BEDROCK GEOLOGY OF PORTIONS OF FISH RIVER LAKE, WINTERVILLE, GREENLAW, AND MOOSELEUK LAKE QUADRANGLES, AROOSTOOK COUNTY, MAINE

by

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ABSTRACT

An area in northern Maine extending from Fish River Lake to Big Machias Lake was investigated. A thick sequence of eugeosynclinal rocks of Middle and possibly Late Ordovician age, Late Silurian age, and Early Devonian age have been differentiated into 7 formations.

The oldest rocks are a thick sequence (greater than 5000 feet) of Middle Ordovician volcanics containing varying amounts of fine grained, water-deposited tuff, tuffaceous and volcanic sandstone, and tuffaceous and volcanic conglomerate. Upper Middle or Upper Ordovician slate containing interbedded graywacke locally overlies the Middle Ordovician volcanics and volcanic sedimentary rocks.

The Taconic orogeny was marked by uplift, nondeposition, and erosion. Deposition resumed in the Late Silurian. Lower Ludlovian volcanics, conglomerates, and limestones lie unconformably upon rocks of Ordovician age. The Lower Ludlovian rocks vary greatly in thickness (0 to nearly 5000? feet) and lithology. They are generally of a shallow-water, near-shore environment, but locally there are mudstones presumably of a deeper water, offshore environment. Portions of this area or surrounding areas were emergent during Early Ludlow time.

Devonian rocks lie disconformably upon Silurian rocks in part of the area and possibly over the entire area. This is due to a Late Ludlow - Manlius-Coeymans emergence. Deposition resumed during New Scotland time with deposition of several hundreds of feet of silty limestone and locally of conglomerate. This basal unit grades both laterally and upward into mudstone and finally into the slate of the Seboomook Formation. The thickness of Devonian rocks is at least 8000 feet and probably is much thicker. Portions of this area or surrounding areas were emergent during New Scotland time. Volcanism occurred during New Scotland time and possibly somewhat later. This volcanism was not as intense as that which occurred during the Ordovician and Silurian.

The Acadian orogeny produced folding, cleavage, faulting, and sub-chlorite zone metamorphism.

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LOCATION AND ACCESSIBILITY

The area investigated covers portions of the Fish River Lake, Winterville, Greenlaw, and Mooseleuk Lake Quadrangles of northern Maine (fig. 1). Approximately 170 square miles were mapped.

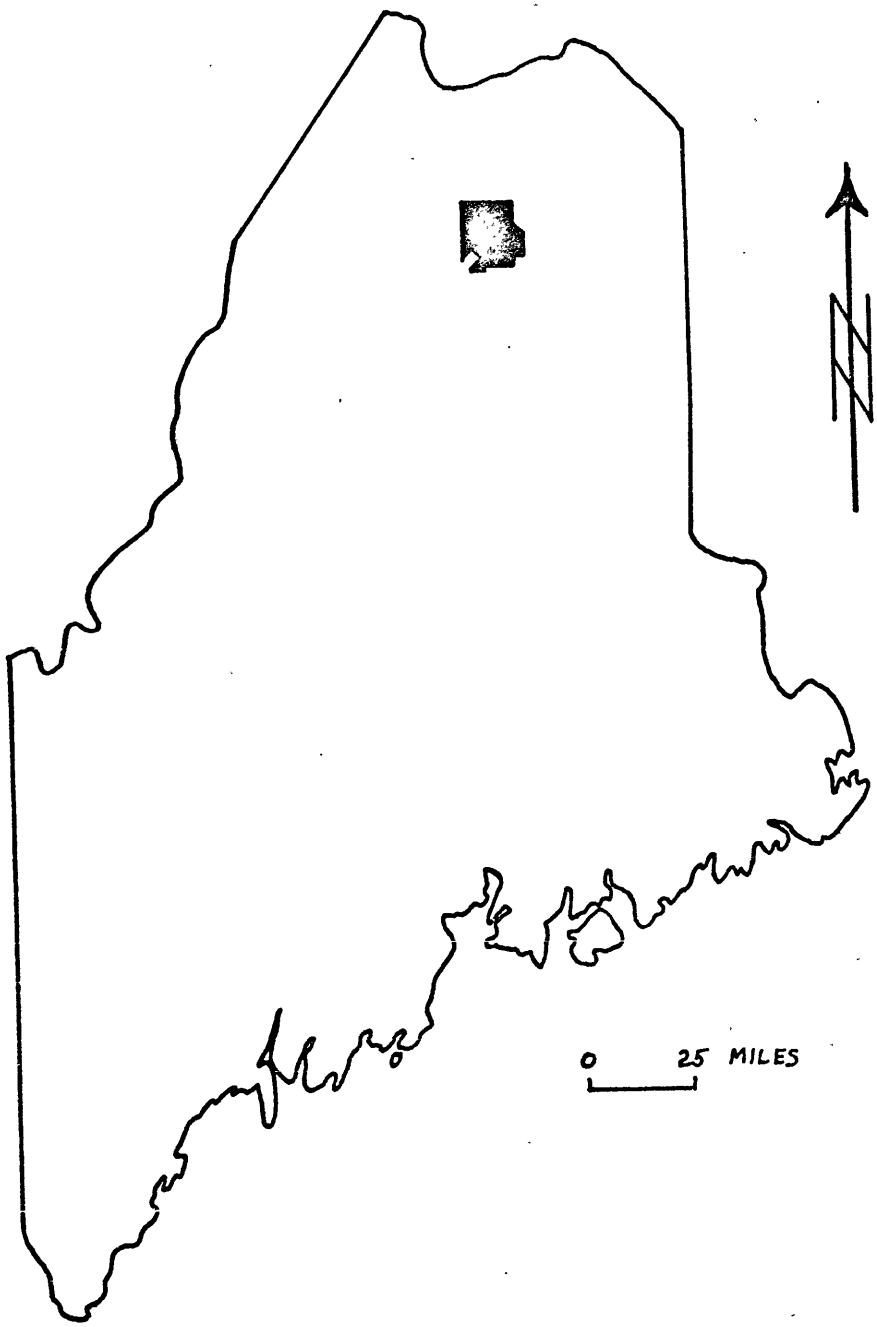
The area is densely forested. Access is by two gravel tote roads, the American Realty Road in the south and the Fox Brook Road in the north. Logging roads and trails afford access to much of the area. The geologic investigation was carried out by working the roads and streams and by making pace and compass traverses through the woods.

PREVIOUS WORK

Other than very broad reconnaissance, the first geologic work in this area was by G.M.Boone (1958). Boone's investigation was primarily around an intrusion in the northern part of the Fish River Lake Quadrangle; however, he also did reconnaissance over the entire Fish River Lake Quadrangle and a portion of the Winterville Quadrangle.

Students at M.I.T. working under Dr. E. Mencher have produced bachelors theses and reports which include

FIG. 1. MAP OF MAINE SHOWING THE LOCATION OF THE AREA INVESTIGATED.



portions of the area presently investigated. These are bachelors theses by W.M.Friedberg and J.L.Petersen (1964). and H.L.Hayes and M.R.Nalbandian (1963) and a report by D.C.Roy (1964). Dr. E. Mencher has done reconnaissance through this and surrounding areas during the summers of 1961 through 1967.

B.A.Hall (1964) has done detailed geology to the southwest in the Spider Lake Quadrangle and surrounding areas.

PRESENT WORK

The writer was engaged in field work during the summers of 1966 and 1967.

REGIONAL SETTING

The area investigated is part of the eugeosynclinal zone of the Appalachian Geosyncline. It has been affected by two major Paleozoic orogenies, the Taconic and the Acadian.

In the northern Appalachians the Taconic orogeny occurred at times ranging from Middle Ordovician through Early Silurian (Boucot and others,1964). It is represented in the area investigated by the writer as an angular unconformity.

The major orogeny affecting northern Maine is the Acadian. The main phase of this orogeny is believed to have occurred between latest Early Devonian or late Middle Devonian time. This was followed by an interval of gentle folding during the later Middle Devonian or Late Devonian (Boucot and others,1964).

A nonsequence, named the Salinic disturbance by Boucot (1962) and characterized by the absence of rocks containing fossils of late Ludlow age and Manlius Coeymans age, has been identified in northern Maine (Pavlides and others, 1964). In places within the area investigated it seems to be represented by a disconformity. It is not known whether this is the case over the entire area.

REGIONAL METAMORPHISM

The rocks in the area investigated have been subjected to regional metamorphism of sub chlorite grade. The writer has not observed any differences in the metamorphic grade between rocks of Ordovician age and those of Silurian and Devonian age. Thus there is no reason to believe the Ordovician rocks were subjected to regional metamorphism during the Taconic orogeny.

In the mafic volcanics, the absence of zoning and

presence of specks of chlorite, carbonate, and white mica in the plagioclase indicate the present plagioclase composition is probably different from the original composition. In this report whenever the writer refers to the mafic volcanics as andesite or basalt, he is referring to the present, not the original, composition of the plagioclase.

STRATIGRAPHY

GENERAL

The bedrock in the area investigated ranges in age from Middle Ordovician to Early Devonian. It has been differentiated into seven formations by the writer. Five of these are new formations named herein by the writer. The other two, the Winterville Formation and Seboomook Formation, are referred to previously existing formations. Two of these formations, the Winterville Formation and Carr Pond Formation, have been subdivided into several members by the writer. These units are (the formations are listed in order of age, whereas the members are not):

	Seboomook Formation
Lower Devonian	Fox Brook Formation
	Moosehorn Stream Formation
	Mud Pond Formation
	Carr Pond Formation
	Member #1
	Member #2
Upper Silurian	Member #3
	Member #4
	Member #5
	Member #6

Middle or Upper Ordovician	Machias River Formation
Middle Ordovician	Winterville Formation
	Clayton Lake Member
	Greenlaw Mountain Member
	Orcutt Mountain Member

The ages of the Winterville Formation, Carr Pond Formation, Moosehorn Stream Fromation, and Fox Brook Formation are established to varying degrees of certainty by fossils found within the the area investigated or in adjacent areas. The ages of the other units are inferred from stratigraphic relationships or on petrologic grounds.

The Upper Silurian and Lower Devonian rocks lie upon Ordovician rocks with profound angular unconformity. Locally evidence is found favoring a disconformity between the Lower Devonian rocks and the Upper Silurian rocks. It is not known whether this is true over the entire area investigated.

Due to poor structural control, paucity of outcrops, and intense folding, the thickness of the various units is poorly known. The writer offers the following crude estimates:

Seboomook Formation	-	greater than 5,000 feet
Fox Brook Formation	-	variable; 1,000 - 3,000 feet in west, possibly greater in east.
Moosehorn Stream Formation	-	variable; 0 - several hundreds of feet.
Mud Pond Formation	-	variable; 0 - several thousands of feet
Carr Pond Formation	-	variable; 0 - 5,000 (?) feet
Machias River Formation	-	minimum of 1,000 feet
Winterville Formation	-	greater than 5,000 feet

ORDOVICIAN ROCKS

The oldest rocks in the area mapped by the writer are of Middle and possibly Late Ordovician age. They have been divided into two formations, the Winterville Formation and the Machias River Formation. These have a composite thickness of at least 5,000 feet, and probably are much thicker. The Winterville Formation is believed to underlie the entire area mapped by the writer and it is usually exposed along the axes of major anticlines. In contrast, the Machias River Formation has only been identified in the south-central part of the map area. It is believed to conformably overlie the Winterville Formation; however, evidence to this effect is lacking. Its absence over the rest of the map area may be attributed to either nondeposition or to erosion during the Early and Middle Silurian. The upper contact of the Winterville Formation with the overlying Ludlovian Carr Pond Formation and the Helderbergian Moosehorn Stream and Fox Brook Formations is an angular unconformity. The contact of the Machias River Formation with the Carr Pond Formation on the west flank of the Greenlaw Anticline is believed to be a fault contact.

WINTERVILLE FORMATION

GENERAL

The name Winterville volcanics was first used by Boone (1958) in an unpublished Ph.D. thesis at Yale University. As sediments have been found interbedded with the volcanics, it has been redesignated the "Winterville Formation" by Mencher (1963, unpublished report).

Within the area covered by this report, the Winterville Formation is composed largely of volcanics. Andesite is the dominant volcanic lithology, whereas basalt and quartz keratophyre are of secondary importance. Sedimentary rocks are commonly but not universally founded interbedded with the volcanics. The major sedimentary rock is a "cherty", fine grained, water-deposited tuff. Sandstone, conglomerate, tuffaceous mudstone, tuffaceous conglomerate, and coarse grained, water-deposited tuff are locally significant. Tuffaceous mudstone and black slate are minor local components.

The Winterville Formation forms the cores of the two major anticlines in the area studied. The volcanics were not found to vary lithologically throughout the area, but the associated sedimentary rocks show considerable areal

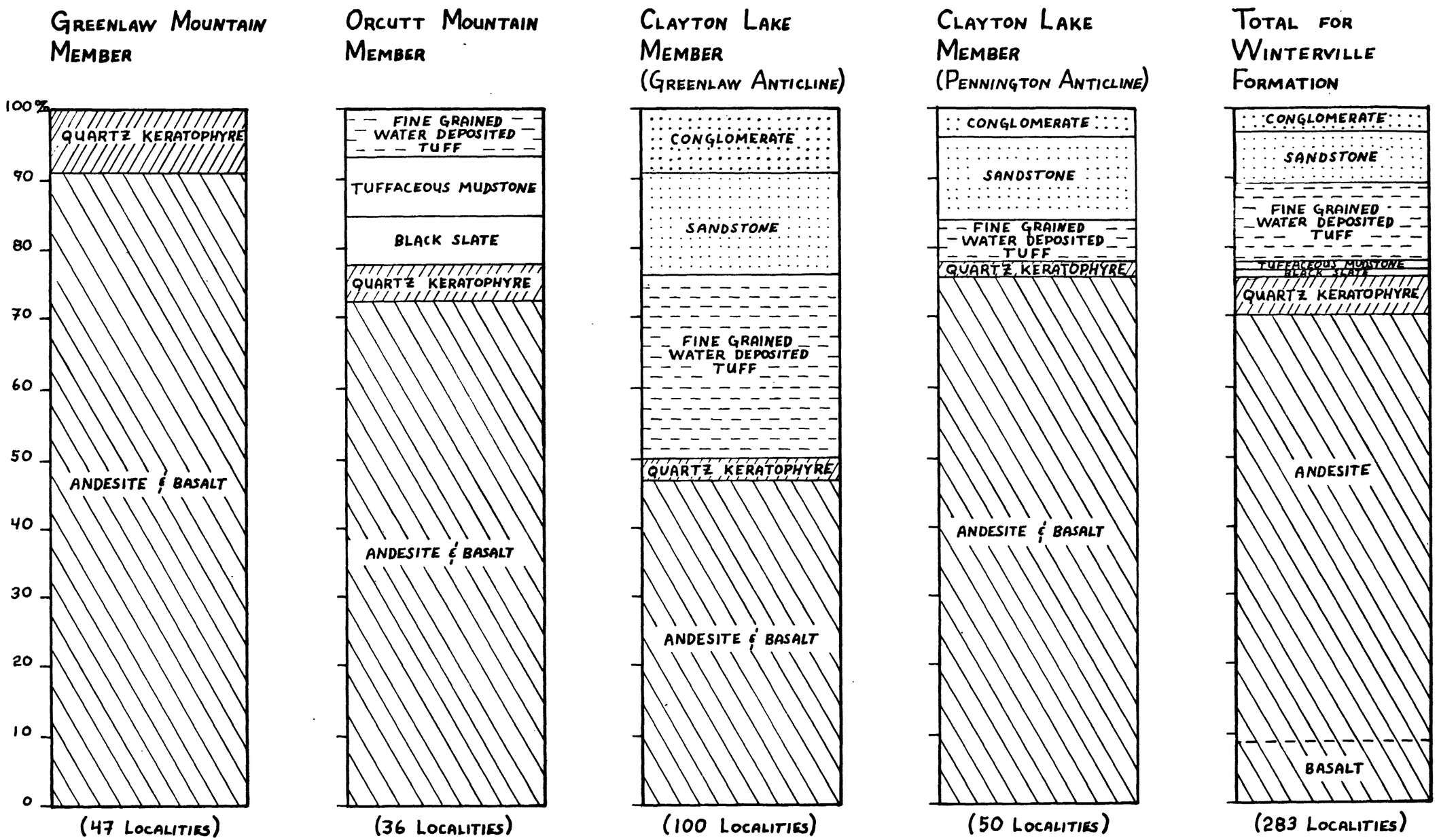
variation. On the basis of this variation, the Winterville Formation is herein subdivided into three lithologic members (fig. 2).

The Greenlaw Mountain Member is named by the writer for Greenlaw Mountain (T12 R7) of the Greenlaw Quadrangle. It is composed entirely of volcanic rocks. Rocks typical of the member are best displayed on the northern portion of Greenlaw Mountain, on Bishop Mountain, and on Carr Pond Mountain.

The Orcutt Mountain Member is named by the writer for Orcutt Mountain (T11 R7) of the Greenlaw Quadrangle. In addition to volcanics similar to those found in the Greenlaw Mountain Member, the Orcutt Mountain Member contains fine grained sedimentary rocks. These include black slate, tuffaceous mudstone, and fine-grained, water-deposited tuff. Rocks typical of the Orcutt Mountain Member are best displayed along the American Realty Road, 0.85 to 1.4 miles west of the Moosehorn Stream crossing.

The Clayton Lake Member is named by the writer for Clayton Lake (T12 R8) of the Mooseleuk Lake Quadrangle. It is composed of volcanics and intercalated sedimentary rocks. The volcanics are similar to those found in the Orcutt Mountain and Greenlaw Mountain Members. Nearly all of the sedimentary rocks appear to have a tuffaceous component. Tuffaceous sandstone and conglomerate are the

FIG.2. — DISTRIBUTION OF LITHOLOGIES IN THE WINTERVILLE FORMATION.



distinctive lithologies of the Clayton Lake Member. Fine grained, water-deposited tuff similar to that found in the Orcutt Mountain Member is also present. Rocks typical of the Clayton Lake Member are best displayed on the hill to the northwest of Clayton Lake.

In summary, the major differences between the various members of the Winterville Formation are reflected in their sedimentary components. The Greenlaw Mountain Member lacks sedimentary rocks and is composed wholly of volcanics. The Orcutt Mountain Member is composed of volcanics and fine grained sedimentary rocks, but it lacks sedimentary rocks containing sand-sized material The Clayton Lake Member contains both fine and coarse grained sedimentary rocks in addition to volcanics.

The stratigraphic relations between the various members of the Winterville Formation are poorly known. This is due to the spotty nature of the outcrop distribution, the lack of a clear understanding of the structure, and the paucity of fossils. It is the opinion of the writer that the various members are, at least in part, time equivalents.

As neither the base nor the original top of any of the members of the Winterville Formation has been recognized, only a minimum value may be assigned for the thickness of any unit. The major difficulty which prevents a meaningful

estimate of the thickness from being made is the lack of structural control. Bedding is difficult to obtain in many areas, and when obtained the attitudes frequently differ widely on outcrops several tens of feet apart. Although the writer feels that faults, both large and small, are abundant within the Winterville Formation, he is not able to assess their importance. Based upon the outcrop pattern the writer offers the following estimates of the thickness of the exposed portion of the various units: Greenlaw Mountain Member - 5,000 feet; Orcutt Mountain Member - 5,000 feet; Clayton Lake Member (in the Pennington Anticline) - 5,000 feet; Clayton Lake Member (in the Greenlaw Anticline) - 3,000 feet; and total for the Winterville Formation - greater than 5,000 feet. It must be emphasized that these values are only crude estimates.

LITHOLOGY

Volcanic Rocks

Approximately 75% of the observed outcrops of the Winterville Formation are volcanics. No significant variation in the nature of these volcanics has been noted among the various members of the Winterville Formation.

Andesites and basalts are the most abundant of the volcanic rocks, together comprising more than 90% of the observed exposures. The remainder are quartz keratophyres.

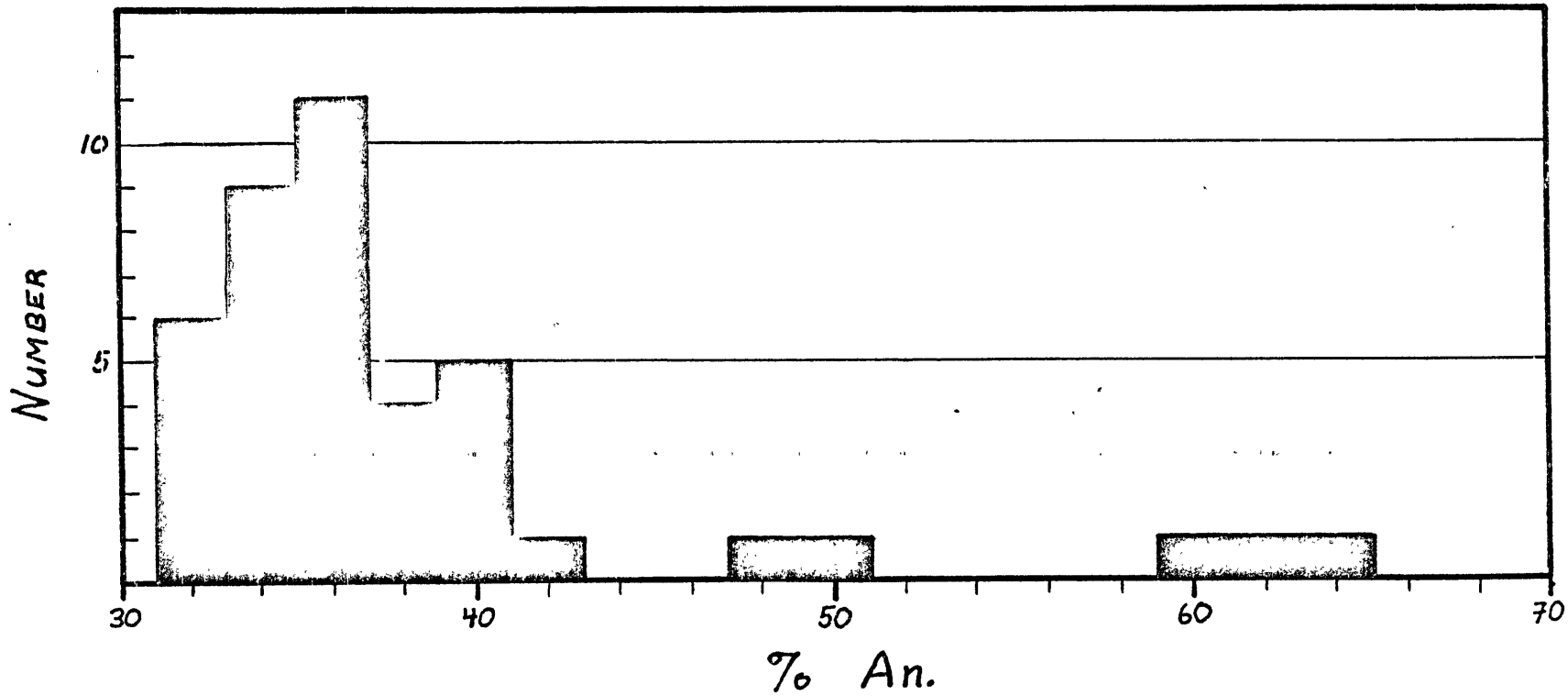
Andesites and Basalts. Plagioclase determinations on 41 samples of andesite and basalt (fig. 3) reveal andesite to be much more abundant than basalt (about 90% andesite and 10% basalt). As the basalts and andesites are indistinguishable in hand sample, and the only notable difference in thin section is the plagioclase composition, they are considered together.

They range in color from medium to dark greenish-gray and gray. The basalts are commonly but not always somewhat darker than the andesites. They typically weather rusty-brown along fractures, and where exposed at the surface they often develop a 2 to 4 mm. thick, light brown, punky weathering rind.

They are sometimes porphyritic, occasionally amygdaloidal, and rarely autobrecciated. Pillows were found at only one locality (#RH-652); however, they may be more abundant as the small size of most outcrops precludes their recognition. Pilotaxitic textures are occasionally recognized.

The andesites and basalts are composed primarily of plagioclase, chlorite, and commonly augite. Quartz,

FIG. 3.— DISTRIBUTION OF PLAGIOCLASE COMPOSITIONS IN ANDESITES AND BASALTS OF THE WINTERVILLE FORMATION.



sphene, leucoxene, ilmenite, pyrite, white mica, and carbonate are often present in subordinate amounts.

The plagioclase of the andesites ranges from sodic to intermediate andesine, whereas that of the basalts ranges as high as intermediate labraborite (fig. 3). It is generally densely charged with specks of chlorite, white mica, and carbonate and is often altered to or replaced by chlorite, white mica, and carbonate.

Augite is present in all the basalts and in one-half of the andesites studied. It usually is found ophitically to subophitically enclosing the plagioclase (fig. 4). Compared to the plagioclase, the augite tends to be clear and relatively unaltered.

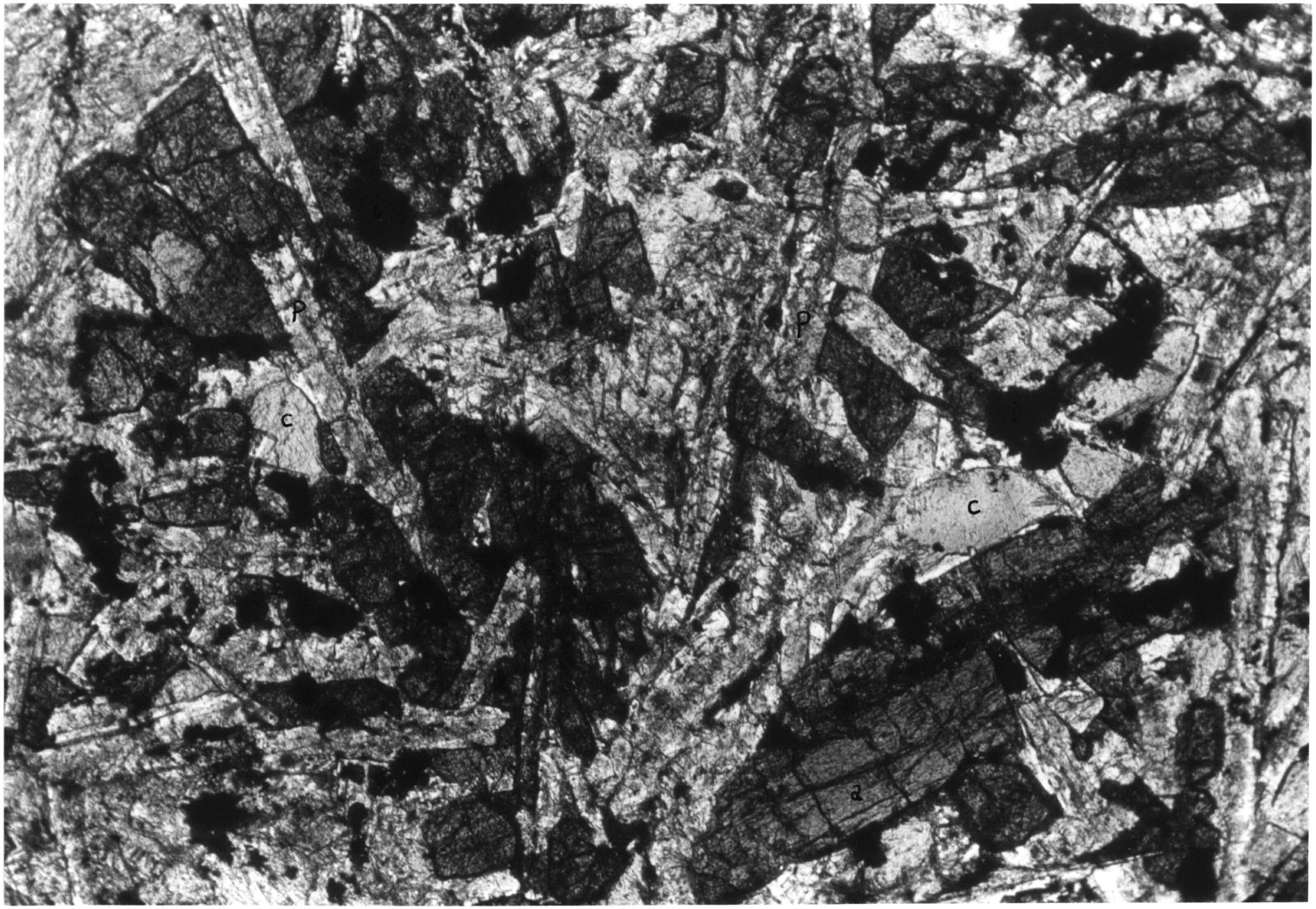
Scaly, flaky, and occasionally fibrolamellar chlorite is intersertal to the plagioclase. White mica is often mixed in small amounts with the chlorite.

Quartz is occasionally present in the andesites as allotriomorphic grains. Although the quartz content may reach 10% or greater, these rocks closely resemble the normal andesites and therefore are refered to as quartz-bearing andesites.

Ilmenite, often occurring as skeletal crystals, is a common accessory. Small (0.001 to 0.01 mm.), leucoxene-coated grains of sphene are suprisingly abundant in some of the thin sections studied. Together with leucoxene,

ig. 4. - Photomicrograph of an augite basalt, Orcutt Mountain Member; Winterville Formation (#RH-739A).
Relatively unaltered augite (a) subophitically incloses calcic andesine laths (p) partially replaced by chlorite and white mica. Intersertal chlorite (c) and ilmenite (i) altered to sphene and leucoxene is also present. Plane light; X60.

Fig. 4



these grains form dense masses pseudomorphous after ilmenite. Similar grains also occur individually or as irregularly shaped aggregates (0.01 to 0.1 mm.) which tend to be concentrated within the intersertal chlorite.

Carbonate and pyrite are frequently present as minor constituents, and together with chlorite, comprise the minerals filling the vesicles.

Modal compositions of typical andesites and basalts from the Winterville Formation are given in fig. 5. For petrographic descriptions of individual samples see p.148 -160.

A quartz diorite with a myrmekitic texture was found at one locality within the Winterville Formation (#RH-319). It is believed to be a small intrusive body probably contemporaneous with Ordovician volcanism as pebbles of similar lithology are present in Ludlovian conglomerates. For a petrographic description of this sample see p.161 .

Quartz Keratophyres. Approximately 10% of the volcanics in the Winterville Formation are quartz keratophyres. They range from light brown to light greenish-gray and weather light brown to rusty brown. They are commonly autobrecciated. The light color and autobrecciated texture are the primary criteria useful in the field to distinguish the quartz keratophyres from the andesites and

FIG. 5. — MODAL[1] COMPOSITION OF ANDESITES AND BASALTS FROM THE WINTERVILLE FORMATION.

LITHOLOGY	AUGITE BASALT	AUGITE BASALT	AUGITE BASALT	AUGITE BASALT	AUGITE ANDESITE	AUGITE ANDESITE	AUGITE ANDESITE	AUGITE ANDESITE	ANDESITE	ANDESITE	QUARTZ-BEARING ANDESITE	QUARTZ-BEARING ANDESITE	QUARTZ-BEARING ANDESITE
SAMPLE #	RH-192	RH-713	RH-739A	RH-803	RH-185	RH-321	RH-333#1	RH-337	RH-85#1	RH-579	RH-85#2	RH-373	RH-709
QUARTZ						3·75					7·5	12·5	11·25
K-SPAR													
PLAGIOCLASE	42·5	39·5	44·75	43·75	36·75	57·75	59·5	57·75	66·25	53·5	43·25	39·0	50·25
AUGITE	26·0	21·75	24·0	24·75	20·75	16·25	13·75	19·0					
INTERSERTAL CHLORITE	18·25	23·75	13·25	13·0	18·0	13·25*	16·0	17·5 *	22·75	17·0	45·0	28·75	27·5*
INTERSERTAL WHITE MICA	0·5	tr.	1·5	6·25		4·0*		2·25*				10·25	4·25*
ILMENITE	0·25	0·75	0·25	2·0	0·25	tr.		1·5		tr.	tr.	2·75	tr.
SPHENE AND LEUCOXENE	12·0	11·5	14·75	10·25	19·5	4·75	10·5	1·75	3·5	18·75	4·0	6·75	4·25
PYRITE			tr.	tr.					0·25	1·25	tr.		
HEMATITE						0·25		0·25				tr.	2·25
SECONDARY CARBONATE	0·5	2·75	1·5						3·5	6·0	0·25		
SECONDARY QUARTZ							0·25						
AMYGDULAR CHLORITE									1·0				
AMYGDULAR PYRITE									1·25				
AMYGDULAR CARBONATE					4·75				1·5				

* INCLUDES A SMALL AMOUNT OF CHLORITE (OR WHITE MICA) PSEUDOMORPHOUS AFTER BIOTITE (?).

(1) 400 POINTS COUNTED.

basalts.

The quartz keratophyres are composed of phenocrysts of quartz and albite lying in a groundmass of quartz, albite(?), and chlorite. The albite phenocrysts are about 0.5 mm. long, idiomorphic to hypidiomorphic, frequently broken, and exhibit alteration to chlorite and white mica.

The quartz phenocrysts average 0.5 mm. in length, are typically deeply corroded, idiomorphic, and usually exhibit straight faces and rounded corners (fig. 6). Often the corrosion has been so intense as to produce rounded forms. Broken crystals are common. Occasionally the hexagonal-bipyramidal form of high-quartz is evident.

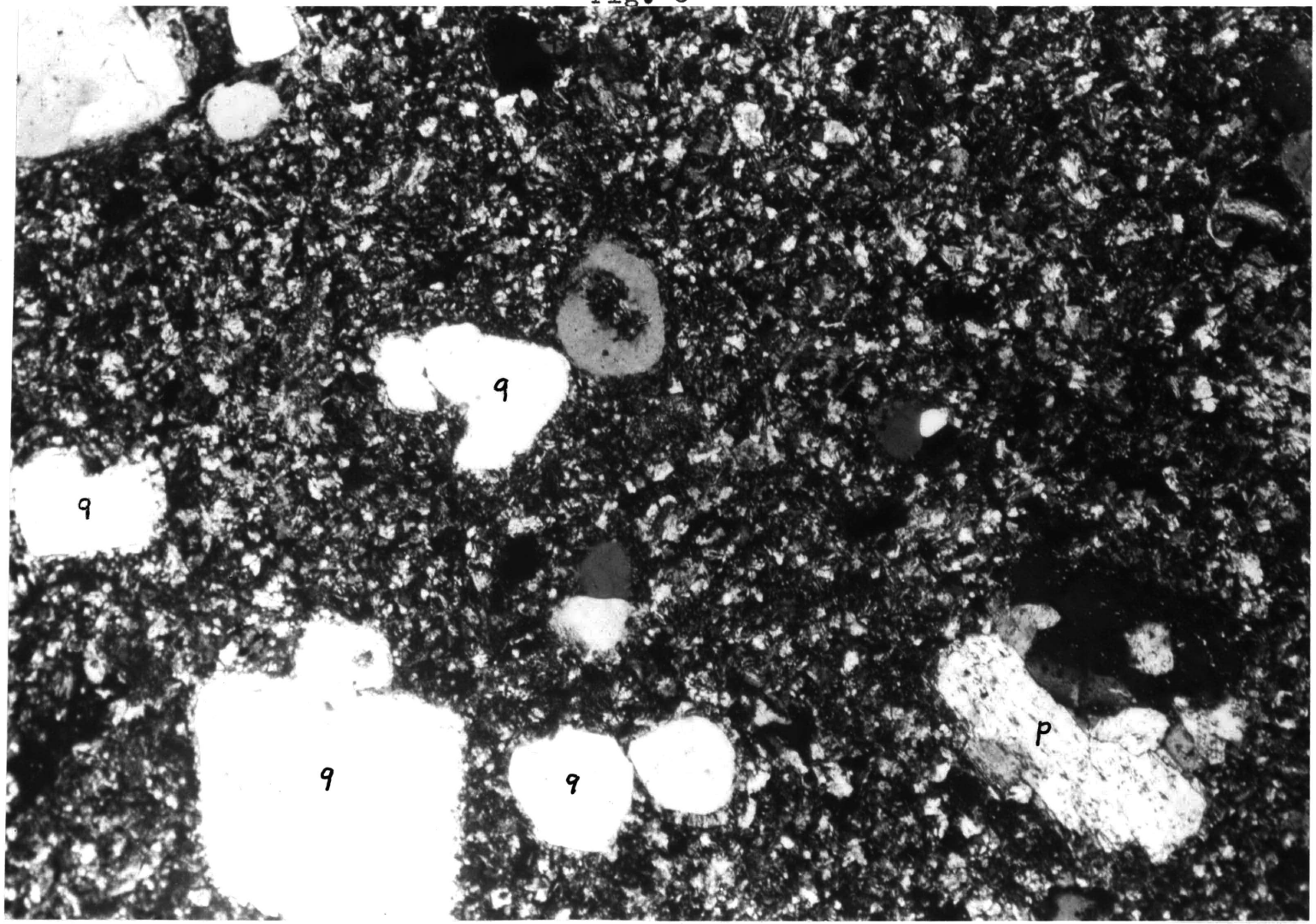
The groundmass consists primarily of interlocking, microcrystalline (0.05 mm.), allotriomorphic quartz and albite(?) with varying amounts of intersertal chlorite and white mica. Small (0.001 mm.), leucoxene-coated sphene grains are often present in minor amounts in the groundmass. The writer interprets this microcrystalline groundmass as being recrystallized glass.

The interfragmental matrix in the autobrecciated quartz keratophyres has essentially the same mineralogy as the groundmass; however, chlorite tends to be more abundant and is often the dominant constituent of the matrix.

For more detailed petrographic descriptions see p. 162 - 163.

Fig. 6. - Photomicrograph of a porphyritic quartz keratophyre; Orcutt Mountain Member, Winterville Formation (#RH-738). Quartz (q) and albite (p) phenocrysts lie in a groundmass of interlocking, allotriomorphic, microcrystalline quartz and albite(?) which probably represents recrystallized glass. Note that the quartz phenocrysts usually exhibit straight faces and rounded corners, but on some the corrosion has been so intense that it produced rounded forms. Crossed nicols; X60.

Fig. 6



The writer has found no evidence to support a subaerial rather than a subaqueous origin for the quartz keratophyres. Their brecciated nature may have been the result of flowage of a solidifying flow, or it could have been due to fragmentation induced by the quenching action of seawater on a subaqueous flow. If the latter interpretation is correct, then it could be termed a hyaloclastite.

Sedimentary Rocks

Sedimentary rocks comprise about 25% of the observed outcrops of the Winterville Formation. Unlike the volcanics, they exhibit marked areal variation. As previously stated, the Greenlaw Mountain Member is devoid of sedimentary rocks, the Orcutt Mountain Member contains fine grained sedimentary rocks, and the Clayton Lake Member contains both fine grained and coarse grained sedimentary rocks. Slate, tuffaceous mudstone, fine grained, water-deposited tuff, sandstone, and conglomerate comprise the sedimentary rocks of the Winterville Formation.

Slate and Tuffaceous Mudstone. Slate and tuffaceous mudstone have been found only in the Orcutt Mountain Member where they comprise about 15% of the exposures. Their

true abundance may be somewhat greater as the associated volcanics would probably tend to be better exposed. They frequently occur together in the same outcrop, and locally they were observed to be interbedded with volcanics. As the outcrops tend to be small and widely spaced, the relationship of the slate and tuffaceous mudstone to the rest of the Orcutt Mountain Member is not well known.

The slates are black, strongly cleaved and jointed, and weather rusty brown. Thin, silty laminae are occasionally present; however, indications of stratification are usually obscured by the well developed cleavage. Graptolites and an occasional brachiopod have been found; however, the rock is usually so badly deformed and strongly weathered that fossils would normally be obscure.

The tuffaceous mudstones range from medium gray to black in color and weather gray to rusty brown. In hand sample they have a siliceous appearance. The more tuffaceous varieties have poorly developed cleavage and a subconchoidal fracture, whereas the less tuffaceous ones tend to have well developed cleavage. Stratification may be indicated by thin, silty laminae, graptolite concentrations, or variation in the tuffaceous component. Graptolites and radiolaria have been found in the tuffaceous mudstone at two localities (#RH-739 and RH-790). A petrographic description of a representative tuffaceous

mudstone is given on p. 164.

The black slates and tuffaceous mudstones represent deposition in a low energy, marine environment which received a fine grained terrigineous component and varying amounts of a tuffaceous component.

Fine Grained, Water-Deposited Tuff. About 10% of the outcrops in the Winterville Formation are fine grained, water-deposited tuffs. They are generally light to dark gray, have a subvitreous luster, and break with an irregular to nearly conchoidal fracture. Their subvitreous luster and nearly conchoidal fracture lead to their hand sample designation as "chert". A tough, 5 mm. thick, light brown, chalky weathering rind is often found on weathered surfaces. Deep green and deep reddish-brown varieties are present but uncommon. Stratification is usually fairly well developed (fig. 7); however, it is often not evident in the field, but in sawed specimens it is almost always visible. Thickness of stratification varies from 1 mm. to several centimeters. Both graded bedding and micro-load-casting have been observed, but they are not common features.

Petrographically the gray, fine grained, water-deposited tuffs consist of a microcrystalline matrix and varying amounts of very fine sand to silt sized grains (fig. 8).

Fig. 7. - Fine grained, water-deposited tuff; Clayton Lake Member, Winterville Formation (#RH-340). Shows well developed laminations, micro-load-casting, and poorly developed cross-lamination.

Fig. 7

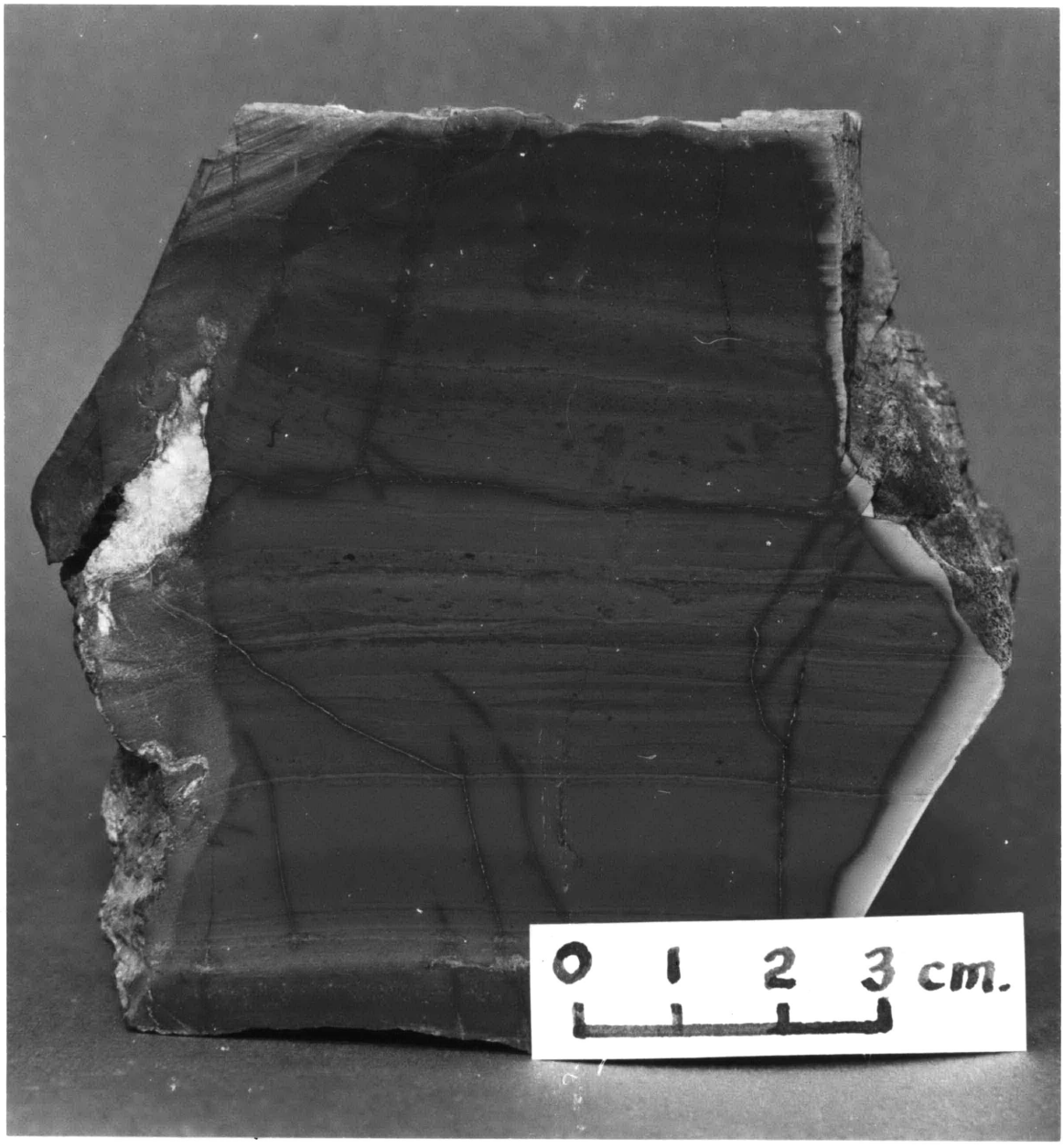
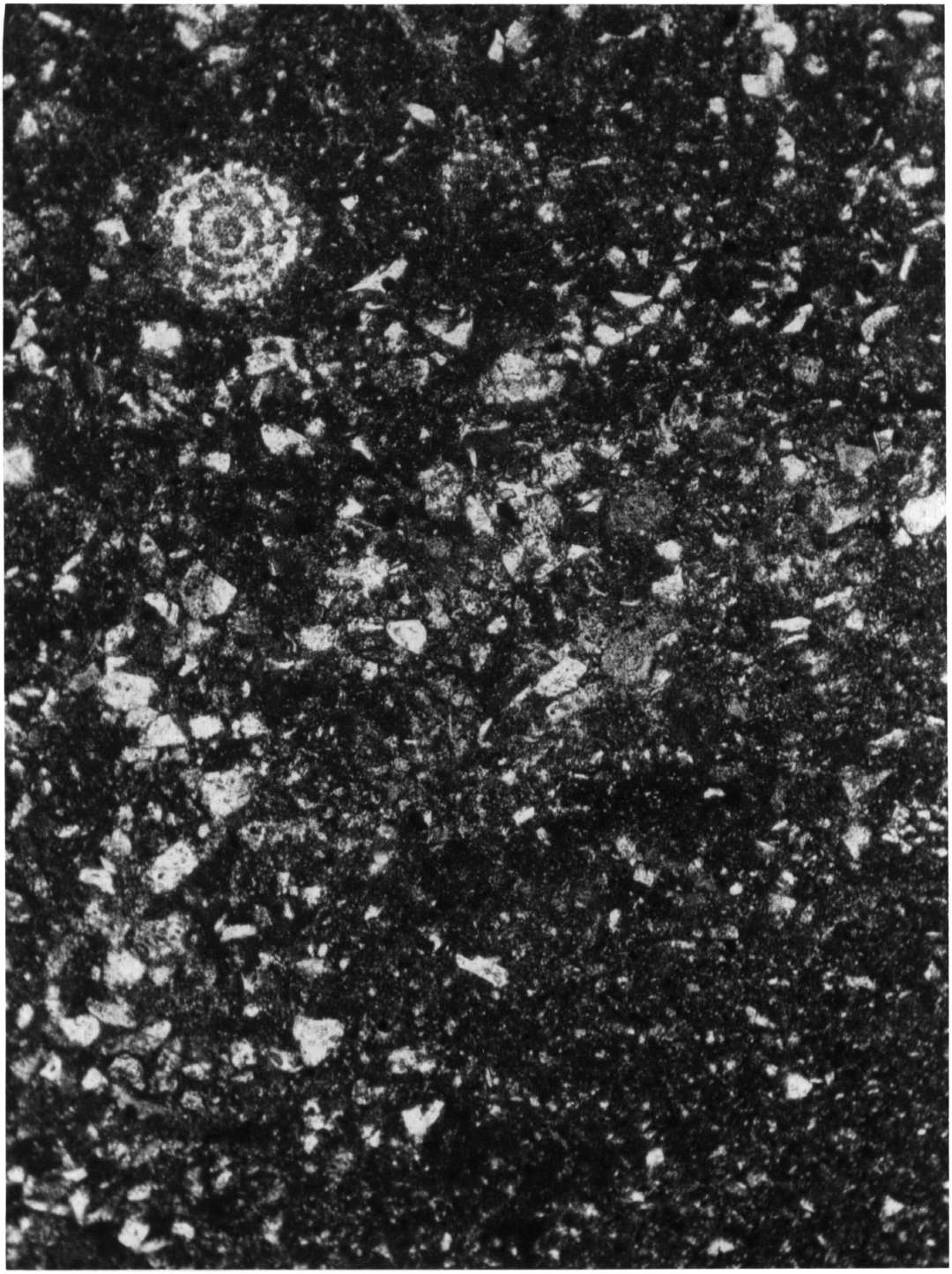


Fig. 8. - Photomicrograph of a fine grained, water-deposited tuff; Clayton Lake Member, Winterville Formation (#RH-340).
Shows a coarse lamina and a portion of a fine lamina. It is composed of recrystallized glass fragments (the individual fragments cannot be separated in the photomicrograph) and angular to subangular fragments of quartz and plagioclase. Note the radiolarian in the upper left.
Plane light; X60.

Fig. 8

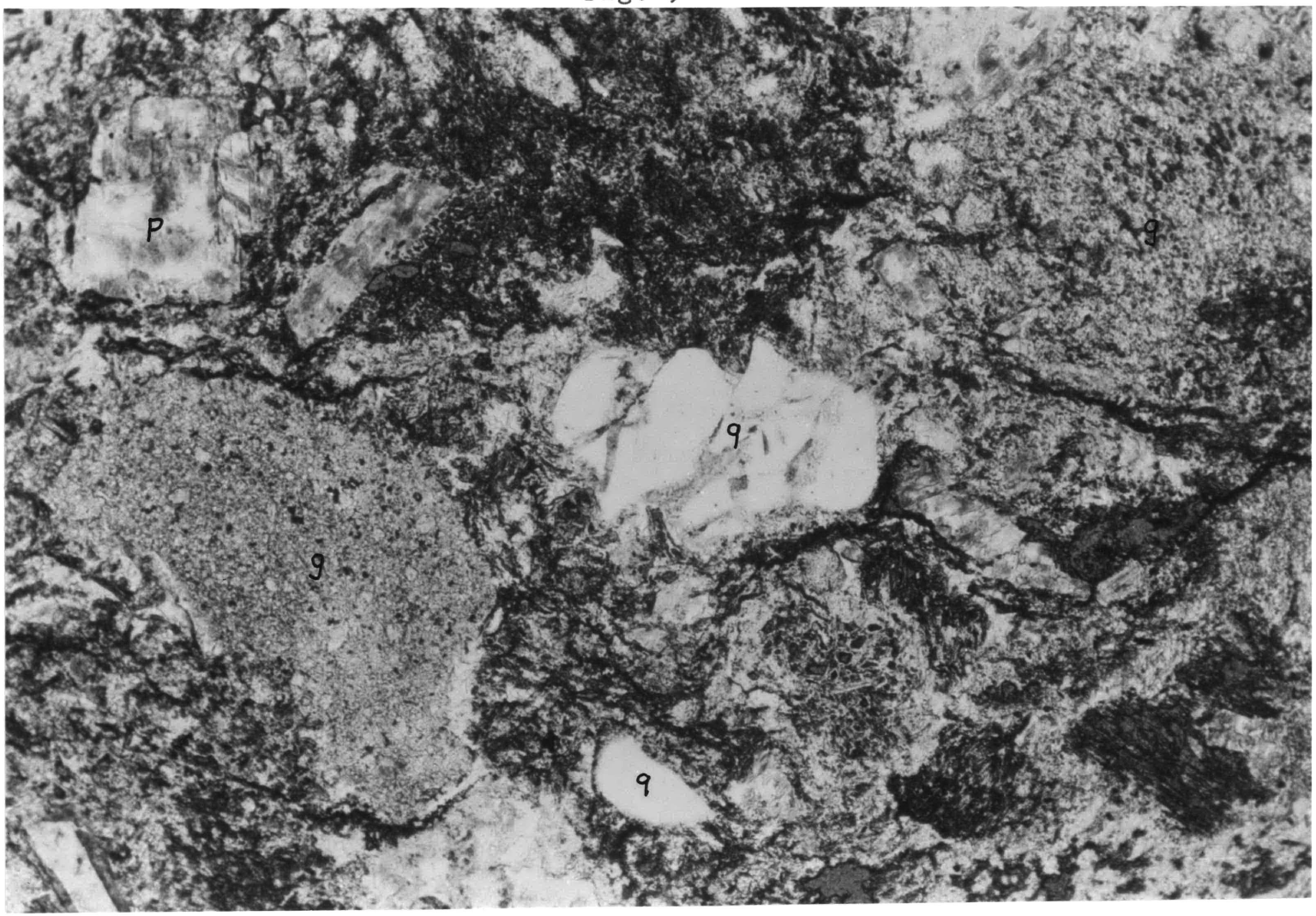


The matrix is composed primarily of interlocking, allotriomorphic grains of microcrystalline (0.002 to 0.02 mm.) quartz and feldspar (albite?) and lesser amounts of scaly chlorite. Clay minerals and occasionally carbonate rhombs and pyrite crystals are also present in the matrix. The silt-sized grains are predominantly angular fragments of quartz and plagioclase. An occasional fragment composed of microcrystalline quartz and albite(?) and chlorite is present. These fragments are thought to represent recrystallized glass.

A thin section cut from a bed grading from coarse "sandstone" to "chert" supports the writer's interpretation that the "cherts" are really fine grained, water-deposited tuffs. In this thin section (#RH-339; see p. 168 for petrographic description) the coarser material consists principally of fragments composed of allotriomorphic, interlocking grains (0.02 mm.) of quartz and feldspar (albite?) (fig. 9). These fragments appear to be vitric shards which later became recrystallized. In addition to these"vitric shards" are broken plagioclase crystals and a few quartz grains. The writer interprets all these components to be the result of explosive volcanism (either subaerial or subaqueous) which was followed by sedimentation in a marine environment. In the finer portions of the graded bed the "vitric shards" are

ig. 9. - Photomicrograph of a water-deposited tuff; Clayton Lake Member, Winterville Formation (#RH-339).
Primarily recrystallized glass fragments (g) with minor plagioclase (p) and quartz (q) grains. Plane light; X60.

Fig. 9



unidentifiable as individuals, but their characteristic texture is still present. This supports the writer's interpretation that these "cherty" rocks are water-deposited tuffs.

Radiolaria were observed in about half the thin sections of fine grained, water-depsoited tuffs. They attain a maximum diameter of 0.2 to 0.4 mm. and are just visible to the unaided eye. Thin sections reveal them to be filled with fibroradiating quartz or mosaics of microgranular quartz and occasionally minor amounts of chlorite and albite(?). Radiolaria bearing spines (fig. 10) are rare. Small, rod-shaped bodies filled with microgranular quartz (fig. 10) have been observed in thin section. These bodies represent broken radiolarian spines. Both skeletons and spines are made strikingly apparent (fig. 11) by deep etching of a fragment of water-deposited tuff in HF.

The abundance of radiolaria may be interpreted to be the result of volcanic activity which increased the Si content of seawater. The silica may have been derived from the release of silica-rich gases and solutions from a submarine eruption, or from the partial solution of vitric shards derived from either submarine or subaerial explosive volcanism. This latter explanation is the most reasonable considering the writer's interpretation

Fig. 10. - Photomicrograph of a ferruginous, radiolaria-bearing, fine grained, water-deposited tuff; Orcutt Mountain Member, Winterville Formation (#RH-799#1).
Shows radiolaria skeletons (white), some exhibiting spines. Also present are broken radiolarian spines (s). The matrix is composed of microcrystalline quartz, chlorite, clay minerals, and hematite. Plane light; X60.

Fig. 10

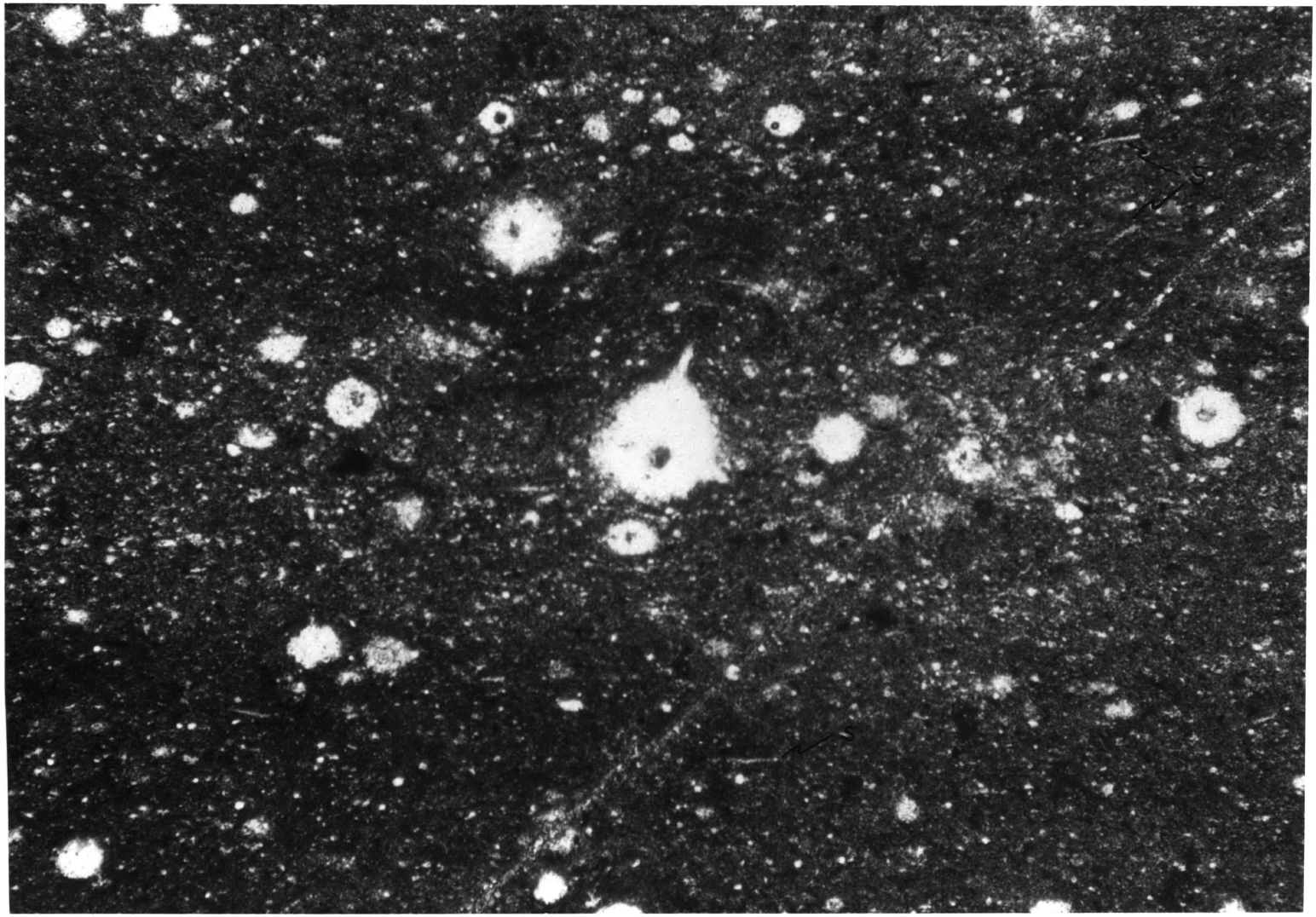
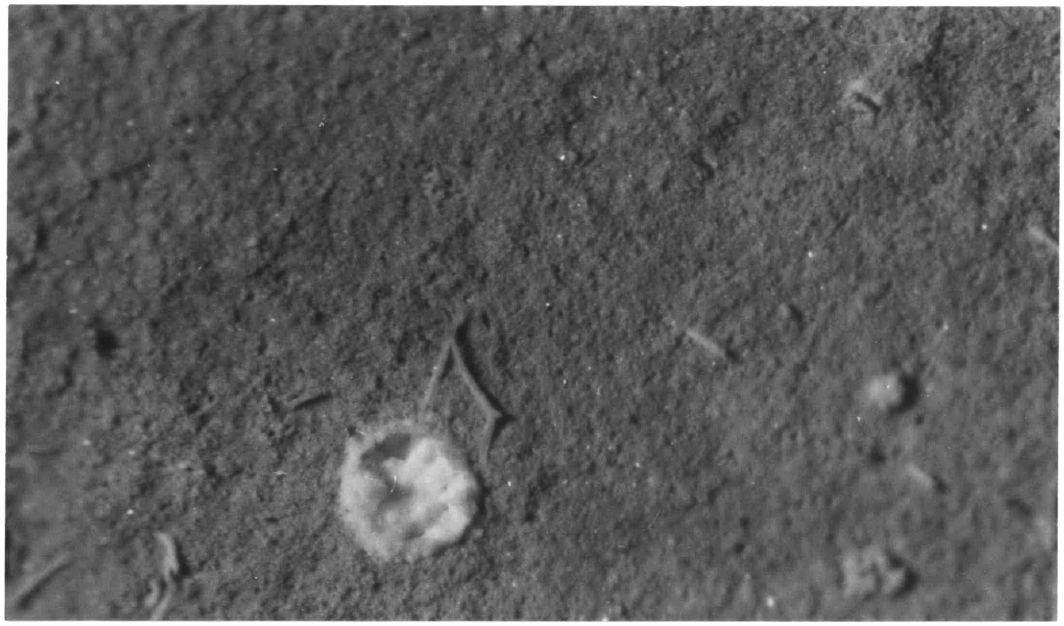
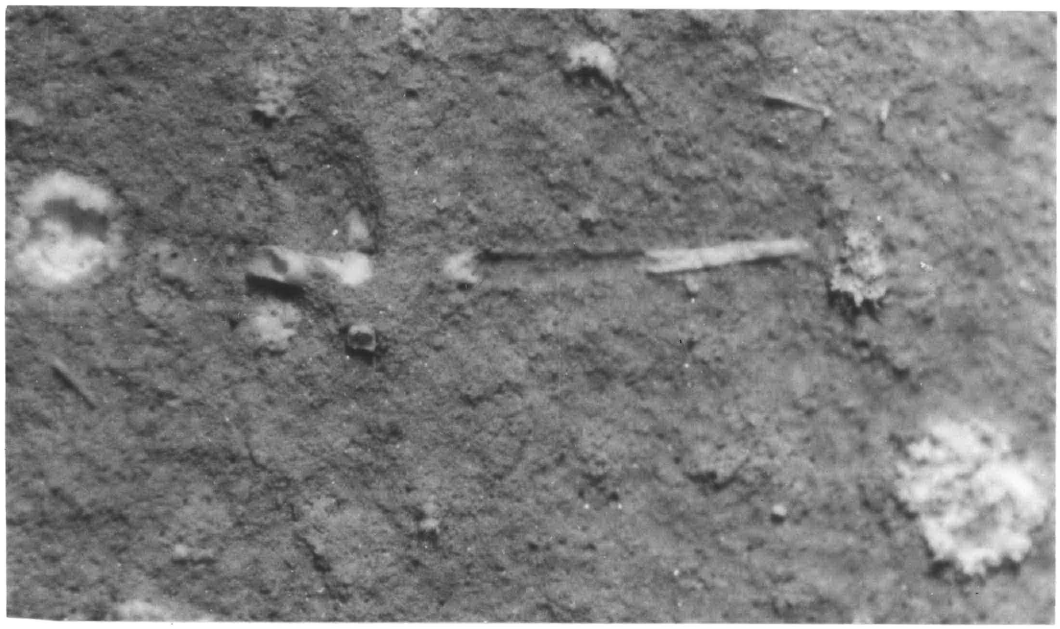


Fig. 11. - Photomicrograph of a ferruginous, radiolaria-bearing, fine grained, water-deposited tuff; Orcutt Mountain Member, Winterville Formation (#RH-799#1).
Shows radiolaria skeletons and spines. Etched in HF. Reflected light; X60.

Fig. 11





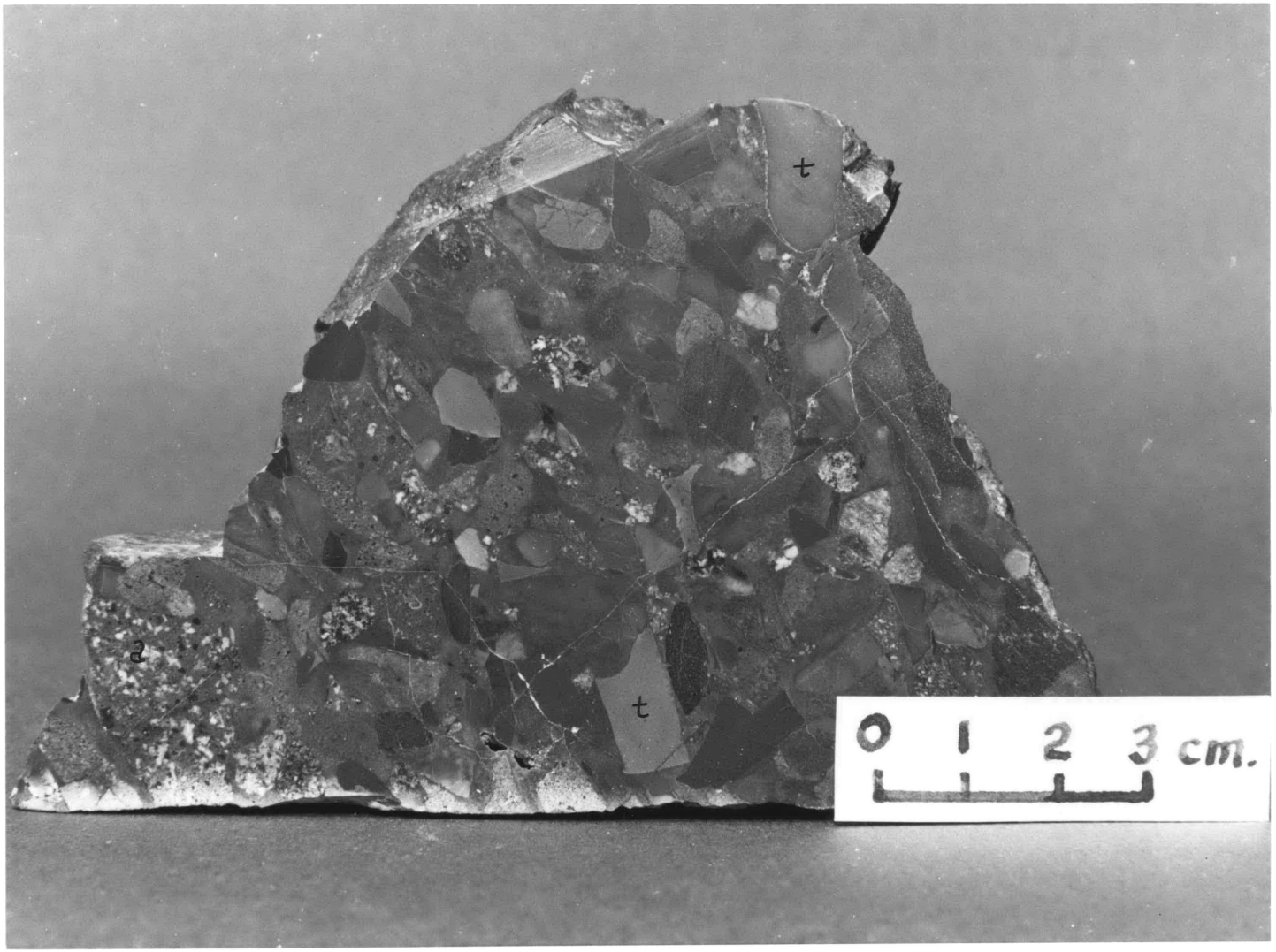
of the matrix as recrystallized vitric shards.

Red, fine grained, water-deposited tuffs are rare. They are petrographically similar to the previously described gray, water-deposited tuffs with the exception that they contain very finely divided hamatite. When grinding thin sections it was noted that these red "cherts" are much more resistant to abrasion than the other Winterville lithologies. This observation is of some significance because the overlying Ludlovian conglomerates occasionally contain abundant pebbles of red chert. A possible explanation for the hematite is that it was precipitated from waters enriched in iron due to the leaching of hot lava by seawater.

Sandstone and Conglomerate. Sandstones and conglomerates are characteristic of the Clayton Lake Member where they comprise about 20% of the exposures. They are not present in the other members of the Winterville Formation. They are gray to greenish-gray and often develop a light brown, chalky weathering rind. Those of medium sand size and finer are frequently difficult to distinguish from volcanic rocks in the field. The conglomerates (fig. 12) tend to be thick bedded, poorly sorted, and locally contain clasts as large as a foot across. The sandstones are usually poorly sorted, but moderately well sorted

Fig. 12. - Tuffaceous conglomerate; Clayton Lake Member, Winterville Formation (#RH-174).
Pebbles are water-deposited tuff (t) and andesite (a).
Matrix is tuffaceous.

Fig. 12



sandstones are not uncommon. The sandstones are generally thick bedded, but a few exhibit thin, well defined bedding. Graded bedding is present in a few sandstones. Six major rock types are present as clasts. These are: quartz; plagioclase; recrystallized glass; quartz keratophyre; andesite; and water-deposited tuff.

The quartz clasts attain a maximum diameter of 1.5 mm. Broken crystals exhibiting one or more faces separated by rounded corners are common (fig. 13 and 14). Very angular grains are also also common, whereas well rounded grains are rare. Occasionally a nearly complete crystal is found. These usually exhibit the hexagonal-bipyramidal form of high quartz. The size and shape of the grains (broken crystals with straight faces and rounded corners) are similar to that of the quartz phenocrysts in the quartz keratophyres. One need not postulate a long abrasion history to account for the well rounded grains as some of the quartz phenocrysts in the quartz keratophyres have been so intensely corroded that they are well rounded (fig. 6).

The plagioclase usually occurs as crystals, most of which are broken. They exhibit little mechanical abrasion. Explosive volcanism probably accounts for the grains with crystal forms because the plagioclase in most of the Winterville volcanics occurs as felted crystals which

Fig. 13. - Photomicrograph of a tuffaceous conglomerate; Clayton Lake Member, Winterville Formation (#RH-330). Shows a broken quartz crystal (q), a recrystallized glass fragment (g), and a fragment of fine grained, water-deposited tuff (t) exhibiting plastic deformation. The matrix is composed of recrystallized glass fragments and quartz and plagioclase grains. Plane light; X60.

Fig. 13

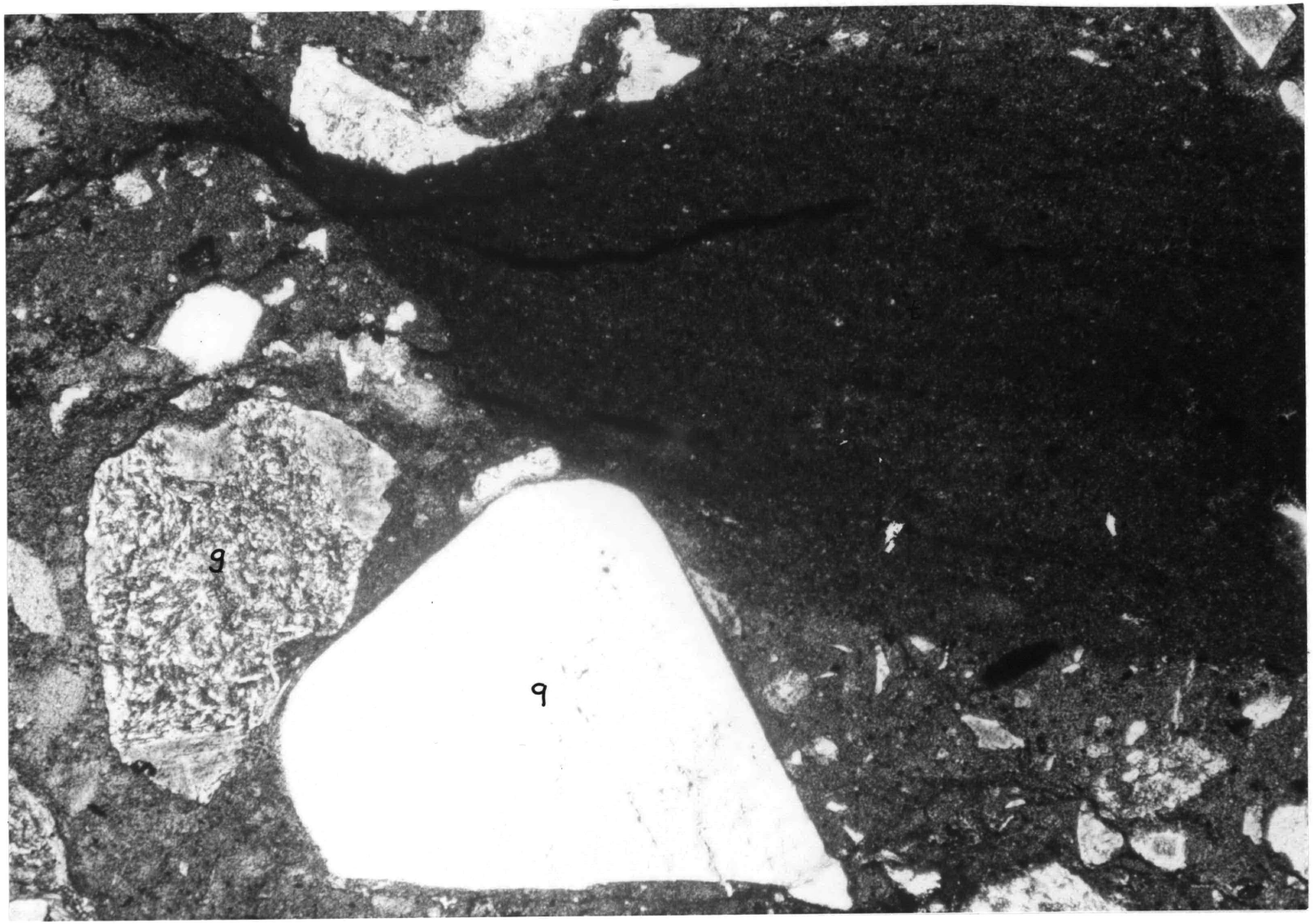
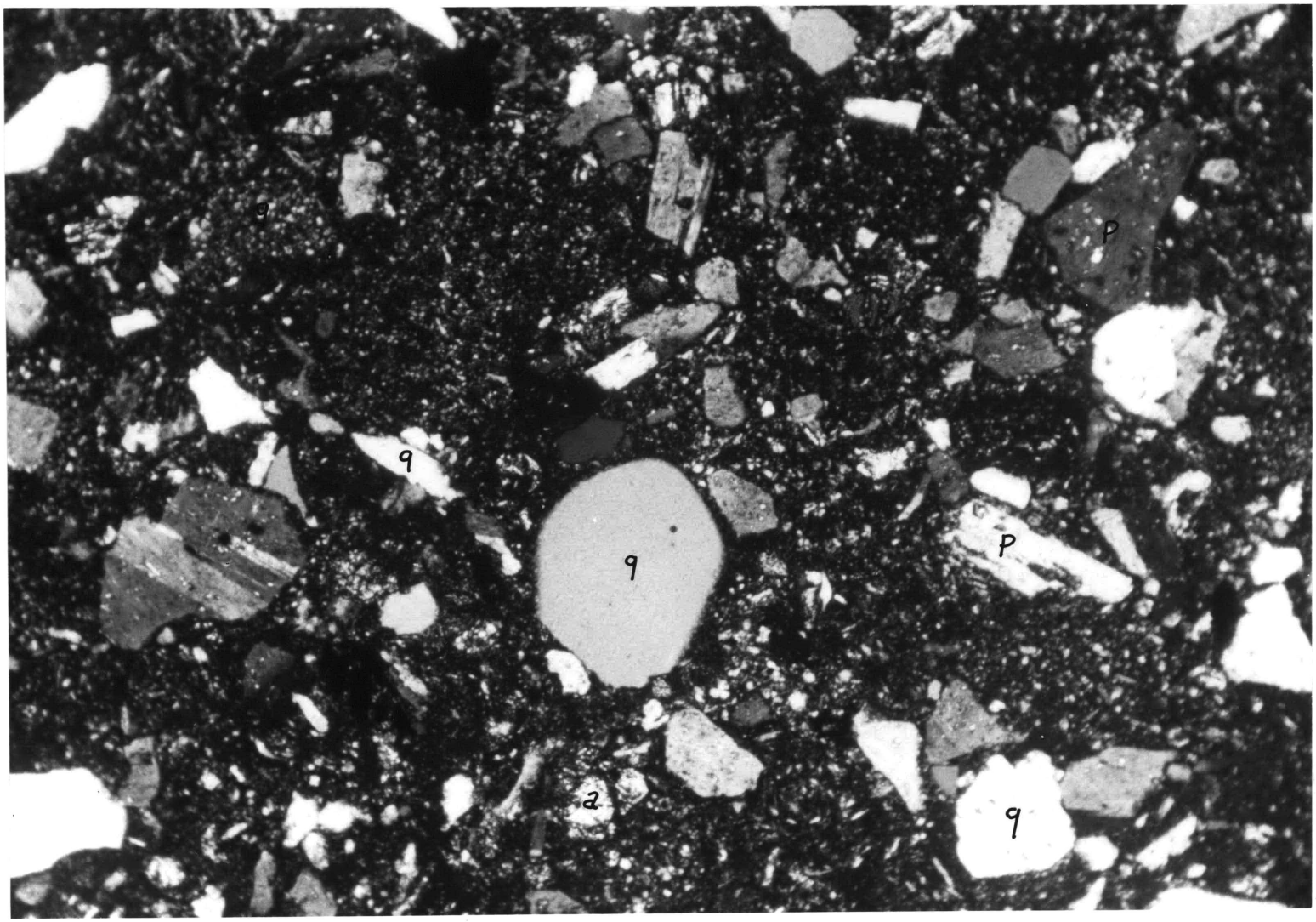


Fig. 14. - Photomicrograph of a tuffaceous sandstone; Clayton Lake Member, Winterville Formation (#RH-279).
Clasts are recrystallized glass fragments (g), broken plagioclase crystals (p), and quartz (q) which occurs as both grains showing crystal faces and very angular fragments. Also present is a minor amount of pyroxene grains (augite?)(a Crossed nicols; X60.

Fig. 14



would be difficult to remove intact through weathering processes. Those grains devoid of crystal faces could have been derived from either the weathering of volcanics or explosive volcanism.

The fragments of recrystallized glass (fig. 9, 13, and 14) are composed of microcrystalline, interlocking, allotriomorphic grains of quartz and plagioclase (albite?), patches of chlorite, and an occasional small plagioclase phenocryst.

The quartz keratophyre fragments are identical to the quartz keratophyres previously described. Its groundmass is a recrystallized glass similar to the previously described recrystallized glass fragments. In fact, these "glass" fragments are most likely fragments of quartz keratophyres which, because of their small size, do not include any phenocrysts.

The andesites are typically fine grained representatives of Winterville andesites.

The water-deposited tuff clasts are identical to those previously discussed. Radiolaria are occasionally present in these clasts. The tuff clasts often exhibit plastic deformation (fig. 13) indicating they were derived from a plastic, cohesive sediment which was probably nearly contemporaneous with deposition of the conglomerate.

The matrix is usually composed of microgranular quartz

and feldspar which is similar to the deformed, water-deposited tuff clasts (fig. 15). Thus it seems that the matrix represents reworked tuffaceous material.

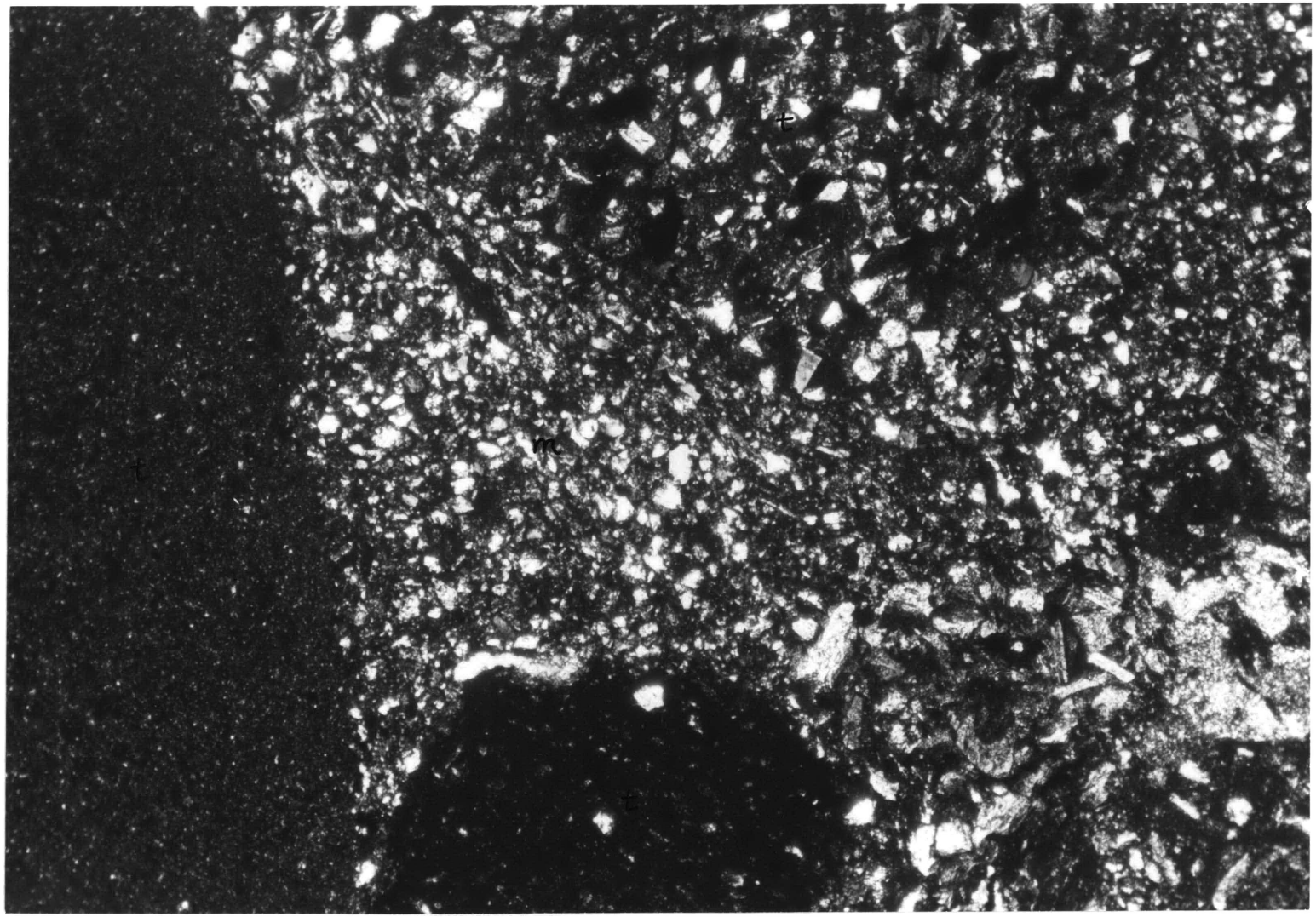
For more detailed petrographic descriptions see p. 170 - 174.

The relative abundance of the clasts mentioned above varies greatly. Any of these rock types may be a major constituent at one locality and be nearly absent at another. This probably indicates that the conglomerates and sandstones had, for the most part, local sources.

The quartz, plagioclase, andesite, "glass", and quartz keratophyre clasts, in many cases, were probably the result of explosive volcanism; however, normal weathering processes probably supplied a variable component. Some of the conglomeratic beds appear to have been deposited by subaqueous plastic mass flows (as used by Dott, 1963) in which the flow churned up the bottom incorporating large blocks of plastic, cohesive, water-deposited tuff. The thickness of these beds is not known, but evidence for a minimum thickness of 30 feet for a single bed is locally available. It is possible that some of these tuffaceous sandstones and conglomerates may be reworked hyaloclastites (as used by Silvestri, 1963).

Fig. 15. - Photomicrograph of a tuffaceous conglomerate; Clayton Lake Member, Winterville Formation (#RH-174). Shows clasts of fine grained, water-deposited tuff (t) in a matrix (m) composed of material texturally similar to one of the tuff clasts. Plane light; X60.

Fig. 15



AGE

The members of the Winterville Formation are interpreted by the writer to be roughly time equivalents. Only two fossiliferous exposures have been found in the Winterville Formation within the area investigated by the writer. Both localities (#RH-739 and #RH-790) are in the Orcutt Mountain Member and consist of graptolitic black slates and tuffaceous mudstones. As the two localities are nearly on strike and are separated by less than 1000 feet, only one collection was made. At the time of the writing determinations have not been received.

Graptolites have been found in the Winterville Formation to the northeast and east of the area investigated by the writer. Parr and Zidle (1963) discovered graptolitic slates at localities about 1 and 3 miles north of Portage. W.B.N.Berry examined collections and assigned both localities as probably belonging to zone 12 (Climacograptus bicornis zone) but possibly zone 11 (Nemagraptus gracilis zone) is also present. Coskren and Lluria (1963) discovered graptolitic slates in the Winterville Formation at two localities about 9 miles NNW of Portage. W.B.N. Berry assigned one of these to zone 12 and the other to either zone 12 or zone 11.

To the southwest, in the Spider Lake Quadrangle, Hall (1964) has described rocks lithologically similar to the Winterville Formation. These are the Bluffer Pond Formation which he describes as

> ... primarily a volcanic unit consisting of basalt and dolerite with lesser amounts of porphyritic rhyolite, rhyolite tuff (?), mafic tuff, black, carbonaceous, occasionally graptolitic chert and slate, and dark gray, tuffaceous, siliceous mudstone (Hall,1964,p.41).

and the Munsungun Lake Formation which he (p.53) describes as containing rhyolitic, pyroclastic rocks, dolerites, red cherts and slates, and mafic volcanic breccias. On the basis of graptolite determinations by W.B.N.Berry, Hall has assigned both of these units to the Middle Ordovician. More specifically, he has assigned the Bluffer Pond Formation to zone 12 and the Munsungun Lake Formation as either entirely within zone 12 or spanning the boundary between zone 12 and zone 13 (Orthograptus truncatus var. intermedius).

On the basis of the above data, the writer tentatively assigns the Winterville Formation to the Middle Ordovician.

MACHIAS RIVER FORMATION

GENERAL

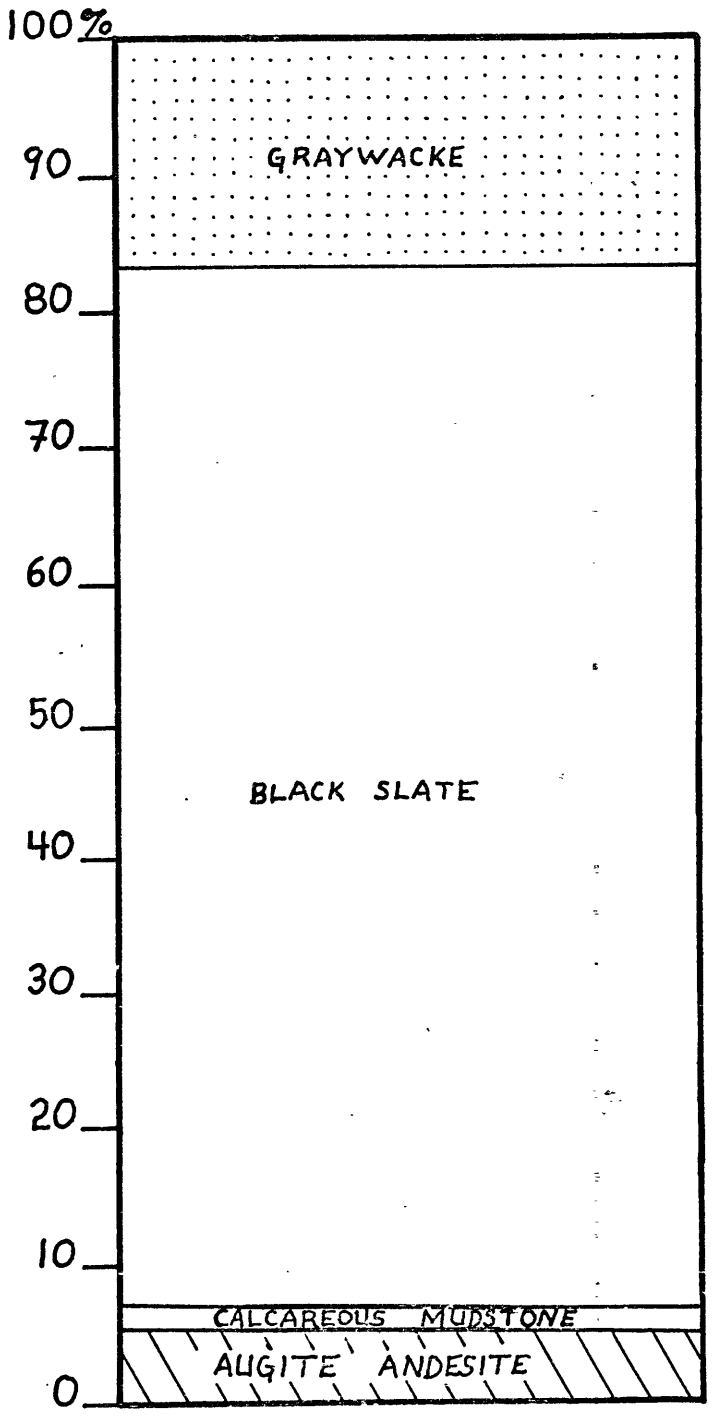
The Machias River Formation is named by the writer for the Machias River of Greenlaw Quadrangle. Black slates locally containing beds of graywacke comprise the greater part of the unit (fig. 16). An andesite similar to the augite andesite of the Winterville Formation is a minor component.

Rocks of the Machias River Formation have been found only on the western side of the Greenlaw Anticline. Good exposures of the slate is found along the tote road 1.4 road miles west of Russell Crossing. An easily located exposure of the sandstone is found on the west bank of the Machias River about 1.2 miles upstream of Russell Crossing.

The thickness of the Machias River Formation is not known due to the intense folding and the probability that its western contact is a fault contact. The writer suggests 1,000 to 2,000 feet as a reasonable estimate for the thickness of the exposed portion.

The nature of the contact between the Machias River Formation and the Winterville Formation is poorly known. Petrologic evidence suggests the Machias River Formation

FIG. 16.— DISTRIBUTION OF LITHOLOGIES IN THE MACHIAS RIVER FORMATION



(17 LOCALITIES)

overlies the Winterville Formation.

LITHOLOGY

Volcanic Rocks

Only one exposure of volcanic rocks was found. This was an augite andesite similar to those in the Winterville Formation. It is medium greenish-gray and weathers rusty brown. Augite occurs as large (to 4 mm.), relatively unaltered, allotriomorphic crystals which ophitically inclose hypidiomorphic sodic andesine laths (to 1.5 mm.). The plagioclase exhibits intense alteration to and replacement by chlorite, carbonate, and white mica. Scaly and fibrolamellar chlorite mixed with a minor amount of white mica is intersertal to the augite and plagioclase. Skeletal crystals of ilmenite partially altered to leucoxene are present. A modal analysis is as follows (#RH-742, 400 points counted):

46.0 %	plagioclase (An35)
25.75	augite
19.75	intersertal chlorite
2.75	intersertal white mica
1.25	ilmenite
4.25	sphene and leucoxene
100.00	Total

For a more detailed petrographic description see p. 176 .

This andesite may represent a subaqueous flow or a shallow intrusive of Ordovician age, but it could possibly be related to somewhat younger activity (Late Silurian or Early Devonian).

Sedimentary Rocks

Slate and graywacke comprise the sedimentary rocks of the Machias River Formation. They lack a tuffaceous component, thus contrasting markedly with the sedimentary rocks of the Winterville Formation.

Slate. The slates are dark gray to black and they often exhibit limonitic staining along joints. Very thin beds and laminae of fine sandstone are occasionally present within the slate. They are strongly folded, intensely sheared, finely cleaved, and exhibit a phyllitic sheen along the cleavage planes. Thin beds of calcareous mudstone have locally been found interbedded with the slate.

Sandstone. Graywacke has locally been found interbedded with the slate. As the exposures are small, the thickness of the sandstone beds are not known, but locally they have a minimum thickness of several feet. They are medium gray and weather light brown. A modal analysis of

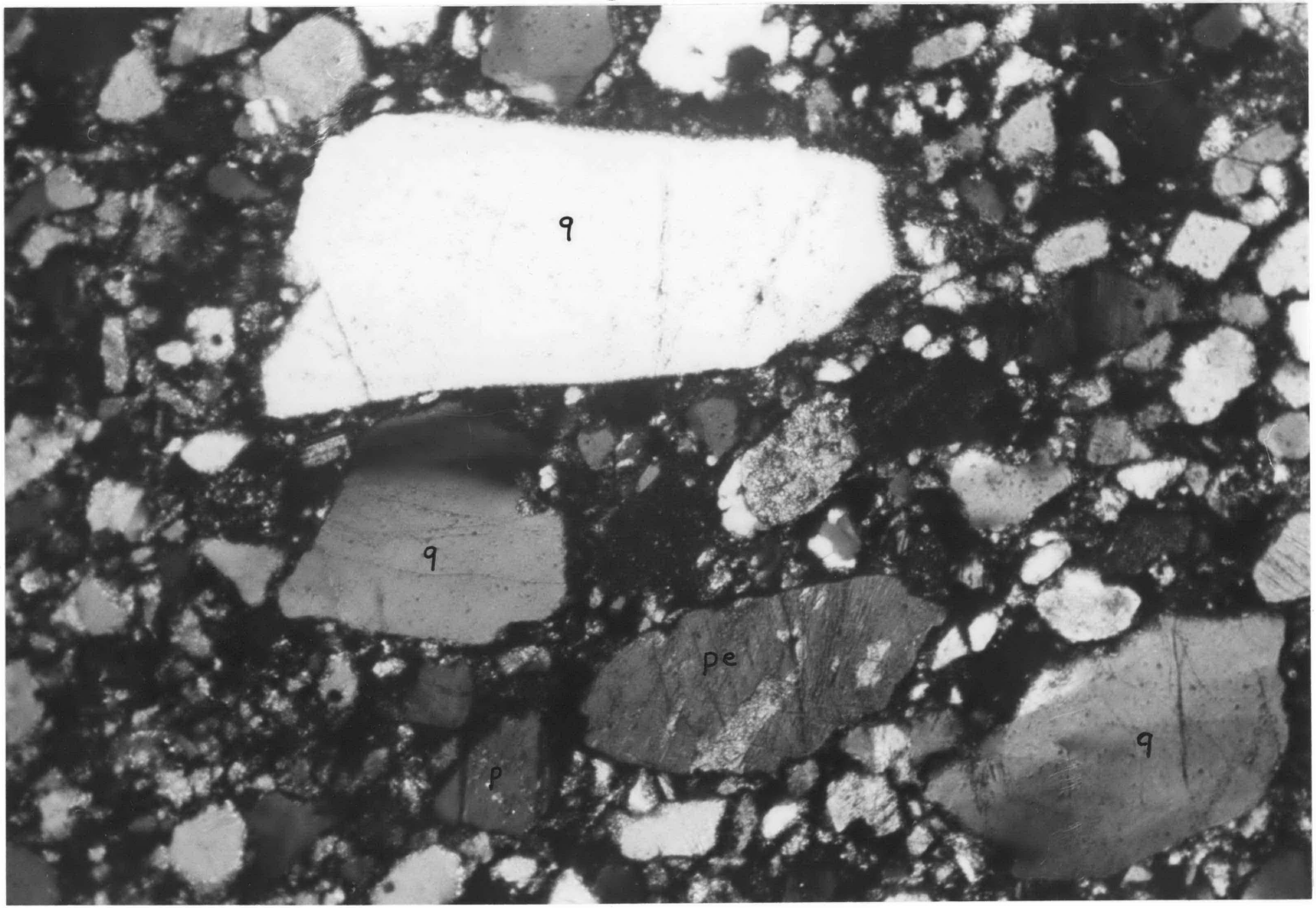
a typical graywacke is as follows (#RH-745; 400 points counted):

58.5 %	quartz
5.75	microcline
1.25	perthite
3.0	plagioclase
8.5	recrystallized glass fragments
0.5	andesite fragments
1.75	fine grained, water-deposited tuff clasts
1.0	slate chips
0.5	ilmenite(?)
0.5	carbonate
tr	detrital muscovite
18.75	matrix
100.00	Total

The quartz grains are subangular to well rounded and they occasionally exhibit two or more poorly defined crystal faces (fig. 17). The form of these grains which exhibit faces suggests they were derived from the quartz keratophyres of the Winterville Formation. The well rounded shape of some of the grains does not necessarily indicate a long abrasion history as some of the quartz phenocrysts in the quartz keratophyres have rounded forms (see p. 30). Other grains (about 20% in one thin section) contain widely scattered accicular inclusions (0.05 mm. X 0.0005 mm.). Similar inclusions have not been observed in any of the quartz of the Winterville volcanics, nor in any of the quartz clasts in the sedimentary rocks of the Winterville. This suggests that part of the quartz of the graywackes

Fig. 17. - Photomicrograph of a graywacke; Machias River Formation (#RH-745)
Shows quartz (q), plagioclase (p), and perthite (pe) grains set in a chloritic matrix. Note the shape of the large quartz grain. It is a broken crystal exhibiting two straight faces. Its shape suggests derivation from the quartz keratophyres of the Winterville Formation.

Fig. 17



was derived from a non-Winterville source.

The feldspars present are plagioclase, microcline, and perthite. The absence of microcline and perthite in the Winterville volcanics indicates a non-Winterville source for these components. The presence of microcline and perthite and the absence of tuffaceous material are the major differences between these graywackes and the sandstones of the Winterville Formation.

Fragments of recrystallized glass (not vitric shards), andesite, and fine grained, water-deposited tuff are minor constituents. They are all typical Winterville lithologies.

The matrix is composed largely of chlorite along with a small amount of white mica.

The writer believes the slate was deposited by suspended transport in relatively deep water (below wave base). This was interrupted by turbidity currents carrying sand sized material. This sand was derived from two sources. Erosion of Winterville lithologies supplied the fragments of recrystallized glass, andesite, and water-deposited tuff, and part of the quartz and plagioclase. The remainder of the quartz (especially those grains containing accicular inclusions), all of the microcline, perthite, and detrital muscovite, and possibly some of the plagioclase was derived from a second source - either an igneous (granitic) body

or sedimentary rocks derived from such a body.

AGE

Fossils have not been found in the Machias River Formation. In the graywackes, the presence of water-deposited tuff clasts similar to those in the Winterville Formation suggest it may be contemporaneous with part of the Winterville, or more likely is younger than the Winterville. The quartz grains showing remnants of the hexagonal-bipyramidal form typical of the quartz phenocrysts in the quartz keratophyres of the Winterville Formation also suggest a Winterville or post-Winterville age.

The absence of tuffaceous material in the Machias River Formation, considered in light of the abundance of tuffaceous material in the Winterville Formation, suggests a non-Winterville age.

The rusty weathering of the Machias River slate suggests they are pre-Ludlovian because this property is not well developed in the slate and mudstone of Ludlow age or younger. This property is characteristic of the slate in the Winterville Formation.

Llandoverian and Wenlockian rocks are absent to the southwest (Hall,1964) and to the north and northeast (Parr and Zidle,1963; Coskren and Lluria (1963); and

Hayes and Nalbandian,1963).

For the reasons given above, the Machias River Formation is tentatively assigned to the upper Middle or Upper Ordovician.

SILURIAN ROCKS

Rocks of Silurian age have been divided into two formations, the Carr Pond Formation and the Mud Pond Formation. They vary greatly in thickness. Their maximum thickness in the area investigated may be nearly 5,000 feet. At other places within the map area, Silurian rocks are absent and Devonian rocks lie directly upon Ordovician rocks. The Carr Pond Formation is a near-shore facies consisting of varying amounts of conglomerate, limestone, and volcanics. It grades both laterally and upward into mudstones of the Mud Pond Formation which represent a deeper-water, further offshore depositional environment.

The Carr Pond Formation lies unconformably upon the Ordovician Winterville Formation. The unconformity is exposed on a ridge top (#RH-780) about 1 mile northwest of Greenlaw Crossing. When the Machias River Formation is present, the Carr Pond Formation is believed to lie unconformably upon it; however, the only place in the map area where they are in contact seems to be faulted. The upper contact of the Silurian rocks seems to be a disconformity in places; however, it is not known whether this disconformity is present over the entire map area. This problem is discussed further on p. .

The age of the Carr Pond Formation is well established as Silurian, probably Ludlovian in whole, and definitely Lower Ludlovian in part. The Mud Pond Formation is believed to be time equivalent of the Carr Pond Formation.

CARR POND FORMATION

GENERAL

The Carr Pond Formation is named by the writer for Carr Pond (T13 R8) of the Winterville Quadrangle. Conglomerate, sandstone, calcareous sediments, and volcanics are the major rock types. However, all of these are not usually present in a given area. The Carr Pond Formation varies greatly in lithology and thickness. The formation has been subdivided into six members by the writer. The nature of these members is illustrated in fig.18 and 30 .

Because of the marked lithologic variation, no single section can be designated as typical of the entire unit. Perhaps the best section is displayed in the woods to the north of Carr Pond. There conglomerate, sandstone, limestone, and volcanics are well exposed. As this section is not readily accessable, the writer suggests a series of outcrops where typical rock types can be seen.

FIG. 18. — DISTRIBUTION OF LITHOLOGIES IN THE CARR POND FM.

MEMBER	THICKNESS (GROSS APPROXIMATION)	# of OUTCROPS	RELATIVE ABUNDANCE OF LITHOLOGIES
MEMBER #1	0 – 1500 ft.	80	ANDESITE & BASALT (?) · CONGLOMERATE (RED PHASE) · CONGLOMERATE (GRAY PHASE) · V.C. & C. SANDSTONE · M. Ss. · MUDSTONE · LIMY MUDSTONE · LIMY Ss. · SILTY LIMESTONE
MEMBER #2	4000 (?)	113	CONGLOMERATE (GRAY PHASE) · V.C. & C. SANDSTONE · M. Ss. · F. Ss. · MUDSTONE
MEMBER #3	700 (?)	8	ANDESITE & BASALT (?) · MUDSTONE · SILTY LIMESTONE
MEMBER #4	1500	25	ANDESITE & BASALT · VITROPHYRE · CONGLOMERATE · F. Ss. · RED SLATE · LIMY MUDST. · LIMY Ss. · SILTY Ls.
MEMBER #5	500 (?) - 1000	16	ANDESITE & BASALT (?) · VITROPHYRE
MEMBER #6	0 - 400 (?)	26	TUFF (?) · MUDSTONE · SILTY LIMESTONE

0 10 20 30 40 50 60 70 80 90 100

Typical conglomerate is well exposed along the American Realty Road at the dam on Big Machias Lake. Readily accessable exposures of limestone and volcanics are found along the road to Milliard's Camp.

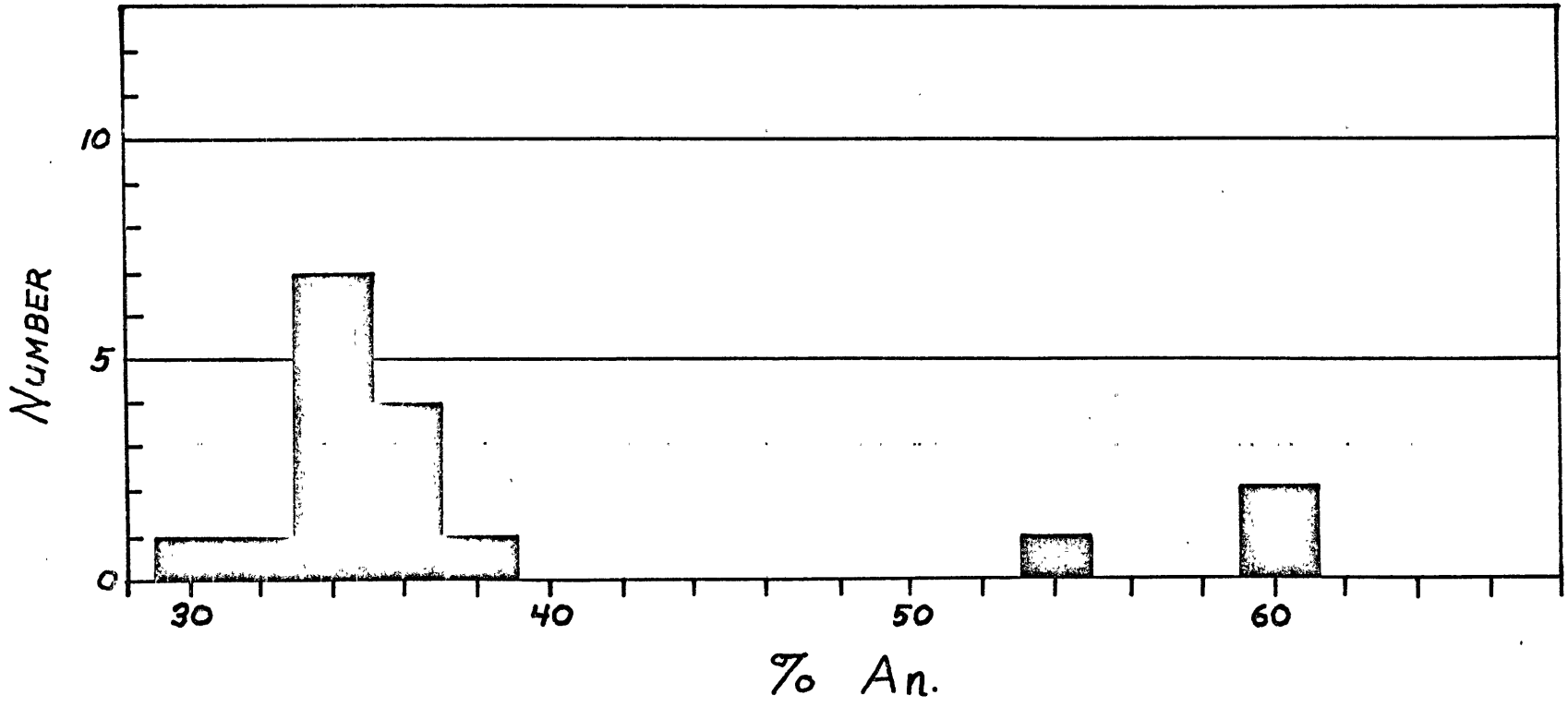
LITHOLOGY

Volcanic Rocks

Volcanics are nonuniformly distributed throughout the Carr Pond Formation (fig.18 and30.) They are major components of some members and are absent in others. They can be divided into two types - 1. andesite and basalt, and 2. vitrophyric quartz keratophyre. The first of these are the most abundant; however, locally vitrophyres are predominant.

Andesite and Basalt. Determinations of the plagioclase composition on 17 samples reveal andesite to be more abundant than basalt (fig.19). The andesite is indistinguishable from basalt is hand sample and in thin section the only apparent difference is the plagioclase composition. They are similar to corresponding lithologies in the Winterville Formation, in fact, many are indistinguishable from Winterville rocks. Some, however, differ slightly

FIG. 19.— DISTRIBUTION OF PLAGIOCLASE COMPOSITIONS IN ANDESITES AND BASALTS OF THE CARR POND FORMATION.



from their Winterville counterparts. These differences are discussed below.

The andesites and basalts are generally light to dark gray, greenish-gray, or green. Some exhibit a reddish-brown coloration which is due to hematitic material. This hematitic material may be evenly distributed throughout the rock, or, where brecciated, it may be concentrated in the interfragmental matrix. This reddish-brown coloration is a valuable criterion for distinguishing these rocks from similar lithologies in the Winterville Formation.

They are sometimes porphyritic and are often amygdaloidal. Volcanic breccias are locally abundant. North of Carr Pond about one-half of the volcanics are volcanic breccias and the fragments often attain dimensions of several inches. In Member #4 autobrecciated volcanics are abundant; however, their brecciated nature is usually detectable only in a sawed specimen. Both of these volcanic breccias commonly have hematitic material concentrated in the interfragmental matrix.

Plagioclase, chlorite, and occasionally augite are the major minerals present in the andesites and basalts. Quartz, sphene, leucoxene, ilmenite, secondary white mica, and hematite may be present in lesser amounts. Modal analysis of four andesites is given in fig.20.

Fig. 20. - Modal[1] composition of andesites from the Carr Pond Formation

Lithology	Amygdaloidal Andesite	Andesitic Volcanic Breccia	Amygdaloidal Andesite	Augite Andesite
Sample #	RH-75#2	RH-77#1	RH-215E	RH-312
Plagioclase	47.25	37.25	58.75	50.5
Augite				22.25
Intersertal chlorite	15.75	61.5(3)	19.25	17.5
Ilmenite				1.25
Sphene and leucoxene	19.25(2)		15.25	7.75
Secondary carbonate	6.25		2.75	
Secondary quartz	1.25			
Amygdular chlorite	2.75	0.75	3.50	0.75
Amygdular carbonate	6.25	0.25	0.5	
Amygdular quartz	1.0	0.25		

1. 400 points counted
2. includes intermixed, finely divided carbonate
3. both intersertal and interfragmental, includes finely divided hematite

The plagioclase of the andesites ranges from sodic to intermediate andesine, whereas the few determinations on basalts were calcic labradorite (fig.19). The plagioclase laths are often charged with specks of chlorite, white mica, and carbonate and they often exhibit alteration to or replacement by chlorite and carbonate.

Augite, when present, usually ophitically or sub-ophitically incloses the plagioclase. It tends to be clear and unaltered, often in marked contrast with the plagioclase.

Scaly and flaky chlorite is present intersertal to the plagioclase.

Quartz is occasionally present in the andesites as small, allotriomorphic grains. It is never abundant; at most it accounts for only a few per cent of the rock.

Ilmenite is often present as skeletal crystals which are often altered to sphene or leucoxene. Small, leucoxene-coated sphene grains similar to those found in the andesites and basalts of the Winterville Formation are common.

For petrographic descriptions of typical andesites see p.179-182.

Vitrophyric Quartz Keratophyre. Vitrophyric quartz keratophyre is abundant only in Member #5 where they comprise about 75% of the observed outcrops. Other than one exposure in Member #4, they are absent from the other members.

They range in color from nearly white to light green, light to medium bluish-gray, and medium to dark brown and purplish-brown. A thick (5mm.), chalky, white weathering rind often develops upon weathering.

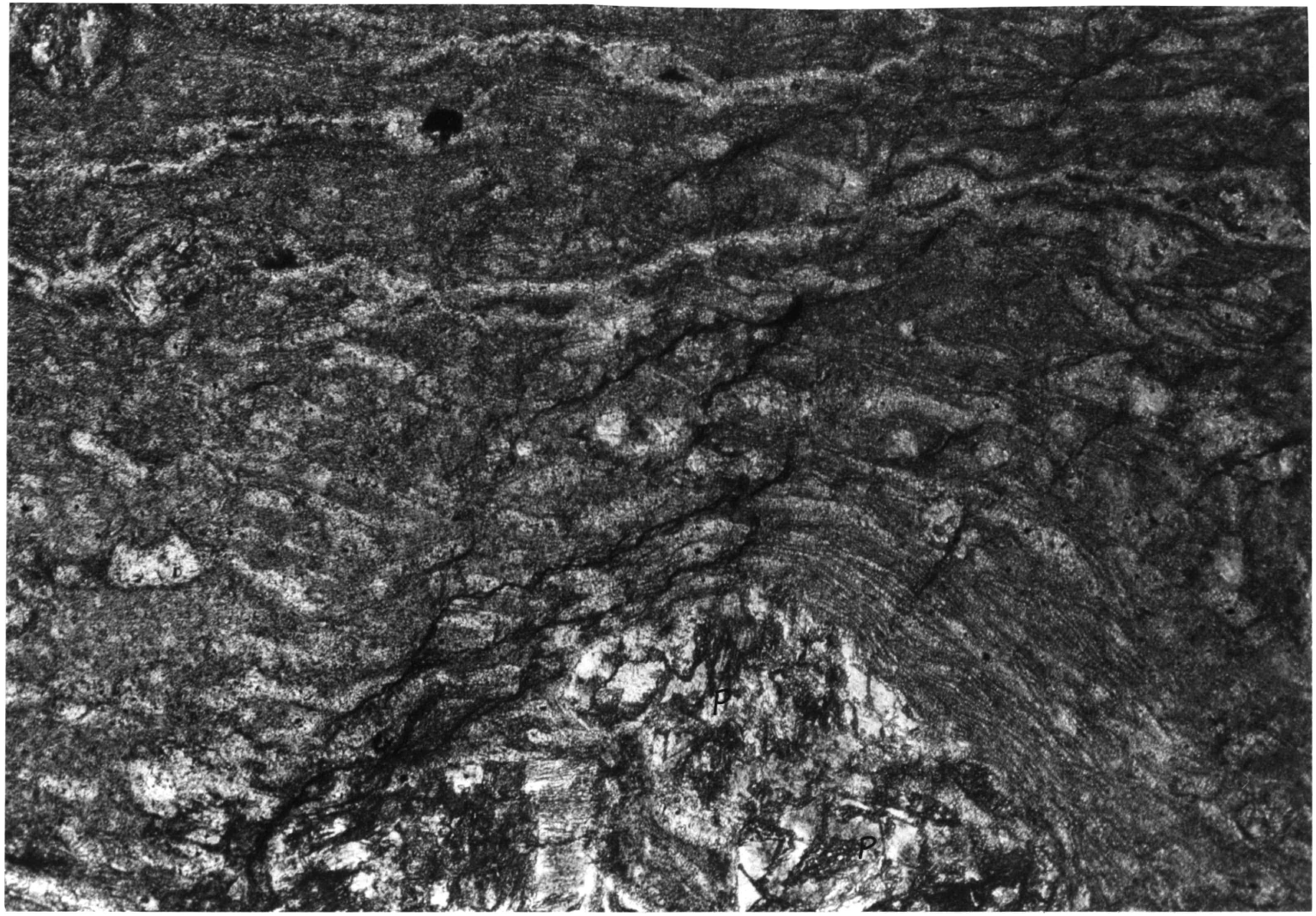
In thin section plagioclase phenocrysts (intermediate andesine) 1 to 3 mm. long lie in a groundmass of interlocking, allotriomorphic quartz and albite(?). The phenocrysts are often broken, charged with specks of chlorite, and slightly to intensely altered to or replaced by carbonate, white mica, and clay minerals. The writer interprets the groundmass as recrystallized glass. A characteristic feature of this groundmass is the well developed flow structure displayed in thin section (fig.21) and occasionally in hand sample. For petrographic descriptions of representative vitrophyric quartz keratophyres see p.183 and 184.

Sedimentary Rocks

Conglomerate, sandstone, and limestone are the major

Fig. 21. - Photomicrograph of a vitrophyric quartz keratophyre; Member # 4, Carr Pond Formation (#RH-211) Intensely altered plagioclase phenocrysts (p) lie in a groundmass of microcrystalline, interlocking, allotriomorphic grains of quartz and albite (?). This groundmass exhibits well developed flow structure. X60.

Fig. 21



sedimentary rocks present in the Carr Pond Formation. They may be present in nearly equal amounts as is the case north of Carr Pond, but more often, either conglomerate and sandstone or only limestone is present in a given area.

Conglomerate. Conglomerate is the predominant sedimentary rock in Members #1 and #2. In hand sample they may be divided into two main types on the basis of color. One is greenish-gray and the other has a distinct reddish-brown color. When both are present in the same area, the "red phase" underlies the "gray phase". The conglomerate is usually thickly bedded and in larger outcrops it is often observed to grade into sandstone. It is generally poorly sorted. In most outcrops the maximum diameter of the pebbles is between ½ and 1 inch; however, outcrops containing clasts several inches in diameter are not uncommon, and near the base of the unit boulders up to 2 feet in diameter are locally present.

The pebbles are predominately quartz keratophyre, andesite, water-deposited tuff, and tuffaceous sandstone. Quartz diorite pebbles are occasionally present. Modal compositions of several conglomerates and very coarse sandstones are presented in fig.22.

Fig. 22. - Modal[1] composition of conglomerates and v.c. sandstones from the Carr Pond Fm.

Lithology	Cong. red phase	Cong. gray phase	Pebbly Ss. gray phase	V.C.Ss. gray phase
Sample #	RH-756	PF-211	RH-81	RH-241
Clasts:				
water-deposited tuff and tuff. ss.	21.25	31.75	9.25	8.75
andesite	17.25	15.5	4.75	17.5
quartz keratophyre	10.75	32.25	70.75	20.5
quartz	6.5			25.0
plagioclase	7.0			8.5
quartz diorite and myrmekite	8.5			1.75
slate chips	3.75			3.75
detrital ilmenite				0.25
carbonate[2]	12.75			1.25
Matrix[3]	12.25	20.5	15.25	12.75

1. 400 points counted
2. includes both fossil fragments and carbonate matrix
3. predominantly chlorite, but includes some carbonate

The quartz keratophyre pebbles are typical representatives of this lithology in the Winterville Formation. They consist of microcrystalline, interlocking, allotriomorphic grains of quartz and albite(?) and occasionally they contain a quartz or albite phenocryst.

The andesite pebbles are nearly all fine grained lithologies similar to Winterville andesite, but some of them could have derived from contemporaneous Silurian volcanics. Augite is notably absent in these pebbles. This is possibly a reflection of lower resistence to weathering.

The water-deposited tuff ("chert" in the hand sample) and tuffaceous sandstone pebbles belong to typical Winterville rock types. They are most commonly red, gray, or green. It is these red "chert" pebbles that impart the red coloration to the "red phase" conglomerate. Radiolarian skeletons are occasionally present in these red "chert" pebbles.

The quartz diorite pebbles consist mainly of quartz and plagioclase (andesine) and they often exhibit a myrmekitic texture. They resemble the quartz diorite found in the Winterville Formation (see p. 28).

Sand sized grains of quartz and plagioclase are abundant. The similarity of shape and size of these quartz grains (fig.23) with the quartz phenocrysts in the

Fig. 23. - Photomicrograph of coarse grained sandstone; Member # 2 Carr Pond Formation (#RH-232)
Grains of quartz (q), plagioclase (p), myrmekite (m), and quartz keratophyre (qk) lie in a chloritic matrix. Note the quartz grain in the lower left exhibiting crystal outlines similar to the quartz phenocrysts found in the quartz keratophyres of the Winterville Formation. X60.

Fig. 23

quartz keratophyres of the Winterville Formation, together with the abundance of quartz keratophyre pebbles in the conglomerate, suggest that much of the quartz was derived from erosion of the Winterville Formation.

Microcline and perthite grains are occasionally present. This indicates a contribution from a granitic source or from a sediment derived in part from a granitic source.

The matrix is generally rich in chlorite and often contains a small amount of carbonate. Hematite is occasionally abundant in the matrix of the reddish-brown conglomerate. Very rarely the matrix appears to have a tuffaceous component; however, it is never as tuffaceous as the conglomerates of the Winterville Formation.

For more detailed petrographic descriptions of these conglomerates see p. 185- 189.

Several criterion are useful for distinguishing these conglomerates from the conglomerates of the Winterville Formation. The most notable difference is that the Winterville conglomerates all have a decidedly tuffaceous matrix, whereas the Carr Pond conglomerates only rarely have a matrix which is even slightly tuffaceous. Plastically deformed water-deposited tuff clasts are present in many of the Winterville conglomerates. The

clasts of water-deposited tuff found in the Carr Pond conglomerates are not plastically deformed. In general the Winterville conglomerates are very poorly sorted, whereas the Carr Pond conglomerates tend to be poorly or moderately sorted. Clasts of myrmekite or myrmekitic quartz diorite are occasionally present in the Carr Pond conglomerates, but have not been observed in the Winterville conglomerates.

Sandstone and Mudstone. Sandstone is abundant in Members #1 and #2. They are most commonly found interbedded with the "gray phase" conglomerate. They are usually coarse grained, however medium and fine grained sandstones are common. They are generally greenish-gray to gray and develop a light brown, chalky weathering rind. The clasts are the same as those composing the conglomerates. The coarse grained sandstones tend to be subgraywackes and lithic graywackes (after Pettijohn, 1957) and the finer ones are lithic graywackes.

Thin beds of mudstone are rarely interbedded with the conglomerate. Greater amounts of mudstone are found west of Rowe Lake in Member #2. These occasionally contain a conglomerate and coarse grained sandstone bed and commonly contain graded sandy laminae.

Calcareous Sedimentary Rocks. When averaged over the entire Carr Pond Formation, silty limestones are not abundant. They are, however, locally abundant and of special interest because they are often fossiliferous. They are generally medium gray to bluish-gray and tend to develop a thick (1 cm.), punky weathering rind. They are often massive in the hand sample, but occasionally bedding is poorly and rarely is well developed. Some are nonfossiliferous, others contain a few scattered fossils, while others are richly fossiliferous. Crinoid columnals are usually the most abundant fossils, brachiopods and corals are occasionally abundant, and trilobites and bryozoa are occasionally present. For a complete fossil listing see p. 131-138. Limestone breccias (fig.24) composed of angular intraclasts an inch or more in diameter have been found at several localities.

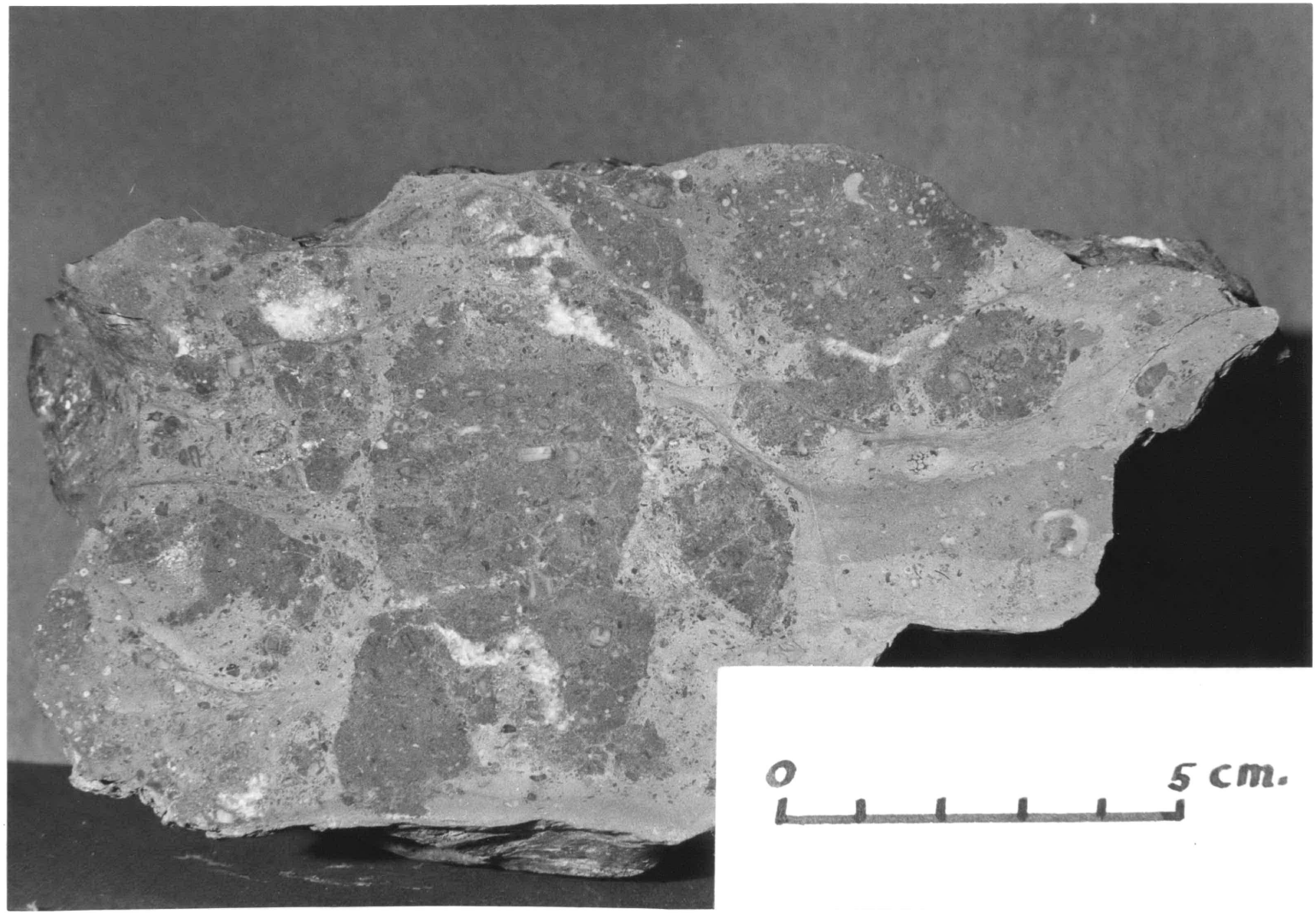
Calcareous mudstone and calcareous siltstone are minor rock types often found associated with limestone.

AGE

Sixteen fossil localities have been found in the Carr Pond Formation by the writer and by Friedberg and Petersen (1964). Collections from these localities have been examined by A.J.Boucot or W.A.Oliver. Most of the fossils

Fig. 24. - Limestone breccia; Member # 4, Carr Pond Formation (#RH-215)

Fig. 24



are found in silty limestones; however one conglomerate and two mudstones have yielded identifiable forms. Crinoid columnals, corals, and brachiopods are the most abundant fossils. Trilobites, bryozoa, and other forms are occasionally present. For outcrop locations, lithologies, and complete fossil listings see Appendix I. The fossils indicate the Carr Pond Formation is Silurian, probably Ludlovian in whole, and definitely Lower Ludlovian in part.

To the southwest in the Spider Lake Quadrangle, Hall (1964) has mapped a sequence of Ludlovian rocks. He designated these as the East Branch Group, and subdivided it into a basal volcanic unit, the Carpenter Pond Formation; a conglomerate unit, the Chandler Pond Formation; and a sedimentary unit, the Third Lake Formation. The East Branch Group is the same age as and lithologically similar to the Carr Pond Formation. The writer considers it to be in part and probably in whole correlative with the Carr Pond Formation. Members #1 and #2 of the Carr Pond Formation seem to be lithologically correlative with the Chandler Pond Formation; Member #4 seems to be lithologically correlative, at least in part and possibly in whole, with the Carpenter Pond Formation; and Member #6 seems to be lithologically correlative with the Third Lake Formation. The writer has not been able to correlate

Members #3 and #5 of the Carr Pond Formation specifically with one of Hall's formations.

MUD POND FORMATION

GENERAL

The Mud Pond Formation is named by the writer for Mud Pond (T13 R7) of the Winterville Quadrangle. It is an Upper Silurian unit composed predominantly of mudstone. It is interpreted as the offshore equivalent of the Carr Pond Formation, with the contact being gradational and interfingering. The thickness of the Mud Pond Formation is not known as the contact with the overlying Devonian strata has not been recognized. It probably attains a thickness of several thousands of feet; however, it is probably quite variable. Rocks typical of the unit and the nature of the contact is best seen in the vicinity of Mud Pond. The unit is believed to continue southward along the east flank of the Greenlaw Anticline. Some of the mudstones and sandstones on Chase Brook Ridge and Freeman Ridge may also belong to this unit. However, as the writer has not been able to find any lithologic difference between the mudstone of the Mud Pond Formation and that of the Fox Brook Formation, and as fossils have not been found near Freeman Ridge or Chase Brook Ridge, these mudstones cannot be definitely assigned to one formation rather than the other.

LITHOLOGY

The Mud Pond Formation consists wholly of mudstone which may locally contain interbedded coarse to fine grained graywacke. The mudstones are gray, greenish-gray, or brownish-gray and they typically lack the well developed rusty weathering characteristic of the Ordovician slate. Thin sand laminae are occasionally present in the mudstone, but more often they appear to be absent. They are moderately to strongly cleaved, the degree of cleavage being a function of the grain size.

The sandstones a re generally gray, fine to medium grained graywackes. Coarse grained sandstones are present near the base of the formation and they resemble the sandstone in the Carr Pond Formation.

AGE

Fossils have not been found in the Mud Pond Formation. However, it is considered to be the offshore equivalent of the Carr Pond Formation whcih is well established as Ludlovian.

DEVONIAN ROCKS

The youngest rocks in the area investigated are of Lower Devonain age. They have been divided into three formations: a basal unit, the Moosehorn Stream Formation; a mudstone unit, the Fox Brook Formation; and a slate unit, the Seboomook Formation. The Moosehorn Stream Formation and the Fox Brook Formation are new formational names introduced herein by the writer. Together they are equivalent to the informal term "Nixon Formation" used by E.Mencher (personal communication) and his students (Friedberg and Petersen,1964; Coskren and Lluria,1963; Hayes and Nalbandian,1963; and Parr and Zidle,1963); however, they differ somewhat from the typical "Nixon" to the northeast. The differences are mostly in the mudstones and they will be discussed in the section on the Fox Brook Formation. The Seboomook Formation is referred to an existing unit used elsewhere in Maine (Perkins,1925; Boucot,1961).

The thickness of the Devonian rocks is poorly known as the mudstone and slate tends to be strongly folded and lacks marker horizons. The writer feels that the composite thickness of Devonian rocks in the area is at least 10.000 feet and possibly is much greater.

Locally there is evidence that the Devonian rocks

disconformably overlie Silurian rocks. It is not known whether the Silurian-Devonian contact is a disconformity throughout the entire map area or only locally. In places Devonian rocks overlie Ordovician rocks of the Winterville Formation with an angular unconformity.

The Moosehorn Stream Formation is a thin silty limestone unit which locally contains conglomerate. It is a shallow-water, near-shore facies.

The Moosehorn Stream Formation grades both upward and laterally into the mudstones of the Fox Brook Formation. The Fox Brook Formation probably represents deposition in a further offshore, deeper-water environment. Locally the Moosehorn Stream Formation seems to be absent and the base of the Devonian section starts with the Fox Brook Formation.

The Fox Brook Formation seems to grade both laterally and upward into the slate of the Seboomook Formation.

The relationship among the various Devonian units is illustrated in fig. 25 and 26.

FIG. 25. — STRATIGRAPHIC SECTION THROUGH THE SILURIAN AND PART OF THE DEVONIAN ON THE NORTH AND EAST FLANK OF THE GREENLAW ANTICLINE.

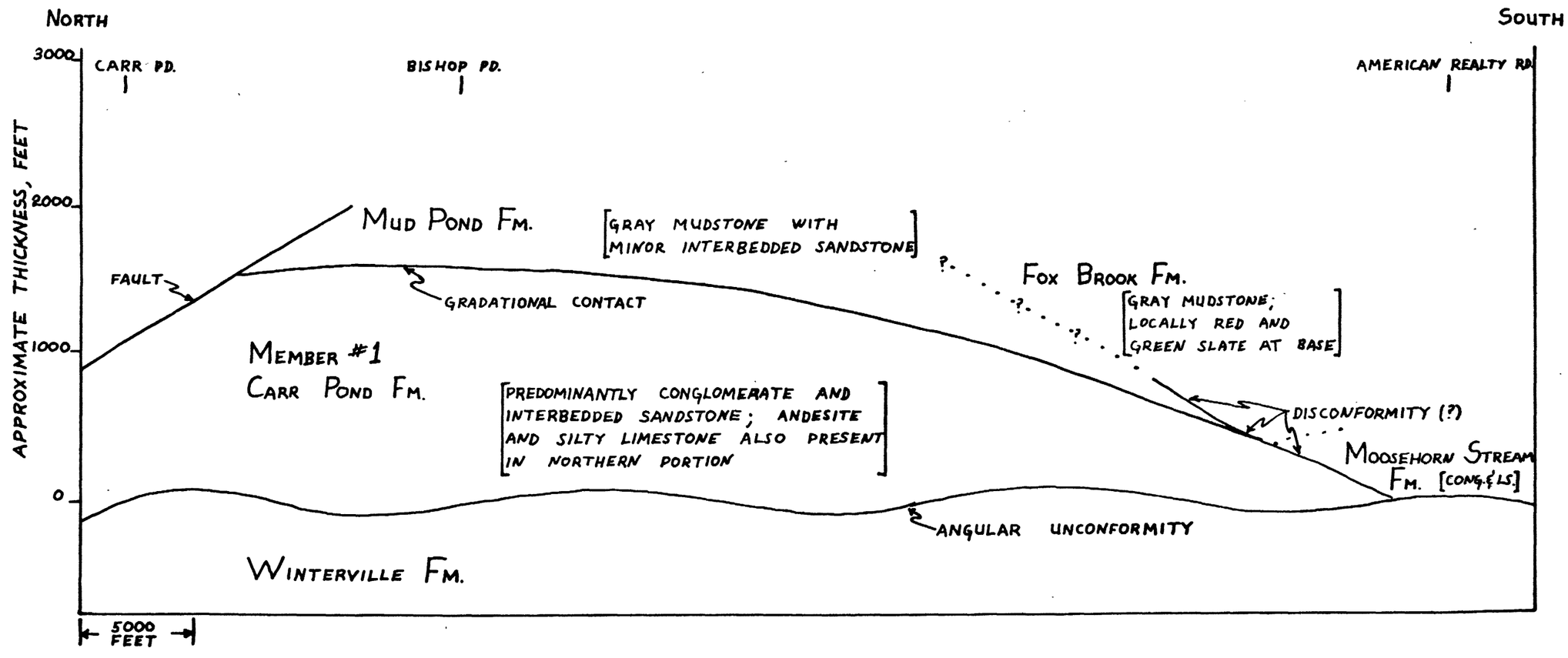


FIG. 26. — STRATIGRAPHIC SECTION THROUGH THE SILURIAN AND PART OF THE DEVONIAN ON THE WEST FLANK OF THE PENNINGTON ANTICLINE.

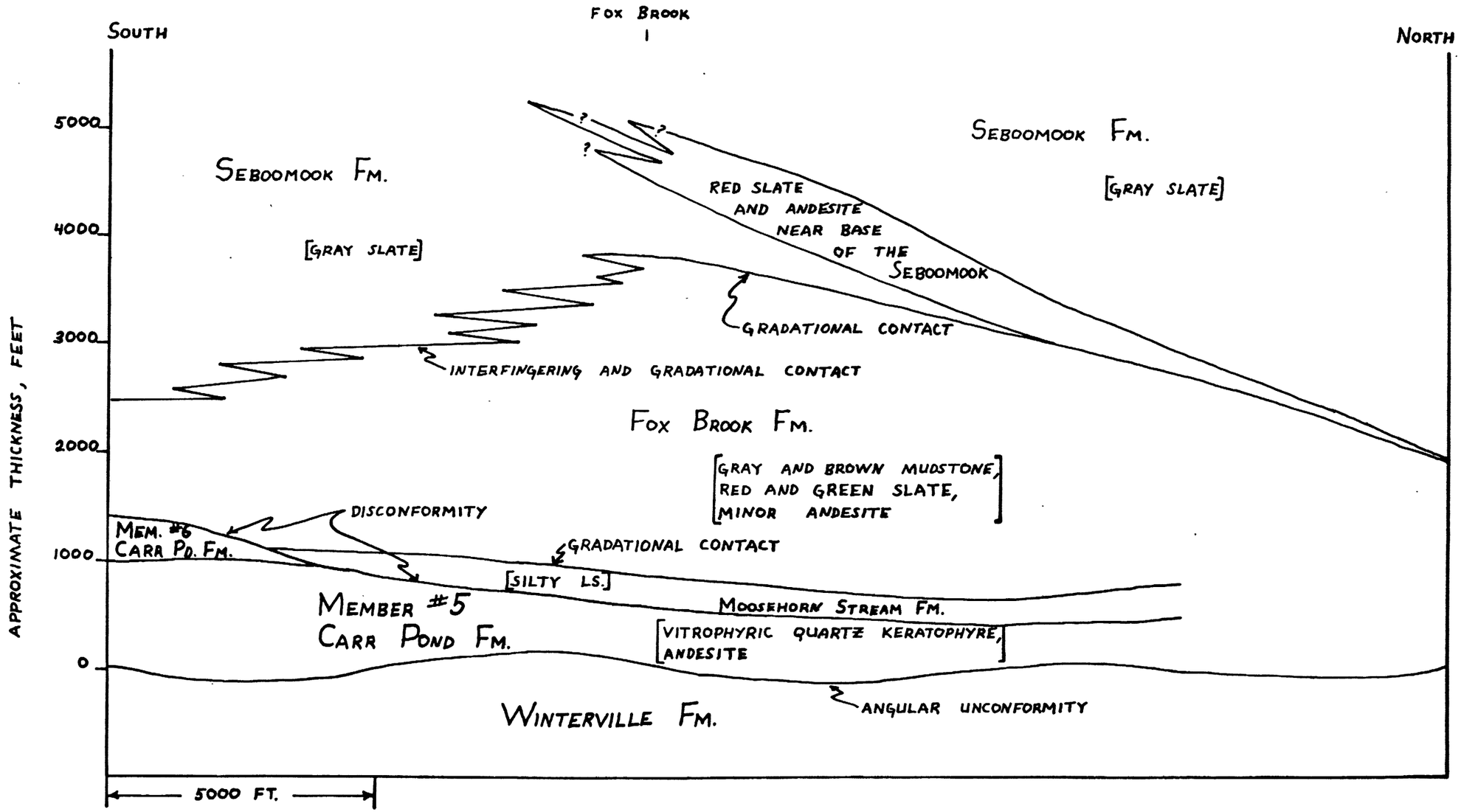
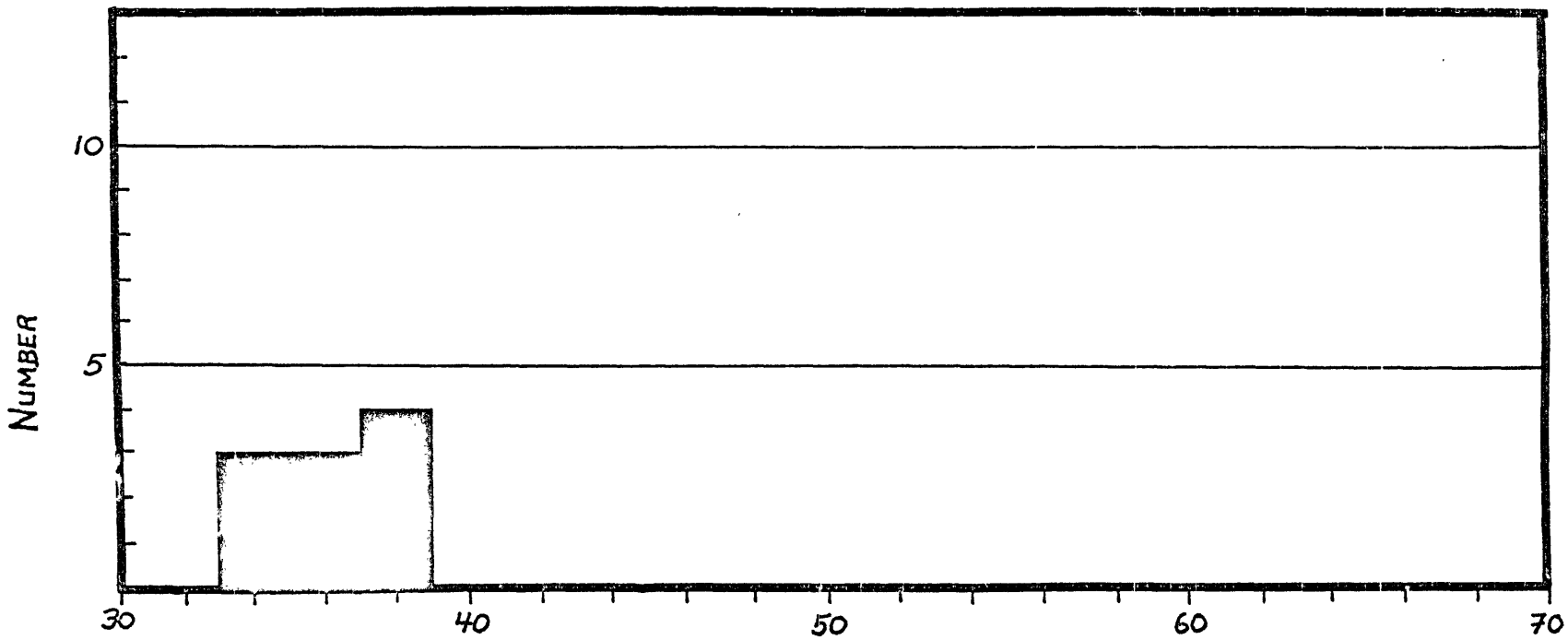


FIG. 27. — DISTRIBUTION OF PLAGIOCLASE COMPOSITIONS IN ANDESITES OF DEVONIAN AGE.



MOOSEHORN STREAM FORMATION

GENERAL

The Moosehorn Stream Formation is named by the writer for Moosehorn Stream (T12 R7) of the Greenlaw Quadrangle. It is the basal Devonian unit over most of the area. It represents a shallow-water, near -shore depositional environment and it is lithologically similar to the Carr Pond Formation. Over most of the area silty limestone is the characteristic rock type. Volcanics, conglomerate, sandstone, mudstone, and red slate are locally present.

Due to the paucity of outcrops, its thickness is poorly known. It is believed to be several hundred feet thick over most of the area, but its thickness is probably quite variable. In places the Moosehorn Stream Formation seems to be absent and the Fox Brook Formation lies directly upon rocks of Silurian age.

LITHOLOGY

Only two exposures of volcanic rocks have been found in the Moosehorn Stream Formation. Both are medium greenish-gray andesite and are indistinguishable from many of the andesites of Ordovician and Silurian age.

A modal analysis of one of these andesites is as follows (#RH-282C; 400 points counted):

7.0	% plagioclase phenocrysts
45.0	plagioclase groundmass
19.5	intersertal chlorite
17.25	sphene and leucoxene
5.0	secondary carbonate
1.5	pyrite
1.5	amygdular chlorite
3.25	amygdular carbonate
100.00	total

For ampre detailed petrographic description see p.190.

Sedimentary Rocks

Calcareous Sedimentary Rocks. Silty limestone is the most abundant rock type in the Moosehorn Stream Formation. These are often very similar in appearance to the massive silty limestone found in the Carr Pond Formation. They are generally medium gray to bluish-gray and weather with a thick (1 cm.), light brown, punky rind. They are frequently massive and show little or no evidence of bedding. Reef flank breccias of the type found in the Carr Pond Formation have not been found within the Moosehorn Stream Formation. Crinoid columnals and brachiopods are often present and corals, trilobites, and gastropods are occasionally present. Complete fossil

listings are given in Appendix I.

Gray, highly cleaved, occasionally fossiliferous calcareous mudstone is locally present. A sandy limestone breccia containing intraclasts several inches in diameter is present of the southwest shore of Fish River Lake (#EM-385). This outcrop may be very close to the base of the Devonian section.

Conglomerate. Conglomerate is present in the Moosehorn Stream Formation along the east flank of the Greenlaw Anticline south of Moosehorn Stream. This conglomerate is lithologically similar to the conglomerate in the Carr Pond Formation. It was probably derived from the same source or possibly could have been derived by reworking of Carr Pond conglomerates. At the time the writer was engaged in field work, this conglomerate was thought to be correlative with conglomerate several miles to the north and this area was not intensively studied. Fossil determinations by A.J.Boucot have shown this to be false. The writer suggests this as an area for future study.

Mudstone and Red Slate. Minor amounts of gray and greensih-gray mudstone and red slate are locally interbedded with calcareous mudstone and silty limestone. They

are lithologically identical to rocks found in the overlying Fox Brook Formation. As the contact between the Moosehorn Stream Formation and Fox Brook Formation is gradational and interfingering, a description of these lithologies is deferred to the discussion of the Fox Brook Formation.

AGE

Nine fossil localities have been found in the Moosehorn Stream Formation by Friedberg and Petersen (1964), E.Mencher, and the writer. Collections from these localities were studied by A.J.Boucot or W.A.Oliver. The fossils indicate a Helderbergian age, definitely New Scotland in part, and possibly New Scotland in whole. Complete fossil listings are given in Appendix I.

To the southwest in the Spider Lake Quadrangle, Hall (1964) has described a thick sequence of rocks of New Scotland age which he calls the Spider Lake Formation. It consists predominately of volcanic flows and pyroclastics and lesser amounts of trachitic flows, calcareous siltstones, impure limestones, and conglomerates. This unit is much thicker (8,000 feet compared to several hundred feet for the Moosehorn Stream Formation) and contains much more

volcanics (the Spider Lake Formation is largely volcanics, whereas the Moosehorn Stream Formation contains only minor amounts of volcanics) than the Moosehorn Stream Formation. The Moosehorn Stream Formation is probably correlative with part of the Spider Lake Formation; however the exact relationship between the two is not known.

FOX BROOK FORMATION

GENERAL

The Fox Brook Formation is a Lower Devonian unit named by the writer for Fox Brook (T13 R8) of the Fish River Lake Quadrangle. It is composed primarily of mudstone, and locally contains red and green slate, andesite, tuff, and tuffaceous sedimentary rocks. Rocks typical of the Fox Brook Formation are best exposed on the hill to the south of Fox Brook.

The mudstone of the Fox Brook Formation is lithologically similar to those of the Mud Pond Formation. As the mudstone is rarely fossiliferous, this lithologic similarity may cause problems in mapping. Such is the case for the mudstone and slate extending from northeast of Chase Brook Ridge to southwest of Sheldon Ridge. These rocks may be entirely of Devonian age, entirely of Silurian age, or rocks of both ages may be present.

The only place where an estimate of the thickness of the Fox Brook Formation may be made is on the southwest flank of the Pennington Anticline. Because the mudstones are intensely folded it is difficult to estimate their thickness. The writer suggests the thickness is quite variable in this region and probably ranges from a

minimum of 1000 feet to a maximum of 3000 feet.

LITHOLOGY

Volcanic Rocks

Andesite. The volcanics of the Fox Brook Formation are all andesitic in composition and are often intensely altered. They are usually light to dark greenish-gray and weather light to dark brown. Occasionally they are autobrecciated. Petrographically they are very similar to the andesites of the Winterville Formation, Carr Pond Formation, Moosehorn Stream Formation, and Seboomook Formation. Plagioclase and intersertal chlorite are the major components. Leucoxene-coated sphene grains, similar to those present in the Ordovician and Silurian andesites, are usually present. Small amounts of pyrite and secondary carbonate may also be present. Augite is an occasional component.

Tuff and Tuffaceous Sedimentary Rocks. These rocks are discussed in the section on red and green slate.

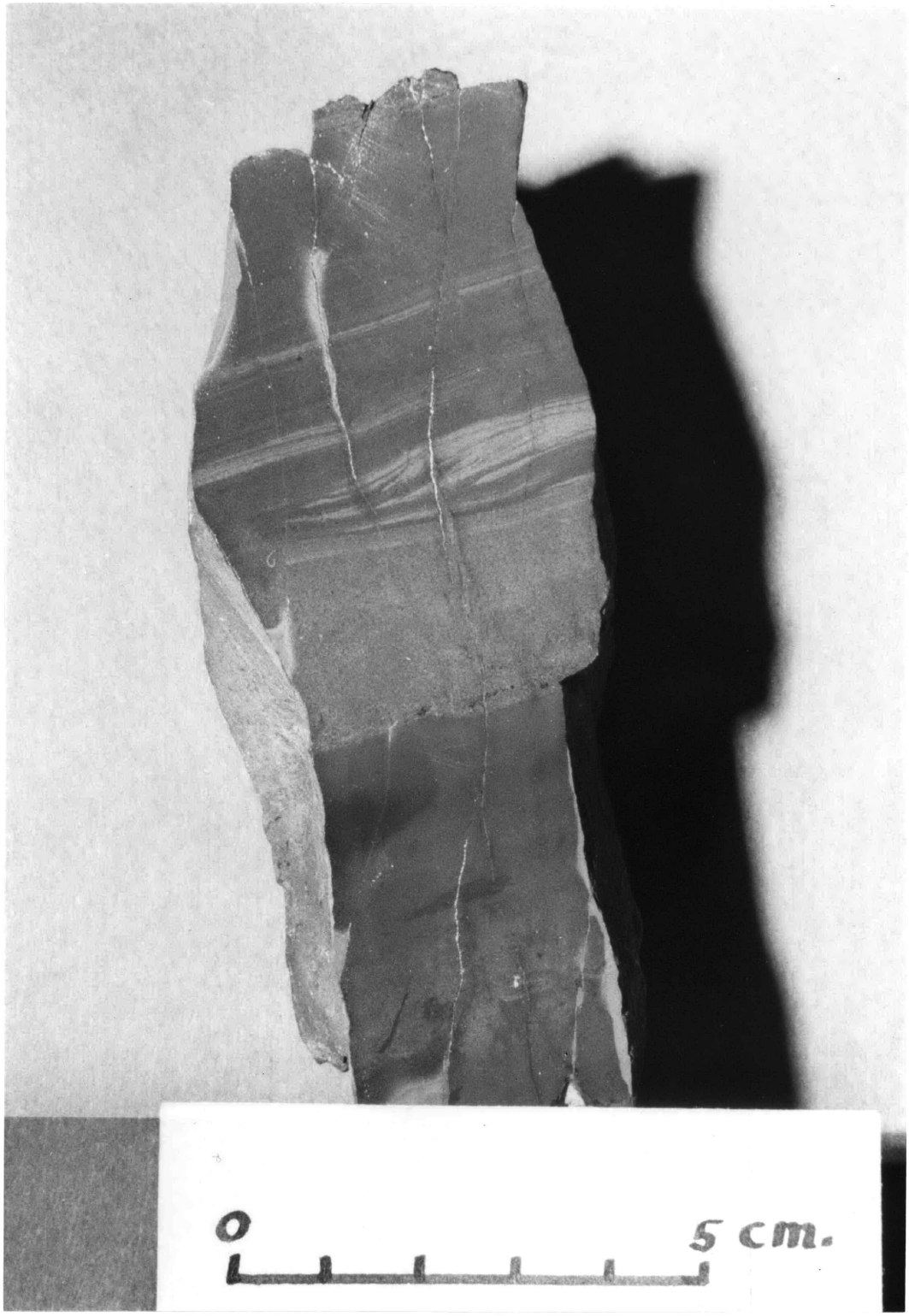
Sedimentary Rocks

Mudstone. Mudstone is the major lithology in the Fox Brook Formation. It is very similar to and perhaps lithologically indistinguishable from the mudstone of the Mud Pond Formation. Typically it is brown, brownish-gray, or gray and weathers light to medium brown. It is moderately well cleaved with the finer grained varieties more strongly cleaved than the coarser ones. Thin beds and laminae of fine grained sandstone (graywacke) are frequently present. These sand units occasionally exhibit graded bedding or ripple cross-lamination of the type associated with turbidity current deposits (fig.28). Macerated plant material has been found at one locality (#RH-41).

Red and Green Slate. Red slate is quite abundant in the lower 2/3 of the Fox Brook Formation on the west flank of the Pennington Anticline. Minor amounts of green slate is frequently associated with these and occasionally andesite and tuff is interbedded with the red slate. The red slate is deep red to reddish-brown and is usually finely cleaved. The green slate range from medium green to greenish-gray. The green slate may form units having a thickness of 10 or more feet, or they

Fig. 28. - Mudstone; Fox Brook Formation (#RH-113). Bedding features suggest deposition from a turbidity current.

Fig. 28



may occur as laminae within the red slate. Locally the green slate becomes siliceous and grades into a green, fine grained tuff. It is suggested that the green color of this slate is due to the presence of a tuffaceous component.

AGE

Fossils are rare in the Fox Brook Formation. Friedberg and Petersen (1964) found fossils at three localities. Two of these are in the upper part of the unit and the third is near the base. A.J.Boucot examined the two collections from the upper part of the unit and did not find any definitive forms. The other collection (#PF-235) was examined by A.J.Boucot and W.A.Oliver who reported a New Scotland age. (For fossil listing see Appendix I).

In the Winterville Quadrangle 1½ miles NNE of Sterling Pond, D.C.Roy (1964) described a sequence of

> ...medium-gray, fine to medium grained, micaceous, carbonaceous, hematite flecked, moderately well cleaved mudstone. Interbedded with these mudstones are beds of fine grained, light gray and buff gray, carbonaceous sandstones which often display abundant plant remains.

Within this sequence Roy found a "shale-chip", intra-formational conglomerate containing abundant brachiopods. These brachiopods were examined by A.J.Boucot and were assigned a Becraft-Oriskany age. These rocks may be correlative with part of the Fox Brook Formation of the west flank of the Pennington Anticline.

Within the area investigated, the Fox Brook Formation is of Lower Devonian age, definitely New Scotland in part, and possibly Becroft-Oriskany in part.

SEBOOMOOK FORMATION

GENERAL

The name Seboomook was first used by Perkins (1925) and has since gained acceptance with geologists working in western and northern Maine.

The Seboomook Formation is the youngest unit in the area investigated. It is for the most part a monotonous slate unit containing minor amounts of interbedded graywacke. Locally red and green slate and andesite is interbedded with the slate near the base of the formation. As the top of the formation has been removed by erosion, its thickness is unknown. Its monotonous nature, the lack of marker beds within the unit, and the intense folding make it difficult to estimate its thickness. The writer assigns a value of 5000 feet as a minimum thickness; however, he feels it is probably much thicker.

LITHOLOGY

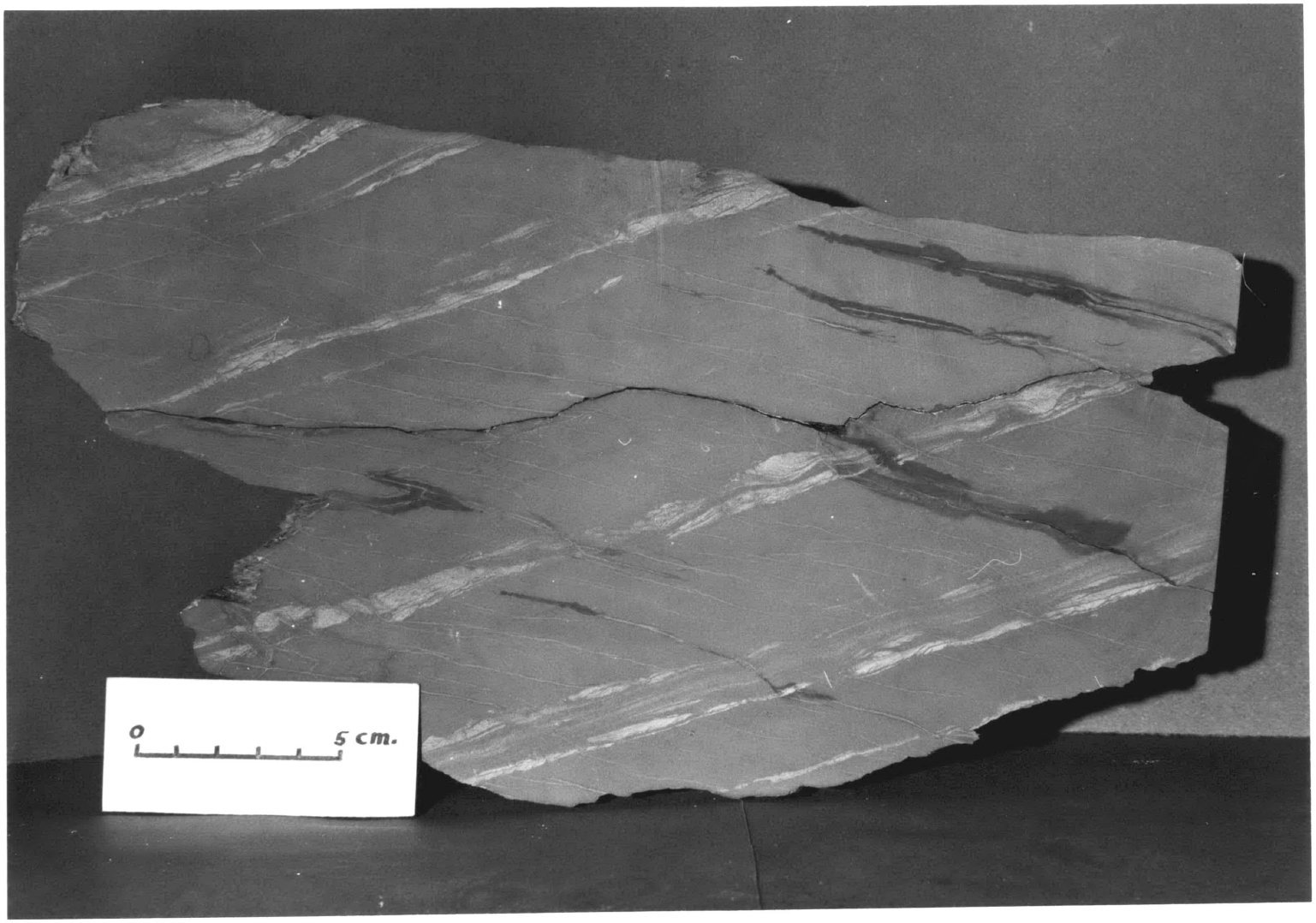
Slate containing interbedded graywacke is the major rock type present in the Seboomook Formation. Andesite and red and green slate is locally present near the base.

Slate and Graywacke. The slate is typically gray, strongly cleaved, and often has a well developed micaceous sheen on the cleavage planes. The writer has chosen to distinguish the Fox Brook Formation from the Seboomook Formation on the basis of their argillaceous sediments. The Seboomook slate is typically gray, finely cleaved, and often has a micaceous sheen on the cleavage planes. The Fox Brook mudstone is usually brown to brownish-gray and not as well cleaved as the Seboomook. This latter difference is probably a reflection of a higher content of clay minerals in the Seboomook slate. The mudstone of the Fox Brook Formation grade both laterally and upward into the slate of the Seboomook Fromation.

Thin beds of light to medium gray, fine grained graywacke are locally present within the Seboomook Formation. When sawed these usually display ripple-cross-lamination. In the protion of the Mooseleuk Lake Quadrangle which was investigated, the Seboomook Formation often consists of fine grained, sandy laminae rhythmically interbedded with argillaceous material. The sand laminae range in thickness from 1 mm to 1 cm. and occasionally they exhibit ripple-cross-lamination. The intervening argillaceous material varies from several millimeters to several centimeters in thickness. (fig.29). Similar material is rare in the Seboomook Formation in the portion of the

Fig. 29. - Rhythmically bedded slate and sandstone laminae;
Seboomook Formation (#RH-248).
Bedding features suggest deposition by turbidity current.

Fig. 29



Fish River Lake Quadrangle investigated; however, isolated fine grained, sand laminae are occasionally present.

Andesite and Red and Green Slate. Andesite and red and green slate is locally interbedded with gray slate near the base of the Seboomook Formation (fig.26). These rocks are well exposed in the North Branch of Fox Brook and in the two streams to the north. Detailed stratigraphic sections showing the interrelationship of these rocks are illustrated in fig. 31.

The andesite ranges from medium green to greenish-gray and reddish brown. They frequently contain amygdules filled with chlorite or carbonate. In thin section they are quite similar to the Ordovician and Silurian andesites. They are composed primarily of andesine laths and intersertal chlorite. The plagioclase is moderately to intensely altered to or replaced by chlorite, white mica, and carbonate. Small, leucoxene-coated grains of sphene, skeletal crystals of ilmenite, and augite are commonly present. They are often porphyritic and occasionally appear to be tuffs.

The green slate is medium green to greenish-gray, finely cleaved, and occur as beds ranging in size from several inches to tens of feet. They are often interbedded with red slate. They are similar to the

green slate of the Fox Brook Formation and the writer feels that the green color is an indication of a tuffaceous component.

The red slate is deep red to reddish brown, finely cleaved, and similar to those found in the Fox Brook Formation.

Andesite, red slate, and green slate has not been found in the Seboomook Formation at any place other than near the base.

AGE

Fossils have not been found within the Seboomook Formation in either the area investigated or in nearby areas. Therefore more subjective criteria must be used to infer its age. As the lower part of the Seboomook Formation in places is facies equivalent to the upper part of the Fox Brook Formation, at least part of the Seboomook is of Becraft-Oriskany age and possibly it may locally be of New Scotland age.

STRUCTURAL GEOLOGY

GENERAL

The main structural features in the area are portions of two major anticlines which bring Ordovician rocks to the surface. One of these, the Pennington Anticline (Pavlides and others, 1964) is present in the northern portion of the area and extends northeastward for some 20 miles. The Greenlaw Anticline, named by the writer for Greenlaw Mountain (T12 R7, Greenlaw Quadrangle), is the major structural feature of the central and southern portion of the area. These anticlines presumably attained their present configuration during the Acadian. This is suggested by the general parallelism of their axes with the cleavage in the surrounding Devonian rocks and by their being shaped by fairly large, post-Helderbergian (probably Acadian) faults. The Taconic may have prefigured these anticlines; but, the extent to which this has occurred, if any, is not known.

The more argillaceous sedimentary rocks are strongly cleaved and are often tightly folded. The coarser grained sedimentary rocks and the volcanic rocks constitute the competent rocks of the region. These lack a cleavage and although folded, the folds do not appear to be tight.

Faulting, both on a large and small scale, is probably the most important mechanism of deformation in these more competent rocks.

FAULTS

Faults are difficult to recognize in this area and their movement is generally not known. The paucity of outcrops, intense folding, rapid facies changes, and general absence of marker beds make identification of faults quite difficult, especially within one lithologic unit. The result of this is that faults may be rather well established in one area , but their continuation into other areas may be uncertain.

The major faults are two northeast trending ones which pass through the center of the area. Evidence for the westernmost one is based on the abrupt termination of the Carr Pond and Fox Brook Formations on the nose of the Pennington Anticline. This fault is continued northeastward as the contact between the Winterville Formation and Devonian (?) mudstones. The eastern fault has been traced from Pratt Lake to Sheldon Ridge and then possibly swings eastward toward Mud Pond. Kink banding in an intensely sheared slate is well developed along this fault on a lumber road 1 mile northwest of Clayton Lake

and has also been observed at several other localities.

The ENE trending fault extending from Clayton Lake to Twentymile Brook is based largely on the facing obtained from graded bedding in Member #2 of the Carr Pond Formation. This indicates that it is the upper part of the Carr Pond Formation which is in contact with the Winterville Formation, thus necessitating a fault.

The second set is a series of generally N-S trending, post Ludlovian faults. The easternmost one is based on the coincidence of the Clayton Lake Member-Greenlaw Mountain Member, Carr Pond Formation - Machias River Formation, and Carr Pond Formation - Greenlaw Mountain Member contacts. The north - south trending fault which cuts the Carr Pond Formation just east of Big Machias Lake is based on lithologic differences and a change in bedding attitudes across the fault. The fault separating Member # 2 of the Carr Pond Formation from Member # 4 of the Carr Pond Formation and Winterville Formation is based on the facies and age differences involved. It is uncertain what happens to this fault south of McGowan Pond.

The writer feels that other major faults are present and that some of those mapped by the writer may not exactly follow the courses shown.

UNCONFORMITIES

Evidence for and the dating of the Taconic and Acadian orogenies and the Salinic disturbance for northern Maine has been summarized by Boucot and others (1964), Pavlides and others (1964), and Hall (1964). The writer will only discuss the evidence for these events which is present in the area investigated.

The contact between Ordovician and Silurian rocks is exposed at only one locality (#RH-780). Here one sees the "red phase" of the Carr Pond Conglomerate separated by a 50 foot interval from typical mafic volcanics of the Winterville Formation. In the intervening 50 feet is a poorly sorted conglomerate containing predominately angular fragments of mafic volcanics. The red "chert" content of this conglomerate increases upwards and this basal conglomerate grades into the typical "red phase" conglomerate of the Carr Pond Formation. Downward it imperceptibly merges with the mafic volcanics of the Winterville Formation. As bedding could not be obtained in the volcanics or the conglomerate and as the actual contact was obscured by weathering, the amount of angular discordance could not be determined. Evidence for a Taconic unconformity is based on the absence of Llandoverian and Wenlockian rocks and by the Ludlovian conglomerates whose pebbles

are nearly all typical Winterville rock types.

Evidence for the Salinic disturbance is based on the absence of fossils of definite Upper Ludlow or Manlius-Coeymans Age and by the proximity of Lower Ludlow and and New Scotland fossil localities on the nose of the Pennington Anticline. It appears to be represented by a nonsequence in at least part of the area, locally some erosion may have occurred (on the east flank of the Greenlaw Anticline), however it may not be present over the entire area.

The Acadian is considered to be the major orogeny in this area. It is marked by folding and faulting which involves rocks of definite New Scotland age within the map area and of Becraft-Oriskany age just outside the map area (1½ miles NNE of Sterling Pond, Winterville Quad., D.C.Roy,1964). The northeast trending faults in the map area are definitely post-New Scotland in age; however, the north trending set may possibly be post-Ludlovian and pre-New Scotland as they do not cut Devonian rocks.

GEOLOGIC HISTORY

The first recorded event in the area is the deposition of a thick sequence of volcanic and sedimentary rocks of the Middle Ordovician Winterville Formation. The volcanics are predominantly mafic volcanics and minor quartz keratophyre. These rocks do not exhibit any noted changes over the area. Coarse and fine grained tuffaceous sedimentary rocks are locally present in the Winterville Formation. Radiolaria and occasionally graptolites are present in some of these, thus indicating a subaqueous origin for at least part of the volcanics. This does not discount the possibility that some of the volcanic rocks may be terrestrial. The presence of pebbles of Winterville andesite in the conglomerates of the Clayton Lake Member suggests that part of the area or adjacent area may have been emergent (as volcanic islands) during part of the deposition of the Winterville Formation.

After the major volcanic activity had come to an end, a black slate locally containing interbedded graywacke was deposited. This is the Machias River Formation which is tentatively assigned to the late Middle or Upper Ordovician. The graywacke was derived from two sources - a Winterville source area and a"granitic" source (or a sediment derived

from such a source).

The Taconic orogeny is marked by a period of uplift and nondeposition. Deposition resumed in Lower Ludlow time. Most of the Silurian sedimentary rocks are of a near-shore, relatively shallow water facies. Lesser amounts were deposited in a relatively deep, off-shore environment and some of the volcanics could possibly be terrestrial. Parts of the area were probably emergent during Lower Ludlow time. Locally the relief was steep as indicated by the thickness and coarseness of the conglomerate comprising Member #2 of the Carr Pond Formation. Thick sequences of volcanics were deposited locally; however, at some places volcanics appear to be absent. Conglomerate, sandstone, and silty limestone are thesedimentary rocks most common in the near-shore facies and mudstone constitutes the bulk of the offshore facies.

Upper Ludlow and Manlius-Coeymans time was a period of non-deposition over part and possibly all of the area investigated. This is known as the Salinic disturbance and is represented by a nonsequence in the stratigraphic record and possibly by local erosion. One episode of faulting may have occurred during this interval; however, evidence supporting this is inconclusive.

Sedimentation began again in New Scotland time with a transgression of the Devonian seas. A thin, basal, near-shore, shallow water facies consisting primarily

of silty limestone with locally abundant conglomerate was the earliest of the Devonian rocks to be deposited. These gave way, both laterally and upward, to the mudstones of the Fox Brook Formation and finally to the slate of the Seboomook Formation which continued into at least Becraft of Oriskany time. The sediment comprising both of these units is considered to have been transported at least in part and possibly in whole by turbidity currents. Volcanic activity occurred during New Scotland and possibly Becraft-Oriskany (?) time as evidenced by the presence of andesites and tuffaceous mudstones in the Fox Brook Formation, Moosehorn Stream Formation, and near the base of the Seboomook Formation. Volcanism did not continue during deposition of the greater part of the Seboomook.

The Acadian orogeny produced folding, cleavage, faulting, and sub-chlorite metamorphism.

APPENDIX I

LOCATIONS AND DESCRIPTIONS OF FOSSIL LOCALITIES

Localities prefixed with EM were collected by E.Mencher and those prefixed with PF were collected by Friedberg and Petersen.

Ages reported by A.J.Boucot in the letter of Jan., 1968 are given in different terms than used in previous reports. He has redefined the term Ludlow, introduced the term Pridoli, and uses the term Helderberg.

WINTERVILLE FORMATION

ORCUTT MOUNTAIN MEMBER

#RH-739

T12 R7
Greenlaw Quadrangle

Location: Outcrop on the north side of the American Realty Road, 0.95 road miles west of the bridge over Moosehorn Stream; 2400 feet north of the south border and 7700 feet east of the west border of T12 R7.

Lithology: Graptolite and brachiopod bearing dark gray slate bed within a siliceous slate which is interbedded with mafic volcanics.

Fossil Listing and Age: Report not received at time of writing.

CARR POND FORMATION

MEMBER # 1

#RH-470 (USMN 13598) T13 R8
Winterville Quadrangle

Location: Outcrop 20 feet south of the top of a 20 foot high rocky knob at an elevation of 1010 ft.; approximately 2800 feet north of the northeastern shore of Carr Pond; 4200 feet west of the east border and 8600 feet north of the south border of T13 R8.

Lithology: Gray silty limestone containing abundant crinoid columnals, brachiopods, and corals.

Fossil Listing and Age: A.J.Boucot in letter of Jan.,1968 reports: "...is of Silurian Age, Upper Llandovery to Pridoli as shown by the presence of Atrypa "reticularis" and a halysitid as well as a heliolitid.

gypidulinid (smooth)
Howellella ? sp.
Leptaena "rhomboidalis"
strophеodontid sp. A
" sp. B
Atrypa "reticularis"
rhynchonellids
rostrospiroids
platyceratids
corals (to Oliver) - haly, helio, favo, etc.
bryozoans (to USNM)"

#RH-477 (USNM 13599) T13 R8
Winterville Quadrangle

Location: 15 feet north of the top of a 20 foot high rocky knob at an elevation of 1030 feet; approximately 4000 feet north of the northeast shore of Carr Pond; 3250 feet west of the east border and 9000

feet north of the south border of T13 R8.

Lithology: Light gray to brown silty limestone weathering chalky white. Abundant crinoid columnals, brachiopods, corals.

Fossil Listing and Age: A.J.Boucot reports in letter of Jan., 1968: "... is of Silurian age as shown by the presence of a dolerorthid and a Sieberella.

rostrospiracea
rhynchonellid
Sieberella (plicate)
dolerorthid (?)
trilobites (to Lesperance)
coral (to Oliver)"

#RH-555 (USNM 17001) T13 R8
Winterville Quadrangle

Location: Broken material (solid outcrop not obtained, but the collection undoubtedly represents bedrock) 50 feet south of the top of a small ridge at an elevation of 1020 feet.; ap proximately 3200 feet north of the northeast shore of Carr Pond; 3750 feet west of the east boundary and 8900 feet north of the south boundary of T13 R8.

Lithology: Gray, medium to fine grained sandstone and calcareous sandstone containing abundant crinoid columnals and brachiopods.

Fossil Listing and Age: A.J.Boucot in a letter of Jan., 1968 reports: "...is of Ludlow-Pridoli Age as shown by the presence of the new genus of Ludlow stropheodontid and Isorthis arcuaria.

trilobites (to Lesperance)
n. gen. "Ludlow" stropheodontid
Isorthis arcuaria
Howellella sp.
Protochonetes? sp.
Meristina sp.
Mesdouvillina sp.
Atrypa "reticularis"

#RH-565 (USNM 17002) T13 R8
Winterville Quadrangle

Location: Outcrop on the south side of a small rise, at an elevation of 1010 feet; approximately 1900 feet north of the northeast shore of Carr Pond; 3600 feet west of the east border and 7500 feet north of the south border of T13 R8.

Lithology: Gray, crinoidal silty limestone.

Fossil Listing and Age: A.J.Boucot in a letter of Jan., 1968 reports: "... contains no brachiopods."

#RH-756 (USNM 13593) T12 R7
Greenlaw Quadrangle

Location: Outcrop 15 feet to the east of the road to Greenlaw Pond, 3.28 road miles from the junction of the "Greenlaw Pond Road" and the American Realty Road at Greenlaw Crossing. 11400 feet east of the west boundary and 15300 feet north of the south boundary of T12 R7.

Lithology: Conglomerate with clasts averaging about $\frac{1}{2}$ inch and containing occasional red "chert" clasts to 6 inches and one to 12 inches.

Fossil Listing and Age: A.J.Boucot in a letter of Jan., 1968 reports: "... is of Ludlow or Pridoli age as shown by the presence of an Isorthis of Ludlow aspect and a heliolitid.

dolerorthid
Leptaena "rhomboidalis"
halysitid (to Oliver)
Isorthis sp. (of Ludlow aspect)
gypidulid?
dalmanellids
atrypaceans?"

MEMBER # 3

#RH-672 (USNM 17009) T12 R9
Mooseleuk Lake Quad.

Location: Outcrop in woods at an elevation of 1060 feet; 10800 feet north of the south boundary and 1300 feet west of the east boundary of T12 R9.

Lithology: Gray, slaty, limy mudstone with occasional brachiopods.

Fossil Listing and Age: A.J.Boucot in a letter of Jan., 1968 reports: "...is of Ludlow-Pridoli Age as suggested by the presence of coarsely plicate Strophonella.

Dalejina
Strophonella (coarsely plicate) sp.
Leptaena "rhomboidalis"
rhynchonellid
coral (to Oliver)"

MEMBER # 4

#RH-215 (USGS 7875-SD) T12 R9
Mooseleuk Lake Quad.

Location: Pavement exposure in a bulldozed cut, 50 feet north of the road going to Milliard's Camp, at a point 1.55 road miles west of the Realty Road - Milliard's Camp Road junction; 5200 feet west of the east border and 5700 feet north of the south border of T12 R9.

Lithology: Gray, silty limestone breccia ("a reef-flank breccia").

Fossil Listing and Age: W.A.Oliver in a letter of Feb. 8, 1967 reports: "The matrix is very crinoidal including columnals up to 1 cm. in diameter. The corals could be either Silurian or Devonian, but the Heliolites? (an external mold only) is very similar to a Heliolites from the Ludlow rocks elsewhere in Maine. As far as I know heliolitids have not been reported from Devonian rocks in New England or eastern Canada. All in all, it seems likely that this collection is Ludlow in age."

#RH-215C (USNM 17013) T12 R9
Mooseleuk Lake Quad.

Location: 20 foot pavement exposure in a bulldozed cut, 15 feet north of the road going to Milliard's Camp at a point 1.55 road miles west of the Realty Road-Milliard's Camp Road junction; 5200 feet west of the east border and 5700 feet north of the south border of T12 R9.

Lithology: Gray mudstone and limy mudstone containing abundant large crinoid columnals (1 cm. diameter) and an occasional coral and brachiopod.

Fossil Listing and Age: A.J.Boucot in a letter of Jan., 1968 reports: "... is of questionable Silurian age. The presence of a possible Eccentricosta suggests a Pridoli Age if this determination is correct.

Corals (to Oliver)
Eccentricosta? sp. (?)
Leptaena "rhomboidalis" "

MEMBER # 6

#RH-134 (USNM 13023) T13 R8
Fish River Lake Quad.

Location: Outcrop on small ridge in woods; 5400 feet east of the west border and 1600 feet north of the south border of T13 R8.

Lithology: Gray silty limestone.

Fossil Listing and Age: A.J.Boucot in a letter of Oct 27, 1966 reports: "...is of Ludlow age as indicated by the presence of Isorthis cf. arcuaria (Henryhouse type).

Isorthis cf. arcuaria (Henryhouse type)
Leptaenisca sp.
Leptaena "rhomboidalis"
trilobites (to Robison)"

#RH-516E (USNM 17000) T13 R8
Fish River Lake Quad.

Location: Buried outcrop (obtained by digging) on the west side of a rise at an elevation of 1120 feet; 4500 feet east of the west border and 1600 feet north of the south border of T13 R8.

Lithology: Gray silty limestone.

Fossil Listing and Age: A.J.Boucot in a letter of Jan., 1968 reports; "...is of Ludlow-Pridoli Age as shown by the presence of Merista and Lissatrypa.

encrinurids (to Lesperance)
Merista sp.
Lissatrypa sp.
Plectodonta sp.
dalmanellid
Leptaena "rhomboidalis" "

#PF-238A T12 R8
Mooseleuk Lake Quad.

Location: Probable outcrop in cut on lumber road; 5300 feet east of the west border and 1700 feet south of the north border of T12 R8.

Lithology: Gray silty limestone breccia (reef-flank breccia)

Fossil Listing and Age: (as reported in Friedberg and Petersen, 1964):
"Identifications by W.A.Oliver, report of December 31, 1963
Cystihalysites sp.
Favosites sp.
Spongophylloides sp.
Tryplasma nordica Stumm
misc. horn corals

age: Silurian, Ludlow"

#PF-264 T12 R8
Mooseleuk Lake Quad.

Location: Present writer could not find outcrop. On lumber road approx. 5100 feet east of the west border and 700 feet south of the north border of T12 R8.

Lithology: Gray silty limestone ?

Fossil Listing and Age: (as reported in Friedberg and Petersen, 1964):

"Identifications by A.J.Boucot, letter of Oct. 30, 1963.

Amphistrophia cf. loeblichi
Gypidula sp.
Strophonella cf. euglypha
Isorthis cf. arcuaria (Henryhouse type)
Atrypa "reticularis"
Leptaena "rhomboidalis"
rhynchonellid
stropheodontid (new genus)

age: Silurian, Lower Ludlow

#PF-266 T12 R8
Mooseleuk Lake Quad.

Location: Boulders on west side of lumber road 75 feet north of drainage; 5100 feet east of the west border and 400 feet south of the north border of T12 R8.

Lithology: Gray silty limestone breccia (reef- flank breccia).

Fossil Listing and Age: (as reported by Friedberg and Petersen, 1964):

"Identifications by W.A.Oliver, report of Dec. 31, 1963.

massive stromatoporoids
Favosites sp.
Thamnopora sp.
Cystiphyllum sp.
Tryplasma ? sp.
misc. horn corals

Age: Silurian, Ludlow "

#PF-267 T12 R8
Mooseleuk Lake Quad.

Location: 10 foot pavement crop on road, 30 feet north of PF-266

Lithology: Gray silty limestone breccia (reef-flank breccia).

Fossil Listing and Age: (as reported in Friedberg and Petersen, 1964):

"Identifications by W.A.Oliver, report of Dec. 31, 1963.

massive stromatoporoid
Aulopora ? sp.
Cladopora sp.
Favosites sp.
horn corals

Age: Silurian, Ludlow"

MOOSEHORN STREAM FORMATION

#RH-4 (USNM 13025) T13 R8
Fish River Lake Quad.

Location: Outcrop on knoll at old Blanchard's Depot Camp 100 feet from shore of Fish River Lake. 10100 feet east of the west border and 19800 feet north of the south border of T13 R8.

Lithology: Gray, silty limestone.

Fossil Listing and Age: A.J.Boucot in a letter of Oct. 27, 1966 reports "...is of New Scotland age as indicated by the presence of Strophonella punctulifera and Levenea.

Strophonella punctulifera
Coelospira sp.
orthotetacid
Leptostrophia sp.
Atrypa "reticularis"
Leptocoelia sp.
Meristella sp.
Mesodouvillina sp.
ambocoelid
Levenea sp.
trilobites (to Robison)"

#EM-385A (USNM 13026) T13 R8
Fish River Lake Quad.

Location: Outcrop on shore of Fish River Lake at Blanchard's Depot Camp. 10300 feet east of the west border and 19700 feet north of the south border of T13 R8.

Lithology: Gray silty limestone.

Fossil Listing and Age: A.J.Boucot in a letter

of Oct. 27, 1966 reports: "...is of New Scotland age as indicated by the presence of Megakozlowskiella, Macropleura, Strophonella punctulifera, and Levenea.

Megakozlowskiella sp.
Macropleura cf. M. macropleura
Delejina sp.
Coelospira sp.
Meristella sp.
Leptostrophia sp.
Leptocoelia sp.
orthotetacid
Strophonella punctulifera
Mesodouvillina sp.
Leptaenisca sp.
Atrypa "reticularis"
Levenea sp.
Platyorthis sp.
Leptaena "rhomboidalis""

#EM-385 (USNM 13028) T13 R8
Fish River Lake Quad.

Location: Same as for EM-385A.

Lithology: Gray silty limestone.

Fossil Listing and Age: A.J.Boucot in a letter of Oct. 27, 1966 reports: "...is of New Scotland age as indicated by the presence of Macropleura, Megakozlowskiella.

Macropleura sp.
Meristella? sp.
trilobites (to Robison)
Leptaena "rhomboidalis"
Megakozlowskiella sp.
Coelospira sp.
Dalejina sp.
Leptostrophia sp.
geniculate leptostrophid
orthotetacid
Metaplasia?"

#RH-37 (USNM 13022) T13 R8
Fish River Lake Quad.

Location: Outcrop on hill top; 7000 feet east of the west border and 6100 feet north of the south border of T13 R8.

Lithology: Gray silty limestone and limy mudstone.

Fossil Listing and Age: A.J.Boucot in a letter of Oct. 27, 1966 reports "...is of New Scotland age as indicated by the presence of Megakozlowskiella and Orthostrophia cf. O. strophomenoides.

Leptaena "rhomboidalis"
dalmanellids
Orthostrophia cf. O. strophomenoides
Megakozlowskiella sp."

#PF-17 T12 R8
Mooseleuk Lake Quad.

Location: Outcrop along lumber road about 1 mile northwest of Clayton Lake. Writer unable to identify outcrop collected by Friedberg and Petersen.

Fossil Listing and Age: (as reported by Friedberg and Petersen,1964):

"Identifications by A.J.Boucot in a letter of Oct. 30,1963.

Strophonella cf. punctulifera
Howellella sp.
Megakozlowskiella sp.
Mesodouvillina sp.
Atrypa "reticularis"

Age: Devonian, New Scotland"

#PF-19

T12 R8
Mooseleuk Lake Quad.

Location: Outcrop on lumber road about 1 mile northwest of Clayton Lake. Writer unable to ideltify outcrop collected by Petersen and Friedberg.

Fossil Listing and Age: (as reported by Friedberg and Petersen, 1964):

"Identifications by A.J.Boucot in a letter of Oct. 30, 1963:

Crytina? sp.
ambocoelid?. sp.

Age: Devonian ?"

"Identifications by W.A.Oliver in a letter of Dec. 31, 1963:

'Thamnopora' sp.
horn coral fragments

Age: Siluro-Devonian"

#PF-21

T12 R8
Mooseleuk Lake Quad.

Location: Outcrop on lumber road about 1 mile northwest of Clayton Lake. Writer unable to identifly outcrop collected by Petersen and Friedberg.

Fossil Listing and Age: (as reported by Friedberg and Petersen, 1964):

"Identifications by A.J.Boucot in a letter of Oct. 30, 1963:

Dalejina sp.
orthotetacid
Atrypa "reticularis"
gypidulinid
orthoceroid

Age: Devonian, C_3 to Frasnian"

#RH-847 (USNM 13594) T12 R7
Greenlaw Quadrangle

Location: Outcrop in woods 1100 feet N35E of the American Realty Road crossing of Moosehorn Stream; 13400 feet east of the west border and 3000 feet north of the south border of T12 R7.

Lithology: Medium gray silty limestone and limy siltstone and light gray, highly fossiliferous silty limestone.

Fossil Listing and Age: A.J.Boucot in a letter of Jan., 1968 reports: "...is of questionable Helderberg age as shown by the presence of Strophonella cf. S. Punctulifera.

rhynchonellid
spiriferid (small)
orthotetacid
favositid (to Oliver)
Strophonella cf. S. punctulifera
Leptaena "rhomboidalis"
platyceratids "

#RH-852 (USNM 13595) T12 R7
Greenlaw Quadrangle

Location: Disturbed material of the north side of the American Realty Road 0.17 road miles east of the bridge over Moosehorn Stream. 1900 feet north of the south boundary and 13600 feet east of the west boundary of T12 R7.

Lithology: Highly fossiliferous, light gray, silty limestone.

Fossil Listing and Age: As reported by A.J. Boucot in a letter of Jan., 1968: "...is of Middle or Upper Helderberg age as shown by the presence of Megakozlowskiella.

Unident brachs.
Leptaena "rhomboidalis"
rhynchonellids
Megakozlowskiella
platyceratids
favositids (to Oliver)
orthotetacids "

FOX BROOK FORMATION

#PF-235 T12 R8
Mooseleuk Lake Quad.

Location: Outcrop on old lumber road. 5000 feet east of the west border and 3100 feet south of the north border of T12 R8.

Lithology: Gray mudstone, moderately well cleaved?

Fossil Listing and Age: (As reported by Friedberg and Petersen, 1964):

"Identifications by A.J.Boucot in a letter of Oct. 30, 1963.

Meristella sp.
Howellella ? sp.
Dalejina sp.
"Proschizophoria" elevata
gypidulind
Megakozlowskiella sp.
Levenea cf. subcarinata
Strophonella ? sp.
Cyrtina sp.
Atrypa "reticularis"
Nucleospira sp.
Leptaena "rhomboidalis"
orthotetacid
rhynchonellid
Dicaelosia sp.
Leptostrophia sp.

Age: Devonian, New Scotland "

"Identifications by W.A.Oliver in a letter of Dec. 31, 1963.

Cladopora sp.
Thamnopora sp.
2 indet. rugose corals

Age: Siluro-Devonian"

APPENDIX II

PETROGRAPHIC DESCRIPTIONS OF SELECTED SAMPLES

WINTERVILLE FORMATION:

SAMPLE: RH-192 UNIT: CLAYTON LAKE MEMBER
WINTERVILLE FORMATION

LITHOLOGY: AUGITE BASALT

LOCATION: Outcrop in woods on north side of ridge.
46° 42.47' N. Lat., 68° 49.08' W. Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Medium dark greenish-gray.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

42.5 %	plagioclase (An60)
26.0	augite
18.25	intersertal chlorite
0.5	intersertal white mica
0.25	ilmenite
12.0	sphene and leucoxene
0.5	carbonate
100.00	total

Hypidiomorphic augite (1mm.) subophitically incloses intermediate labradorite laths (0.5mm.). The augite is relatively unaltered, whereas the plagioclase is replaced by carbonate, chlorite, and white mica. Scaly and flaky chlorite is intersertal to the plagioclase and augite. Ilmenite, present as skeletal crystals, is nearly completely altered to sphene and leucoxene. Small (0.01 mm.) leucoxene-coated sphene grains occur as dense, irregularly shaped aggregates which are most abundant in the chlorite, but are occasionally present in the plagioclase and augite crystals.

SAMPLE: RH-713 UNIT: GREENLAW MOUNTAIN MEMBER
WINTERVILLE FORMATION

LITHOLOGY: AUGITE BASALT

LOCATION: Outcrop in woods 100 feet west of top of hill. 46° 40.28' N. Lat., 68° 42.24' W. Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Dark greenish-gray.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

39.5 %	plagioclase (An64)
21.75	augite
23.75	intersertal chlorite
tr.	intersertal white mica
0.75	ilmenite
11.5	sphene and leucoxene
2.75	carbonate
100.00	total

Hypidiomorphic augite (0.8 mm.) subophitically incloses intermediate labradorite laths (0.8 mm. long). The augite is relatively unaltered. The plagioclase exhibits moderate replacement by chlorite, white mica, and carbonate. Intersertal chlorite is present as aggregates of radial, flaky crystals. Ilmenite occurs as skeletal crystals partially to completely altered to leucoxene-coated sphene. Sphene is present as small (0.002 mm.), granular crystals which are often coated with leucoxene. They usually form irregularly shaped aggregates (0.1 mm.). These aggregates are most common in the intersertal chlorite, but are also found in lesser amounts within the augite and plagioclase crystals.

SAMPLE: RH-739A UNIT: ORCUTT MOUNTAIN MEMBER
WINTERVILLE FORMATION

LITHOLOGY: AUGITE BASALT

LOCATION: Outcrop on north side of American Realty Road. 46° 39.70' N. Lat., 68° 39.88' W. Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Medium dark greenish-gray.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

44.75 %	plagioclase (An48)
24.0	augite
13.25	intersertal chlorite
1.5	intersertal white mica
0.25	ilmenite
14.75	sphene and leucoxene
tr	pyrite
1.5	carbonate
100.00	total

Hypidiomorphic augite (to 1 mm.) subophitically incloses hypidiomorphic andesine laths (0.6 mm. long). The augite is relatively unaltered, whereas the plagioclase exhibits intense replacement by chlorite and white mica. Scaly and flaky chlorite and flaky white mica is intersertal to the augite and plagioclase. Sphene is present as small (0.002 mm.) grains which are often coated with leucoxene. The sphene occurs as individual grains, aggregates of several grains, and as large (to 0.2 mm.), irregularly shaped aggregates pseudomorphous after ilmenite.

SAMPLE: RH-803 UNIT: ORCUTT MOUNTAIN MEMBER
WINTERVILLE FORMATION

LITHOLOGY: AUGITE BASALT

LOCATION: Outcrop in woods on hill top along T12 R7 - T11 R7 Townline.
46° 39.30' N. Lat., 68° 39.32 ' W. Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Medium greenish-gray.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

43.75 %	plagioclase (An_{50^+})
24.75	augite
13.0	intersertal chlorite
6.25	intersertal white mica
2.0	ilmenite
10.25	leucoxene
tr	pyrite
100.00	total

Hypidiomorphic augite (to 3 mm.) ophitically incloses hypidiomorphic sodic labradorite laths (1 mm. long). The augite is relatively unaltered, whereas the plagioclase exhibits intense replacement by chlorite, white mica, and leucoxene. Flaky, scaly, and fibrolamellar chlorite and flaky white mica is intersertal to the plagioclase and augite. Skeletal ilmenite crystals (to 1 mm.) are present and exhibit partial to complete alteration to leucoxene.

SAMPLE: RH-185 UNIT: CLAYTON LAKE MEMBER
WINTERVILLE FORMATION

LITHOLOGY: PORPHYRITIC AUGITE ANDESITE

LOCATION: Outcrop on old lumber road.
46° 43.36' N. Lat., 68° 47.98' W. Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Medium greenish-gray. Carbonate filled amygdules to 5 mm.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

2.0 %	plagioclase phenocrysts
34.75	plagioclase groundmass (An38)
20.75	augite
18.0	intersertal chlorite
0.25	ilmenite
19.5	sphene and leucoxene
4.75	carbonate (amygdaloidal in part)
100.00	total

Hypidiomorphic plagioclase phenocrysts (to 3mm.) lie in a groundmass of allotriomorphic augite (to 1.5 mm.) subophitically inclosing hypidiomorphic intermediate andesine laths (0.5 mm. - 1.0 mm. long). The augite exhibits moderate alteration to chlorite and the plagioclase exhibits moderate replacement by chlorite and white mica. Flaky and scaly intersertal chlorite is abundant. Ilmenite is present as skeletal crystals which are partially to completely altered to leucoxene and sphene. Sphene is present as skeletal crystals which are partially to completely altered to leucoxene and sphene. Sphene is present as small (0.002 mm.), leucoxene-coated grains which tend to form dense aggregates (0.01 - 0.1 mm.). Sphene is most abundant in the intersertal chlorite, but it is not uncommonly found replacing plagioclase and augite. Carbonate filled amygdules (to 5 mm.) are present.

SAMPLE: RH-321 UNIT: CLAYTON LAKE MEMBER
WINTERVILLE FORMATION

LITHOLOGY: PORPHYRITIC AUGITE ANDESITE

LOCATION: Outcrop in woods on hill top.
46° 43.75' N.Lat., 68° 45.46' W.Long.

MEGASCOPIC DESCRIPTION: Augite phenocrysts in an aphanitic groundmass. Medium greenish-gray.

MICROSCOPIC DESCRIPTION:

MODAL ANALYSIS (400 points counted):

3.75 %	quartz
57.75	plagioclase (phenocrysts and groundmass) (groundmass= An32)
16.25	augite (phenocrysts and groundmass)
13.25	chlorite (intersertal and pseudomorphous after biotite?)
4.0	white mica (intersertal and pseudomorphous after biotite?)
tr	ilmenite
4.75	sphene and leucoxene
0.25	hematite
100.00	total

Glomeroporphyritic, hypidiomorphic to idiomorphic augite (0.5 - 3.0 mm.) and hypidiomorphic plagioclase (1 mm.) lie in a matrix composed of hypidiomorphic sodic andesine (0.3 mm.), allotriomorphic quartz (0.2 mm.), allotriomorphic augite (0.2 mm.), and intersertal chlorite and white mica. The augite is relatively unaltered, whereas the plagioclase exhibits intense alteration to chlorite and white mica. Quartz is present as intergranular, deeply corroded crystals. Leucoxene-coated sphene grains (0.002 mm.) form dense aggregates pseudomorphous after ilmenite. Mixtures of fibrolamellar chlorite and white mica occur as masses (0.5 - 1,0 mm.) having crystal outlines and are possibly pseudomorphous after biotite. Hematite occurs as small (0.01 mm.), scaly masses.

SAMPLE: Rh-333#1 UNIT: CLAYTON LAKE MEMBER
WINTERVILLE FORMATION

LITHPLOGY: PORPHYRITIC AUGITE ANDESITE

LOCATION: Outcrop in woods 100 feet south of hill top. 46° 43.54' N.Lat., 68° 47.06' W.Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Medium greenish-gray.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

4.0 %	plagioclase phenocrysts (An34)
55.5	plagioclase groundmass
tr	augite phenocrysts
13.75	augite groundmass
16.0	intersertal chlorite
10.5	sphene and leucoxene
0.25	secondary quartz
tr	secondary albite
100.00	total

Glomeroporphyritic, idiomorphic to hypidiomorphic, sodic andesine (1.0 - 1.5 mm.) and idiomorphic augite (0.5 - 1.5 mm.) lie in a matrix of felted plagioclase laths (0.2 mm.), allotriomorphic augite (0.2 mm.), and intersertal chlorite. The plagioclase exhibits intense alteration to chlorite and white mica. The augite exhibits minor to nearly complete alteration to chlorite. Small (0.001 mm.), leucoxene-coated sphene grains occur as dense aggregates within the intersertal chlorite or pseudomorphous after ilmenite. Secondary quartz and albite are present in minor amounts filling fractures.

SAMPLE: RH-337 UNIT: CLAYTON LAKE MEMBER
WINTERVILLE FORMATION

LITHOLOGY: AUGITE ANDESITE

LOCATION: Outcrop in woods.
46° 43.96' N. Lat., 68° 47.85' W. Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Medium greenish-gray.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

57.75 %	plagioclase (An36)
19.0	augite
17.5	chlorite (intersertal and pseudomorphous after biotite?)
2.25	white mica (intersertal and pseudomorphous after biotite?)
1.5	ilmenite
1.75	sphene and leucoxene
0.25	hematite
100.00	total

Hypidiomorphic augite (0.2 - 0.4 mm.) subophitically incloses hypidiomorphic, intermediate andesine (0.2 - 0.8 mm.). The augite exhibits minor alteration to chlorite. The plagioclase exhibits moderate replacement by chlorite and white mica. Scaly and flaky chlorite and fibrolamellar white mica is intersertal to the augite and plagioclase. Mixtures of fibrolamellar chlorite and white mica are also present in masses having crystal outlines and are possibly pseudomorphous after biotite. Ilmenite occurs as fractured, skeletal crystals (to 1 mm.) which are partially altered to sphene and leucoxene. Hematite is present in small amounts along fractures.

SAMPLE: RH-85#1 UNIT: GREENLAW MOUNTAIN MEMBER
WINTERVILLE FORMATION

LITHOLOGY: AMYGDALOIDAL, PORPHYRITIC ANDESITE

LOCATION: Outcrop on south shore of Carr Pond.
46° 45.76' N.Lat., 68° 43.86' W.Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Medium greenish-gray. 1 mm. amygdules filled with carbonate, chlorite, and pyrite.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

7.5 %	plagioclase phenocrysts
58.75	plagioclase groundmass (An35)
22.75	intersertal chlorite
3.5	sphene and leucoxene
0.25	nonamygdular pyrite
3.5	nonamygdular carbonate
1.0	amygdular chlorite
1.25	amygdular pyrite
1.5	amygdular carbonate
100.00	total

Glomeroporphyritic, hypidiomorphic plagioclase (1mm.) lie in a matrix of felted, hypidiomorphic sodic andesine laths (0.25 mm. long) and intersertal chlorite. The plagioclase phenocrysts are partially to nearly completely replaced by chlorite, white mica, and to a lesser extent carbonate. Sphene occurs as small (0.002 mm.), leucoxene-coated grains which tend to form dense, irregularly shaped aggregates (0.05 mm.). The sphene is largely confined to the chlorite matrix and is rarely found within the plagioclase crystals. The amygdules are filled with a mixture of carbonate, chlorite, and pyrite.

SAMPLE: RH-579 UNIT: ORCUTT MOUNTAIN MEMBER
WINTERVILLE FORMATION

LITHOLOGY: AMYGDALOIDAL ANDESITE

LOCATION: Outcrop in woods to north of the American Realty Road.
46° 39.32' N.Lat., 68° 43.00' W.Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Medium greenish-gray. Carbonate filled amygdules to 10 mm.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

53.5 %	plagioclase
17.0	intersertal chlorite
tr	ilmenite
18.75	sphene and leucoxene
1.25	pyrite
6.0	nonamygdular carbonate
3.5	amygdular carbonate
100.00	total

A felted network of hypidiomorphic sodic andesine laths (0.5 mm. long) lie in an intersertal matrix of flaky and scaly chlorite. The plagioclase exhibits moderate replacement by chlorite, white mica, and carbonate. Sphene, occurring as small (0.002 mm.) grains which are often coated with leucoxene, is an abundant accessory. The sphene usually occurs as dense aggregates (to 0.2 mm.), some of which are clearly pseudomorphous after skeletal ilmenite crystals. Pyrite is present as irregularly shaped masses and partially formed crystals (0.1 mm.) which tend to form around grains. Carbonate filled amygdules (3 - 10 mm) are present.

SAMPLE: RH-85#2 UNIT: GREENLAW MOUNTAIN MEMBER
WINTERVILLE FORMATION

LITHOLOGY: AUTOBRECCIATED QUARTZ BEARING ANDESITE

LOCATION: Outcrop on south shore of Carr Pond.
46° 45.76' N.Lat., 68° 43.86' W. Long.

MEGASCOPIC DESCRIPTION: Autobrecciated with irregularly shaped fragments to 10+ mm. Aphanitic. Medium greenish-gray.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

7.5 %	quartz
43.25	plagioclase (An35)
45.0	intersertal chlorite
tr	ilmenite
4.0	sphene
tr	pyrite
0.25	carbonate
100.00	total

The fragmental material consists of a felted network of hypidiomorphic, sodic andesine laths (0.25 mm. long) and allotriomorphic quartz (0.1 mm.) in a matrix of intersertal chlorite. The quartz exhibits replacement by chlorite around grain boundaries. The plagioclase exhibits moderate replacement by chlorite and white mica. Intersertal chlorite appears as scaly and flaky masses. Small (0.001 mm.), leucoxene-coated grains of sphene form dense, irregularly shaped aggregates (0.03 mm.) which are largely confined to the chlorite matrix.

The interfragmental matrix consists of abundant carbonate alnog with moderate amounts of fine grained quartz and feldspar and intersertal chlorite and white mica. Minor amounts of pyrite and leucoxene-coated sphene are also found in the interfragmental matrix.

SAMPLE: RH-373 UNIT: CLAYTON LAKE MEMBER
WINTERVILLE FORMATION

LITHOLOGY: QUARTZ BEARING ANDESITE

LOCATION: Outcrop in woods.
46° 45.07' N.Lat., 68° 45.04' W.Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Medium greenish-gray.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

12.5 %	quartz
39.0	plagioclase (An32)
28.75	intersertal chlorite
10.25	intersertal white mica
2.75	ilmenite
6.75	sphene and leucoxene
tr	hematite
100.00	total

Quartz occurs as correded, allotriomorphic crystals (0.1 - 0.4 mm.) which often partially inclose the plagioclase laths. The plagioclase forms a network of hypidiomorphic laths (0.2 mm.) which exhibit moderate alteration to chlorite and white mica. Scaly and flaky chlorite, and flaky and fibrolamellar white mica are intersertal to the plagioclase. Ilmenite occurs as skeletal crystals (to 0.1 mm.). Small (0.002 mm.), leucoxene-coated sphene grains are found as an alteration product of ilmenite and as dense, irregularly shaped aggregates (0.05 mm.) in the intersertal chlorite. Hematite is present as small (0.01 mm.) flakes.

SAMPLE: RH-709 UNIT: GREENLAW MOUNTAIN MEMBER
WINTERVILLE FORMATION

LITHOLOGY: QUARTZ BEARING ANDESITE

LOCATION: Outcrop in woods 300 feet southwest of the Carr Pond fire tower.
46° 45.03' N. Lat., 68° 42.30' W.Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Medium gray.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

11.25 %	quartz
50.25	plagioclase (An38)
27.5	chlorite (intersertal and pseudomorphous after biotite?)
4.25	white mica (intersertal and pseudomorphous after biotite?)
tr	ilmenite
4.5	sphene and leucoxene
2.25	hematite
100.00	total

A felted network of hypidiomorphic andesine laths (0.5 mm. long) and intergranular, allotriomorphic quartz (0.1 mm.) lie in an intersertal matrix of scaly and fibrolamellar chlorite and white mica. The plagioclase exhibits moderate alteration to chlorite and white mica. Also present are some mixtures of fibrolamellar muscovite and chlorite which appear to have crystal outlines and may possibly be pseudomorphous after biotite. Sphene occurs as small (0.005 mm.), leucoxene-coated grains which may occur singly, but usually occur as irregularly shaped aggregates (to 0.2 mm). The sphene is most abundant in the chlorite matrix, but it is also found within plagioclase grains. Hematite occurs as patchy, irregularly shaped masses (0.01 - 0.4 mm.).

SAMPLE: RH-319 UNIT: CLAYTON LAKE MEMBER
WINTERVILLE FORMATION

LITHOLOGY: QUARTZ DIORITE

LOCATION: Outcrop in woods.
46° 43.74' N.Lat., 68° 45.65' W.Long.

MEGASCOPIC DESCRIPTION: Medium grained, medium greenish-gray.

MICROSCOPIC DESCRIPTION: Hypidiomorphic plagioclase (An38) crystals 1 - 2 mm. in length and charged with specks of white mica and chlorite is the major constituent. Allotriomorphic quartz (to 0.5 mm.), allotriomorphic augite (to 1 mm.), and intersertal chlorite are abundant. Skeletal crystals of ilmenite, largely altered to leucoxene, is present in small amounts. Myrmekitically intergrown quartz and plagioclase is a notable feature.

INTERPRETATION: The writer considers this to be a small, dike-like intrusion, probably contemporaneous with Winterville volcanism.

SAMPLE: RH-738 UNIT: ORCUTT MOUNTAIN MEMBER
WINTERVILLE FORMATION

LITHOLOGY: AUTOBRECCIATED, PORPHYRITIC QUARTZ KERATOPHYRE

LOCATION: Outcrop on north side of the American Realty Road.
46° 39.68' N.Lat., 68° 40.32' W.Long.

MEGASCOPIC DESCRIPTION: Autobrecciated with fragments to 4+ cm. Aphanitic. Fragments light brown in a dark brown matrix.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION. (400 points counted):

6.25 %	quartz phenocrysts
7.25	plagioclase phenocrysts (albite)
74.75	quartz and feldspar groundmass
9.25	chlorite
0.5	white mica
1.25	sphene and leucoxene
tr	hematite
0.75	secondary quartz
100.00	total

The fragmental material consists of glomeroporphyritic quartz and albite lying in a groundmass of quartz, feldspar (albite?), and chlorite. The feldspar phenocrysts occur as idiomorphic to hypidiomorphic crystals (0.5 mm.) exhibiting minor replacement by chlorite and white mica. The quartz phenocrysts are deeply corroded, idiomorphic, hexagonal-bipyramidal crystals (0.3 mm.), most of which have straight sides and rounded corners, although ofter the corrosion has been so intense as to produce rounded forms. The groundmass consists of interlocking allotriomorphic quartz and feldspar (albite?) crystals (0.03 mm) exhibiting replacement by chlorite and white mica. The groundmass probably represents recrystallized glass. Sphene occurs as small (0.001 mm.), leucoxene-coated grains. Secondary quartz fills small fractures.

SAMPLE: RH-830 UNIT: GREENLAW MOUNTAIN MEMBER
WINTERVILLE FORMATION

LITHOLOGY: AUTOBRECCIATED, PORPHYRITIC QUARTZ KERATOPHYRE

LOCATION: Outcrop in woods.
46° 44.38' N.Lat., 68° 39.96' W. Long.

MEGASCOPIC DESCRIPTION: Autobrecciated with fragments to 1 cm. Fragments light brown in a dark gray matrix.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

2.0 %	quartz phenocrysts
1.25	plagioclase phenocrysts (albite)
58.0	groundmass
38.75	interfragmental matrix
100.00	total

The fragmental material consists of quartz and albite phenocrysts in a groundmass of quartz, albite?, chlorite, and white mica. The quartz phenocrysts (0.5mm.) are deeply corroded and often broken. The original form cannot be positively determined, but they appear to have had the hexagonal-bipyramidal form typical of high-quartz. The albite phenocrysts (0.5 mm.) are hypidiomorphic to idiomorphic, often broken, and exhibit minor replacement by chlorite. The groundmass consists primarily of interlocking, allotriomorphic quartz (0.1 mm.) and albite ? (0.05 mm.). Flaky and fibrolamellar chlorite and white mica are abundant in the groundmass. Small (0.001 mm.), leucoxene-coated sphene grains occur as irregularly shaped aggregates (0.02 mm.) scattered through the groundmass. The groundmass probably represents recrystallized glass.

The interfragmental matrix consists predominantly of chlorite and white mica with smaller amounts of microcrystalline quartz, albite ?, and leucoxene-coated sphene. Hematite is a minor constituent of the interfragmental matrix.

SAMPLE: RH-739 UNIT: ORCUTT MOUNTAIN MEMBER
WINTERVILLE FORMATION

LITHOLOGY: RADIOLARIA AND GRAPTOLITE BEARING, TUFFACEOUS MUDSTONE

LOCATION: Outcrop on north side of the American Realty road. 46° 39.71' N.Lat., 68° 40.10' W.Long.

MEGASCOPIC DESCRIPTION: A dull, black, "cherty" mudstone containing scattered graptilites and interbedded with a graptolitic black slate and andesite?. It is coarsely cleaved parallel to the bedding and breaks with an irregular fracture. Thin, quartz-filled fractures are present.

MICROSCOPIC DESCRIPTION: Radiolaria are concentrated in thin beds. They tend to be slightly elipsoidal in shape, attain a maximum diameter of 0.2 mm., and are filled with both fibroradiating quartz and mosaics of interlocking, microcrystalline quartz. Spines have not been observed.
The matrix consists of quartz grains (0.002 - 0.01 mm.), white mica flakes (0.01 mm.), and carbonaceous material in addition to a large amount of clay minerals.

INTERPRETATION: The writer interprets this rock as the result of deposition of both a fine grained ash and a fine grained terrigineous component. The increased silica content of sea water by the partial solution of the vitric shards would favor the development of radiolaria. The quartz particles are believed to be partially terrigineous and partially the product of crystalization of the vitric shards. The clay minerals are believed to be for the most part derived from the alteration of the vitric shards. Possibly, the siliceous aspect of the rock is wholly the result of radiolaria debris, and a distinct tuffaceous component is lacking.

SAMPLE: RH-799 #1 UNIT: ORCUTT MOUNTAIN MEMBER
WINTERVILLE FORMATION

LITHOLOGY: FERRUGINOUS, RADIOLARIA BEARING, FINE GRAINED, WATER-DEPOSITED TUFF.

LOCATION: Outcrop in woods.
46° 39.06' N.Lat., 68° 40.10' W.Long.

MEGASCOPIC DESCRIPTION: Deep, dull, reddish brown weathering a dull brick red. Occasional 1 mm. thick, discontinuous, dark gray laminae. Dull, "cherty" luster. Breaks with a subconchoidal fracture.

MICROSCOPIC DESCRIPTION: Radiolaria are represented by nearly spherical bodies (maximum diameter 0.3 mm.) filled with both fibroratiated quartz and mosaics of interlocking, microcrystalline quartz. Individuals showing remnants of spines are present, but rare. Radiolarian remains comprise 5% of the thin section studied, however their concentration varies markedly over distances of several millimeters perpendicular to bedding. Rod-shaped bodies (up to 0.1 mm. long and 0.01 mm. wide) are scattered throughout the matrix. These probably represent broken radiolarian spines. The matrix consists of a mosaic of small (0.001 mm. - 0.002 mm.), interlocking quartz grains, each grain exhibiting an undulose extinction. The matrix is colored red by small (less than 0.001 mm.), disseminated grains of hematite. Irregularly-shaped masses (0.001 mm.) of chlorite and clay minerals, flakes of white mica (0.01 mm.), and rhombs of carbonate (0.02 mm.) are present in varying amounts in the matrix. Terrigineous components appear to be absent.

INTERPRETATION: This rock appears to be the result of deposition of fine-grained ash in a marine environment. The ash, settling through the water, would partially dissolve, increasing the silica content of the water and producing conditions favorable for the development of radiolaria. Reorganization of the vitric shards would result in the matrix of quartz, chlorite, clay minerals, white mica, and carbonate. The hematite is believed to have been precipitated from water whose iron content had been increased by the interaction of sea water with hot lava. This may indicate that the eruption supplying the ash may have been subaqueous.

SAMPLE: RH-799#2 UNIT: ORCUTT MOUNTAIN MEMBER
WINTERVILLE FORMATION

LITHOLOGY: RADIOLARIAN BEARING, WATER DEPOSITED TUFF.

LOCATION: Outcrop in woods.
46° 39.06' N.Lat., 68° 40.10' W.Long.

MEGASCOPIC DESCRIPTION: A subvitreous, medium bluish-gray, "cherty" rock weathering light brown. Breaks with a subconchoidal fracture.

MICROSCOPIC DESCRIPTION: Radiolaria are represented by nearly spherical bodies (maximum diameter 0.4 mm.) filled with both fibroradiated quartz and mosaics of interlocking, microcrystalline quartz with lesser amounts of chlorite, clay minerals, and carbonate rhombs. Terrigineous material appears to be absent.

INTERPRETATION: The writer interprets this rock as the result of deposition of fine-grained ash in a marine environment. The ash, settling through water would partially dissolve, thereby increasing the silica content of the water. This would produce a condition favorable for the development of radiolaria. Reorganization of the vitric shards would result in the finely crystalline matrix of quartz, chlorite, clay minerals, and carbonate.

SAMPLE: RH-340 UNIT: CLAYTON LAKE MEMBER
WINTERVILLE FORMATION

LITHOLOGY: FINE GRAINED, WATER-DEPOSITED TUFF

LOCATION: Outcrop in woods.
46° 43.83' N Lat., 68° 46.82' W. Long.

MEGASCOPIC DESCRIPTION: Medium green weathering light brown. Well defined laminae ranging in thickness from ½ to 10 mm.

MICROSCOPIC DESCRIPTION: The laminae are the result of textural variation. The coarser laminae consist of silt-sized grains (maximum diameter 0.05 mm.) of quartz, plagioclase, rock fragments, and minor pyroxene(?). The grains are predominantly angular. Subrounded grains are also present, but this is probably the result of corrosion. The rock fragments consist primarily of recrystallized glass shards. These are composed of microcrystalline quartz and varying amounts of albite(?) and chlorite.

Irregularly shaped masses of carbonate are a minor constituent of the coarser laminae. These carbonate masses have approximately the same size distribution as do the quartz and plagioclase grains. Matrix comprises about 50% of the coarser laminae. It consists chiefly of chlorite, clay minerals, microcrystalline quartz and feldspar, and lesser amounts of carbonate and pyrite. The finer laminae exhibit a significant decrease in the maximum grain size (0.01 mm. maximum) and increase in the matrix content over the coarser laminae. Otherwise the finer laminae closely resemble the coarser laminae previously described.

Radiolaria, represented by spherical bodies filled with microcrystalline quartz, and occasionally some albite and chlorite, are scattered throughout the section. Spines have not been observed; but internal lattice structure is evident in some individuals. The largest individuals (to 0.4 mm. maximum) are found associated with the coarser laminae, whereas the finer grained laminae typically contain smaller individuals.

INTERPRETATION: The writer suggests that the matrix is in large part reorganized vitric shards and the fragmental material represents ejecta. The association of the largest radiolaria with the coarsest laminae suggests reworking of a previously deposited ash.

SAMPLE: RH-339 UNIT: CLAYTON LAKE MEMBER
WINTERVILLE FORMATION

LITHOLOGY: WATER-DEPOSITED TUFF.

LOCATION: Outcrop on woods.
46° 43.88' N.Lat., 68° 46.82' W.Long.

MEGASCOPIC DESCRIPTION: Beds several inches thick exhibit well developed grading from coarse sand sized to silt sized. The coarser portions range from medium to light greenish-gray. The finer portions are medium olive green, have a subvitreous luster, and display poorly developed, discontinuous parallel lamination. The rock weathers rusty brown.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted) of the coarser beds:

1.5 %	Quartz crystals
18.5	Plagioclase crystals
tr	Pyroxene
0.25	Lithic fragments
79.75	Other (in large part fragments of recrystallized glass)
100.00	total

The quartz occurs as corroded, often broken, and occasionally embayed crystals (to 0.5 mm.) which occasionally exhibit the hexagonal-bipyramidal form typical of high-quartz. The plagioclase crystals (to 1 mm.) are usually deeply corroded and broken, only occasionally do they exhibit crystal faces. Pyroxene (augite?) is present in minor amounts as small (to 0.3 mm.) crystals. The bulk of the rock consists of allotriomorphic, interlocking grains (0.02 mm.) of quartz and feldspar (albite?). This, at first, appears to be matrix; however, it is truly fragmental (to 1 mm.), each fragment differing slightly in texture from neighboring fragments and separated from one another by chlorite and a small amount of leucoxene. The writer interprets these fragments as recrystallized glass shards.
The finer portion consists of scattered angular grains (0.1 mm.) of quartz and feldspar set in a microcrystalline matrix composed of a mosaic of small (0.02 mm.), interlocking, allotriomorphic grains of

quartz and feldspar along with small (0.01 mm.) scales of chlorite and some clay minerals. One circular body (0,2 mm.), filled with granular quartz, possibly represents a radiolarian.

INTERPRETATION: The writer considers this to be a water-deposited tuff which is composed primarily of vitric shards (now recrystallized) and contains minor amounts of quartz fragments, lithic fragments, and pyroxene. The graded bedding may indicate deposition by turbidity currents.

SAMPLE: RH-279 UNIT: CLAYTON LAKE MEMBER
WINTERVILLE FORMATION

LITHOLOGY: TUFFACEOUS SANDSTONE

LOCATION: Outcrop on old lumber road.
46° 43.96' N Lat., 68° 47.08' W.Long.

MEGASCOPIC DESCRIPTION: Medium grained, greenish-gray sandstone weathering light brown.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

7.0 %	quartz
27.5	plagioclase
36.0	recrystallized glass fragments
2.75	fine grained, water deposited tuff fragments
5.0	volcanic rock fragments
3.0	pyroxene (augite?)
18.75	matrix
100.00	total

The quartz grains occur as broken crystals (to 0.6 mm.) often exhibiting one or two faces joined by rounded corners. Occasionally more complete crystals are found. These are of the hexagonal-bipyramidal form typical of high quartz and are very similar in size and shape to the quartz phenocrysts in the quartz keratophyres of the Winterville Formation. Some of the quartz grains are very angular and splintery or p laty in thin section. These grains may have been derived from explosive volcanism or from weathering of quartz keratophyres (these commonly have broken crystals).
Plagioclase occurs as crystals or broken crystals (to 0.6 mm.) which exhibit little mechanical abrasion. Subrounded grains (to 1.0 mm.) composed of micro-crystalline, interlocking, allotriomorphic grains of quartz and plagioclase with intersertal chlorite appear to represent recrystallized glass shards. These occasionally contain plagioclase phenocrysts. The clasts of very fine grained, water-deposited tuff ase similar to those previously described in the Winterville Formation (RH-340, etc.). They attain

a size of 1 mm. and often exhibit plastic deformation indicating they are contemporaneous with deposition of the sandstone.
The volcanic rock fragments are very fine grained andesites of typical Winterville character.
Pyroxene (augite?) occurs as subangular grains which attain a maximum size of 0.4 mm.
The matrix is largely microcrystalline quartz and feldspar and probably represents an original ash matrix.

INTERPRETATION: The writer interprets this rock as a tuffaceous, water-deposited sandstone. The quartz may have been derived from explosive volcanism or by weathering of the quartz keratophyres of the Winterville Formation. The plagioclase crystals are thought to have been derived from explosive volcanism rather than by weathering as they frequently occur as complete crystals exhibiting little abrasion. The glass and andesite fragments were probably derived from explosive volcanism (subaqueous or subaerial) along with the quartz and plagioclase. The plastic deformation observed in the very fine grained, water-deposited tuff clasts indicate they are penecontemporaneous with deposition and were torn up from a previously deposited, cohesive, and plastic tuff by the current transporting the other components.

SAMPLE: RH-174 UNIT: CLAYTON LAKE MEMBER
WINTERVILLE FORMATION

LITHOLOGY: TUFFACEOUS CONGLOMERATE

LOCATION: 100 feet north of old lumber road.
46° 43.48' N.Lat., 68° 47.88' W.Long.

MEGASCOPIC DESCRIPTION: A poorly sorted, silty conglomerate containing boulders up to 1 foot in diameter. The clasts are predominately angular fragments of "chert" (a fine grained, water-deposited tuff) which are most commonly gray or green. Volcanic rock fragments are also abundant. A tabular block of tuffaceous (?), coarse grained siltstone 12 inches by 3 inches in size exhibits intense plastic deformation. The matrix is composed of material similar to the particles composing these tuffaceous siltstone blocks. Interbedded with the conglomerate is a tuffaceous, siltstone similar to the deformed block and to the matrix of the conglomerate. A minimum thickness of the conglomerate bed is 30 feet; however, it may be considerably thicker.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

23.25 %	volcanic rock fragments
47.0	water-deposited tuff clasts
29.75	matrix
100.00	total

The volcanic rock fragments are for the most part fine-grained andesites typical of the Winterville Formation.
The clasts of water-deposited tuff are fine grained and are similar to those previously described from the Winterville Formation. Radiolarian skeletons have been found in several of these clasts, but they are generally rare. Some of the clasts exhibit plastic deformation; this indicates they were deposited while in a cohesive, plastic condition.
The matrix consists of 0.05 mm., angular grains of quartz and plagioclase, some white mica flakes, and masses of secondary carbonate. There are indications of devitrified ash being intergranular to these grains in the matrix, but this is largely altered to clay minerals. Some of the fine grained, water-deposited

tuff clasts (which contain a notable amount of recrystallized glass fragments) contains quartz and feldspar grains of the same size and form as those of the matrix. This strongly suggests that the matrix was derived from an unconsolidated equivalent of the water-deposited tuff fragments.

INTERPRETATION: The writer interprets this conglomerate as having been deposited by a subaqueous plastic mass flow (as used by Dott,1963). The flow consisted of andesite clasts which were derived by weathering of Winterville lithologies, and of fragments of water-deposited tuff which were torn from the bottom in a cohesive, plastic state. The matrix appears to be tuffaceous and is composed of material very similar to some of the water-deposited tuff clasts. It probably represents previously deposited tuffaceous material which was less cohesive than the material forming the penecontemporaneous clasts and thus was disrupted into its individual grains by the flow. A marine depositional environment is suggested by the presence of radiolaria in some of the tuffaceous clasts.

SAMPLE: RH-330 UNIT: CLAYTON LAKE MEMBER
WINTERVILLE FORMATION

LITHOLOGY: TUFFACEOUS CONGLOMERATE

LOCATION: Disturbed outcrop in woods.
46° 44.12' N.Lat., 68° 45.96' W.Long.

MEGASCOPIC DESCRIPTION: Conglomerate composed of subrounded clasts (to 30 mm.) of light brown volcanics and gray "chert" (fine grained, water-deposited tuff) (to 3 cm.) which exhibit intense plastic deformation. The matrix is fine grained, gray material of the same character as the components of the tuff clasts.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

4.0 %	quartz
3.5	plagioclase
2.75	andesite fragments
51.5	quartz keratophyre and recrystallized glass fragments
38.25	fine grained, water-deposited tuff clasts and matrix.
100.00	total

The andesite fragments are subrounded and are composed of very fine plagioclase laths.
The quartz keratophyre clasts consist of quartz and albite phenocrysts in a very fine grained groundmass. The quartz phenocrysts are frequently broken and occasionally embayed. They attain a maximum diameter of 1.5+ mm. They frequently exhibit two or more straight faces joined by rounded corners. Occasionally they have been so intensely corroded that they are well rounded. The hexagonal-bipyramidal form of high-quartz has been observed on several well formed crystal. The albite phenocrysts are often broken and attain a maximum length of 1 mm. The groundmass of the quartz keratophyre clasts consists of interlocking, allotriomorphic grains (0.02 - 0.04 mm.) of quartz and albite(?) along with patchy masses of chlorite. This groundmass appears to be a devitrified glass.
The fragments of fine grained, water-deposited tuff are typical of those previously described in the Winterville Formation. They exhibit intense plastic

deformation and appear to have been"squeezed" between grains so as to form part of the "matrix".

The matrix consists of material similar to the water-deposited tuff clasts mixed with small grains of quartz, plagioclase, and glass. It appears to have been derived from material similar to that forming the tuff clasts, but somewhat less cohesive so that it was broken into small fragments which became smeared out during deposition.

The individual quartz and plagioclase are identical to those found in the quartz keratophyres of the Winterville Formation.

INTERPRETATION: The writer interprets this conglomerate to have been deposited by a subaqueous, plastic mass flow similar to the proposed mechanism for RH-174. The quartz and plagioclase clasts were obviously derived from the same source as the quartz keratophyre fragments. This may have been through explosive volcanism or it could have been by intense fracturing due to the quenching of a subaqueous flow by sea water. If this latter interpretation is correct, then this conglomerate may be a reworked hyaloclastite (as used by Silvestri,1963).

SAMPLE: RH-742 UNIT: MACHIAS RIVER FORMATION

LITHOLOGY: AUGITE ANDESITE

LOCATION: Outcrop in woods.
46° 38.60' N.Lat., 68° 45.26' W.Long.

MEGASCOPIC DESCRIPTION: Dull, medium greenish-gray weathering rusty brown. Somewhat sheared.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

46.0 %	plagioclase (An35)
25.75	augite
19.25	intersertal chlorite
2.75	intersertal white mica
1.25	ilmenite
4.25	sphene and leucoxene
100.00	total

Augite (to 4 mm.) ophitically incloses hypidiomorphic sodic andesine laths (to 1.5 mm.). The augite is relatively unaltered, whereas the andesine is intensely altered to chlorite, carbonate, and white mica. Scaly and fibrolamellar chlorite, mixed with a small amount of white mica, is intersertal to the augite and plagioclase. Ilmenite is present as skeletal crystals (to 0.5 mm.) which are largely altered to leucoxene. Small (0.002 mm.), leucoxene-coated sphene grains are present in small amounts in the chlorite matrix.

SAMPLE: RH-745 UNIT: MACHIAS RIVER FORMATION

LITHOLOGY: COARSE GRAINED GRAYWACKE

LOCATION: Outcrop in woods.
46° 38.32' N.Lat., 68° 44.18' W.Long.

MEGASCOPIC DESCRIPTION: Coarse grained, poorly sorted, gray sandstone weathering light brown.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

58.5 %	quartz
5.75	microcline
1.25	perthite
3.0	plagioclase
8.5	recrystallized glass fragments
0.5	andesite fragments
1.75	fine grained, water-deposited tuff clasts
1.0	slate chips
0.5	ilmenite?
0.5	carbonate
tr	detrital muscovite
18.75	matrix
100.00	total

Poorly sorted.
Quartz occurs as subangular to well rounded grains averaging 3/4 mm. in diameter and attaining a maximum diameter of 1½ mm. Occasionally a quartz grain exhibits two or more poorly defined crystal faces. The shape and size of these grains suggest they were derived from the quartz keratophyres of the Winterville Formation. Approximately 20% of the quartz grains contain sparce accicular inclusions 0.5 mm. X 0.0005 mm. Similar inclusions were not observed in any of the quartz keratophyres or quartz-bearing andesites of the Winterville Formation. The writer feels that this quartz was derived from a non-Winterville source, probably from the same source that supplied the microcline. The well rounded quartz grains do not necessarily indicate a long abrasion history as the quartz phenocrysts of the quartz keratophyres of the Winterville Formation are often strongly corroded.
The microcline grains are subrounded to rounded and average ½ mm. in diameter.
Plagioclase occurs as subrounded to subangular grains averaging ½ mm. in diameter.
The fragments of recrystallized glass are generally subrounded to rounded and they attain a maximum diameter of 1 mm. They are similar to the "glassy" groundmass in the quartz keratophyres of the Winterville

Formation.
The andesite fragments belong to typical Winterville lithologies, are subrounded to rounded, and attain a diameter of 1 mm.
The fragments of fine grained, water-deposited tuff are typical Winterville lithologies. They occur as rounded to subrounded grains attaining a maximum diameter of 1½ mm.
The slate fragments attain a diameter of 1 mm. and are probably penecontemporaneous.
White mica flakes are present in trace amounts. They attain a length of 0.1 mm., are commonly bent, and they appear to be detrital.
The matrix is largely scaly chlorite with minor amounts of white mica and small, irregularly shaped masses of leucoxene-coated sphene also present.

INTERPRETATION: The writer, from evidence based on similar sandstones within the formation, believes these sandstones were emplaced by turbidity currents. They have a mixed source. Part of the quartz; all of the recrystallized glass, andesite, and water-deposited tuff, and possibly all of the plagioclase were derived from the Winterville Formation. Part of the quartz and all of the microcline and perthite were derived from an igneous source area or from sediments derived from an igneous area.

SAMPLE: RH-75#2 UNIT: MEMBER #1
CARR POND FORMATION

LITHOLOGY: AMYGDALOIDAL ANDESITE

LOCATION: 30 foot ledge on south side of ridge.
46° 46.20' N.Lat., 68° 42.72' W.Long.

MEGASCOPIC DESCRIPTION: Aphanitic, medium green andesite with 5 mm. amygdules.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

47.25 %	plagioclase (An36)
15.75	intersertal chlorite
19.25	sphene, leucoxene, and very fine carbonate
1.25	secondary quartz
6.25	secondary carbonate
2.75	amygdular chlorite
6.25	amygdular carbonate
1.0	amygdular quartz
100.00	total

A felted network of sodic andesine laths (0.4 mm.) exhibiting moderate alteration to chlorite, white mica, and carbonate lies in a groundmass of intersertal chlorite. Small (0.001 mm.) grains of leucoxene-coated sphene and carbonate are mixed to form irregularly shaped masses in the chlorite matrix. The amygdules are filled with one or more of the following: carbonate; chlorite; and quartz. Nonamygdular secondary carbonate and quartz are minor constituents.

SAMPLE: RH-77#1 UNIT: MEMBER #1
CARR POND FORMATION

LITHOLOGY: ANDESITIC VOLCANIC BRECCIA

LOCATION: Outcrop on ridge in woods.
46° 46.24' N.Lat., 68° 42.80' W.Long.

MEGASCOPIC DESCRIPTION: A volcanic breccia composed of purplish-brown, aphanitic andesite fragments (several inches in maximum diameter) set in a chlorite matrix.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

37.25 %	plagioclase (An34)
5.0	intersertal chlorite
56.5	interfragmental matrix (hematite and chlorite)
0.75	amygdular chlorite
0.25	amygdular quartz
0.25	amygdular carbonate
100.00	total

A felted network of hypidiomorphic sodic andesine laths (0.15 mm. long), partially altered to chlorite, white mica, and carbonate, lies in a groundmass of intersertal chlorite and an opaque mixture of finely divided hematite and carbonate. Amygdules (to 1.5 mm.) are filled with quartz, chlorite, and carbonate.

SAMPLE: RH-215E UNIT: MEMBER # 4
CARR POND FORMATION

LITHOLOGY: AMYGDALOIDAL ANDESITE

LOCATION: Outcrop on south side of road to Milliard's camp, 1.55 road miles from the American Realty Road. 46° 40.65' N.Lat., 68° 50.66' W.Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Medium olive green. carbonate and chlorite filled amygdules (to 1 cm.) are present.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

58.75 %	plagioclase (An36)
19.25	intersertal chlorite
15.25	sphene and leucoxene
2.75	secondary carbonate
3.50	amygdular chlorite
0.5	amygdular carbonate
100.00	total

A felted network of hypidiomorphic sodic andesine laths (0.5 mm.) lie in a matrix of intersertal chlorite. The plagioclase exhibits moderate replacement by chlorite and carbonate. Small (0.002 mm.), leucoxene-coated sphene grains form irregularly shaped aggregates in the chlorite matrix, especially around plagioclase grain boundaries.

SAMPLE: RH-312 UNIT: MEMBER # 4
CARR POND FORMATION

LITHOLOGY: AUGITE ANDESITE

LOCATION: Outcrop in woods.
46° 40.70' N. Lat., 68° 50.75' W. Long.

MEGASCOPIC DESCRIPTION: Aphanitic, greenish-gray andesite.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

50.5 %	plagioclase (An34)
22.25	augite
17.5	intersertal chlorite
1.25	ilmenite
7.75	sphene and leucoxene
0.75	amygdular chlorite
100.00	total

Allotriomorphic augite (to 2 mm.) subophitically incloses hypidiomorphic andesine laths (to 1 mm. long). The augite is relatively unaltered whereas the plagioclase exhibits moderate alteration to chlorite and white mica. Scaly and flaky chlorite occurs intersertal to the augite and plagioclase and also as vessicle fillings. Ilmenite occurs as skeletal crystals which are commonly partially altered to leucoxene. Very finely crystalline leucoxene-coated sphene occurs as irregularly shaped aggregates (0.03 mm.).

SAMPLE: RH-134D UNIT: MEMBER # 5
CARR POND FORMATION

LITHOLOGY: VITROPHYRIC QUARTZ KERATOPHYRE

LOCATION: Outcrop in woods.
46° 45.34' N.Lat., 68° 48.14' W.Long.

MEGASCOPIC DESCRIPTION: Medium bluish gray. 1 - 3 mm. phenocrysts in a fine grained groundmass displaying well developed flow structure.

MICROSCOPIC DESCRIPTION: Andesine phenocrysts (An_{40}) (to 3 mm.) lie in a groundmass of microcrystalline, interlocking, allotriomorphic quartz and plagioclase grains. The plagioclase phenocrysts are often broken and exhibit minor alteration to white mica and clay minerals. The groundmass exhibits well developed flow structure and is altered to clay minerals. Leucoxene pseudomorphous after ilmenite is present in small amounts. The writer interprets the groundmass as representing recrystallized glass.

SAMPLE: RH-211 UNIT: MEMBER # 4
CARR POND FORMATION

LITHOLOGY: VITROPHYRIC QUARTZ KERATOPHYRE

LOCATION: Outcrop on south side of road to Milliard's Camp; 0.8 road miles west of the T12 R8 - T12 R9 townline.
46° 40.82' N.Lat., 68° 50.35' W.Long.

MEGASCOPIC DESCRIPTION: Light bluish-gray. 1-3 mm. phenocrysts in a fine grained groundmass which displays very well developed flow structure. Chalky, white weathering rind 5 mm. thick.

MICROSCOPIC DESCRIPTION: Andesine (An36) phenocrysts (to 3 mm.), intensely altered to carbonate, lie in a groundmass of interlocking, allotriomorphic, microcrystalline (0.01 - 0.1 mm.) quartz and albite and clay minerals. Leucoxene pseudomorphous after ilmenite is present in small amounts. Flow structure is very well developed in the groundmass which the writer interprets as recrystallized glass.

SAMPLE: RH-76 UNIT: MEMBER # 1
CARR POND CONGLOMERATE

LITHOLOGY: ROUNDSTONE CONGLOMERATE (RED PHASE)

LOCATION: Outcrop in woods north of Carr Pond.
46° 46.10' N. Lat., 68° 43.08' W.Long.

MEGASCOPIC DESCRIPTION: Poorly sorted, thickly bedded conglomerate containing pebbles to 2 inches in diameter. The pebbles are predominantly rounded to subrounded, but subangular pebbles are not uncommon. The pebbles fall into two main types - volcanic and "cherts". The larger pebbles are predominantly light colored porphyritic lithologies which resemble the quartz keratophyres of the Winterville Formation. Nearly all the "chert" pebbles are reddish-brown colored and resemble the red, water-deposited tuffs of the Winterville Formation. Green "chert" clasts are uncommon. The matrix is colored reddish-brown and together with the red "chert" clasts it imparts a distinct reddish color to the rock.

MICROSCOPIC DESCRIPTION: The pebbles are of two major types: 1. volcanic; and 2. water-deposited tuff and tuffaceous sandstone. Most of the volcanic pebbles are quartz keratophyres similar to the quartz keratophyres of the Winterville Formation. Very fine grained andesite pebbles are also present. These are similar to some of the finer grained andesites of the Winterville Formation; however, they could have been derived from contemporaneous Silurian volcanics. Most of the pebbles of water-deposited tuff and tuffaceous sandstone are densely charged with finely divided hematite. These pebbles are very similar to some of the "red, water-deposited tuffs" found in the Winterville Formation.
The sand-sized material consists of fragments of the above mentioned lithologies and clasts of quartz and plagioclase. The quartz and plagioclase appears to have been derived from Winterville rocks, however some may have been derived from another source. This is suggested by the presence of accicular inclusions in some of the quartz grains. Similar inclusions have not been found in any of the quartz in the Winterville volcanics; however, they have been found in quartz grains in the graywacke of the Machias River Formation. Microcline, perthite, and detrital white mica are present in trace amounts. The matrix is composed of very finely divided hematite and locally of carbonate.

SAMPLE: RH-756 UNIT: MEMBER # 1
CARR POND FORMATION

LITHOLOGY: ROUNDSTONE CONGLOMERATE (RED PHASE)

LOCATION: Outcrop on east side of lumber road, 3.28 miles north of the American Realty Road. 46° 41.83' N. Lat., 68° 39.02' W.Long.

MEGASCOPIC DESCRIPTION: Poorly sorted roundstone conglomerate interbedded with a very coarse grained sandstone. "Chert" pebbles are abundant. These "chert" pebbles are often reddish brown in color, are angular to rounded, and attain an extreme size of 12 X 5 inches. Light colored quartz keratophyre and greenish gray andesite pebbles are present. Crinoid columnals are abundant and brachiopods are present in small numbers.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

10.75 %	quartz keratophyre pebbles
17.25	andesite pebbles
21.25	water-deposited tuff and tuffaceous ss pebbles
6.5	quartz
7.0	plagioclase
8.5	quartz diorite and myrmekite
12.75	carbonate
3.75	slate chips
12.25	matrix
100.00	total

The quartz keratophyre, water-deposited tuff, and tuffaceous snadstone clasts are typical of Winterville lithologies. The andesite is similar to some Winterville andesite, but could have been derived from contemporaneous Silurian volcanism. The quartz diorite clasts are composed of quartz and plagioclase (andesine) crystals which attain a length of 1 mm. Myrmekitic textures are common in these quartz diorite clasts. The carbonate occurs as irregularly shaped masses which for the most part are crinoidal columnals. The matrix is composed of chlorite and carbonate.

SAMPLE: PF-211 UNIT: MEMBER # 1
CARR POND FORMATION

LITHOLOGY: ROUNDSTONE CONGLOMERATE

LOCATION: Ledge 200 feet north of cabins on N side of Carr Pond.
46° 46.20' N. Lat., 68° 43.48' W. Long.

MEGASCOPIC DESCRIPTION: Roundstone conglomerate, poorly sorted, contains as occasional clast to 6 inches. Pebbles are predominantly light colored volcanics. and green, gray, and red "chert". Greenish-gray colored weathering light brown.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

31.75 %	water-deposited tuff ("chert") clasts
32.25	quartz keratophyre and quartz clasts
15.5	andesite
20.5	matrix
100.00	total

The water-deposited tuff clasts are typical Winterville lithologies. An occasional radiolarian skeleton has been observed in these clasts.
The quartz keratophyre clasts are similar to the quartz keratophyres of the Winterville Formation. They consist of microcrystalline, allotriomorphic, interlocking grains of quartz and albite (?) with an occasional phenocryst of quartz and albite. Some of the quartz grains appear to have been derived from the quartz keratophyres; however, some could have been derived from another source. The andesite clasts are typical of the fine grained Winterville andesites; but some could have been derived from contemporaneous Silurian volcanics.
The matrix consists of irregular, patchy masses of carbonate and chlorite.

SAMPLE: RH-81 UNIT: MEMBER # 1
CARR POND FORMATION

LITHOLOGY: PEBBLY, VERY COARSE GRAINED SANDSTONE

LOCATION: Outcrop in woods.
46° 46.36' N. Lat., 68° 42.46' W. Long.

MEGASCOPIC DESCRIPTION: Gray, poorly sorted pebbly sandstone, weathers brown.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

9.25 %	fine grained, water-seposited tuff clasts
70.75	quartz keratophyre fragments and quartz
4.75	andesite clasts
15.25	matrix
100.00	total

The fragments of water-deposited tuff are fine grained, and generally rounded. They are typical Winterville lithologies. The quartz keratophyre clasts are sub-rounded to well rounded and consist of interlocking, allotriomorphic, microcrystalline grains o f quartz, albite, and an occasional quartz or albite phenocryst. They are typical representatives of quartz keratophyres of the Winterville Formation. The quartz clasts appear for the most part to have been derived from the weathering of the quartz keratophyres of the Winterville Formation.
The andesite fragments are very fine grained and are usually rounded. They could have been derived from Winterville andesites or from contemporaneous Silurian volcanics.
The matrix is composed of chlorite and microcrystalline quartz and albite ?. It appears to be partially tuffaceous.

SAMPLE: RH-241 UNIT: MEMBER # 2
CARR POND FORMATION

LITHOLOGY: VERY COARSE SANDSTONE

LOCATION: Outcrop on north side of 20-Mile Brook. 46° 41.68' N. Lat., 68° 48.30' W. Long.

LITHOLOGY: Interbedded very coarse sandstone, pebbly sandstone, and roundstone conglomerate. Medium greenish-gray.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

20.5	%	quartz keratophyre clasts
17.5		andesite clasts
8.75		water-deposited tuff and tuffaceous ss. clasts
25.0		quartz
8.5		plagioclase
1.75		quartz diorite and myrmekite
1.25		carbonate
3.75		slate chips
0.25		detrital ilmentite
12.75		matrix
100.00		total

Quartz keratophyre and water-deposited tuff fragments belong to typical Winterville lithologies. The quartz and plagioclase grains appear to have been derived for the most part from the Winterville volcanics, but part may have been derived from another source. The andesite is very fine grained and resembles the Winterville andesites, but part could have been derived from contemporaneous Silurian volcanics. Rounded clasts of quartz diorite closely resemble the quartz diorite found in the Winterville Formation and often have a myrmekitic texture.
The matrix is composed of chlorite, carbonate, and a small amount of leucoxene-coated sphene.

SAMPLE: RH-282C UNIT: MOOSEHORN STREAM FROMATION

LITHOLOGY: ANDESITE

LOCATION: Outcrop on old lumber road.
46° 44.02' N. Lat., 68° 47.20' W.Long.

MEGASCOPIC DESCRIPTION: Aphanitic. Medium greenish-gray. Carbonate and chlorite filled amygdules.

MICROSCOPIC DESCRIPTION:

MODAL COMPOSITION (400 points counted):

19.5	intersertal chlorite
7.0	plagioclase phenocrysts
45.0	plagioclase (An34)
17.25	sphene and leucoxene
1.5	amygdular chlorite
3.25	amygdular carbonate
1.5	pyrite
5.0	carbonate
100.00	total

Allotriomorphic plagioclase phenocrysts several mm. long lie in a groundmass of 0.5 mm. long plagioclase laths which are moderately replaced by chlorite and white mica and occasionally sphene and leucoxene. Intersertal chlorite is abundant. 0.03 mm. grains of leucoxene-coated sphene are abundant.

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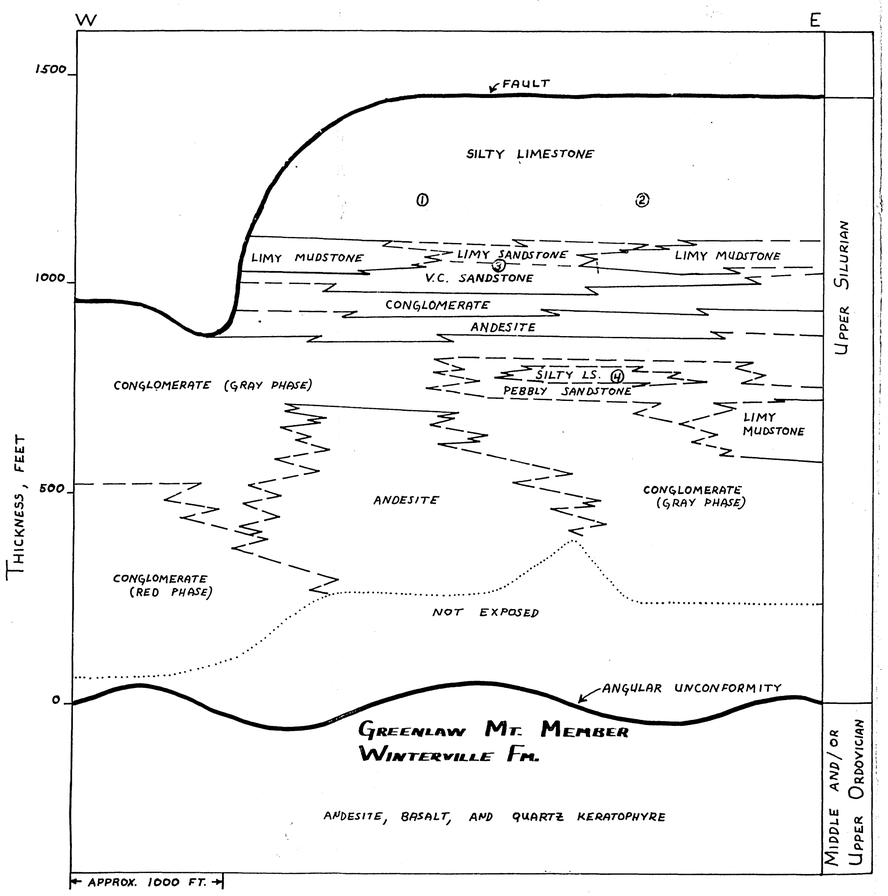
Fig. 30. — Stratigraphic Sections of the Carr Pond Formation

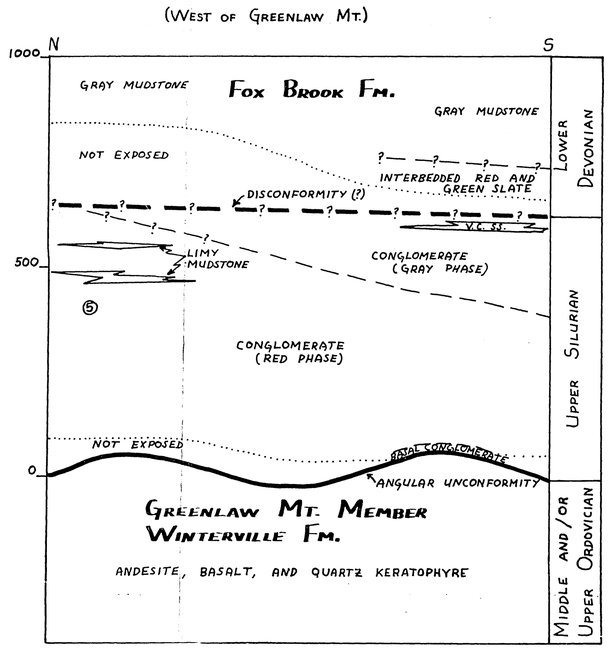
MEMBER #1

(North of Carr Pond)



MEMBER #1

(West of Greenlaw Mt.)

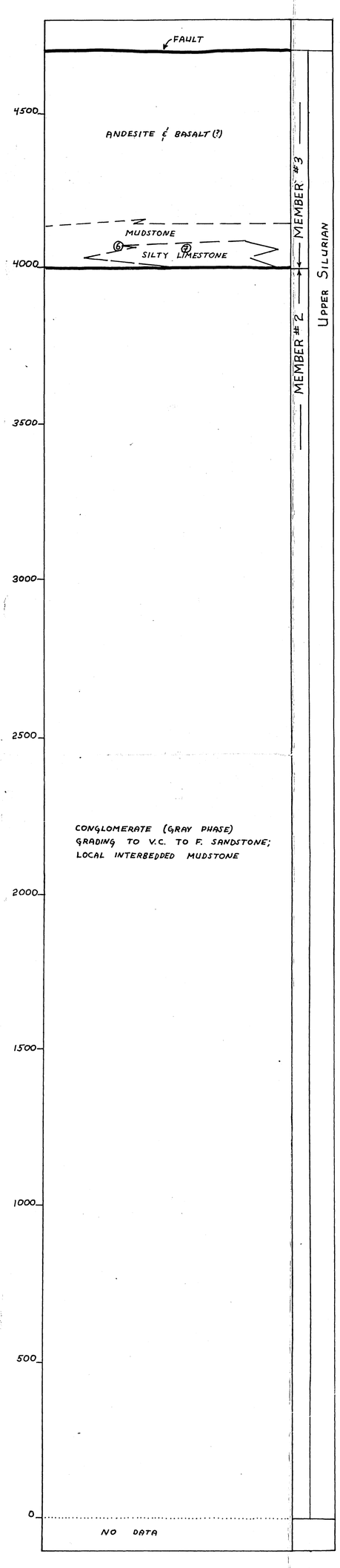


Fossil Localities
(see Appendix I for determinations)

① RH-470	⑧ RH-215
② RH-477	⑨ RH-215C
③ RH-555	⑩ PF-235, PF-235A
④ RH-565	⑪ PF-238A
⑤ RH-756	⑫ PF-266, PF-267
⑥ RH-672	⑬ RH-134
⑦ RH-262	

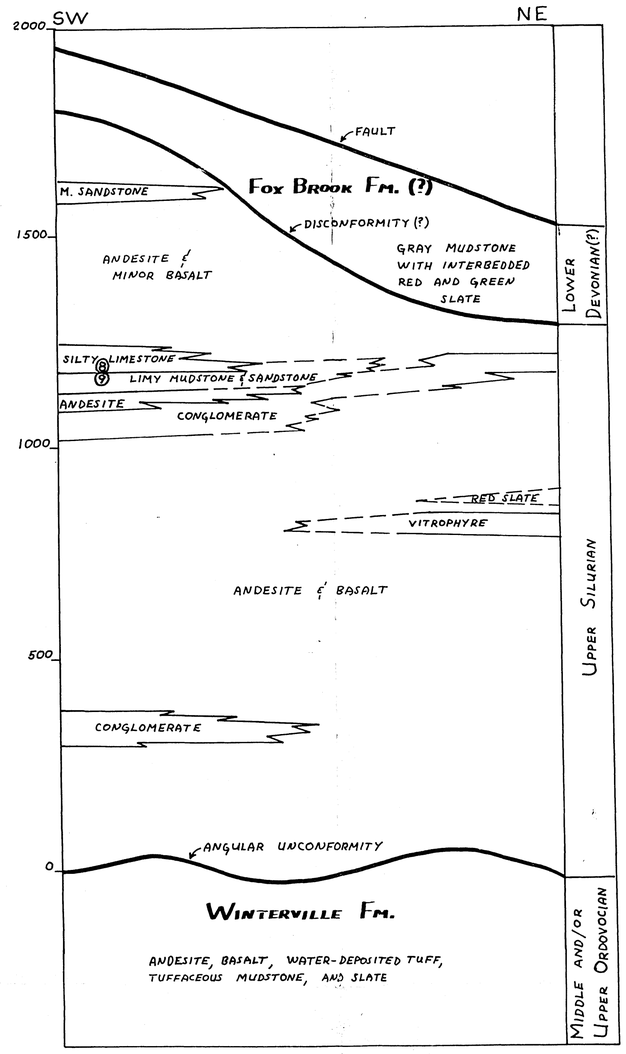
MEMBERS #2 & 3

(Northwest and South of Big Machias Lake)



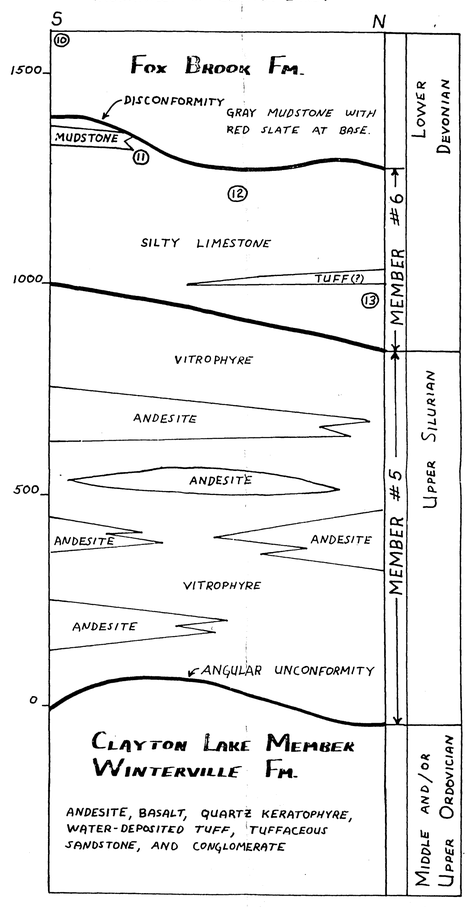
MEMBER #4

(West of Big Machias Lake)



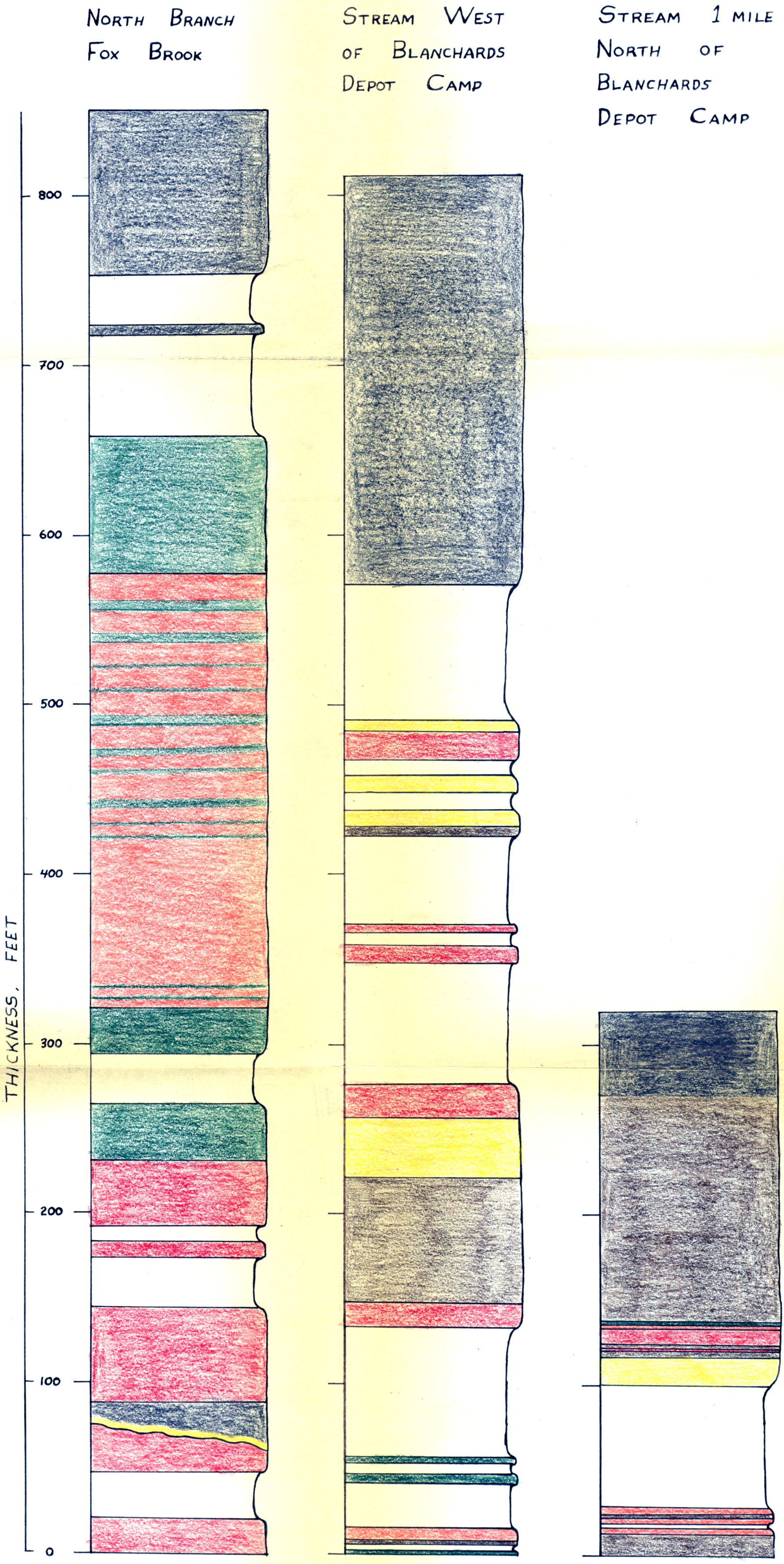
MEMBERS #5 & 6

(Northwest of Clayton Lake)



Note: these sections are highly interpretative

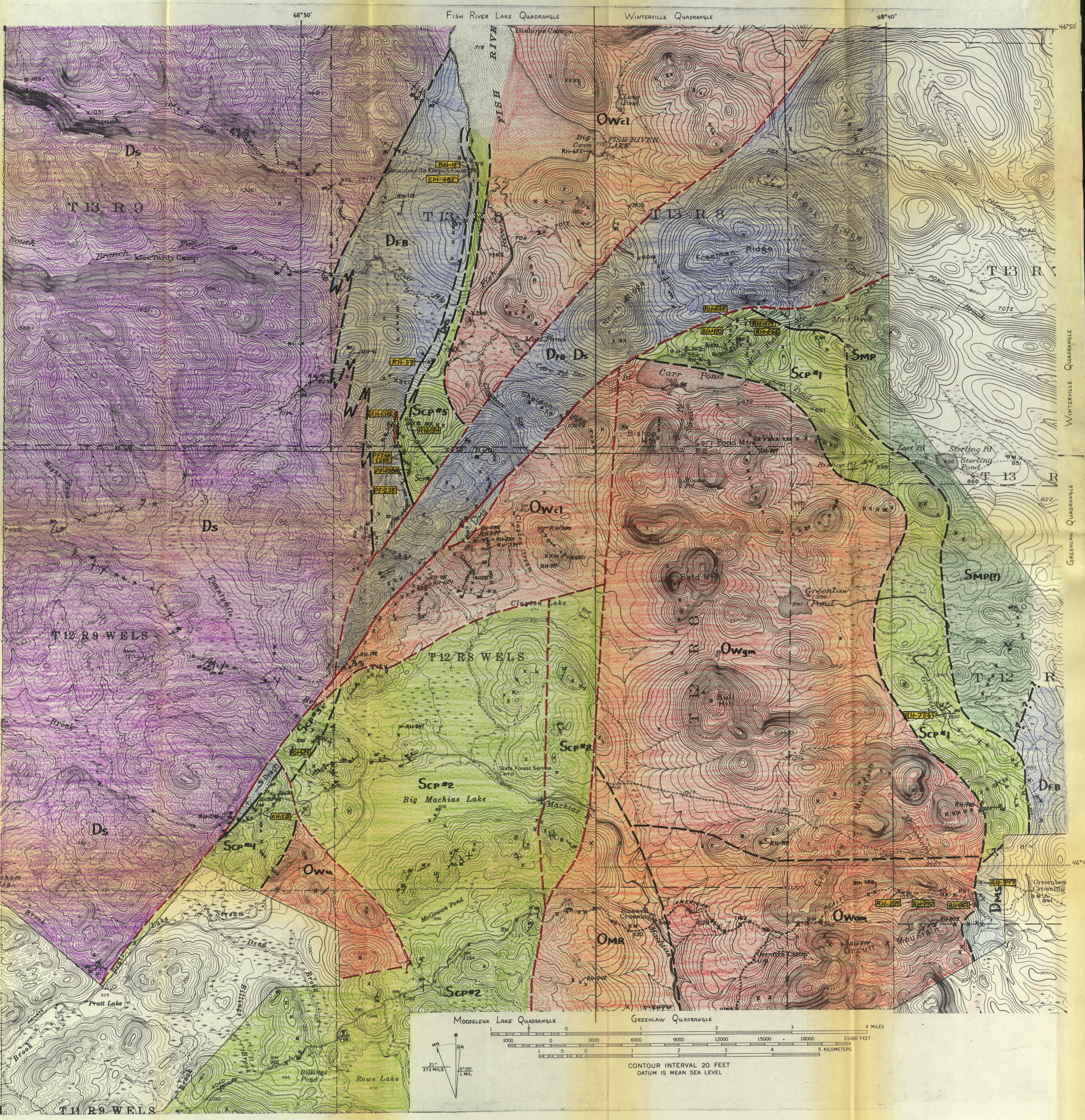
FIG. 31. — STRATIGRAPHIC SECTIONS THROUGH THE ANDESITES AND RED SLATES NEAR THE BASE OF THE SEBOOMOOK



KEY

- GRAY SLATE
- RED SLATE
- ANDESITE
- GRAY MUDSTONE
- GREEN SLATE
- BAKED MUDSTONE, TUFFACEOUS MUDSTONE, AND TUFF

Geologic Map of Portions of the Fish River Lake, Winterville, Greenlaw, and Mooseleuk Lake Quadrangles, Aroostook County, Maine



LOWER DEVONIAN	Seboomook Fm.	Ds	Gray slate locally containing thin beds and laminae of fine grained graywacke. Locally red slate, green slate, and mafic volcanics near base.
		DFB-Ds	Mixed Seboomook slate and Fox Brook mudstone.
	Fox Brook Fm.	DFB	Mudstone; minor mafic volcanics, red slate, and green slate.
	Moosehorn Stream Fm.	DMS	Predominantly silty limestone; minor mafic volcanics, red slate, and sandstone. Locally a conglomerate.

— — — Disconformity — — — — — —

UPPER SILURIAN	Mud Pond Fm.	Smp	Mudstone, locally contains interbedded graywacke.
	Carr Pond Fm.	Scp	Scp#6 — Member #6. Silty limestone; minor mudstone and tuff (?).
			Scp#5 — Member #5 Vitrophyric quartz keratophyre; minor mafic volcanics
			Scp#4 — Member #4 Predominantly mafic volcanics; minor vitrophyric quartz keratophyre, conglomerate, sandstone, silty limestone, and limy mudstone.
			Scp#3 — Member #3. Mafic volcanics; minor mudstone and silty limestone.
			Scp#2 — Member #2. Conglomerate and sandstone; mudstone generally very minor
			Scp#1 — Member #1. Conglomerate, sandstone, and mafic volcanics; minor mudstone and silty limestone.

— — — Unconformity — — — — — —

MIDDLE or UPPER ORDOVICIAN?	Machias River Fm.	OMR	Predominantly black slate; minor graywacke and mafic volcanics
MIDDLE ORDOVICIAN	Winterville Fm.	Ow	Owgm — Greenlaw Mountain Member. Mafic volcanics; minor quartz keratophyre.
			Owom — Orcutt Mountain Member. Mafic volcanics; minor quartz keratophyre, black slate, and fine grained, water-deposited tuff.
			Owcl — Clayton Lake Member Mafic volcanics; minor quartz keratophyre, fine grained, water deposited tuff, tuffaceous sandstone, and tuffaceous conglomerate.
			Owu — Undifferentiated Winterville

Contacts
- Well located or approximate
- Poorly located or uncertain

Faults
- Well located or approximate
- Poorly located or uncertain

Symbols
- 20 — Strike and dip of bedding, arrow gives facing if present
- x — Outcrop location
- x — Fossil locality, refer to Appendix I.
- x — Locality discussed in text