Elevations within this depression are generally less than 1000 feet though a low ridge, extending northeast from where the railroad track swings northwest, serves to separate the drainage pattern.

The depressed area is almost wholly enclosed by a partially dissected upland with a mean elevation over 1100 feet and hills attaining 200 feet more than this. To the north and west are minor hills and valleys trending north or northeast and incised by east-west valleys. These are underlain by quartzose schists similar to the Sutton mountains. East of the depressed area the higher elevations reflect the underlying impure quartzites and volcanic rocks.

The most rugged topography occurs on the north flank of Mount Orford in the southeast part of the area. Elevations here exceed 2450 feet.

Surface drainage is provided by small streams and brooks. The main stream in the north drains westerly and flows for the most part on glacial debris, across the regional strike of the underlying bedrock. The brooks to the south drain towards the south, consequent to the rock structure.

Stukely and Bowker lakes whose elevations are approximately 925 and 1025 feet respectively are interesting in that they follow closely the configuration of underlying ultrabasic rocks. Bowker lake is reported to be extremely deep.

Inspection of the land surface and distribution of glacial debris suggests Stukely lake at one time was a part of a southwesterly flowing drainage system subsequently modified by glaciation.

Along the stream in range VII, Stukely township, laminated clay and silt beds dip up to 10^{o} northwest. These attitudes may indicate post-glacial modification of the land surface.

GENERAL GEOLOGY

The Stukely area is underlain by a wide variety of metamorphosed sedimentary, volcanic and intrusive rocks believed mainly early Paleozoic in age.

The oldest rocks, termed the Sutton schist, are an intricately folded assemblage of low-grade quartzose schists with minor interbedded quartzite, graphitic and chloritic schists. These are folded into an anticlinal structure whose axial zone appears to transect the north-western corner of the area.

On the southeast flank of, and partially overlying the Sutton rocks, is the Caldwell group - a steeply dipping, folded, assemblage of impure sandstones slates and acidic to basic lavas. These rocks may be of Cambrian-Ordovician age.

Serpentinized ultrabasic rocks are abundant and appear to be generally older than some large complexes of gabbroic and dioritic rocks. Minor amounts of granitic rocks appear to be the youngest intrusives in the area.

All the non-intrusive rocks are believed to have been deformed at similar times but to varying degrees.

Insert "table of formations" see page 11

SUTTON SCHISTS

The Sutton schists, within the Stukely area, are mainly complexely folded sedimentary rocks intercalated with minor amounts of altered basic volcanic rocks.

These schists are a part of an extensive belt of similar rocks which extends from Vermont northeasterly through the Eastern townships, constituting the Sutton range.

Previous workers have designated these rocks as Sutton schists, Sutton Mountain series, Sutton series, Sutton Mountain schists, Sutton group, Sutton facies and altered equivalent of Caldwell group.

The overall stratigraphic nature of these rocks and their relation to less altered rocks to the east (Caldwell group) is not clear although the latter appear generally younger.

The area covered by the writer's work is too limited to permit regional projection of the data. However, within the Stukely area, the Sutton rocks and Caldwell group are distinct units and the term Sutton Schist will be retained. Whether these rocks may be designated a stratigraphic group or formation must await further work.

Insert on page 10
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Table of Formations

RECENT and PLEISTOCENE		Boulder till; fluvioglacial sand, gravel and clay; stream and lake deposits.	
POST ORDOVICIAN ?	Intrusive Rocks	(Trap and porphyritic dykes)	
		(Granite, granodiorite, quartz diorite)	
		Quartz gabbro	
		Hornblende gabbro, diorite, green gabbro, pyroxene-feldspar rock.	
		Pyroxenite Serpentinite, serpentinized peridotite and dunite, talcose schists.	
ORDOVICIAN - CAMBRIAN ?	CALDWELL GROUP	Southeast sedimentary assemblage	Subgraywacke, quartz arenite, minor slate and small-quartz-pebble conglomerate; rhyolite agglomerate; graphitic slate; black quartzite; purple slate; quartz-sericite schist and phyllite.
		Basic volcanic assemblage	Chloritized basic lava; volcanic breccia and conglomerate; quartz-sericite-chlorite schist.
		Northwest sedimentary and volcanic assemblage	Subgraywacke, quartz graywacke, quartz arenite, minor siltstone, slate and small-quartz-pebble conglomerate; graphitic slate; black quartzite; limestone; purple slate; quartz-sericite schist; meta-quartzite; intermediate lava; acid volcanic rocks.
	SUTTON SCHISTS	Eastern member	Graphite - sericite schist; sericite(-chlorite) schist; chlorite schist.
		Western member	Quartz-sericite (-feldspar-chlorite) schist and quartzite; quartz-sericite-graphite schist; magnetite-epidote-chlorite (-hornblende) schist; marble.

The Sutton schist, within the map-area, may be divided into an eastern and a western member. The division is made on the basis of lithology, amount of ~~introduced~~ quartz and degree of structural disturbance. Thus most rocks of the Western member (excepting the magnetite-epidote-chlorite schist and marble) are quartz-rich, poor in micaceous minerals and are highly contorted and folded. The rocks of the Eastern member are poor in quartz, consist essentially of secondary micaceous minerals, are commonly graphitic and do not exibit the complex folding to the degree observed in the Western member.

The contact between the two members is not well defined. A transitional zone up to 1000 feet surface width exists and outcroppings within this zone have intermediate characteristics. However, the rocks east of the transitional zone are distinctive and the subdivision into the members reflects differences in the original lithology of the metamorphosed rocks.

Western member

The Western member of the Sutton schists underlies most of the northwestern half of the map area.

The extreme structural disturbance and thickening due to folding precludes a determination of the stratigraphic succession or an estimate of the true thickness.

The mappable lithologic types are: quartz-sericite (-feldspar[1]-chlorite) schist and quartzite, quartz-sericite-graphite schist, magnetite-epidote-chlorite (-hornblende) schist and marble.

Quartz-sericite (-feldspar-chlorite) schist and quartzite.

Quartzose, micaceous schists constitute over 80 per cent of the Western member. The rock outcrops well, underlying the northwestern upland areas and good exposures may be seen in lots 18-21, range V, Stukely township.

The proportion of quartz to secondary micaceous minerals is variable. The rocks range locally from fine-grained micaceous schist intercalated with streaks and bands of milky quartz to comparatively massive pure quartzites with traces of white mica along widely spaced cleavage surfaces. The general nature of these rocks is illustrated in Plates II-B, III-A and III-B.

The purer quartzites are rare but when present (as in lots 21 & 22, range VI, Stukely twp.) provide determination of primary bedding. Elsewhere, sedimentary structures are rare. Clearly defined bands, varying in the content of micaceous minerals reflect primary bedding and a few instances of possible graded bedding were noted.

1 Mineral species enclosed by brackets indicates the constituent is not always present in appreciable quantities, but occurs commonly enough to be a general characteristic.

Table 1 summarizes the types and quantity of minerals seen in thin sections.

Table 1
Mineral composition of quartz-sericite (-feldspar-chlorite) schist.

Mineral	% Range#	% Average#
quartz	18 - 77	55
secondary white micas (mainly sericite or muscovite)	10 - 60	29
chlorite	4 - 10	8
feldspar (mainly albite)....................	1 - 10	4
accessory minerals: magnetite, ilmenite, leucoxene, pyrite, hematite, garnet, zircon, epidote, sphene (?)........................	2 - 6	4
		100

estimation of 5 thin sections.

The quartz is for the most part recrystallized, introduced or a local segregation. Rarely a few rounded sedimentary grains are preserved (Plate V-C), or their outline marked by zoning of extinction and/or inclusions. Granulation is common. The average grain size is in the .05 - .3 mm range.

The secondary micas consist essentially of sub-oriented shreds of muscovite commonly interlaminated with chlorite. A few grains of alkali and plagioclase feldspar may be identified in most thinsections. Occasionally the grains of feldspar are sub-rounded, composite, granulated and have flakes of mica moulded over the surface of the grain. This suggests a detrital origin. Elsewhere, albitic plagioclase contains concentric inclusions of micaceous minerals, transects the folia of the matrix and is not granulated. These are crystalloblastic and locally constitute 30 per cent of the rock (Plate V-B).

The accessory minerals; garnet, zircon and sphene (?), are scarce, occur as small rounded grains and appear to be in part detrital. The remaining accessories listed in table 1 are mainly secondary minerals. Leucoxene may be quite abundant.

The schistose fabric of the rock is imparted by segregations of quartz and the oriented micaceous minerals. Crenulation of micaceous flakes and an associated transecting cleavage are also present. The fabric elements of the Sutton schist as a whole will be discussed after outlining the nature of the remaining lithologic types of both members.

Quartz-sericite-graphite schist

Graphite bearing schists are interbedded with the quartz-sericite schist and constitute less than 6 per cent of the Western member. Individual beds and zones vary from less than a foot to several hundred feet in apparent thickness.

Exposures of the rock may be seen in lots 22 and 23 and along the creek bed in the northern part of lot 20, range VI of Stukely township.

The distribution and proportion of the graphite vary locally from thin streaks accompanying sericite in medium-grained quartzose rocks to fine-grained schists in which sericite and graphite are the main constituents. In the latter rocks, fragments of thin beds of light-coloured, very fine-grained quartzite may occasionally be observed in a crumpled schistose matrix. These fragments are relatively unaltered and the incompetency of the matrix and the chemical inertness of the graphite probably served as a protective factor.

Microscopic examination of the rocks reveals the same general characteristics observed in the quartz-sericite schist. The quartz generally has sutured boundaries and lepidoblastic muscovite. Rounded quartz grains are not uncommon in micaceous portions of the rock and small metacrysts (?) of feldspar may be present. The graphite generally is disseminated throughout the mica, seldom with the quartz. Detrital zircon and garnet are occasionally visible.

Magnetite-epidote-chlorite (-hornblende) schist.

Chlorite-rich schists are an especially distinctive rock type of the Western member. The most persistent band ranges from 400 to 1000 feet in width and extends north from lot 20, range II Stukely township, to a point near the village of Notre Dame de Bonsecours, a distance of over 3 miles. Outcrops of identical rock between glacial drift in the northwestern part of the map area indicate a much wider zone less than 2000 feet west of the first band.

Thin beds of similar rocks occur elsewhere in the area. Contacts between the chloritic schist and the quartzose schist, where observed, are distinct and conformable.

Hand samples are fine grained, dark green, foliated through cohesive and usually contain small perfect octahedrons of magnetite (Plate V-D) and sometimes flakes of specularite. A few streaks of amygdaloids were observed but generally the rocks are quite homogeneous. Carbonate and quartz veinlets are not uncommon.

Thinsections of the rock are composed mainly of a complex aggregate of chlorite and epidote with lesser amounts of quartz and albite. The crystals of magnetite are idioblastic but at least a portion of the quartz and clear albite has formed after the magnetite, as evidenced by fragment-like inclusions of the latter in the quartz and feldspar.

The magnetite-epidote-chlorite schist not uncommonly contains small zones with medium-grained, massive textures. The mineralogy of these zones differs essentially from the usual schist. Hornblende, in crudely prismatic to bladed forms, constitutes up to 34 per cent of the rock and magnetite is virtually absent. It could not be decided whether these zones are less metamorphosed portions of the original rock, a relic of retrograde metamorphism or an amphibolitized portion of the magnetite-epidote-chlorite schist.

In any case, both facies of the schist were probably basic igneous rocks. The apparent conformity to the quartzose schists and the aforementioned amygdules suggest an extrusive origin.

Marble

A few exposures of marble are present in lot 23, range VI and lot 21 range III Stukely township. Residual float was also noted in lot 23, range V.

These appear to represent a thin discontinuous horizon near the east margin of the Western member.

The rock is usually cream coloured on fresh surfaces and weathers to a light buff. The texture is medium grained and the rock quite massive. Vigorous effervescence with dilute HCl suggests a high calcium carbonate content. Occasionally the rock contains some micaceous and graphitic material and is schistose. A thinsection of a typical specimen of the purer rock revealed a few ~~larger~~ crystals of dolomite, imbedded in a finer-grained sheared matrix of calcite. Quartz and secondary micas constitute less than 2 per cent of the rock.

Eastern member

The Eastern member consists mainly of fine-grained graphitic schist or phyllite and fine-grained micaceous schists.

These rocks occur in a band, averaging over 3000 feet in apparent width, which separates the quartzose schists of the Western member from the medium-grained clastic sedimentary rocks of the Caldwell group. The member does not resist weathering as well as the more quartzose schists and outcrops sparcely. The best exposures may be seen in lots 24 and 25, range VI, Stukely township.

As noted previously the Western member grades into the Eastern member. In the southwestern corner of the map area, the Eastern member appears to be missing.

The main lithologic types of the member are graphite-sericite schist, sericite (-chlorite) schist and chlorite schist.

Graphite-sericite-schist

Graphite bearing schists or phyllites constitute over one half of the member and occur as thin bands within the sericite schist and as a band up to 2000 feet in apparent thickness, in contact with the Caldwell clastics to the east.

The rock is black, occasionally stained with iron oxides and consists essentially of secondary micas and graphite with minor amounts of both original and introduced quartz. Some thin beds containing carbonate are present but no limestone was encountered. The carbonate beds are graphitic and not dissimilar from the usual schist. One interesting stratum was encountered in the northeast corner of lot 25, range VI, Stukely township. Here a thin bed of porous, black massive rock with a distinctive felty texture is interbedded with graphitic phyllite. The rock is calcareous and may be tuffaceous.

A few brecciated beds of fine-grained quartzite are present. The width of these beds does not exceed a few inches where observed.

Microscopic examination of samples of the graphite-sericite schist indicate the rock is composed mainly of secondary white micas admixed with graphite and intercalated with fine-grained sutured quartz in a schistose fabric.

Accessory magnetite, zircon, feldspar, chlorite, pyrite and hematite are usually present. The zircon and magnetite appear rounded and detrital and occur with the masses of sutured quartz,- suggesting that a portion of the quartz is recrystallized rather than introduced.

Sericite (-chlorite) schist.

Sericite schists are quantitatively next in importance to the graphitic schists. Most of these rocks occur in a band immediately west of the graphite-sericite schist.

Hand specimens of the rock are fine grained and composed mainly of micaceous minerals. The colour is usually light silvery grey but occasionally quite greenish.

Microscopic study indicates these rocks are composed of a sub-oriented aggregate of sericite and opaque clayey material with varying amounts of chlorite. Coarser crystals of muscovite are common and transect the finer sericitic material, (Plate V-F). Visible quartz is not abundant and apparently constitutes less than 20 per cent of the rock. A portion of this quartz occurs as well defined veinlets and is introduced.

A slight coarsening of texture and an increase in quartz is apparent in specimens from the western part of the band. Beds containing small metacrysts of plagioclase (Plate V-E) are not uncommon but the development of the plagioclase appears to be a local phenomenum and not due, for instance, to increased regional metamorphism.

Accessory minerals, such as noted in the coarser schists are not readily seen. A few small grains of leucoxene (?) are occasionally visible.

Chlorite schist

Exposures of dark green chlorite schist occur in lot 27, range VIII and lot 25 range VI, Stukely township. The former occurrence is a band up to 400 feet wide, conformable to the sericite schist. The second occurrence is a bed less than 10 feet wide.

The rock is similar to the magnetite-epidote-chlorite schist of the Western member but lacks the abundant crystals of magnetite.

Thinsection examination indicates the rock is usually composed of a fine-grained schistose and granulated aggregate of epidote, chlorite and calcite with less than 30 per cent quartz, minor feldspar and approximately 1 per cent granular magnetite and ilmenite. P432

Minor Secondary Structures and Fabric.

The minor secondary structures observable in hand specimen, thin section and outcrops will be outlined here previous to consideration of the overall structure of the Sutton schists.

a) schistosity and foliation

Segregated, discontinuous layers of quartz, ~~and/or~~ orientation of micaceous minerals, elongation and granulation of quartz grains, and layering due to mineralogic variations provide the foliation and schistosity.[1] This is the dominant fabric element in the Western member and is less pronounced in the Eastern member.

The occasional preservation of primary bedding indicates the foliation is generally parallel.

1 These terms as used herein are not completely synonymous. Schistosity is the tendency of a rock to break along closely spaced parallel planes whereas foliation is due to general parallelism of planer zones differing in texture and mineralogy. In the Sutton rocks both directional elements are due to the same feature; viz. parallelism of minerals and are essentially parallel.

The foliation commonly appears folded[1] (Figure 1 and Plate III-B) and considering the exactitude with which the foliation follows the intricate contortions, it is quite certain that the foliation and schistosity developed before the observed folding.

The general trend of the foliation through the Sutton schist is arcuate; trending north or slightly west of north in the southwest and gradually swinging to the northeast in the northern and northeastern parts. The dips are mostly steep and to the east, occasionally flat or to the west. In the northwestern corner of the area, the dips are consistently to the west.

b) fracture cleavage

A cleavage direction discordant to the foliation is present in both members of the Sutton (Plate III-A). It is best developed in less competent micaceous zones of the Western member and in the incompetent rocks of the Eastern member. This cleavage appears as parallel fractures 2 to 6 mm. apart transecting, and under some circumstances, offsetting the folia of the schist (see figure 1).

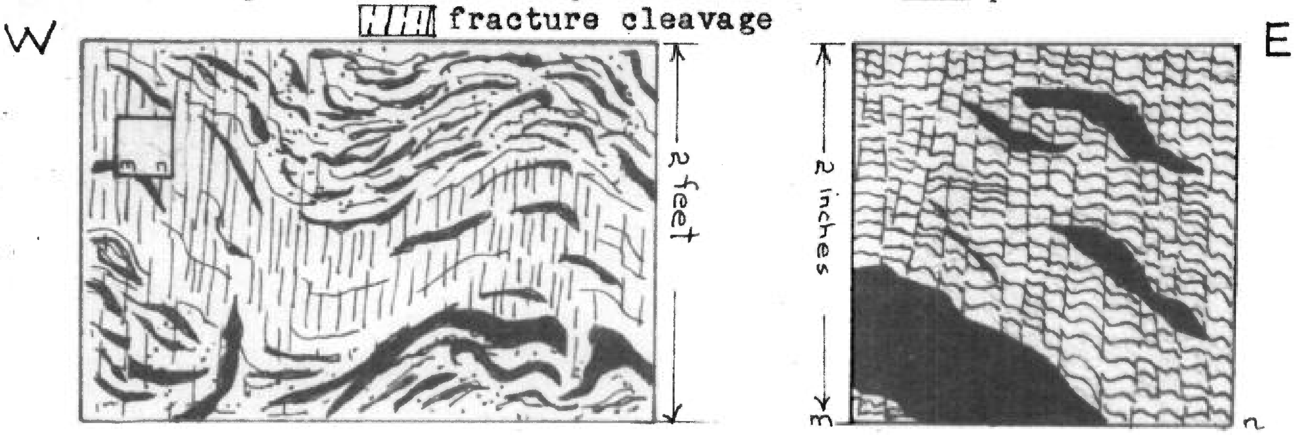
1 Measuring this foliation in folded outcrops is partially subjective: If the minor folds were fairly open and of regular size then the strike was taken across the noses of the folds. If, as is common, the folds were irregular, then the strike was taken perpendicular to the plunge. If the folds were very tight then the strike was taken parallel to the limbs.

Figure I

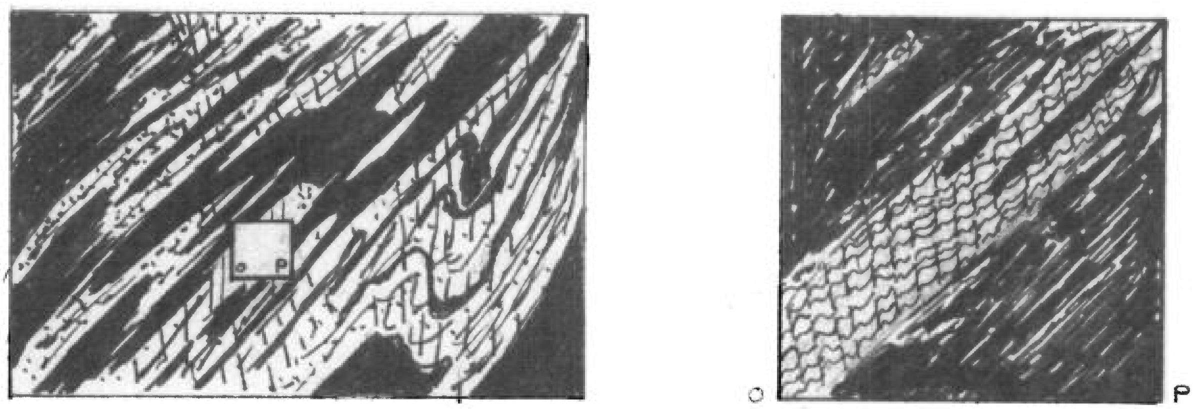
Foliation, fracture cleavage and fold relations in Sutton schist (sketched from outcrops).

quartz   quartz-mica   plicated mica

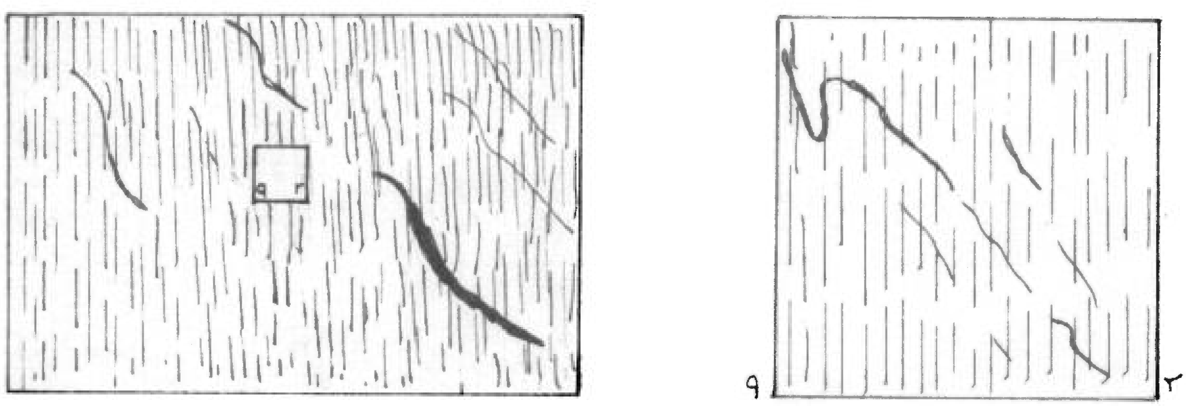
fracture cleavage



a) Minor folds plunge north. Note movement sense in crenulated mica; east side up in accord with position on east limb of anticlinal fold and offsetting of smaller folia of quartz.



b) Section of west limb of small anticline whose axial plane dips steeply east. Note correlation of crenulation shape with small drag fold.



c) Outcrop of micaceous Eastern Member. Fracture cleavage is dominant and few streaks of quartz & subtle foliation mark foliation analogous to that in more quartzose schists.

In the incompetent graphitic and sericitic schists of the Eastern member this cleavage may occasionally form the dominant planes of weakness in a particular outcrop. This relation may be observed in cases where a few thin contorted streaks of quartz and subtle foliation of micaceous material (comparable to the coarse foliation of the quartzose schists) are present. The poor expression of the original foliation and predominance of the fracture cleavage are due to the scarcity of quartzose material.

~~The orientation of this cleavage is comparatively~~ con~~sistent; trending northeast (10 to 50 degrees clockwise from the general trend of the foliation) and dipping stee~~ply ~~southeast.~~

A most important feature of this fracture cleavage is its parallelism to the axial planes of small folds and presumably larger structures.

c)pseudo-cleavage

A reorientation of micaceous minerals in accord with the development of crenulations and fracture cleavage occasionally results in the development of planes of weakness oriented at a small angle to the foliation (fig. 2).

As these planes of weakness are more or less accidental in their development, they may be termed pseudo-cleavage.

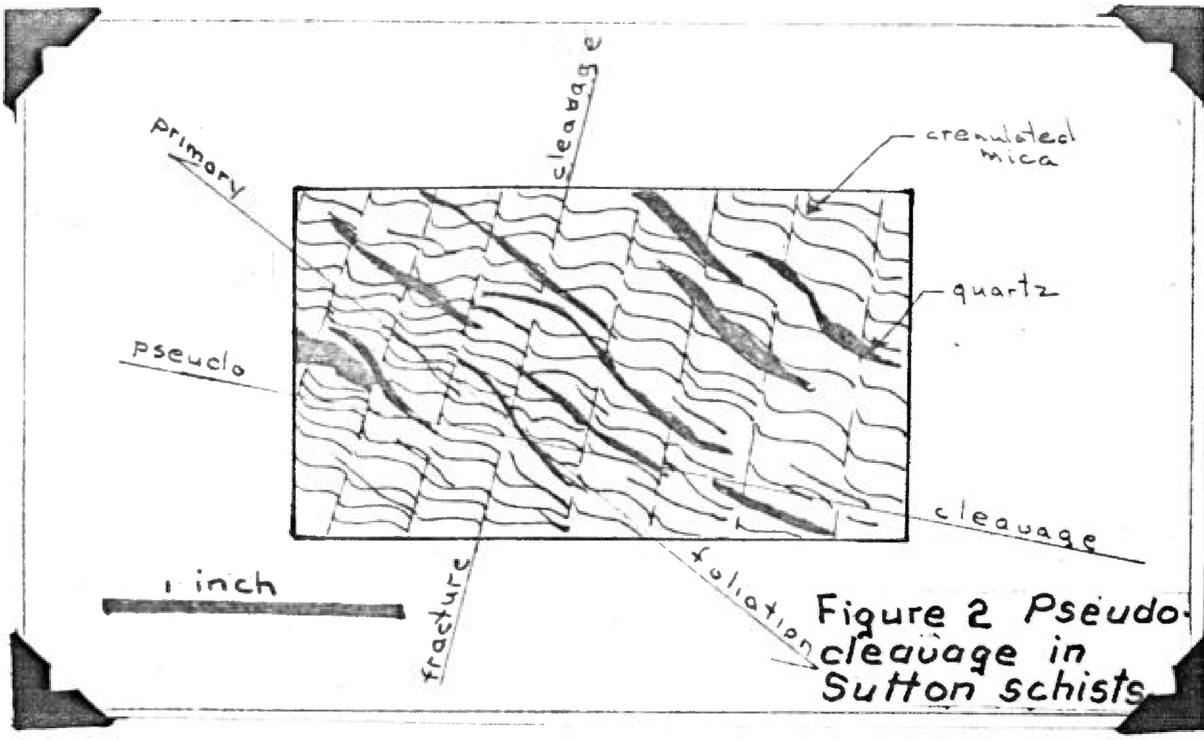


Figure 2 Pseudo-cleavage in Sutton schists

d) minor folds

An abundance of minor folds with wave lengths from 2" to several hundred feet is characteristic of the quartzose schists of the Western member, less common (or apparent) in the Eastern member and rare in the magnetite-chlorite schist. Individual folds and subsidiary folds of compound folding may be asymmetrical or symmetrical upright or overturned, concentric or similar, tight or open (Plates III-A, III-B, IV-B).

The asymmetry of small folds was found in many cases to be a reflection of their position on larger folds. Thus the nose, crest or trough zone has generally symmetrical subsidiary folds. The subsidiary folds on the limbs of larger folds are asymmetrical and the longer anticlinal limbs lie away from the crestal zone.

The pattern of the orientation of these is indicated on the map. It may be seen that the asymmetrical or "drag" folds usually have an orientation consistent with a position on the east limb of an anticline. Occasionally the west limbs of smaller folds are indicated. It may be seen in large outcrops, that as the smaller folds are compounded into larger, there is a consistency in the orientation of the axes. It is probable that this would be roughly true even for larger folds. It follows that reversals in plunge across the strike may indicate a change in the nature of the fold.

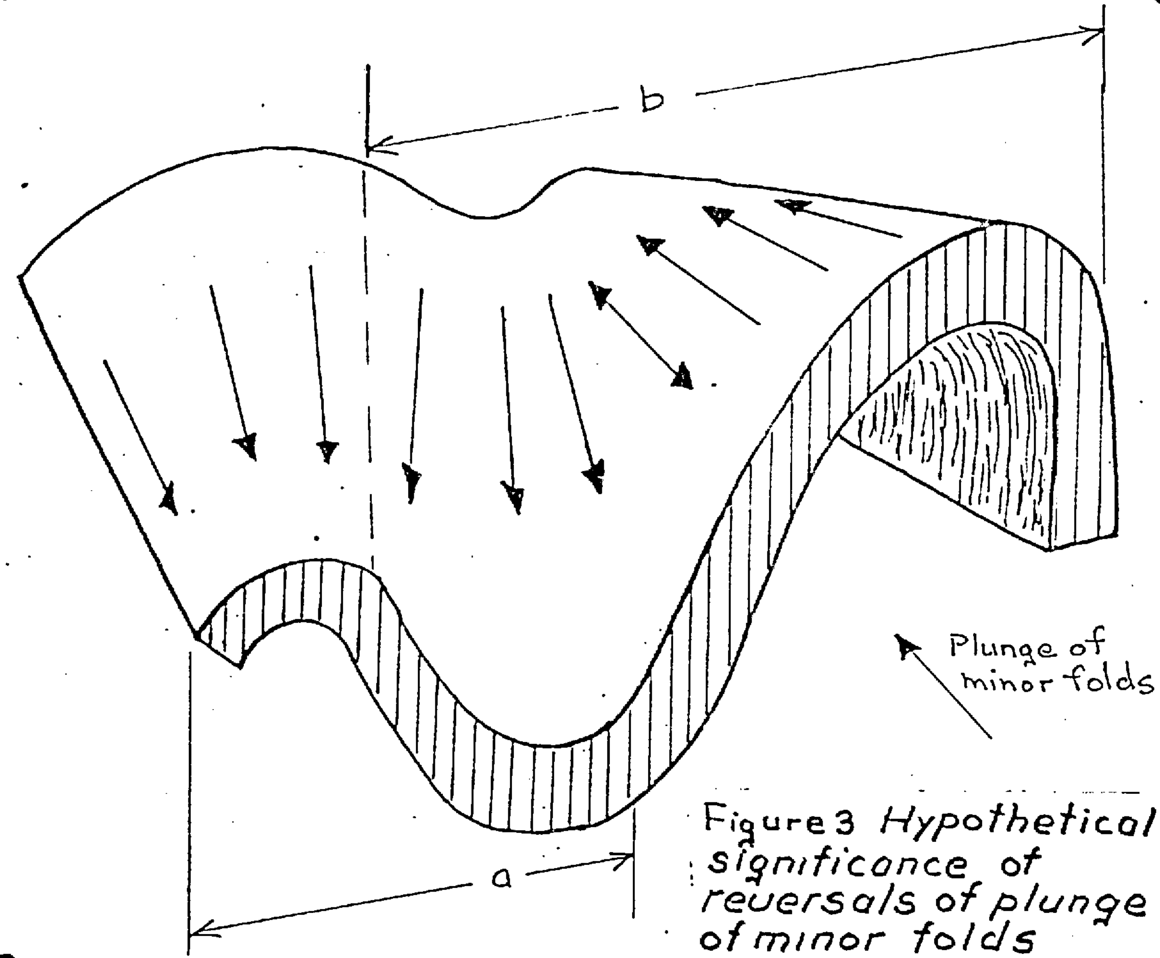


Figure 3 Hypothetical significance of reversals of plunge of minor folds

Figure 3 indicates a hypothetical situation to be particularly expected in the case of concentric and en echelon folds. In the interval "b", the reversals in plunge of minor folds indicate a syncline and anticline but, in the interval "a", there is no reversal in plunge of minor folds and the presence of larger folds is not indicated.

It is apparent that reversals in plunge of minor folds are significant criteria of folding but not conclusive evidence for the nature or absence of larger folds.

e) crenulations

Crenulated surfaces, moulded from bent flakes of micaceous minerals are everywhere developed in the Sutton schists and most obvious in the dark intercalations in the quartzose schists and the incompetent Eastern member (Plate IV-A).

The development of the fracture cleavage (see figure 2) was closely related to the distortion of the micas. The original orientation of the micas appears to have been parallel to the coarser foliation and when the fracture cleavage intersects the foliation at an acute angle, the crenulations are analogous to minute drag folds between the fracture surfaces.

The axes of the crenulations parallel the plunge of minor folds and presumably bear the same relation to larger folds.

f) Other minor features such as incipient boudinage and quartz-rod structures are locally developed. Their orientation is usually in accord with that of other lineations such as intersections of schistosity, foliation and fracture cleavage and axes of folds and crenulations.

General Structure of Sutton schist.

The pattern of the minor structural features and lithology indicate that the Sutton schist, within the map area, is an assemblage of intricately folded rocks dipping predominantly east or southeast and locally to the northwest. Exposures in the northwest corner dip northwest.

Figure 4 illustrates the structural interpretation. It can be seen that the Sutton rocks lie mainly on the east limb of an anticlinorium whose axial zone transects the northwest corner of the map area.

Similar conclusions regarding the anticlinal nature of the Sutton rocks have been reached by almost all previous workers in the region. Some workers in these rocks, notably White and Jahns (1950), Béland (1951) and Cooke (1954), indicate the possibility that the anticlinal structure of the Sutton rocks is a foliation dome and not a result of flexure folding.

The minor folds in the Stukely area appear to be normal flexures with asymmetry similar to that expected on the limb of an anticlinorium.

An important feature to account for is the northerly trend of the long band of magnetite-epidote-chlorite schist, (presumably a conformable volcanic rock) which appears divergent to the general northeasterly trend of the rocks to the east of the band. This implies an apparent thickening of the quartzose schists east of the band.

The relations indicated in figure 4 account for this in part as being due to a gentler overall dip east in the northern part of the schist and the superimposition of folds. Evidence for this folding is seen in range VI where the distribution of the chloritic schist, graphitic schist and quartzite, along with minor structures indicate a ~~large~~ "drag" fold plunging northeast and overturned to the west.

In ranges VII and VIII, the several reversals of the plunge of minor folds, reversals in dips of foliation and the distribution of quartz-sericite-graphite schist imply a number of small anticlines and synclines. The probability that both northeast and southwest plunges are present has been indicated. (page 27)

It is possible that the two parallel bands of magnetite-epidote-chlorite schist, in range VII are equivalent to the same horizon. Judging from the foliation in the western part of the wider band, the dip is to the west whereas that in the band 2000 feet to the east, is to the east. This might imply an anticlinal structure continuous with an assumed anticlinal axis in the quartzose schists to the northeast. Unfortunately the nose of the presumed fold does not outcrop.

Folding does not wholly account for the apparent thickening within the Sutton rocks east of the chloritic schist. Critical outcrops are scarce in lots 20 and 21, range III (southwestern corner of area) but the chloritic schist and marble appear to be less than a few hundred feet apart; the Eastern member of the Sutton appears to be missing; and the Caldwell group (slate and graywacke) outcrops less than 2000 feet to the east.

This is markedly different from the situation in range VI, three miles to the north, where the marble outcrops at least 3000 feet east of the magnetite-epidote-chlorite schist and 4000 feet west of the Caldwell group.

If the previous conclusions that the magnetite-epidote-chlorite schist is everwhere conformable to the quartzose schists and that the occurrences of marble are stratigraphically equivalent then several structural possibilities are apparent:

1) The thinning is due to limited deposition of the original sedimentary rocks.
2) Erosion has removed a portion of Sutton rocks.
3) Structural dislocation
4) Combination of two of the above.

No strong evidence favours any of these but possibility "2" would require two times of erosion; one previous to the deposition of the limestone and another after the deposition of the Eastern member and before the deposition of the Caldwell group. This is possible but rather coincidental.

The third possibility is not unattractive. The abrupt termination of the Eastern member, slight discordance between the trends of the Sutton and Caldwell and a topographic depression marked by the creek bed suggest faulting between the Caldwell group and Sutton schists. At this point such a fault might be a continuation of the schistose zone extending northeast along the west side of Bowker lake, and Selwyn (1883), Clark (1934), Ambrose (1942), Fortier (1945) and Cooke (1950) have suggested a regional fault of which this would be a part.

However, such a fault would not account for the proximity of the marble to the magnetite-epidote-chlorite schist in lot 21, range III. Lacking further evidence, the thinning of the Sutton rocks between the chlorite schist and marble may be tentatively ascribed to limited deposition of original sedimentary rocks. The Sutton - Caldwell contact may be an unconformity or a fault.

CALDWELL GROUP

The rocks here designated Caldwell group are a steeply dipping assemblage of interbedded impure feldspathic sandstones, quartzose sandstones, siltstones and slates intercalated with acidic to basic volcanic rocks. They underlie most of the southeastern half of the map area.

All the rocks have suffered deformation and are usually schistose, however, to a lesser degree than the adjoining Sutton schists.

The term "Caldwell Series" was first applied by MacKay (1921) to designate an assemblage of impure quartzites, slates, and volcanic rocks in the Beauceville area. A provisional Cambrian age was assigned. Cooke (1950) subsequently applied the term "Caldwell group" in a broader sense to include similar rocks southward as far as the Vermont boundary.

The exact stratigraphic relation of the Caldwell to the Sutton schists is uncertain. Cooke (1950, p.19), Ambrose (1942) and others have noted that the contact between the two is marked by a gradational increase in the amount of shearing. Mainly on this feature, Cooke (1950) has considered the Sutton schist as the metamorphosed lower part of the Caldwell. Cooke also defines the Caldwell group as all rocks underlying the "Beauceville conglomerate" of the Beauceville group and (p. 40) indicates the Beauceville overlies the Caldwell with angular unconformity. This interpretation has not been accepted by all workers in the immediate region.

A number of other stratigraphic names have been applied to the rocks of the Sutton range and the physiographic equivalent both in the United States and southeastern Quebec. The structural complexities and lack of paleontological information generally have limited precise and consistent stratigraphic separations.

Within the Stukely area the rocks indicated as Sutton schists and Caldwell group are each lithologically distinct and, from structural evidence, the latter overlies the Sutton. The Caldwell rocks are lithologically similar to the original Caldwell series of MacKay (1921) and the nomenclature and implied correlation will be provisionally used herein.

The east limit of the Caldwell type of rocks is disrupted by intrusion or lies outside the map area. Lacking a complete section, it seems advisable to limit any attempt at a formal stratigraphic separation.

The sedimentary rocks of the group are effectively separated by the band of basic volcanic and intrusive rocks which extends northeasterly through the group. For purposes of discussion the group may be conveniently divided threefold into: a band of mainly sedimentary rocks west of the basic volcanic rocks (Northwest sedimentary and volcanic assemblage);

the separating volcanic rocks (Basic volcanic assemblage) and the sedimentary and volcanic rocks east of the basic volcanic rocks (Southeast sedimentary assemblage).

Northwest sedimentary and volcanic assemblage

The first subdivision, the Northwest sedimentary and volcanic assemblage, is the most important unit of the Caldwell. These rocks flank the Sutton schist and extend through the map area with an average breadth of 6000 feet. Intermediate and acidic volcanic rocks of irregular distribution are intercalated.

The main sedimentary rock types are subgraywacke and quartz graywacke with interbeds of quartz arenite, siltstone, grey and graphitic slates, black quartzite, ~~meta quartzite~~, purple slate and limestone. In places these rocks have been converted to quartz-sericite schists and possibly metaquartzite.

Table 2

	£1	£2	£3
quartz	40	65	72
feldspar: plagioclase, alkali feldspar, microperthite	30	10	4
slate fragment	1		
groundmass: more or less converted to a quartz-feldspar-muscovite chlorite aggregate	26	23	20
accessory: magnetite, ilmenite, leucoxene, biotite, zircon, fragmental ferromagnesian mineral	3	2	4
	100	100	100

£1 - graywacke; average of 2 thinsection estimations
£2 - subgraywacke; 1 thinsection estimation
£3 - black orthoquartzite; 1 thinsection estimation

Table 2 summarizes the general composition of the coarser rocks.

The subgraywacke is the main lithologic type. Individual beds range from less than a foot to over fifty feet in thickness. Hand specimens of the rock are medium grey on fresh surfaces and commonly appear bleached in the zone of weathering. The coarsest and most abundant detrital material is angular to rounded grains of vitreous quartz (less than, 1mm to .5mm, maximum dimension). These grains constitute from 30 to 60 per cent of the rock and may be graded as to size and quantity (Plate VI). The quartz and feldspar grains are imbedded in a fine-grained matrix which has been converted to an aggregate of quartz, feldspar, chlorite and secondary micas (Plate VII-A).

The subgraywacke commonly grades into or is interbedded with quartz graywacke. The latter rock is darker, chloritic and contains more apparent feldspar, slate fragments and argillaceous material. Small grains of quartz, similar to those in the subgraywacke, are always present, though not as abundant (Plate VII-B). Good exposures of the rock may be seen in the northern part of lot 28, range VIII, Stukely township.

Light coloured, fine to medium-grained quartz arenite, ~~or orthoquartzite~~ consisting mainly of a dense aggregate of quartz grains is not uncommonly associated with the subgraywacke. Individual beds are generally thin, ill-defined and lack continuity. They possibly represent washed or winnowed portions of the subgraywacke.

Erratically distributed thin beds and lenses of intraformational, small-quartz-pebble conglomerate grade into the medium-grained clastic rocks. Rounded pebbles of quartz, and a few fragments of feldspar, dark slate and chert or rhyolite constitute up to 70 per cent of the rock. The size of this material seldom exceeds 7mm. The matrix is poorly sorted and similar to the subgraywacke. The larger quartz grains are commonly composite and similar to those found in coarse-grained granitic rocks or vein quartz. None of the material resembles the Sutton Schist or reworked Caldwell rocks.

The thin interbeds of grey siltstone and silty slate are quantitatively next in importance to the coarser clastic rocks. The width of these beds varies from a few inches to several feet, and occasionally there is a gradation from graywacke to siltstone to silty slate. Where outcrops are abundant (such as northwest of Stukely lake) it is possible to separate zones in which slaty and silty beds predominate over coarser clastic rocks. Such zones are indicated on the map.

A zone up to 500 feet wide, in which graphitic slates predominate, may be traced from the northeast corner of the map area to near the northwest corner of Stukely lake, and intermittently to the southwest on strike. The rock has a flaky cleavage ~~surfaces and the cleavage surfaces have~~ with a micaceous sheen. The graphitic slates included in and along the east contact of the acid volcanic rocks east of Bowker lake differ from the usual type. They are harder and tend to break into long splinters. Tuffaceous beds are associated and the slates may be largely tuffaceous themselves.

A <u>metaquartzite</u> dissimilar to other rocks of the Caldwell sequence outcrops southwest, west and north of Stukely lake. Hand specimens of the rock are tough and quartzose and the colour varies from medium grey to blackish. Iron oxide stain commonly impregnates the rock giving a rusty colour. Discrete pebbles of quartz are not uncommon, but primary sedimentary structures are seldom discernable in the field. One large outcrop exibited folded bedding joints and a bed with large angular fragments of chert or rhyolite. Thinsections indicate the rock contains up to 65 per cent quartz usually with irregular boundaries but occasionally subrounded. Altered feldspar and granular aggregates of secondary minerals and calcite constitute 25 per cent of the rock and coarse flakes of muscovite and chlorite 8 per cent. Ilmenite, leucoxene, magnetite, pyrite, zircon, and spinel (?) are accessory. Occasionally a few round rock fragments of uncertain parentage (graywacke ?) are observable (Plate VIII-B-C). The rock seems to have been extensively recrystallized.

The alteration of these rocks is puzzling. Although they are ~~intimately~~ intruded by the ultrabasic rocks and to a lesser extent, ~~the~~ granitic rocks, the alteration does not appear to vary in respect to the position of the intrusive contacts. The subgraywacke-metaquartzite contact was not exposed but appears quite abrupt. Dykes of serpentinized peridotite have had little contact effects (except for talcification) on intruded subgraywacke elsewhere.

The strata immediately west of the metaquartzite in lot 26, range V, Stukely township, face west. Further to the west, the strata face east - implying a minor synclinal axes probably lies immediately east of the band of intermediate lava. As strata east of the basic volcanic assemblage face east, there must be an intervening anticlinal fold. It is possible that the axis of this fold is located within the metaquartzite.

Interbeds of black orthoquartzite, limestone and purple slate are quantitatively unimportant in the Caldwell sequence. The black orthoquartzite is a distinctive rock and usually occurs as thin beds in the graphitic slates. There are two discrete outcrops immediately south of Stukely lake. The texture and mineralogy are similar to the subgraywacke except for a higher quartz content and a better degree of sorting (Plate VIII-A). The color is due to disseminated graphite.

One outcropping of limestone was observed in a creek bed in lot 24, range III, Stukely township. Here a three foot bed of dense, fine-grained grey limestone is interbedded with graphitic slate and laminated siltstone to the east and west respectively.

The purple slate occupies a minor synclinal structure in lot 28, Range VI, Stukely township and could not be traced along strike.

The volcanic rocks intercalated with the sedimentary rocks include acid and intermediate types. The latter outcrops along the east margin of a diorite sill a mile west of Stukely lake. The rock is light grey-green, dense and massive, occasionally schistose. The close spatial relation to the sill suggests that the "flow" is a chilled facies of the intrusive. However, several sharp contacts were observed between the two rocks and pillow and amygdaloidal structures occur in lot 25, range V, Stukely township.

The siliceous volcanic rocks occur mainly near the east boundary (presumably the top) of the assemblage. A band over 1000 feet wide parallels the road in the south central part of the area and identical rocks occur east of Bowker lake. The first band is separated, in part, from the basic volcanic rocks by a thin bed of graphitic slate. The second occurrence also has graphitic slate along the east contact and is transected by ultrabasic rocks. Mapping done to the east of this slate indicates that there is an intervening band of subgraywacke and slate and another lense of siliceous volcanic rocks before the basic volcanic contact.

The acid volcanic rocks comprise massive flows and pyroclastic rocks. Fine to medium-grained tuffs and coarse agglomerates are everywhere associated. The massive flows are hard, dense and fracture conchoidally. Rude banding is usually observed and the color on fresh surfaces may be yellow, grey, light brown or black. Outcrops are fractured and sheared. Interesting exposures of pyroclastic zones may be seen in the volcanic rocks east of Bowker lake. Here the west margin of the band is marked by coarse agglomerate occasionally with occluded cobbles of the Caldwell sedimentary rocks. Tuffaceous beds occur through the band and appear to become more numerous and thicker to the southeast.

Examination of thinsections indicates the more massive flows are a microcrystalline aggregate of quartz and opaque secondary minerals impregnated with shreds of brown mica and a minor amount of chlorite. Crystallites and "spongy" granules are disseminated throughout the rock. A few vaguely outlined phenocrysts of quartz, streaks with iron oxide and graphite pigmentation and clots of pyrite are present. The original rock appears to have been rhyolitic.

Basic volcanic assemblage

A band of basic volcanic rocks extends through the southeast part of map area. De Romer has mapped the extension of these rocks southward ("banded greenstone", de Romer 1958) and mapping by the present writer indicates they extend northeast outside the area, to the vicinity of Chain-of-Ponds lake. Here, the continuity appears disrupted.

Cooke (1950, p. 80) includes these rocks in the "Bolton Group" of Devonian or later age, and indicates they lie with angular unconformity on the Caldwell sequence. This relation is not apparent in the Stukely area. The basic volcanics are intercalated between sedimentary rocks of similar lithology and with a minor exception appear everywhere conformable to the sedimentary rocks.

The exception is the apparent discordance between volcanic rocks and subgraywacke in the southeast corner of the map area. Here the relation may be due to structural disturbance.

The writer concurs with the majority of previous workers in the immediate region and considers these volcanic rocks a conformable member of the Caldwell sequence.

A persistent zone of volcanic breccia and amphibolitic lava (?) outcrops on the east flank of the intrusive complex in the southeast corner of the area. This is the local of the aforementioned discordance and, as these rocks present other interesting features, they will be considered separately from the main band of basic volcanic rocks.

This main band approximates 3000 feet in apparent width and although the orientation of primary structures is inconsistent, the dip appears steep.

Hand specimens are various shades of a dark green. The rocks are sheared and exibit distinctive banding and lamination due to differences in hardness, colour and streaks of magnetite and specularite dust. In some instances the banding is reflected in different degrees of chloritization.

Primary volcanic structures, with the exception of the coarser banding and more regular laminations, are scarce. A few instances of crude pillow structures, amygdaloidal streaks and breccia zones were noted. Veinlets of carbonate and epidote and splotches of jasperoidal chert are locally abundant.

Not uncommonly the foliation in portions of these rocks is locally discordant to the foliation elsewhere. In some cases this is due to disruption of blocks of lava with ~~surfacial~~ areas of over 1000 square feet. The general aspect is that of a giant breccia. The feature may be essentially primary; originating shortly after extrusion.

Microscopic examination indicates that these rocks have been extensively altered to a fine-grained schistose aggregate of secondary minerals. One section of the massive rock revealed the following mineral percentages: chlorite +50, quartz 10, saussuritic masses +20 epidote 8, carbonate and accessory magnetite 6. No feldspar was identified and the original texture has probably been destroyed. The general composition of the alteration products suggests the original rock was basaltic in composition.

The general alteration of the basic volcanic rocks is that of low-grade regional metamorphism. Local amphibolitic facies occur but are randomly distributed throughout the volcanic rocks and insignificant in size. One of these occurs 6000 feet south of the small island in the southeast arm of Stukely lake. The rock consists of coarse, elongated clusters of hornblende arranged in a strongly gneissose fashion in a matrix similar to the epidotized and chloritized volcanic rocks elsewhere. The transition into the surrounding volcanic rocks is completely gradational.

The main band of basic volcanic rocks appears split by the massif of basic intrusive rocks in the southeast part of the area. The rocks on the east flank are mainly volcanic pyroclastics and recrystallized volcanic (?) rocks. Southwest of Buzzel lake the pyroclastic rocks are interbedded with the usual chloritized lava. Further to the south they are confined to a zone usually less than 1200 feet wide, which is in contact with, and partially invaded by, the basic intrusive. This contact is ill-defined and consists of a hybrid zone in which volcanic inclusions abound.

Hand specimens of the pyroclastic rock are distinctive. Sharply defined, light and dark green fragments, commonly shard-like, are embedded in a dense, hard, lighter green matrix. The fragments are usually less than 20 mm. long and may constitute 30 per cent of the rock. Disseminated pyrrhotite is characteristic of the rock and contributes to a rusty weathered surface.

Thinsections of the rock are uninformative, both matrix and fragments having been converted to a semi-opaque

In a few instances portions of a fragment appear broken off and separated by the matrix. No grading of material was noted. These features suggest the rock is a flow breccia rather than an agglomerate. (insert)

mainly of rounded fragments of volcanic material ranging from sand to boulder size. These mainly consist of basic volcanic rock (occasionally amygdaloidal) and the flow breccia described previously. The matrix appears to be poorly sorted clastic fragments, of tuffaceous nature. Thin beds of better sorted tuffaceous grit, often lenticular in form, are not uncommon.

Judging from the composition of the rock, the lack of sorting, rounded detritus and position on the east margin of the volcanic rocks; this is a locally reworked portion of the main volcanic assemblage. A short interval of erosion before the deposition of the sedimentary rocks to the east is probable.

A further complication exists in the extreme southeast corner of the area where a wedge of gneissose hornblendic rocks appears in sharp contact with relatively unaltered pyroclastic and sedimentary rocks to the west and northeast respectively.

The central part of this "wedge" closely resembles a coarse bi-mineralic gneiss composed of about equal amounts of black and grey material. The appearance is similar to that of the amphibolitic zones in basic volcanic rocks discussed previously.

A thinsection of the rock consisted of 40 per cent shreddy and fiberous ~~tremolitic~~ hornblende arranged in thin discontinuous folia and surrounded by a brown semi-opaque groundmass containing accessory quartz, plagioclase, chlorite, epidote, zoisite, amphibole, apatite (?) and hematite. The opaque portion appears composed mainly of very fine clay minerals. A part of the quartz and feldspar occurs as thin veinlets.

This "gneiss" is the core of the ~~lobe~~ wedge. Around most of the circumference this rock grades into foliate, fine to medium-grained black rocks composed essentially of hornblende. The weathered surface of the fine-grained type of this amphibolite has an appearance identical to the basic volcanic rocks.

Gneissose structure was never observed in the basic intrusive rocks elsewhere in the area and, judging from the gradation into volcanic rocks and composition, the amphibolite and gneissose rocks are the altered equivalents of a basic volcanic rock.

The foliation strikes generally east and dips moderately north; sharply discordant to the attitude of the sedimentary rocks. The margin of the altered volcanic rocks is marked by steep valleys and escarpments.

The alteration of the volcanic rocks to amphibolite might be expected along the contact of a large intrusive mass but, in the case outlined above, a band of relatively unrecrystallized pyroclastic rocks separates the amphibolite from the intrusive contact. Also the sedimentary rocks within 150 feet of the amphibolite are virtually unaltered.

It is possible that the volcanic rocks were amphibolitized near the basic intrusion and subsequently displaced to their present position. The escarpments along the present contacts and the discordance mentioned above suggest the amphibolitic zone is a wedge shaped horst and the contacts with the sedimentary rocks and pyroclastic rocks are faults.

A few thin beds of quartz-sericite-chlorite schist are intercalated in the main band of volcanic rocks. Rounded grains of quartz and occasionally traces of graphite within these rocks suggest a sedimentary origin and the rock is similar in appearance to schistose graywacke elsewhere.

Southeast sedimentary assemblage

The Southeast sedimentary assemblage constitutes the sedimentary rocks east of the basic volcanic rocks. The east boundary of these rocks is not included in the map area but was mapped in part by the writer's party. The assemblage outcrops in a curved band, convex to the west and bounded on the east by intrusive rocks. The intrusive contact lies 3000 feet east of the south-east tip of Stukely lake. The strata face east and dip vertically or are slightly overturned and dip west.

The general rock types are identical to those of the sedimentary rocks west of the main volcanic band though a lesser degree of shearing is apparent. A sequence west to east from the contact with the basic volcanics near Buzzel lake is tabulated below:

volcanic rocks	
schistose & silicified subgraywacke minor phyllite	+ 300 feet
subgraywacke and quartz arenite	+ 900 feet
black ~~arkin~~ quartzite	+ 200 feet
graphitic slate, subgraywacke & siltstone ..	+ 2000 ft.
intrusive rocks	

It is noteworthy that the subgraywacke grades into the black quartzite and that the carbonaceous content of the black quartzite may be genetically related to that in the graphitic slate.

North of the cross-fault at Stukely lake a sequence from subgraywacke to graphitic slate is similar. However one outcrop of purple slate appears to represent a stratum between the subgraywacke and basic volcanics and a bed of coarse rhyolite agglomerate is interbedded with subgraywacke. No outcroppings of the black quartzite were observed.

General Structure of Caldwell ~~Group~~ Rocks

The Caldwell rocks are not as complexely deformed as those of the Sutton. Shearing is everywhere apparent but less intense east of the main volcanic band. Two slightly discordant shear directions and crenulations on cleavage surfaces are occasionally observable.

The criteria for delineation of folds are mainly reversals in tops of strata and inclination of bedding. The relation between schistosity and bedding does not appear diagnostic; Both are usually parallel and, in the more massive or homogeneous outcrops, it is difficult to deduce whether the foliation of the rocks is attributable to shearing or is an original sedimentary structure. The direction of dip of the schistosity itself appears erratic and, in some cases, changes within an outcrop.

Conclusive field indications of tops are not abundant. In the sedimentary rocks the usual determinations were dependent on finding size gradation of quartz grains combined with sorting within a specific bed of subgraywacke. In ideal cases, one contact of a bed has an obvious concentration of quartz grains which become less abundant and generally smaller toward the presumed top of the bed (Plate VI). Grading in size of particles alone, does not appear to be a consistent or reliable index to tops. Several instances were noted where the gradation, though subtle, appears reversed within one outcrop.

Variation in the quantity of quartz grains is likewise not conclusive. It is not improbable that concentrations of quartz grains in some cases mark the tops of beds; the finer argillaceous material having been winnowed or washed away during sedimentation.

Other evidence for top determination is found when fragments of subgraywacke or slate occur along the presumed base of a bed of slate or subgraywacke.

Within the pyroclastic volcanic rocks southwest of Buzzel lake there are two instances where a fragmental lava grades west into more massive lava which in turn has an abrupt transition into another band of fragmental lava. This sequence suggests the first fragmental zone is the top of one flow and the second the top of another flow. The lavas thus face to the east.

The band of acid volcanic rocks east of Bowker lake has a persistant agglomeratic facies along the northwest margin. It might be concluded that the top is to the northwest. However, cobbles of graywacke and slate are not uncommon in the agglomerate. The obvious source of this material is the sedimentary rocks west of the lava. This being the case, it is possible that the agglomerate marks the bottom rather than the top and the rocks face southeast rather than northwest.

The conclusions drawn from the above criteria are that the Caldwell rocks face generally to the southeast but are locally reversed, such as northwest and west of Stukely lake, due to folding. The northwestern part of the group dips generally to the east whereas the southeastern part dips vertically or steeply west and is overturned.

The rocks west of Bowker lake dip and face southeast. Immediately east of the lake the dips are steeply northwest and a questionable top determination suggests the tops are ~~to~~ also northwest. Further to the east the tops again face southeast. These relations, though not conclusive, suggest a synclinal axis underlies Bowker lake and an anticline lies immediately southeast of the lake. No conformation of this could be garnered from the lithology.

The probability that the rocks west and southwest of Stukely lake are folded has been noted in the discussion of the metaquartzite.

General Lithologic Relations of Caldwell Rocks

Dispite complications due to intrusion and folding, a rude sedimentation sequence is apparent in the Caldwell group. Thus the more feldspathic and unsorted rocks occur along the west margin (bottom) of the group; a general increase in slaty beds is observed from west to east in both assemblages on either side of the basic volcanic rocks; and graphitic slates are best developed in the east parts of both assemblages.

The Caldwell rocks are, in part, an example of graywacke sedimentation; impure feldspathic sandstones exibiting graded bedding and intimately interbedded with siltstone and silty slate. As has been often noted in the literature, graywacke sedimentation has certain inherent problems. In particular it is difficult to account for the wide aerial extent of individual graded beds of relatively coarse, poorly sorted detrital material that exibit none of the characteristics expected of sand deposits (eg. crossbedding, ripple marks). Or, in other words, it is necessary to envision an extremely competent medium of transportation operating cyclically over relatively short intervals of time. Kuenen and Migliorini (1950) provide an attractive explanation in accounting for such features by submarine turbidity currents. That is, graded graywackes and mudstones are not the products of primary deposition rather a product of redeposition (Pettijohn, 1950, p. 171).

Such a process may have been operative at times during Caldwell sedimentation.

Age

The Caldwell rocks are provisionally assigned to the Cambrian - Ordovician period. No fossils were encountered in the mapped area. Graptolitic slates of middle Ordovician age (Cooke 1950 pp. 45-48) occur in Castle brook, approximately three miles south of the southeastern corner of the map area. The associated rocks cannot be directly correlated with the Caldwell group but are lithologically similar, especially to the slates and quartzites east of Stukely lake.

INTRUSIVE ROCKS

Serpentinite, serpentinized peridotite and dunite, talcose schists.

Serpentinized ultrabasic rocks are the most abundant intrusive rocks in the area. The usual forms of intrusion are as sills, dykes and irregular masses elongated parallel to the regional structure. Occasionally the larger intrusives truncate the country rock. The dykes and sills commonly occupy the contact between contrasting rock types.

The areas around and under Stukely and Bowker lakes appear to have been loci of intrusion. A noteworthy feature is that no ultrabasic ~~intrusions~~ rocks were found in the Sutton Schist.

The majority of exposures are more or less completely serpentinized but remnants of peridotitic appearance are not uncommon. The degree of serpentinization is variable within an outcrop and no overall pattern was detected in the field. Thus most of the rocks were aggregately mapped as serpentinite and serpentinized peridotite. The identifiable dunitic facies are small and rare.

Hand specimens are variable in appearance. The most common type is mottled greenish-black in colour and usually speckled with ragged crystals of pyroxene or pseudomorphs embedded in a dense aggregate of serpentine minerals. Small crystals of black chromite and magnetite are almost always visible. Outcrops usually have a brecciated appearance and crossing fractures lined with slickenslided apple-green serpentine. Masses of picrolite with crystals exceeding one foot in length and traces of cross and slip fiber asbestos are not uncommon. Carbonate minerals in small crystals impregnating the rock are locally abundant.

Microscopic examination of these rocks indicates that even the fresher appearing samples are highly serpentinized. Pseudomorphic aggregates of antigorite with parallel streaks of magnetite mark original grains of pyroxene (clinopyroxene and bastite ?) and a network of magnetite probably reflects original granular olivine (Plate X-A).

Two varieties of highly serpentinized rock are of interest. One of these is exposed along the road between lots 25 and 26, range VI, Stukely township. This is a part of a thin sill or dyke which has a length of over 3 miles and a width of approximately 150 feet. The feature of interest is that rounded fragments (up to 14 inches) of serpentinized peridotite are embedded in a highly schistose groundmass of serpentine (Plate IX). The second variety is exposed north and south of the southeast arm of Stukely lake. These rocks are composed essentially of light green serpentine. Small corroded to angular fragments of dark green serpentinite are scattered throughout the lighter green material and the superficial aspect is that of a volcanic breccia. The rock contains disseminated chromite and occasionally picrolite.

Talcose schists, massive impure talc and aggregates of light green serpentine and actinolite are common along the margins of the larger masses of serpentinized peridotite and are occasionally present within the intrusive.

Pyroxenite

Massive pyroxenite occurs as small discrete intrusive masses or associated with the serpentinized peridotite. These constitute less than 2 per cent of the ultrabasic rocks.

Hand specimens may be dark green or brown in colour. The latter appears due to surficial weathering. Typical hand specimens are tough and appear monomineralic with crystal dimensions averaging 6 mm. The rock appears less serpentinized than the peridotite. Irregular zones containing splotches of coarse feldspar crystals may occasionally be noted in an outcrop.

A thinsection of a very coarse-grained facies which occurs west of Stukely lake is composed of clinopyroxene (augite-ferroaugite series) of which approximately 30 per cent has been converted to flakey antigorite and chlorite. Two thinsections of a macroscopically similar rock, that appears to be a large inclusion in a gabbroic massif, consist mainly of uralitic hornblende with lesser amounts of augite. Magnetite and a small mass of olivine are present and the rock is slightly serpentinized (Plate X-C).

Evidence for determining the age relation between the peridotite and pyroxenite is scanty. One instance of a gradual transition from serpentinized peridotite to coarse-grained pyroxenite was noted and elsewhere in the region Fortier (1945, p.2) has found that pyroxenite dykes cut peridotite. Two embayed inclusions of pyroxenite ~~(altered mainly to uralitic hornblende)~~ were observed in the dioritic rocks in the southeast corner of the area and the peridotite-pyroxenite transition mentioned above appears to represent a large inclusion or roof-pendant. An intimate mixture of pyroxenite and basic intrusive rocks, similar to those described below, outcrops on the island in Bowker lake. Neither of the rock types obviously intrudes the other. Around the margin of the massif of basic rocks in the southeast corner of the area are occasional masses of ultrabasic rocks.

These appear to be truncated by the basic rocks. Nowhere was a gradational transition between the ultrabasic and basic rocks ~~was~~ observed.

Because of the above features, the pyroxenite and serpentinized peridotite are believed to be coeval and generally older than all other intrusive rocks in the area.

Hornblende gabbro, diorite, green gabbro, pyroxene-feldspar rock.

A complex of mainly dioritic to gabbroic rocks underlies the hills in the southeast corner of the area and identical rocks occur in a large sill a mile west of Stukely lake. Dykes of diorite in the vicinity of the lake may be related intrusions.

Evidence that these are younger than the bulk of the ultrabasic rocks has been noted previously. A few rude dykes of granite, aplite and granodiorite intrude the basic rocks and if these dykes are coeval with the more extensive occurrences of granite around Stukely lake, then the basic rocks are older than the granite.

The major facies of the intrusive complexes (hornblende gabbro, diorite and green gabbro) exibit gradational contacts and occasionally mutually transecting relations. The rocks are much saussuritized and uralitized. Thus distinctions, both in the field and under the microscope, are somewhat arbitrary.

The hornblende gabbro and diorite are generally medium to coarse grained and grey in colour. In hand specimen the main constituents, black hornblende and grey feldspar, are commonly well defined. The diorite usually contains visible quartz and 20 to 40 per cent black hornblende. The hornblende gabbro contains over 50 per cent hornblende and dark minerals. Both facies have random coarse crystals of hornblende (over 50 mm. maximum dimension) with a sieve texture.

A thinsection of the diorite indicated these mineral percentages; plagioclase 50, hornblende 40, quartz 10, accessory leucoxene. The plagioclase is extensively saussuritized but identifiable as andesine. Its relation to hornblende suggests an original diabasic texture. A section of the hornblende gabbro is somewhat similar except for a higher percentage of hornblende, lack of quartz and an abundance of zoisite.

The rocks of the large sill west of Stukely lake and those in lots 27 and 28, range III, Stukely township (underlying a satellitic hill of the main massif) are dominantly of the dioritic type. The majority of exposures elsewhere are intermediate between the hornblende gabbro and diorite.

The rocks of the western half of the main intrusive are distinctly more variable than those of the eastern half. ~~and~~ Inclusions, both cognate and of the intruded volcanic rocks, are more abundant in the western half.

Small irregular zones with very coarse-grained or pegmatitic textures are common in these rocks. The best occurrence is in the northwest part of the sill west of Stukely lake. Here a basic pegmatite zone may be traced for 6000 feet between range lines II and III. The width of the zone averages 200 feet and on both sides there is a gradational, though abrupt, transition into the medium-grained rocks.

One thinsection of the rock revealed characteristics similar to the gabbroic rocks. Saussuritized plagioclase (Ab_{65} An_{35} ?) constitutes 40 per cent of the rock. The remainder is mainly hornblende with remnants of pyroxene of the augite-ferroaugite series and aggregates of zoisite, clinozoisite and chlorite.

A few outcrops of a pegmatitic pyroxene-feldspar rock occur mainly along the west margin of the above pegmatitic zone. The general aspect of the rock is similar to the feldspathic zones in pyroxenite elsewhere. The genetic implication might be that the pyroxenite (associated with the serpentinized peridotite) is a differentiate of the basic rocks. Some evidence that the ultrabasic intrusions were earlier than the hornblende gabbro has been indicated previously and it is believed that the pyroxene-feldspar rock is a local facies of the basic rocks whose genesis is not directly related to the bulk of the ultra-basic rocks. The possibility that the ultrabasic rocks were emplaced early in the same period of intrusion as the hornblende gabbro is not precluded.

The remaining important basic rock type has been designated "green gabbro". The major occurrence is in the central part of lot 28, range III, Stukely township.

Hand specimens are usually coarse grained and contain phenocrysts of plagioclase. Erratically distributed fine-grained facies are not uncommon. The colour is usually dark green. However the transition into the surrounding grey diorite and hornblende gabbro is gradational.

A thinsection of the rock contains the following mineral percentages: hornblende 40, altered feldspar 40, augite (diallage) 15, and accessory chlorite, albite, magnetite pyrrhotite and chalcopyrite (?). The original feldspars are altered to semi-opaque secondary minerals. The diallage occurs as stubby prisms enclosed in an intricate network of optically continuous green hornblende (Plate XI-A).

Quartz gabbro

An elongate, lobate mass of quartz gabbro outcrops in the interior part of the basic complex in the southeastern corner of the area. Smaller, discrete masses are also present.

Hand specimens are dark grey-green on fresh surfaces and contain irregular masses of vitreous quartz (up to 40 per cent by volume) imbedded in a matrix similar in appearance to the hornblende gabbro. Large crystals of hornblende with a sieve texture are not uncommon. Outcrops of the above rock occasionally contain zones in which the quartz has more intimently impregnated the rock. Such zones have characteristics usually ascribed to secondary silicification.

The transition of the quartz gabbro into hornblende gabbro was observed twice. In each case the contact was indistinct but marked by an abrupt absence of quartz.

A thinsection of the rock indicated that the quartz is embedded in a matrix of iron-bearing secondary minerals which include a member of the clinozoisite-epidote series and chlorite. Albite, augite and leucoxene are the main accessory minerals.

The quartz is crushed, exibits a strong undulatory extinction and is characterized by an abundance of dusty inclusions. The grain boundaries invade, and include, portions of the matrix.

It appears certain that the rock is a facies of the other basic intrusives. The generally random distribution of quartz as discrete masses is suggestive that the silica was an intricate part of the original magma. In partial contradiction to this are the few small veinlets of quartz, the aforementioned silicified zones and the replacement relations observed microscopically which suggest the quartz has been, in part, introduced. These two features are not incompatible if the rock represents a portion of an original gabbroic intrusion containing a late magmatic concentration of silica.

Trap and porphyritic dykes

The dioritic and gabbroic rocks are commonly cut by two main types of dyke rocks. These are a trappean rock usually containing disseminated pyrrhotite ~~(Plate X-A)~~ and fine-grained diorite with small subhedral phenocrysts of feldspar.

Granite, granodiorite and quartz diorite.

Granitic rocks occur mainly along the south shore and immediately west of Stukely lake. They appear to intrude the serpentinized rocks and the occurrence of similar rocks cutting the basic intrusives has been noted previously.

The rocks are variable in composition and texture. The outcrops near the south shore of the lake are massive, medium to coarse grained and pink. In hand specimen they appear composed mainly of pink and grey feldspar and quartz. Dark minerals are scarce and altered. The above rock locally grades into a granodiorite with more ferromagnesian minerals and little quartz.

A granite type, as seen in thinsection, consists mainly of kaolinized and sericitized oligoclase and orthoclase. The oligoclase is quantitatively predominant, commonly zoned and occasionally porphyritic. Quartz usually constitutes less than 20 per cent. In one section, with 35 per cent, a portion of the quartz is in small rounded grains and may be a contaminant from the intruded sedimentary rocks. In the thinsections examined, dark minerals are scarce and mainly biotite and the alteration products hematite, magnetite, chlorite (some penninite) and muscovite (Plate XI-C). The other accessory minerals include leucoxene, apatite, zircon and sphene.

The granodiorite differs from the granite in that crudely prismatic hornblende (rather than mica) is abundant and the quartz percentage is less than 10.

The granitic rocks west of the lake appear to be small dykes and lenticular masses. A medium-grained gneissose granite outcrops near the start of the road to the southwest corner of the lake. Elsewhere the rock is fine grained and aplitic or granophyric. The intruded metaquartzites occasionally contain small lenses of coarse quartz-feldspar-chlorite aggregates. These may be related to the granitic rocks.

Dykes of an intermediate intrusive rock, here termed quartz diorite, outcrop sparcely along a northeast zone extending from the west shore of Stukely lake to a point 3000 feet east of the south tip of Bowker lake. A typical exposure may be seen near the north boundary of lot 26 range IV, Stukely twp., a few feet south of the road.

Hand specimens are grey in colour, fine to medium grained and usually contain a few phenocrysts of grey feldspar. Corroded fragments of black material similar to serpentinized peridotite are so common as to be characteristic. The quartz content is variable. It usually exceeds 15 per cent and near the ill-defined margin of the intrusive may range up to 40 per cent. The latter feature is best developed when the intruded rock is the Caldwell metaquartzite.

Thinsection study indicates the feldspars are more or less completely converted to secondary minerals. Acid andesine is present and some orthoclase and microperthite. The dark inclusions noted above are an aggregate of antigorite and prochlorite with some leucoxene. The texture of the rock is hypautomorphic-granular.

The characteristics of the quartz diorite differ from those of the diorite observed in the large intrusive complexes and elsewhere. The inclusions of altered ultrabasic material indicate post-ultrabasic emplacement. The rocks are spatially related to the granitic intrusives. In one instance, quartz veinlets (of granite affinity ?) were observed to be transected by the quartz diorite. These features suggest the rock is one of the latest intrusions[1] in the area and not coeval with the larger occurrences of hornblende gabbro and diorite.

PLEISTOCENE AND RECENT

A veneer of glacial drift overlies most of the area and, particularly on the northwest slopes of ridges, may be up to 40 feet thick. A few small morainic deposits are also present.

Glacial striae and gouges are oriented approximately northwest. Two sets of striae with slight differences in orientation were observed in several instances.

The presence of large blocks of Caldwell quartzite in the northern and western parts of the area suggest ice movement from the southwest. Chatter marks, plastering of debris on northwest slopes and erratics of Sutton schist south of Stukely lake indicate a movement from the northwest. Two opposite ice movements seem possible and judging from

1 Fortier (1945, p.3) and others have noted lamprophyre dykes and Monteregian (?) alkaline rocks in the region. None of these were observed in the Stukely area.

the more extensive effects of that from the northwest; it would be the later. The apparent northwest movement is anomalous for the region and may reflect a local accumulation of ice on Orford mountain and subsequent downward mobilization.

Considerable thickness of bedded gravels overlain by over 30 feet of sand (Plate I-B) occur mainly in the northwest part of the area. These possibly represent beach deposits.

A little more than a mile to the southeast of the above deposits, over eleven feet of silt and clay is exposed along a creek (Plate II-A).

The recent deposits are mainly fluvial sands and gravels along the creek beds and organic material partially infilling Buzzel lake.

STRUCTURAL GEOLOGY

Schistosity and Foliation

All non-intrusive rocks in the area exibit varying degrees of schistosity and foliation. The serpentinized ultrabasic rocks are commonly schistose and dioritic rocks in the vicinity of Stukely lake are occasionally sheared.

The foliation of the Sutton rocks is most obvious (p. 22) and it appears that the causitive stresses pre-dated a period of intense folding. A comparative decrease in the degree of schistosity is apparent throughout the Caldwell rocks, particularly the eastern extremities.

Superimposed on the general foliation of the Sutton rocks is a discordant cleavage, here termed fracture cleavage (p. 23) whose development probably accompanied the folding of the schists. Further to the east, two directions of schistosity are occasionally developed in the Caldwell rocks. Both the Caldwell and Sutton rocks exibit crenulated cleavage surfaces and particularly in the quartz-sericite schist of the Caldwell the fabric closely resembles that of the Sutton rocks.

The above features suggest that the Caldwell and Sutton rocks were both stressed at two separate times and that the amount of stress varied - being more intense in the zone of the Sutton rocks.

Folding

As has been noted previously, the Sutton rocks occupy the core of an anticlinorium whose axial zone transects the northwest corner of the area. In accord with this the Caldwell rocks generally face and dip to the southeast. Local reverdals of this condition are due to minor folds and overturning. The folding in the Sutton rocks is more intricate than that in the Caldwell group. However the fold orientations ~~(as far as can be deduced in the field)~~ appear similar.

No evidence of superimposed folding was detected. However the fact that a secondary foliate structure of the Sutton rocks is folded suggests the possibility that the development of this foliation may have accompanied a disturbance preceding that more obviously reflected in the present schists.

The serpentinized ultrabasic rocks of the area have several features of interest: they are almost everywhere concordant sills and dykes; they are commonly schistose; and they are concentrated within the Caldwell rocks and never in the Sutton. The first two points suggest the emplacement of the ultrabasics occurred before or during the folding.

Speculations on the third point must remain as such but if the Sutton rocks attained their present schistose and permissive state before the main folding (which appears to be the case) then preferential intrusion into the more resistant Caldwell rocks appears anomalous. The relative competency does not appear to have been a factor as both Caldwell quartzites and slates are intruded.

An hypothesis preferred by the writer is that the Sutton and Caldwell rocks each attained its maximum deformation at approximately the same time; that flexture folding resulted in a compressional zone within the Sutton schists (as demonstrated by the intense crumpling and mechanics of folding) and that the Caldwell rocks occupied the tensional part of the limb zone.

The emplacement of the ultrabasic rocks would thus be temporarily favoured by a tensional zone on the limb of the anticlinal structure expressed by the Sutton and Caldwell rocks.

Data in the Stukely area add little to the determination of the times of orogeny. Thw two disturbances reflected in the rocks appear post-middle Ordovician and may correspond to the Taconic revolution at the close of the Ordovician period and the Acadian disturbance in Devonian time.

<u>Faulting</u>

A few small strike-slip faults marked by zones of brecciation, silicification and shearing occur in the Caldwell group. The schistose, silicified zone which extends southwest along the west side of Bowker lake for over two miles may reflect an important fault zone. A selvedge of serpentinized peridotite, in places extremely schistose (Plate IX-B) extends along this zone and in part marks the Caldwell - Sutton contact. Specific evidence for a continuation southeast is lacking but such a fault accounts in part for the proximity of the Caldwell rocks to the magnetite-epidote-chlorite schist in the southeast corner of the map area and the termination of the Eastern member of the Sutton schist.

A limited number of outcrops in lot 24, range III, Stukely township indicate a silicified and markedly brecciated zone that grades northwest into less deformed Caldwell rocks. A similar situation exists to the southwest and it is possible that a fault zone extends northeast under the blanket of drift to tie up with a schistose zone at the southwest tip of Stukely lake.

Cross or transverse faulting is apparent in the Caldwell rocks. This is best demonstrated north of the east arm of Stukely lake where the band of basic volcanic rocks has been relatively displaced north side west. This apparent displacement might be attributed to disruption by the intrusive rocks except that a wedge of graphitic slate and subgraywacke, exposed on the lake shore, suggests otherwise. The assumed fault occupies a topographic linement extending from the tip of the small bay in Stukely lake to the east arm of the lake.

The fault may be extended to the east to account for lithologic discontinuities in the Caldwell group. It is possible that these are facies' changes and that the fault dies out as a flexure.

ECONOMIC GEOLOGY

No significant amounts of base metal minerals have been previously reported in the area mapped but the location within the "Serpentine Belt", the wide variety of rock types, possible structural controls and economic occurrences of copper a few miles to the southwest are encouraging features.

The general region has been the scene of intermittent prospecting and mining for the past 100 years and some of the exploration pits in the Stukely area may date black to the time of the American civil war.

Minor amounts of chalcopyrite, asbestos, chromite and talc were encountered in the area mapped. The locations and general features are listed below.

The copper occurrence at the Quebec Copper Corporation's Huntington Mine is located 3 miles south of the southwest corner of the map area. The mineralization occurs for the most part near a contact between altered basic volcanic rock and serpentinized peridotite. Similar circumstances in the Stukely area may be considered generally favourable for prospecting. In particular the volcanic - ultrabasic contacts immediately east of Stukely lake merit investigation. Outcroppings here are unfortunately scarce.

Copper:

a) Location: Central part of lot 28, Range III, Stukely twp.-- approximately 2400 feet south of north boundary of lot and 1000 feet west of Stukely - Orford township boundary.

Mineralization: A few grains of chalcopyrite occur in massive, coarse-grained green gabbro. The sulphide appears to be a primary mineral along with magnetite. One small float of silicified rock with disseminated pyrite and a few grains of chalcopyrite was noted to the west of the assumed gabbro contact.

b) Location: Extreme southeastern corner of map area -- approximately 2000 feet north of south boundary of map and 500 feet west of the east boundary.

Mineralization: A few grains of chalcopyrite with malachite occur in a small hornblendic alteration zone associated with the ultra-basic rock.

c) Location: Small point on east shore of Stukely lake approximately 1500 feet north of largest island.

Mineralization: Disseminated pyrite with a few specks of chalcopyrite in silicified, schistose sedimentary rock.

d) Location: Quartzose rocks immediately west of Stukely lake.

Mineralization: The altered quartzites are often pyritic and locally a small amount of malachite and azurite stain is visible.

e) Location: 1600 feet southeast of road that is east of and parallel to Bowker lake and near the boundary between Range A and Range F, Orford township.

Mineralization: Disseminations and almost massive knots of pyrrhotite with minor pyrite, magnetite and chalcopyrite and a few thin veinlets of chalcopyrite occur in sheared and brecciated serpentine. The mineralized zone does not exceed ten feet in width where observed, and strikes approximately northeast, parallel to the shear. Sparcely mineralized outcrops may be traced intermittently for several hundred feet within the map area and one outcrop with disseminated chalcopyrite occurs on strike, some 1100 feet northeast of the map area. A few old pits have been put down to trace the mineralization.

f) Location: Range E, Orford township. Thirty feet west of road parallel to Bowker lake and 400 feet southwest of point where road leaves map area.

Mineralization: Disseminated chalcopyrite with malachite occurs in a carbonated, chloritic rock (altered volcanic rock ?). The mineralization and rock type could not be traced more than one hundred feet. The width of the mineralized zone does not exceed two feet where observed.

g) Location: Northeast part of Range XVIII, Orford township -- approximately 2000 feet southeast from shore of Stukely lake and 3900 feet west of east boundary of map area.

Mineralization: Malachite stain and chalcopyrite (?) occur in sheared basic volcanic rock. The occurrence is close to an assumed mass of ultrabasic rock.

Chromite

Disseminated chromite occurs throughout the serpentinized peridotites in the area. Minor concentrations in knots, lenses and banded disseminations were noted around Stukely lake.

Several lenses, up to one foot in width occur in the serpentinized rocks immediately northwest of Stukely lake in range B, Orford township,- approximately 400 feet northwest of the lake shore and 2800 feet southwest of the north tip of the lake.

Select samples of this mineralization contain 70-75% of black chromite embedded in a matrix of light green serpentine. A few old trenches are present.

Asbestos

Minor slip fiber and narrow cross fiber (less than 1/8 inch) crysotile asbestos occurs throughout the serpentinized rocks around and under Stukely and Bowker lakes.

Claims covering both lakes are presently held by the Canadian Johns-Manville Company. Work done by this company includes a magnetometer and geologic survey and diamond drilling of both lakes. All of 11 diamond drill holes encountered serpentinized ultrabasic rocks with some asbestos.

Talc

Bands and lenses of impure talc are common along the contact zones of the serpentinized rocks. The best occurrences observed are in the southern portion of lot 26, Range V, Stukely township where the width of one zone exceeds eight feet. The latter showing is approximately 500 feet east of the road crossing the lot, and 500 feet north of the south boundary of the lot.

Typical samples of the impure talc are dense and massive, occasionally sheared. The color is mottled greenish-yellow and a few small crystals of magnetite and chromite (?) are usually present.

Gravel and sand deposits

Accessable deposits of sand and gravel underlie portions of lots 19 and 20, Range VI, and lots 17 and 18, Range VIII, Stukely township. These are being utilized for road fill and cover. A few small deposits occur elsewhere; particularly in those areas indicated as drift covered on the map.

Marble

The occurrences of crystalline limestone in the area (lot 23, Range VII, Stukely township), while of good quality are too limited in extent for commercial development.

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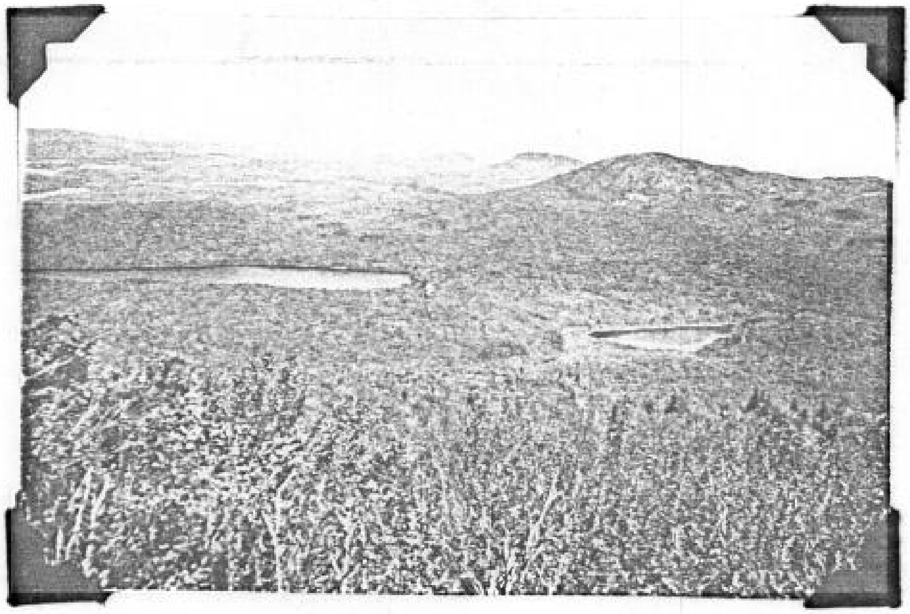
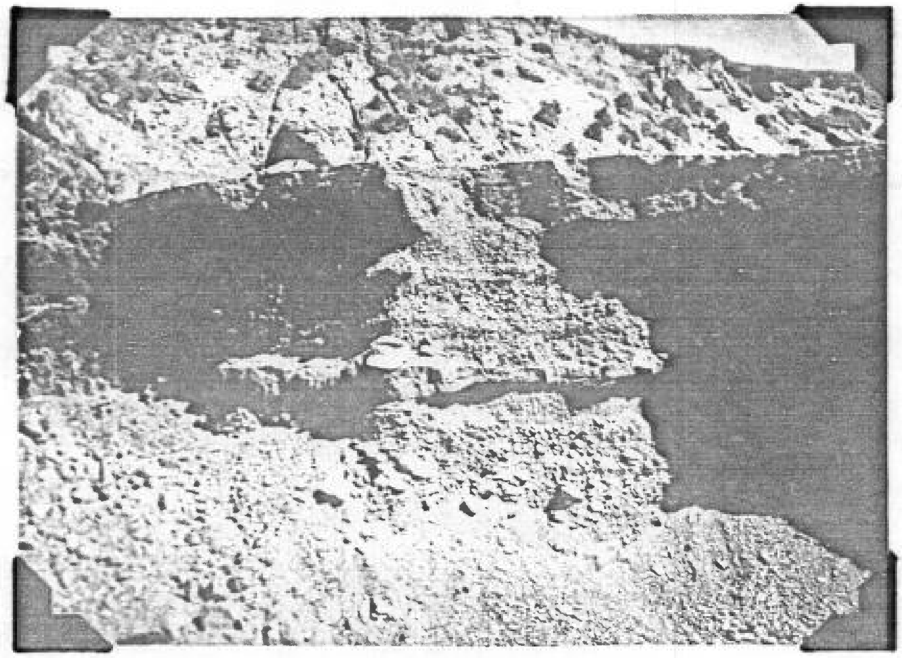
Plate I



A- Looking north from north slope Mount Orford.



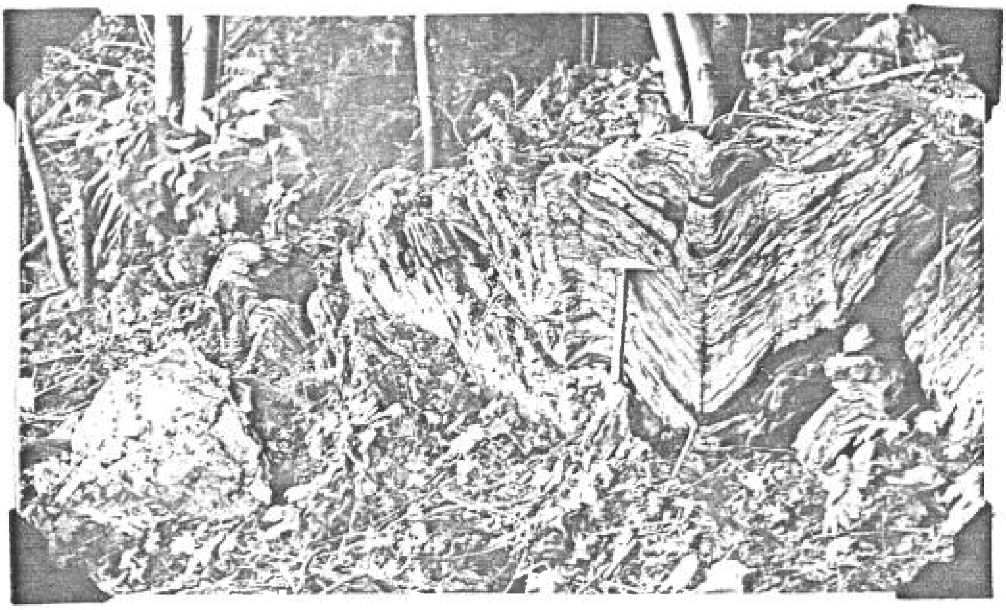
B- Bedded gravels overlain by sand.

Plate II

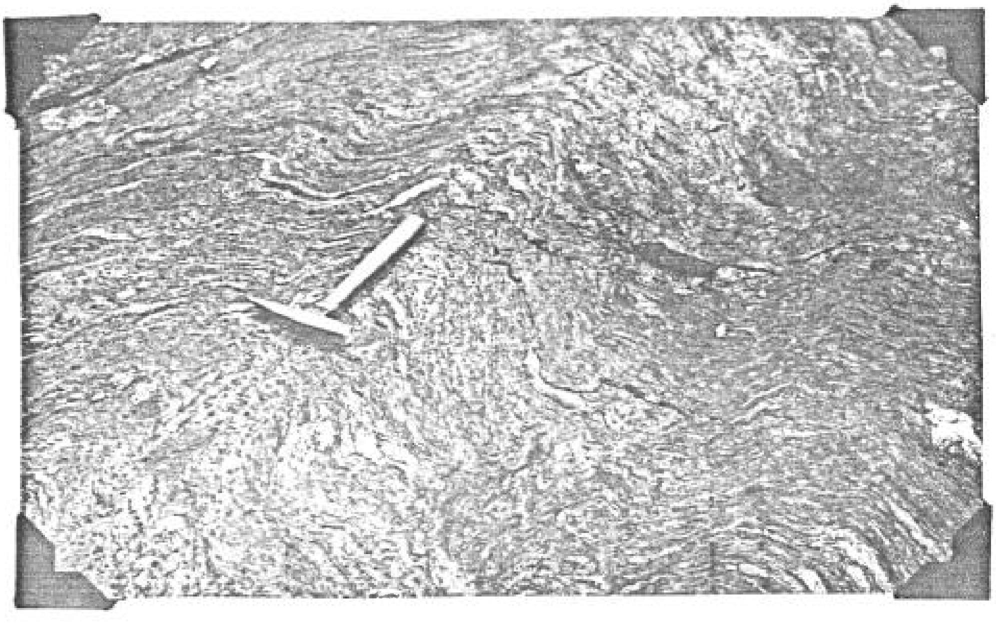
A- Laminated silt and clay. Note dip to left.

B- Sutton quartzite with quartz veinlets.

Plate III

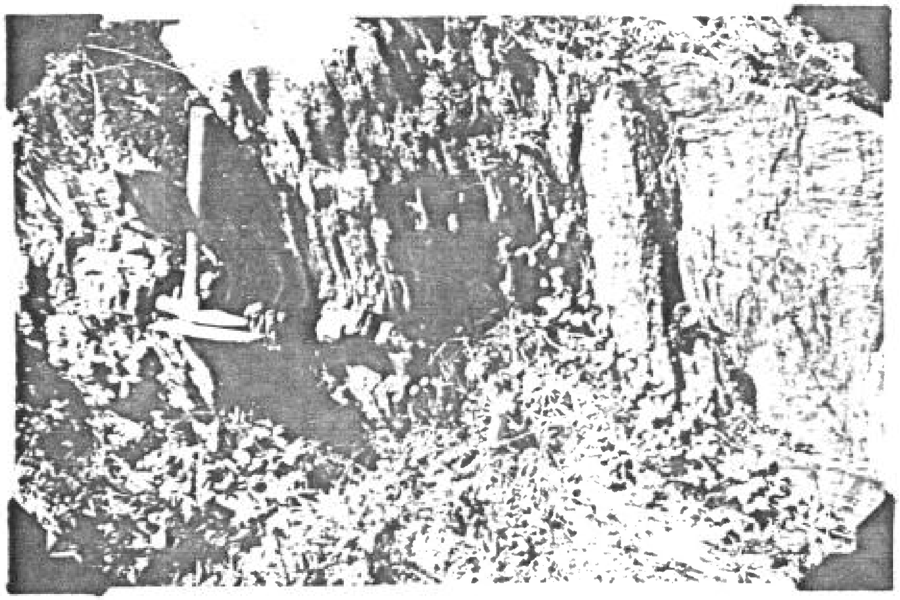


A- Sub-parallel fold in Sutton schist. Note how fold dies out vertically and well developed axial plane cleavage and crenulations.



B- Intricate folding in Sutton schist.

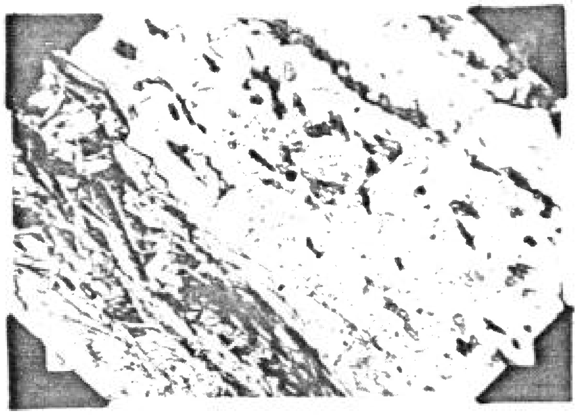
Plate IV



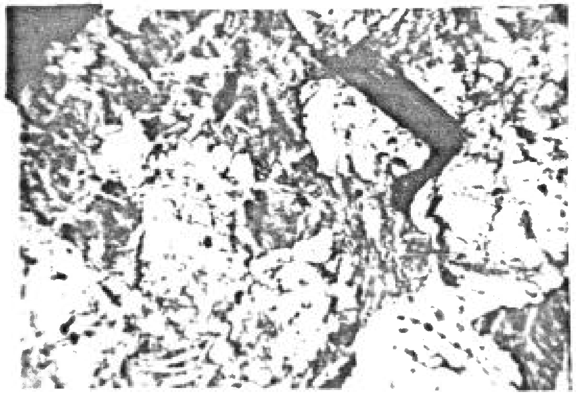
A- Drag fold in Eastern Member Sutton Schist.
Note plunging crenulationsat right.

B- Small fault in magnetite-epidote-chlorite schist.

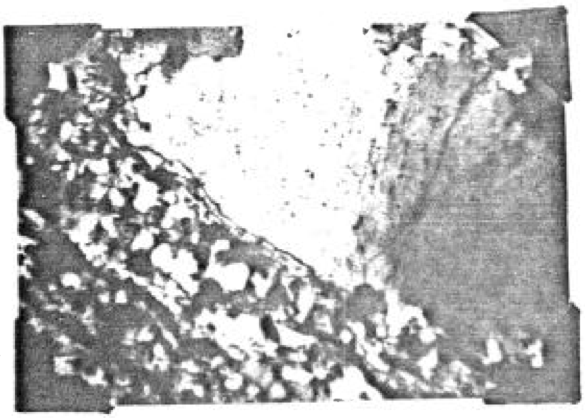
Plate V



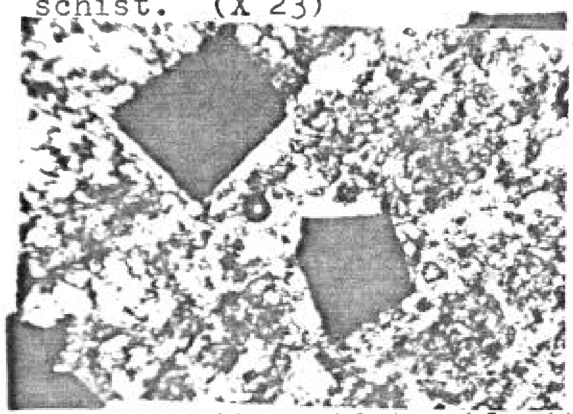
A- General relations quartz-sericite schist. (X 23)



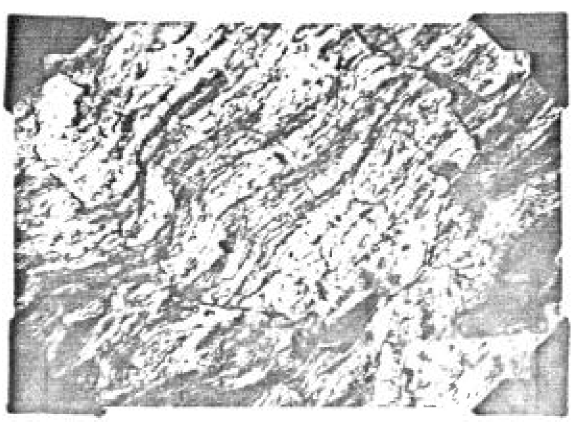
B- Plagioclase with zonal inclusions and bent crystal of ilmenite-leucoxene in quartz-feldspar-sericite schist. (X 23)



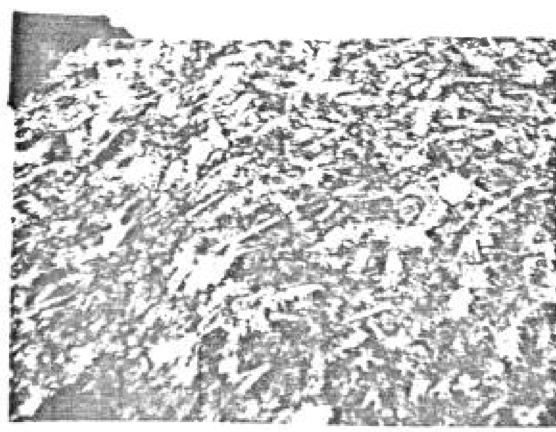
C- Detrital grain of quartz in quartz-sericite schist. (crossed nicols, X 23)



D- Magnetite-epidote-chlorite schist. (X 23)



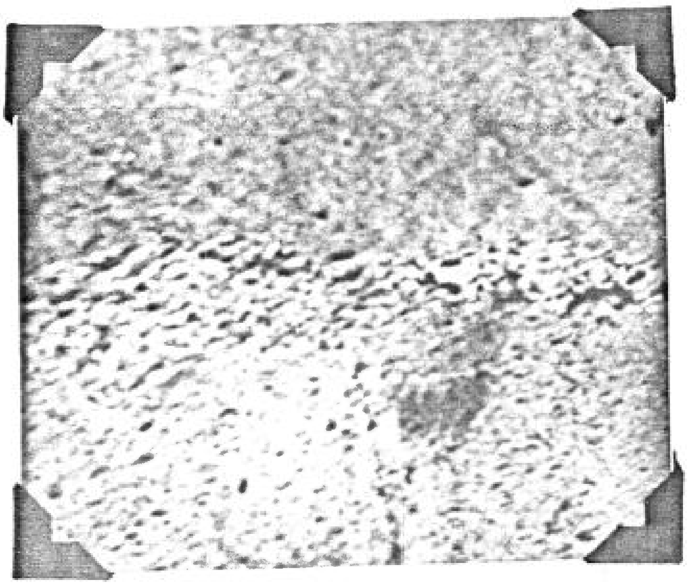
E- Metacryst of plagioclase with remnants of crenulated mica (helicitic structure). (X 74)



F - Sericite schist. Note larger random crystals of muscovite in finer-grained sericitic groundmass ~~and transecting cleavage.~~ (crossed nicols, X 46).

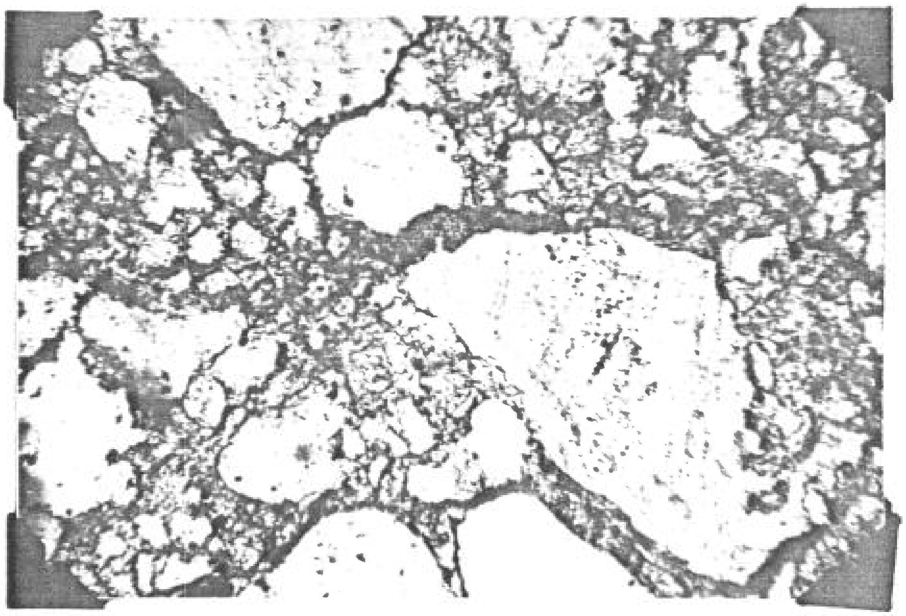
Plate VI

A- Caldwell subgraywacke. Brecciated bed of quartzite above hammer. Photo taken looking east.

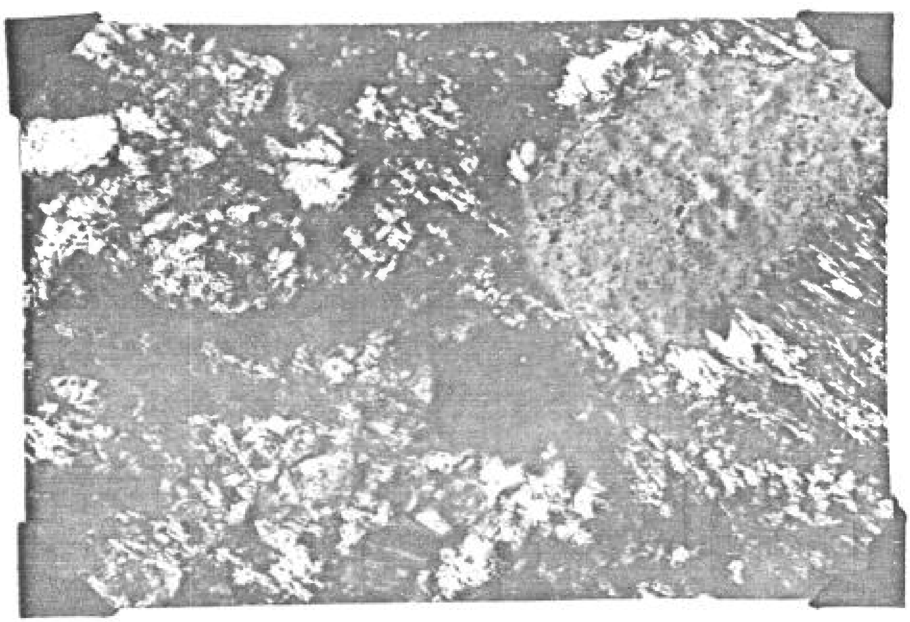


B- Detail just below hammer handle in photo A. Sorting and size grading of quartz grains indicates beds face west.

Plate VII

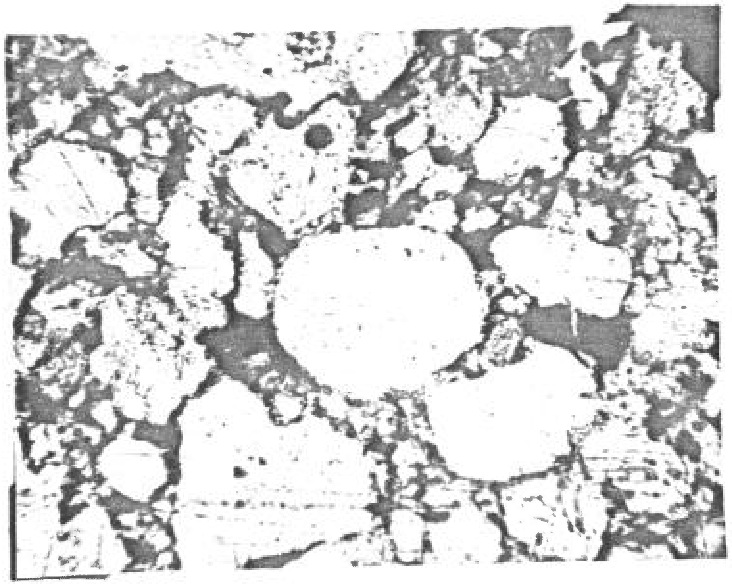


A - Caldwell subgraywacke. Fragments are mainly quartz with an abundance of fine inclusions. (X 32)

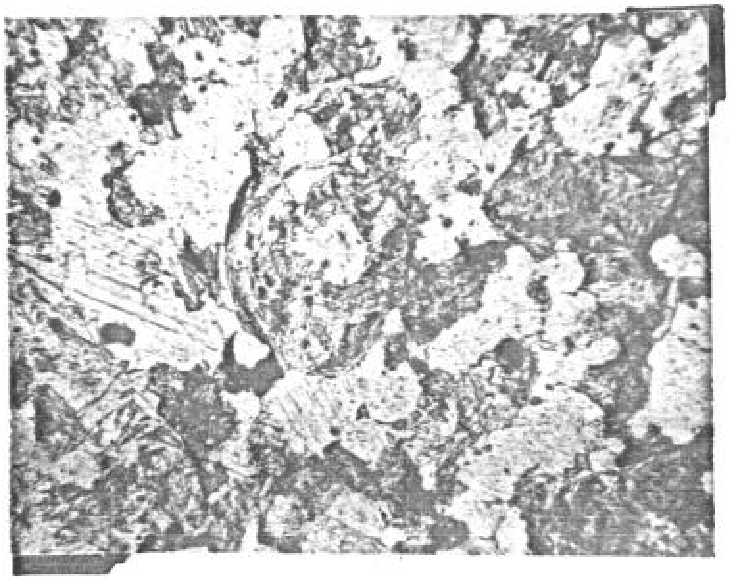


B- Fine-grained graywacke (siltstone). Note schistose matrix and invasion of feldspar fragment by chlorite and sericite. (crossed nicols, X 110)

PLATE VIII



A - Caldwell black orthoquartzite. Note variation in sphericity of quartz grains. (X 32)

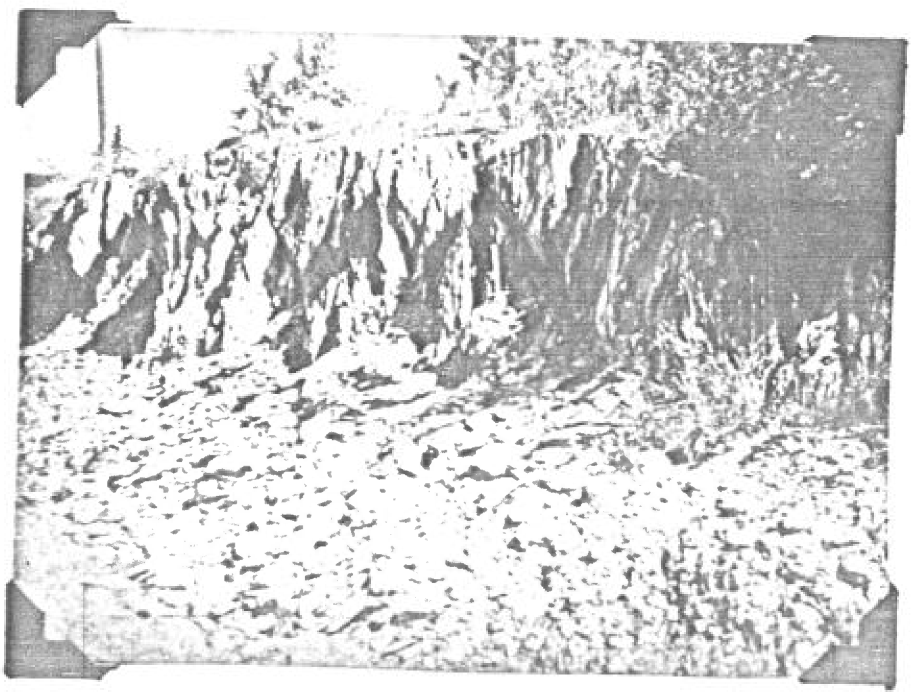


B- Metaquartzite. Quartz (white) and aggregate of altered feldspar and secondary minerals. Large crystal of muscovite to left of round rock fragment in center of field. (X 32)

C- Detail of rounded rock fragment (in photo B) possibly of graywacke parentage. (crossed nicols, X 110)

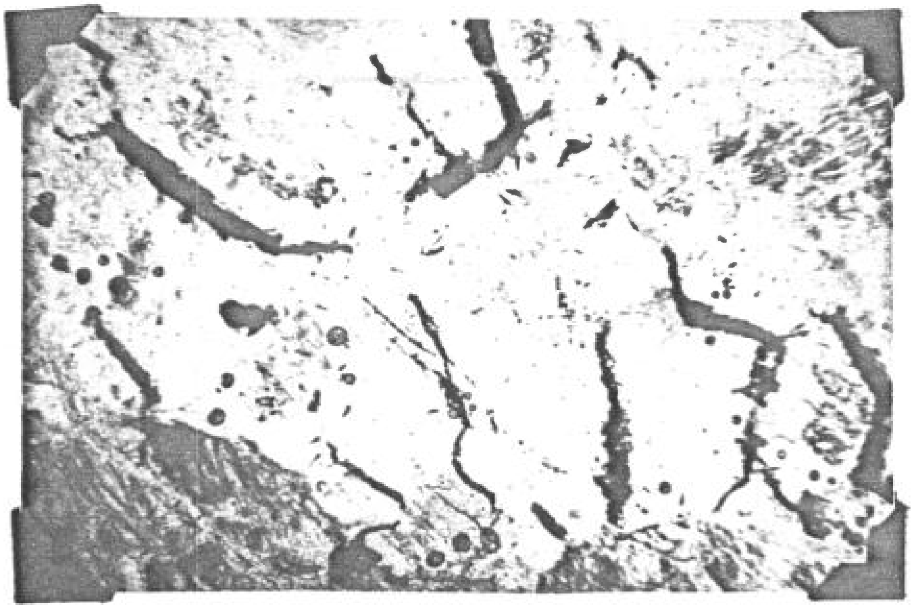
Plate IX

A- Nodular structure in serpentinized peridotite.

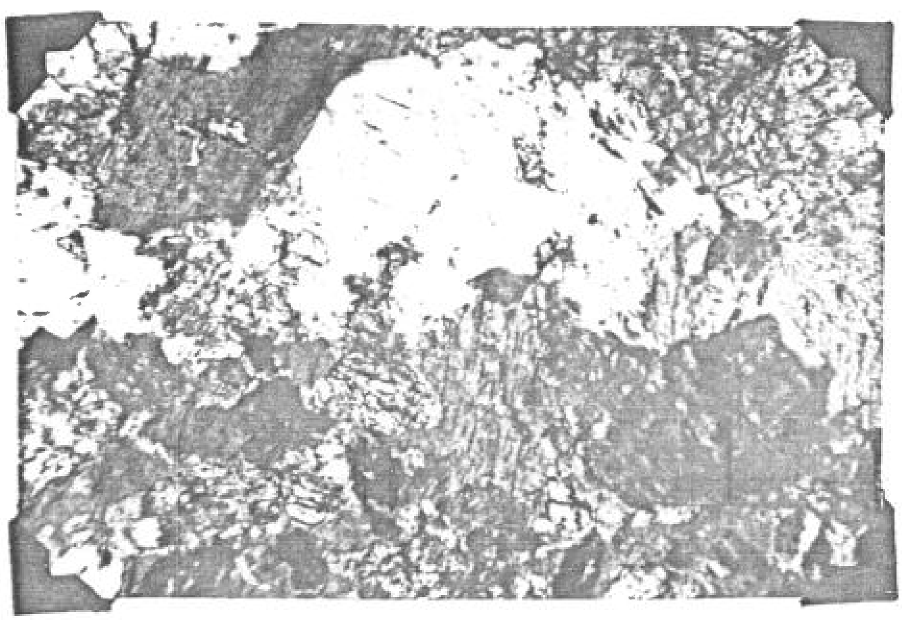


B- Serpentine schist.

Plate X



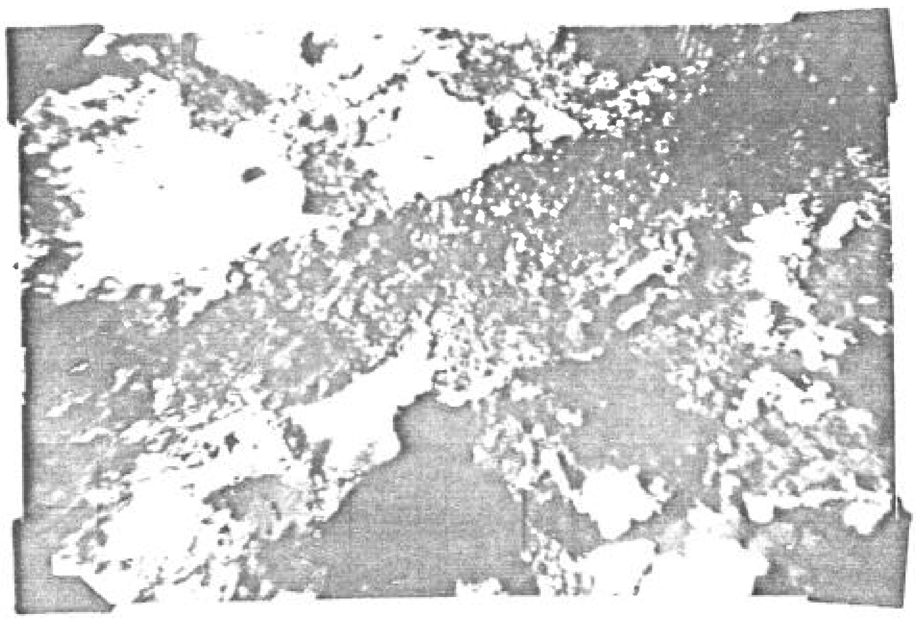
A- Serpentinized peridotite. Network of black magnetite marks original grains of olivine. (X 37)



B- Uralitic pyroxenite. (crossed nicols, X 37)

Plate XI

A - Green gabbro. Pyroxene enclosed in hornblende. Opaque material is mainly alteration products of feldspar. (crossed nicols, X 32)



B- Veinlet of zoisite in altered diorite. (crossed nicols, X 37)