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The Depot Mountain Formation: Transition from Syn- to Post-Taconian Basin along the Baie Verte-Brompton Line in Northwestern Maine

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ABSTRACT

The Depot Mountain Formation of northwestern Maine is part of a belt of Ordovician and Silurian rocks that includes the Magog Group of the St. Victor synclinorium in the Eastern Townships of Quebec to the southwest and the Cabano Formation and younger units in the Lake Temiscouata region of Quebec to the northeast. Fossil localities within the Depot Mountain and regional correlations suggest an age span of early Late Ordovician (Caradocian) to middle Llandoverian of the Silurian. The Depot Mountain Formation has been divided into two members. The lower member is composed of medium- and thick-bedded feldspathic and lithic graywacke with interlayered dark gray slate and siltstone. Felsic water-laid tuff and volcaniclastic sharpstone conglomerate form subunits that can be mapped locally within the lower member. The abundance of volcanic detritus in the sandstone beds together with the interlayered pyroclastic rocks suggest deposition contemporaneously with volcanism in the Ascot-Weedon-Winterville-Munsungun arc during Taconian arc-continent collision. The upper member consists of interlayered lithic graywacke, pebble conglomerate, dark gray or black slate, and siltstone. Sedimentary and metasedimentary clasts are conspicuous in the sandstones and conglomerates of the member; volcanic clasts are low in abundance or absent. Turbidite features are well displayed in some of the graywacke beds of the formation despite a well-developed foliation in the case of sandstone beds in the upper member. Stratigraphic continuity of the two members is so far everywhere obscured by faults, but both members appear to share a single deformation with nearby Siluro-Devonian rocks and are inferred to have been deposited in sequence. Precise correlation of the lower member within the St. Victor synclinorium is not possible. It is lithologically similar to lower portions of the Magog Group (Frontiere and Etchemin Formations), but appears temporally equivalent to the upper Magog (Beauceville and St. Victor Formations). The upper member is a lithologic match for the Cabano Formation (Caradocian-Early Llandoverian) and is similar to the St. Victor Formation of the Magog Group. Deposition of the lower member was in a fore-arc basin above the St. Daniel mélange and Baie Verte-Brompton line and contemporaneously with volcanism of the "Ascot-to-Winterville" arc (to the southeast) during late phases of Taconian plate collision in the Late Ordovician. Deposition of the upper member appears to have taken place in the same, or modified, basin with detritus supplied from largely metasedimentary terranes in the arc or from accreted Taconian uplands to the northwest in the Notre Dame anticlinorium. Basin evolution was undoubtedly complex and the Depot Mountain Formation is likely part of a complicated stratigraphic system.

INTRODUCTION

Northwestern Maine lies along the northwestern margin of the Connecticut Valley-Gaspé synclinorium where the thick Devonian synclinorium sequence is in fault contact with rock units of Cambro-Ordovician, Siluro-Ordovician, and Silurian age. These pre-Devonian rocks record a depositional and tectonic history that spans and succeeds the Taconian orogeny along the Baie Verte - Brompton line. The Depot Mountain Formation, of Ordovician and Early Silurian age, is a continuation into Maine of the mostly flysch sequence (Magog Group) of the St. Victor synclinorium in the Eastern Townships of Quebec. The thick succession of graywacke, slate, and tuffaceous rocks of the synclinorium have been interpreted as deposited in a back-arc basin during the Taconian collision of a volcanic arc and the ancestral North American continent by St-Julien and Hubert (1975). However, more recent Taconian reconstructions for western New England by Stanley and Ratcliffe (1985), for eastern New York by Bradley and Kusky (1986), and for eastern Quebec by Cousineau and St-Julien (1985, 1986) suggest that the synclinorial succession may have formed in a fore-arc basin above an accretionary wedge. Either interpretation places the Depot Mountain Formation in a belt of flysch that is related to at least the late phases of suture development along the Baie Verte-Brompton line.

The Depot Mountain Formation is particularly interesting because it not only contains Late Ordovician (Caradocian) graptolites in what is now defined as its lower member, but in its upper member shows lithologic similarities to the along-strike Cabano Formation of Caradocian-to-Early Llandoverian age. The Cabano Formation is the oldest unit in what has generally been regarded as a post-Taconian basin along strike to the northeast in the Lake Temiscouata region of Quebec. The Depot Mountain and Cabano Formations, and the synclinorium sequence all share a single cleavage (regional S_2) with the nearby Devonian rocks of the Connecticut Valley-Gaspé synclinorium (Cousineau, 1982; Roy, 1982a,b; Lesperance and Greiner, 1969) and were therefore not intensely deformed until the Acadian orogeny. Cousineau (pers. commun., 1987), however, suggests that the Magog Group may have undergone a mild deformation during the Taconian that produced open folds and thrust faults, but no cleavage. Thus the transition from an arc-related basin, contemporaneous in part with Taconian orogenesis, to a post-orogenic basin appears to have taken place within the Depot Mountain Formation without significant pre-Acadian deformation.

BACKGROUND

General Geology

The general geology of northwestern Maine is summarized in the map of Figure 1. The northeast-trending Rocky Mountain fault, which separates the Devonian flysch in the Connecticut Valley-Gaspé synclinorium from the older rock units, is probably a thrust fault that is coextensive with an unnamed fault in the Lake Temiscouata region to the northeast (Lajoie et al., 1968; David et al., 1985) and with the La Guadaloupe fault to the southwest in the Eastern Townships of Quebec. Northwest of the Rocky Mountain fault, the pre-Devonian formations form two northeast-trending lithic belts that increase in age to the northwest. Adjacent to the Rocky Mountain fault is a belt consisting of Siluro-Ordovician flysch of the Depot Mountain Formation overlain by limestone, basalt, and phyllite of the Late Silurian Fivemile Brook Formation. At Rocky Mountain itself, the fault places the Devonian against Silurian felsic volcanic rocks of the Rocky Mountain quartz latite and eventually cuts out both the Fivemile Brook Formation and the upper member of Depot Mountain northeastward toward Rivière Bleue, Quebec.

The Depot Mountain Formation is in contact along the Dead Brook fault with a broad belt of polydeformed phyllite and quartzite considered to be a continuation of the Saint Daniel Formation from adjacent Quebec (Osberg et al., 1985). The Saint Daniel Formation is a mélange that lies in sharp contact with a belt of deformed ophiolite and metasedimentary rocks of the Caldwell and Rosaire groups along the Baie Verte-Brompton line in southeastern Quebec and is overlain unconformably by, or is in fault contact with, the thick Ordovician (Llandeilian-Caradocian), and younger(?), flysch of the Magog Group in the St. Victor synclinorium (St-Julien and Hubert, 1975; Slivitzky and St-Julien, 1987). The mélange of the Saint Daniel Formation together with the underlying deformed ophiolite and the overlying flysch sequences are generally viewed as parts of an accretionary complex formed during the Taconian orogeny along the early Paleozoic margin of North America during the span of Late Cambrian through Late Ordovician (Caradocian). This accretionary complex therefore extends through northwestern Maine and again into Quebec where it is largely covered by Siluro-Devonian rocks in the Lake Temiscouata region.

The trace of the Baie Verte-Brompton line into Maine is not well established. Its location in Figure 1 is projected from the southwest based on the trend of small ultramafic bodies in southeastern Quebec described by Hebert and Laurent (1977), Laurent (1975), and St-Julien and Hubert (1975). In Quebec the Baie Verte-Brompton line lies just to the southeast of the ophiolite masses and between them and the mélange of the Saint-Daniel Formation. As the line is traced northeastward toward Maine, the ophiolite masses become smaller and less continuous and have not been seen in Maine. As projected into Maine, the line is within a wide domain of complexly deformed "broken" formations whose northwestern limit is not established and may not be sharply defined. In Quebec to the north and west of Seven Islands, Béland (1957) mapped two groups (Fig. 1), the Caldwell Group at and near Seven Islands and the Rosaire Group farther northwest. Béland was uncertain concerning the relative

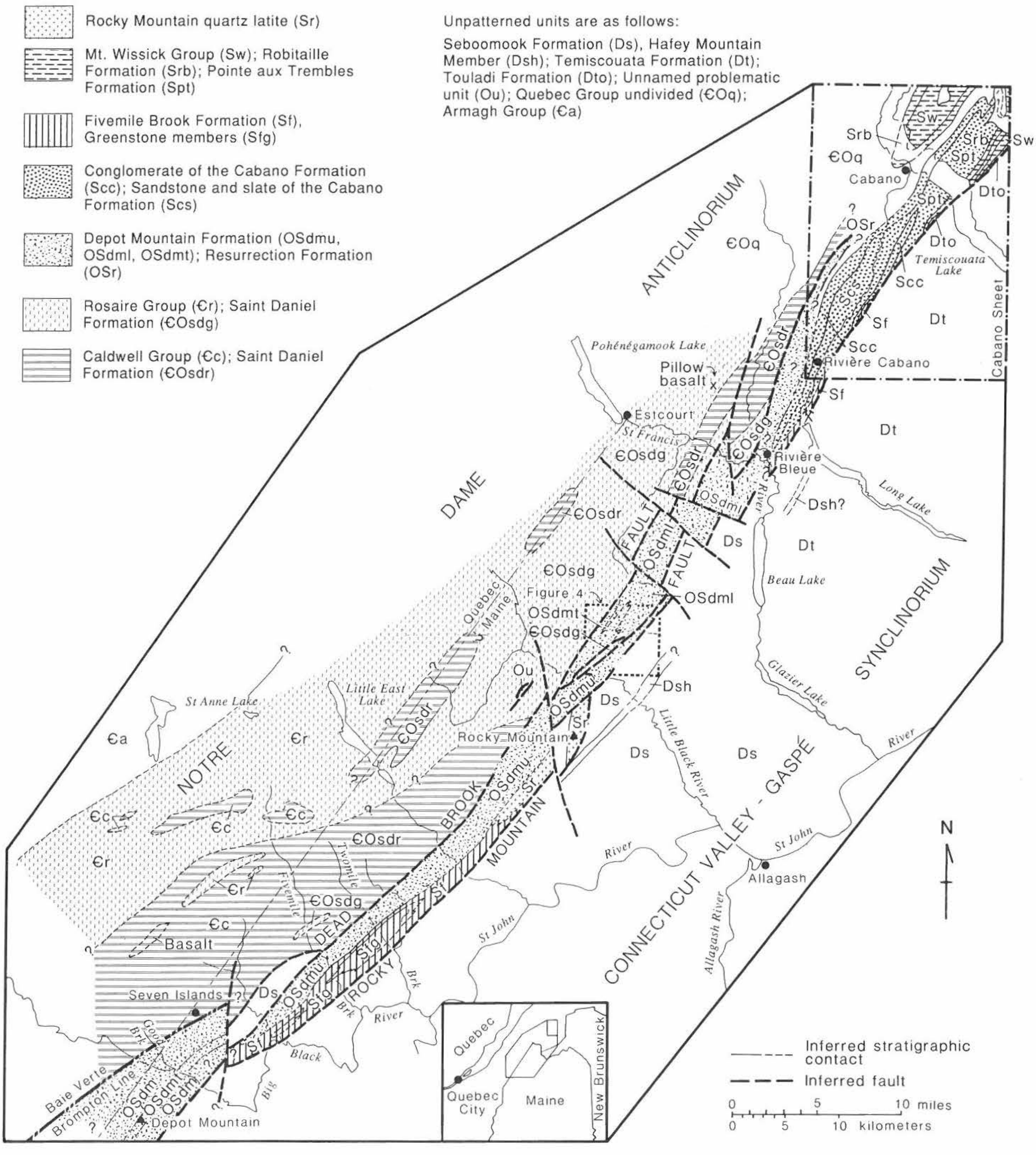

Figure 1. Geologic map of northwestern Maine and adjacent Quebec and New Brunswick. Formation descriptions for units in Maine are given in Figure 2. The map is both simplified and modified from a 1:62:500 map by Roy (1982a) for Maine and 1:63,360 maps of the Ste-Perpetue area (Béland, 1962) and the Squatec Sheet (Lesperance and Greiner, 1969) in Quebec.

Age	Column	Thickness	Rock Units
E. - M. Devonian	Ds (Dsh)	2000$^+$ m	Seboomook Formation Ds: Gray slate and phyllite with equal or less cleaved graywacke. Minor pebble conglomerate. Dsh: Hafey Mountain Member: Massive siliceous quartz arenite, less gray slate and graywacke; 0-800 m thick.
			Rocky Mountain fault
Late Silurian	Sr	0 - 1000 m	Rocky Mountain quartz latite Sr: quartz latite and eutaxitic rhyolite
Late Silurian	Sf (Sfg)	300 - 1800 m	Fivemile Brook Formation Sf: Calcareous phyllite and slate, biomicrite. Sfg: Greenstone members: basalt flows, sills, pyroclastic rocks; 0-1000 m thick.
Middle Ordovician - Early Silurian	OSdmu -----?----- OSdml (OSdmt)	2000$^+$ m	Depot Mountain Formation OSdmu: Gray slate, lithic graywacke with metasedimentary detritus, much less pebble conglomerate. OSdml: Medium/thick bedded feldspatholithic graywacke with abundant volcanic detritus, less gray slate. OSdmt: Crystal and lithic water-laid tuff, volcaniclastic sandstone and conglomerate, and siliceous slate within the Lower Member.
			Dead Brook fault
Cambrian - Early Ordovician	€Osdg (€Osdr) ------------ €Osdr (€Osdg)	2000$^+$ m	"Saint Daniel Formation" €Osdg: Polydeformed and disrupted gray phyllite with beds and bed fragments of laminated/cross-laminated metasiltstone and massive quartzite; outcrops and terranes of gray phyllite and silty carbonate/calcareous siltstone. €Osdr: Disrupted gray, red, and green slate and feldspathic sandstone; massive quartzite.

Figure 2. Composite stratigraphic section for northwestern Maine as established by Boudette et al. (1976) and Roy (1982a).

ages of the two groups, but suggested that the small lenticular terranes of one group within the other are stratigraphic lenses. The rocks representing both groups are shown as the Saint Daniel Formation in Maine as discussed below.

Northeastward into the Lake Temiscouata region, the Rocky Mountain fault brings Devonian flysch of the Temiscouata Formation in the Connecticut Valley-Gaspé synclinorium into contact with various Silurian formations as it cuts along the limb of a major unnamed Acadian syncline. At Rivière Bleue, the fault places the Temiscouata Formation against limestone and basalt that is here considered to be an equivalent of the Silurian Fivemile Brook Formation. The generally poorly exposed Fivemile Brook Formation, designated as an unnamed Silurian unit by Lajoie et al. (1968), appears to stratigraphically overlie the Cabano Formation. At Lake Temiscouata, the fault separates younger Silurian units (Pointe-aux-Trembles and Robitaille Formations and units of the Mount Wissick Group) together with the enigmatic Middle Devonian Touladi Formation (limestone) from the synclinorium flysch. Reconnaisance mapping between Rivière Bleue and Lake Temiscouata suggests that the Cabano Formation is underlain or in fault contact with either graywacke, equivalent to the lower member of the Depot Mountain Formation, or polydeformed rocks generally equivalent to the Saint Daniel Formation as mapped in Maine (Fig. 1).

Previous Work

Except for brief but arduous excursions along portions of the St. John and Allagash Rivers and their tributaries by Jackson (1838), Hitchcock (1861), and Wing (1951), systematic geologic investigation of northwestern Maine began with the reconnaissance work in 1967 by the U.S. Geological Survey reported by Boudette et al. (1976). In 1979, a Maine Geological Survey project funded by the U.S. Army Corps of Engineers investigated the mineral resource possibilities of the region by concentrating efforts in three small areas known to contain volcanic rocks (Roy, 1980a). A second field season in 1981 was devoted to reconnaisance mapping north of Rocky Mountain and into Canada (Roy, 1982a), together with a geochemical study of volcanic rocks in the Five Mile Brook Formation (Schwartz and Hon, 1983; Schwartz et al., 1984). Later, the sedimentary rocks of the Fivemile Brook Formation were studied (Dubois and Roy, 1985; Dubois, 1986). The most recent investigations in Canada along strike to the northeast are those by Lesperance (1959, 1960), Lesperance and Greiner (1969), Lajoie et al. (1968), Morin (1984), David et al. (1985), and David and Gariépy (1986, 1987). To the west and southwest, studies by Béland (1957, 1962), Cousineau (1982; 1987), and Cousineau et al. (1984a,b) as well as those by Slivitzky and St-Julien (1987) and St-Julien (1987) are the most relevant to this discussion.

STRATIGRAPHIC SETTING OF THE DEPOT MOUNTAIN FORMATION

Older Rocks: Saint Daniel Formation (€Osdg, €Osdr)

Boudette et al. (1976) first recognized that the oldest rock unit in northwestern Maine is a polydeformed phyllite and quartzite sequence which they divided into the "Estcourt Road" and "Lac Landry" sequences. Roy (1980a; 1982 a,b) assigned the rocks of both sequences to the Estcourt Road Formation, a

"disrupted formation" ("broken formation" of Hsu, 1974), and reported mélange with rounded blocks of quartzite, graywacke, and chert in the unit in several places. During compilation of the 1985 state map (Osberg et al., 1985), the Estcourt Road Formation was regarded as an extension of the Saint Daniel Formation/mélange into northwestern Maine and is so shown on the map. The unit is clearly lithologically similar to much of the Saint Daniel Formation as it has been traced recently through the Eastern Townships of Quebec to the Maine border by Cousineau (1987; pers. commun., 1986). However, the outcrop width of the formation in Maine is much wider than mapped by Canadian geologists in the Eastern Townships. As shown on the Maine bedrock map, it forms a belt at least 10 kilometers wide northeast of Seven Islands in Maine (Fig. 1). Since the Saint Daniel Formation shown on the Maine map is made up in large part of disrupted stratigraphy of the Caldwell and Rosaire Groups, it does not strictly conform to the definition of the Saint Daniel Formation (mélange) in its type area (Williams and St-Julien, 1982; Cousineau and St-Julien, 1986). Current detailed mapping within the Saint Daniel Formation as presently defined in Maine by S. G. Pollock may produce subdivisions of the unit and result in the separation of polydeformed Caldwell and Rosaire rocks from "true" mélange of the Saint Daniel Formation as mapped in Canada. Cousineau et al. (1984b) report the presence of Saint Daniel-like mélange with Rosaire rock types as blocks along several oblique faults that cut the Caldwell Group and urges caution in considering all such mélanges as Saint Daniel Formation (Cousineau, pers. commun., 1987). Whatever results from subsequent study of this belt in Maine, it is clear that these rocks have undergone much tectonism and that formations and groups in the lithostratigraphic sense will be very difficult to define. It is more likely that the belt will be divided into tectonic units or "lithodemes" as defined by the North American Commission on Stratigraphic Nomenclature (1983). For the purposes of this paper, however, the term "formation" will be used following the usage of Osberg et al. (1985) on the Maine map.

As designated in Maine, the Saint Daniel Formation is composed of two types of metasedimentary "sequences" or "domains" that both show bedding transposition (Fig. 2). The most extensive is Sequence I (€Osdg in Fig. 2), composed of gray and black phyllite interlayered on the scale of centimeters with beds of calcareous, quartzose, fine-grained sandstone and siltstone. Limestone and quartzite beds and "blocks" are present locally in this sequence. Recent mapping indicates that a sequence of gray phyllite, silty carbonate, and lesser quartzite, currently included in Sequence I and similar rocks assigned to the Trinite Group of Lajoie (1971), may eventually be separately mapped. In most outcrops of Sequence I, the bedding is transposed along the most prominent foliation, interpreted to be regional S_1, producing lens-shaped bed fragments of sandstone and siltstone and delimbed fold hinges of F_1 folds. In the vicinity of Estcourt, outcrops of mélange containing rounded blocks of chert and graywacke as well as one possible large block of pillow basalt (Fig. 1) are seen within Sequence I.

Sequence II (€Osdr of Fig. 2) consists of red and lesser green slate interbedded with red, green, and white thick-bedded quartzite and feldspathic quartzite. Bedding transposition is less conspicuous in pavement exposures of the thin-bedded slate portions of this second sequence, but massive quartzite beds are typically "segmented" and some appear to be boudin blocks.

As stated above, the Saint Daniel Formation in Maine is on strike from both the Rosaire and Caldwell groups as mapped by Béland (1957) in the St. Maglorre and Rosaire-St. Pamphile areas in Quebec to the southwest, and the Quebec Group (principally units 1A, 1B, and 1C) to the northeast as mapped by Lesperance (1960) and Lesperance and Greiner (1969). Sequence I of the unit in Maine is lithologically similar to the Rosaire Group and units B and C of the Quebec Group; Sequence II is a good lithologic correlative of the Caldwell Group and unit A of the Quebec Group. Nonfossiliferous red and green quartzites interbedded with red slates in the vicinity of La Resurrection in the Cabano sheet, assigned to the Late Silurian Robitaille Formation by Lajoie et al. (1968) and Lesperance and Greiner (1969), are here considered to be part of Sequence II as traced northeastward in reconnaissance mapping from Maine (Fig. 1).

Since there are no fossil localities in the Saint Daniel Formation in Maine, the age of the formation must be inferred from regional considerations. The mélange involves the disruption of strata lithologically similar to those of the Caldwell and Rosaire Groups. Part of the Rosaire Group is correlated with the Oak Hill sequence which contains an Early Cambrian fauna. The Caldwell Group, and its inferred equivalent, the Armagh Group, are also considered to be Early Cambrian, but may range into the Late Cambrian based on regional correlations summarized by St-Julien and Hubert (1975). The tectonic disruption of the two groups to form the mélange took place during the time span of Late Cambrian to the Middle Ordovician. The young limit on the deformation is taken to be represented by the age of the oldest rocks inferred to be present in the St. Victor synclinorium.

The Saint Daniel Formation is everywhere separated from the Depot Mountain Formation by the Dead Brook fault, but the evidence for the fault is mostly circumstantial. The inference that a fault separates the two units is based on the contrast in structural histories across the contact and the absence of stratigraphic evidence within the Depot Mountain Formation that suggests an unconformity. The contact is closely located just south of the St. Francis River where rocks of both the Saint Daniel Formation and Depot Mountain Formation appear to have been sheared, but lack brittle fracture features seen along faults involving Devonian rocks. Near the St. Francis River the contact may be pre-Acadian, possibly late Taconian, but elsewhere the Dead Brook fault as presently mapped may be younger, as for example where a sliver of fossiliferous Devonian slate and sandstone (Boudette et al., 1976; locality F-300) is present along the fault near Seven Islands. Thus it is possible that the Dead Brook fault is composite and contains segments formed during more than one deformational event.

Unnamed Problematic Unit (Ou)

Northwest of Rocky Mountain, along the main logging road, there is a series of exposures of quartzite, quartzite conglomerate, siltstone, and slate that are at present difficult to match with surrounding units. One siltstone bed within these rocks contains an abundant and diverse fauna. The fossil locality is F-117 of Boudette et al. (1976) which they assigned originally to a belt of rocks they called the "Strata of the Rocky Brook Terrane." The "Rocky Brook Terrane" has now been subdivided by Roy (1980a, 1982a) into rocks presently assigned to the Saint Daniel and Depot Mountain Formations. The fossils (pelecypods, brachiopods, and trilobites) were originally recovered by R. B. Neuman from laminated calcareous siltstone. These fossils were assigned a Siluro-Devonian age by Neuman (Boudette et al., 1976), and this determination was used to place the rocks of the "terrane" in that time span. Since the subdivision of the terrane suggested that the rocks in the vicinity of the fossil locality were likely to be of pre-Silurian age, I requested a reassessment of the collection and clarification as to the precise location of the locality. Neuman (on brachiopods), J. Pojeta and R. J. Zhang (on pelecypods), W. A. Oliver (on corals), all of the USGS, and P. J. Lesperance (on trilobites) of the University of Montreal determined the following fauna to be present in the collection -- Brachiopods: dalmanellid, strophomenide, and a coarse-ribbed orthid; Corals: *Paleofavosites*(?) sp., rugose coral fragments; Pelecypods: *Ambonychia* sp., *Modiolopsis*(?) sp.; Trilobites: *Achatella* sp., *Remopleurides* s. l. sp., *Erratencrinurus* (*Cettencrinurus*) n.(?) sp. The age suggested collectively by these fauna, especially the pelecypods, is Ashgillian of the Late Ordovician (Maysvillian-Richmondian) as reported in letters by Neuman, Pojeta, Oliver, and Zhang to the present writer in 1983 and by Lesperance to Neuman in 1985.

Originally a very small outcrop, the locality was well exposed during the 1987 field season and is now surrounded by new outcrops of the Saint Daniel Formation. Since the fossiferous rocks and the sequence in which they are found do not appear to be polydeformed, they do not seem to be part of the older Saint Daniel Formation even though that formation is the only unit that contains similar quartzites. Although the Depot Mountain Formation is inferred to span an age range that includes the Ashgillian, it does not contain quartzites. The rocks of this fossiliferous sequence are therefore presently interpreted to be in a fault slice within the Saint Daniel terrane.

Younger Rocks

The Depot Mountain Formation is overlain by the Fivemile Brook Formation and the Rocky Mountain quartz latite. Though the contacts with these units have not been observed, there is no evidence of a structural break where the contacts are closely approached, as along Twomile Brook and on the western flank of Rocky Mountain. The contact is inferred to be an unconformity with little or no angularity. The hiatus represented by the unconformity is probably roughly equivalent to the Middle Silurian hiatus that is well documented in the Lake Temiscouata region between the Late Llandoverian Pointe-aux-Trembles Formation and younger units of the Upper Silurian (Lajoie et al., 1968). The local, apparently stratigraphic, association of felsic volcanic rocks of the Rocky Mountain quartz latite with limestone, phyllite, and basalt of the Fivemile Brook Formation suggests that these two younger units are essentially coeval.

Fivemile Brook Formation (Sf). The Fivemile Brook Formation is composed of light greenish gray, variably calcareous phyllite interlayered with thin beds of biomicritic limestone (Roy, 1982a,b; Dubois and Roy, 1985; Dubois, 1986). Locally, as at the type section in Fivemile Brook, alkali basalt is abundant as flows as well as dikes and sills (Schwartz and Hon, 1983; Schwartz et al., 1984). The basalt is sufficiently abundant to be mapped as greenstone members (Sfg on Fig. 1; Boudette et al., 1976; Roy, 1982a). The Late Silurian (Ludlovian) age of the Fivemile Brook Formation is based on corals found near the base of the exposed section at Fivemile Brook (Boudette et al., 1976). Where extensively exposed in the watersheds of the both Twomile and Fivemile Brooks, the Fivemile Brook Formation forms a homoclinal sequence facing southeast. Felsic volcanic rocks, largely rhyolite, are seen interlayered with basalt in the greenstone unit just northeast of Fivemile Brook and apparently within the Fivemile Brook Formation just southwest of Rocky Mountain. These occurrences, together with the association of limestone and basalt of the Fivemile Brook Formation with the felsic volcanic rocks near Rocky Mountain itself, imply that the eruptions of basalt and the felsic volcanic rocks are penecontemporaneous with the sedimentary rocks of the formation. The Fivemile Brook Formation has not been observed in Maine between Rocky Mountain and the St. Francis River and is inferred to have been structurally removed along the Rocky Mountain fault. Along the continuation of the fault northeast of Rivière Bleue in Quebec, previously unreported basalt and unnamed Silurian limestones (Lajoie et al., 1968) are here considered to be remnants of the Fivemile Brook Formation preserved in fault slivers.

Dubois (1986) recently completed a detailed study of the type section of the Fivemile Brook Formation along Fivemile Brook. He found that, in the lower part of the formation, the limestone, calcareous phyllite, and basalt flows are ordered into cycles that reflect the depositional influences of newly erupted flows in a generally subsiding shallow-water basin. A cycle begins with a basalt flow, from 2 to 31 meters thick, succeeded by medium-to-thick bedded coralline and crinoidal limestone with minor interbedded phyllite, followed upward by calcareous phyllite with progressively fewer thin beds of micrite. Well oxidized upper parts of several of the flows suggest that the tops of these flows were at, or above, sea level and that water depths during depositon of the lower part of the formation were on the order of 10 to 20 meters. The upper part of the formation is almost entirely calcareous phyllite that represents deep subtidal deposition on a basin floor no longer experiencing basalt flows.

Although the Fivemile Brook Formation and the younger flysch of the Devonian in the Connecticut Valley-Gaspé synclinorium are regarded to be in fault contact across most of northwestern Maine (Fig. 1), Dubois (1986) believes that the contact between these units is probably gradational in the Fivemile Brook section based on the presence of poorly exposed calcareous sandstone of Devonian aspect interlayered with calcareous phyllite northwest of the Rocky Mountain fault. If this conclusion is valid, then the basin which began during the deposition of the shallow-water lower phase of the Fivemile Brook Formation evolved into a deep-water flysch basin in the Devonian.

Rocky Mountain Quartz Latite (Sr). Boudette et al. (1976) assigned the latitic rocks at Rocky Mountain and near Pockwock Stream, southwest of the mountain, to a "Quartz Latite" subunit of their "Fivemile Brook Sequence". Roy (1980a, 1982a,b) mapped the latite as a unit separate from a revised Fivemile Brook Formation. Here the name "Rocky Mountain quartz latite" is suggested for these largely, but not exclusively, felsic rocks. Possibly as much as 1000 m of fragmental siliceous lithic and crystal tuffs with much less mafic rock are preserved in a syncline at Rocky Mountain. These volcanic rocks apparently rest stratigraphically on the upper member of the Depot Mountain Formation along the west slopes of the mountain and are in fault contact with Devonian flysch to the east of the mountain. Strata in the Depot Mountain Formation and Rocky Mountain quartz latite are parallel, which suggests that the two units are either conformable or, more likely, disconformable. As suggested above, the presence of basalt within the felsic sequence and the association of the sequence with rocks typical of the Fivemile Brook Formation on the southern slopes of the mountain suggest the probability that the felsic eruptives are part of a Late Silurian bimodal volcanic series (Schwartz et al., 1984). No rocks comparable to the Rocky Mountain quartz latite have been described along strike, either to the northeast or southwest in Quebec, but Cousineau et al. (1984b) and Duquette (1961) report the presence of felsic intrusives along or near the La Guadeloupe fault.

DEPOT MOUNTAIN FORMATION

The dark slates, lithic and feldspathic graywacke, and volcaniclastic rocks that comprise the Depot Mountain Formation where assigned to the "Depot Mountain Sequence" by Boudette et al. (1976). Graptolites found by them in a slate bed at the type locality on the western slopes and summit of Depot Mountain are of Late Ordovician age and are associated with thickly bedded volcaniclastic sandstone and water-laid lithic and crystal tuffs. Coarse grained and pyritiferous volcaniclastic conglomerate at Depot Mountain was correlated with other more polymictic conglomerates to the northeast near Rocky Mountain and mapped as a subunit within the sequence. Boudette et al. (1976) recognized the possible correlation of part of the Depot Mountain Sequence with the Silurian Cabano Formation based on lithologic similarity and along-strike position, but were not able to confirm the correlation. Local detail and additional reconnaissance mapping by Roy (1980a, 1982a) indicated that the "Depot Mountain Sequence" is both lithologically distinctive and of such regional extent that formational rank is appropriate (Roy and Lowell, 1983). The conglomerate subunit as mapped by Boudette et al. (1976) was found not to be mappable as a member and water-laid tuffs were found to form stratigraphic horizons that could be mapped at least locally. More recently, the formation has been subdivided into two members, inferred to be upper and lower, based on graywacke composition and on the association of tuffs with graywacke enriched in volcaniclastic detritus. This subdivision at present is confined to the portion of the belt between Seven Islands and Rivière Bleue as shown in Figure 1 and on the recent state map (Osberg et al., 1985). The lower member, though present at Depot Mountain, has not yet been separated from the upper member south of Seven Islands. Between Seven Islands and Rocky Mountain, the lower member appears to be cut out by the Dead Brook fault and north of Rocky Mountain the upper member is apparently removed in part by the Rocky Mountain fault.

Lower Member (OSdml)

The rocks within the Depot Mountain Formation similar to those of the type locality at Depot Mountain are here assigned to the lower member. The lower member consists mostly of thick-bedded, dark gray, fine-to-coarse grained, feldspathic graywacke interbedded with dark gray and black slate or phyllite. Locally within the member are sequences of lithic and crystal tuff commonly associated with green and green-gray siliceous slate/argillite and conglomerate composed exclusively or largely of angular felsic volcanic clasts. Roundstone conglomerate, largely composed of felsic clasts, is also seen locally within the lower member. The thickness of the lower member is unknown.

Sandstone. The lower member is best exposed north of Rocky Mountain where it can be traced across the St. Francis River to the vicinity of Cabano in Quebec. Within this exposure belt, outcrops of dark gray, very feldspathic lithic sandstone, generally graywacke, predominates. The sandstone beds range from a few tens-of-centimeters to several meters thick, are typically noncleaved or poorly cleaved, and are medium-to-coarse in grain size. A characteristic white "chalky" weathering patina is usually present.

Most outcrops of the sandstone do not display complete beds and internal parallel- or cross-stratification are not seen. In these outcrops only portions of thick beds are visible and it is difficult to be precise concerning their mode of deposition. Since some thinner beds (< 0.3m) do display T_b and T_c turbidite divisions and graded bedding, more massive beds are inferred to also represent very rapid deposition from sand-ladened turbidity currents where sedimentary structures do not develop (Roy, 1987). In some outcrops soft-sediment deformation is seen that

TABLE 1. MODAL ANALYSES OF MEDIUM- AND COARSE-GRAINED SANDSTONES FROM THE DEPOT MOUNTAIN FORMATION[1] AND PRINCIPAL MODAL COMPONENTS (AFTER DICKINSON AND SUCZEK, 1979) FOR THE TRIANGULAR PLOTS OF FIGURE 3.

MODAL COMPONENTS	ANALYSIS NUMBER								
	Lower Member						Upper Member		
	2563	2627	3068	3149	3173	3203	2621	2530	2635
Quartz[2]	35.0	25.0	23.6	18.4	19.5	32.6	36.2	41.7	33.8
Feldspar[3]	17.0	26.0	34.3	41.7	38.5	21.2	4.8	11.7	18.2
Detrital muscovite	0.5	1.0	--	--	0.5	1.0	1.0	--	--
Detrital biotite	--	0.5	3.6	--	--	0.5	--	--	--
Detrital chlorite	--	1.5	--	3.5	2.0	1.5	0.5	--	--
Detrital carbonate	4.0	3.0	--	0.5	--	1.5	1.9	--	1.0
Opaque minerals	0.5	--	1.4	--	0.5	--	--	1.0	--
Argillaceous matrix	27.0	20.5	20.8	23.9	15.5	13.9	25.1	29.6	18.9
Secondary carbonate	1.0	--	--	--	--	--	6.3	--	6.1
Siltstone	2.0	4.3	0.9	1.5	4.5	3.0	14.0	6.8	11.6
Slate/Shale	0.5	1.5	1.9	2.0	--	5.9	5.8	1.5	3.5
Phyllite	0.5	1.5	1.9	3.5	2.0	4.5	2.9	3.4	5.0
Schist	--	--	1.9	--	1.0	2.0	1.0	2.4	1.5
Volcanic rocks[4]	7.8	15.2	9.2	5.0	16.0	11.9	--	1.9	0.5
Unidentified	--	--	0.5	--	--	0.5	0.5	--	--
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Qm	49.2	28.8	30.1	24.5	23.0	36.4	48.2	55.4	43.3
F	27.0	38.1	48.1	58.7	47.8	27.9	8.8	18.8	25.5
Lt	23.8	33.1	21.8	16.8	29.2	35.7	43.0	25.8	31.2
Qp	16.7	17.8	8.1	4.0	2.1	12.7	29.0	21.4	10.2
Lv	41.7	55.4	54.1	40.0	66.6	38.1	--	9.5	2.0
Lsm[5]	41.7	26.8	37.8	56.0	31.3	49.2	71.0	69.1	87.8

[1]Analyses of 200 counts performed by R. D. Collins.
[2]Includes monocrystalline and polycrystalline monomineralic quartz grains and quartz crystals in phaneritic quartz-feldspar grains.
[3]Includes monocrystalline and polycrystalline monomineralic feldspar grains and feldspar crystals in phaneritic quartz-feldspar grains.
[4]Predominantly quartz-bearing devitrified felsic volcanic rock fragments and generally much lesser intermediate and mafic volcanic rock fragments.
[5]Includes all sedimentary and metasedimentary rock fragments.

suggests development of ball-and-pillow and shale injection features that are consistent with rapid deposition of sand onto high water-content basinal muds. Some "soft-sediment" deformation, particularly pelite injection, may, on the other hand, be related to deformation of semiconsolidated sediments under high pore pressure conditions during the late Taconian as discussed below.

In thin section, the sandstones are seen to be composed of angular-to-subrounded, generally monocrystalline quartz with angular feldspar in proportions equal to or greater than those for quartz (Table 1). These mineral grains together with 5-16% volcanic fragments are set in a matrix (defined as less than 30 microns) composed of finely crystalline chlorite, muscovite, opaques, and silt-sized quartz and feldspar grains. The matrix proportions of 14-27 volume percent are consistent with typical depositional porosities of sandstone. The abundance of feldspar grains with sharp grain boundaries suggests that the matrix is largely "primary", though it may have formed in part from the breakdown of sub-30 micron feldspar and shale/mud clasts. Volcanic rock fragments are mostly quartz-bearing with many showing devitrification textures. A lesser population of quartz-absent clasts showing felty and pilotaxitic textures with interstitial chlorite is also present. Sedimentary and metasedimentary clasts, with few exceptions, are low in abundance.

Following the general conventions of Dickinson and Suczek (1979), the proportions of framework grains in five lower member sandstones are plotted on Qm-F-Lt and Qp-Lv-Lsm diagrams in Figure 3. The sandstones of the lower member fall within the fields suggesting derivation from a "magmatic arc" which is consistent with interpretations suggested for some of the flysch of the St. Victor synclinorium by St-Julien and Hubert (1975) and Cousineau and St-Julien (1985).

Water-laid Tuffs (OSdmt). Provenance of the lower member sandstones in a volcanic terrane is echoed by the presence, locally within the member, of pyroclastic rocks. These rocks are perhaps best displayed on Depot Mountain itself, but they are seen in scattered localities along the trend of the formation to the northeast as in the area of Figure 4. At Depot Mountain light green-gray, fine-grained, crystal and lithic tuffs in beds from one centimeter to a meter or so thick are interbedded with silicified dark-gray and green laminated slate to form a water-laid tuff sequence that is several hundred meters thick. The tuff beds are typically graded, but generally lack current-generated sedimentary features suggesting that they were formed by settling of ash

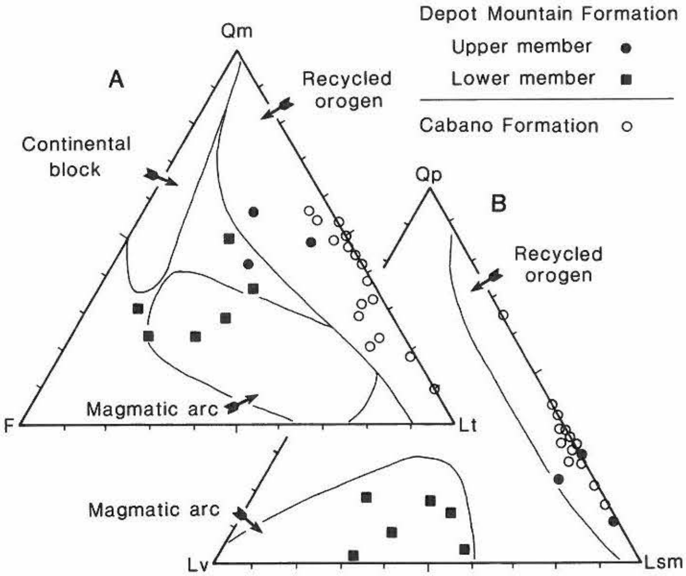

Figure 3. Principal component triangular diagrams showing the compositions of sandstones from the Depot Mountain and Cabano Formations. Cabano Formation data from David et al. (1985). (a) Qm-F-Lt diagram: Qm pole, monocrystalline detrital quartz grains; F pole, monocrystalline and polycrystalline feldspar detrital grains and feldspar crystals in phaneritic quartz-feldspar detrital grains; Lt pole, all fine-grained rock fragments. (b) Qp-Lv-Lsm diagram: Qp pole, polycrystalline quartz detrital grains; Lv pole, volcanic rock fragments; Lsm pole, all sedimentary and metasedimentary rock fragments.

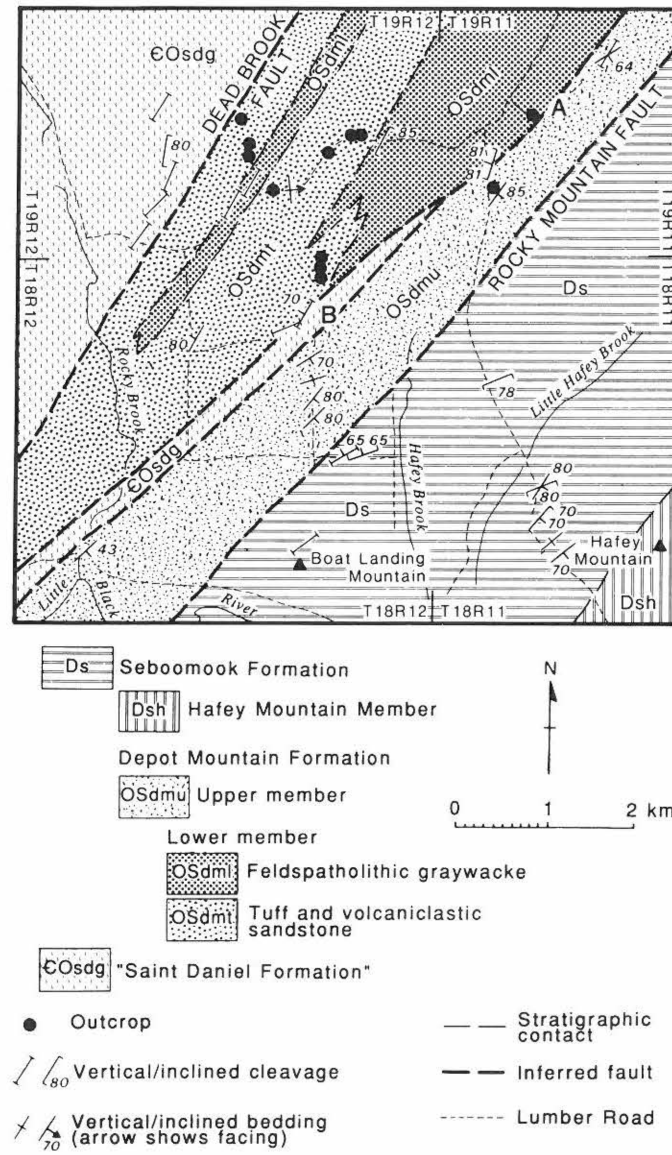

Figure 4. Geologic map showing the outcrop control in the only area where the lower (OSdml/OSdmt) and upper (OSdmu) members of the Depot Mountain Formation are presently known to be in contact. A fault contact between the members is observed at location A; at location B, a fault sliver of the Saint Daniel Formation is seen to be between the members. The location of this map area is shown in Figure 1.

through a still-water column. Flame structures are common along the bottoms of these fine-grained tuff beds. The green tint in the color of these rocks is due to abundant chlorite and epidote alteration.

At the summit of the mountain near the site of the former fire tower, thick beds of sharpstone conglomerate are composed almost entirely of angular granule- and pebble-sized light-gray fragments of felsite and much less mafic rock set in a subordinate tuffaceous matrix. Texturally homogeneous beds of this conglomerate, up to 4 m thick, are present. It is not clear how these beds were deposited, but it is possible that they formed by debris-flow transport of coarse material from relatively nearby eruptive centers, since they show little evidence of grain size separation.

The tuffaceous rocks interbedded with green-gray siliceous argillite, slate, and feldspathic graywacke north of Rocky Mountain (Fig. 1) are well exposed along a logging road (Fig. 4; Stop B-5 of Roy and Lowell, 1983). These crystal and lithic tuffs are also interbedded with gray slate and lithic/feldspathic graywacke. Both lamination and devitrification textures are conspicuous in some of the tuffs.

Upper Member (OSdmu)

The upper member is well exposed between Seven Islands and Rocky Mountain where it usually underlies the Fivemile Brook Formation. Typical exposures can be seen along lumber roads on the western slopes of Rocky Mountain (for example, Stop B-2 of Roy and Lowell, 1983) and along Twomile Brook and the major lumber road that crosses it. The member consists of dark gray, foliated, lithic graywacke interbedded with equal or greater proportions of laminated gray slate. Locally, beds of conglomerate are present that are interbedded with graywacke, but these conglomerates cannot as yet be mapped as subunits within the member. The thickness of the member is not yet well established due to internal folds and poor outcrop control, but it

may exceed 1000 meters based on apparently homoclinal sequences on the western flank of Rocky Mountain and near the upper contact of the member along Twomile Brook.

Sandstone. Sandstones of the upper member differ from those of the lower member in their higher quartz-to-feldspar ratios, relatively low content of volcanic rock fragments, and much higher proportions of sedimentary and metasedimentary clasts (Table 1). Indeed the most conspicuous feature of these sandstones is the abundance of siltstone and foliated pelitic clasts which, together with the foliated interstitial matrix, impart a pronounced cleavage to the rocks. The foliation in most of the pelitic clasts appears to be post-depositional since it is parallel to the foliation in the matrix. Some of the fine-grained interstitial material included in the matrix appears to have been deposited as fine-grained (silt or fine-sand sized) particles of shale. The framework grain size of the sandstone is remarkably uniform, in the range of medium to coarse sand. Even laminated beds that are only a few centimeters thick are of medium grain size in many instances. Graded bedding, parallel lamination, ripple-drift cross lamination, and sole features typical of turbidites are commonly present in the sandstone beds.

The triangular diagrams of Figure 3 show that the principal framework grain modes of the three analyzed upper member sandstones are similar, though somewhat more feldspathic, to sandstones from the Cabano Formation analyzed in a similar fashion by David et al. (1985). In addition, it can be seen that these diagrams discriminate the sandstones of the two members and place them in different provenance provinces as defined by Dickinson and Suczek (1979). The sandstone compositions confirm the conclusion that the upper member and its probable correlative, the Cabano Formation, may be largely derived from nearby orogenic metasedimentary sequences as suggested by Lajoie et al. (1968) and David et al. (1985) and discussed below. In contrast, the provenance of the lower member is more consistent with a volcanic arc provenance.

Stratigraphic Relations and Age

Fossil Localities. There is one fossil locality in the Depot Mountain Formation and it is in the lower member. The graptolites from this locality on Depot Mountain itself, reported by Boudette et al. (1976) though not described in detail, were considered to be similar to those from the Beauceville Formation of the Magog Group and assigned a "Middle Ordovician" age. More recently, W. B. N. Berry (pers. commun., 1987) indicated a likely Caradocian age, placing the graptolites in the Late Ordovician according to the time scale by Palmer (1983). Lithologic and temporal correlations of the Depot Mountain Formation with the formations of the Magog Group are at present problematical and await careful mapping southwestward from the Seven Islands area of Maine into Quebec. Lithologically, the lower member is possibly most similar in sandstone composition to the lower Frontiere Formation, the basal unit of the redefined Magog Group as described by Cousineau (1982), Cousineau et al. (1984a), and Cousineau and St-Julien (1985). The Frontiere Formation is, however, pre-Caradocian and is currently considered to be late Arenigian or Llanvirnian (late Early or early Middle Ordovician) by Cousineau (pers. commun., 1987). On the other hand, the St. Victor Formation, at the top of the Magog Group and with sandstones generally similar to the upper member of the Depot Mountain Formation, contains graptolites of Caradocian age. To complicate matters further, I consider the unfossiliferous graywacke of the enigmatic Resurrection Formation, interpreted to be of possible late Silurian age by Lesperance and Greiner (1969) and Lajoie et al. (1968), to be a good lithologic match for the lower member. As discussed below, it may well be that a strict "layer cake" succession of lithologically distinctive units with narrowly restricted age ranges is not present and, instead, a complicated temporal and spatial pattern of lithofacies was developed within the synclinorial stratigraphy.

There are no fossil localities in the upper member. The age of the upper member is constrained by the age (Late Silurian) of the Fivemile Brook Formation that is stratigraphically above it and the age of the lower member which seems to be largely subjacent. If the upper member is a direct correlative of the Cabano Formation as discussed above, then the member spans the Caradocian of the Ordovician to the middle Llandoverian of the Silurian (David et al., 1985; Lajoie et al., 1968). The Caradocian age for the basal part of the Cabano Formation is based on graptolites of both the *gracilis* zone and the *multidens* zone that were recently found stratigraphically below the base of the massive sandstones and conglomerates near Biencourt, Quebec, by J. David (P. J. Lesperance, pers. commun., 1986). It is therefore possible that the age ranges of the two members of the Depot Mountain Formation overlap, suggesting that major regional lithofacies variations may be present within the formation and in coeval flysch sequences to the northeast as well as to the southwest.

In summary, the rocks assigned to the Depot Mountain Formation appear to extend in age from at least the Caradocian to the middle of the Llandoverian. The formation therefore spans the time interval from the late events of the Taconian orogeny into the period of the "successor basins".

Contact Between the Lower and Upper Members. Unfortunately, a stratigraphic contact between the two members of the Depot Mountain Formation has not yet been observed. The best chance to study the relationship between the members was considered to be in the region shown in Figure 4 where the two members are in proximity with the closest outcrop control. During the 1987 field season, a N40^{o}E-trending fault-contact between rocks of the two members was well exposed in a small road-metal borrow pit at locality A. The exposed part of the vertical fault zone is about 20 m wide and contains blocks of graded conglomerate, sandstone, and slate of the upper member within it. The adjacent felsites of the lower member are sheared and locally brecciated. Slickensides on fault-parallel foliation surfaces within the fault zone indicate that the eastern block is upthrown. At locality A, the fault is parallel to, and about 0.5

kilometers northwest of, the trace of the Rocky Mountain fault which separates the upper member from Devonian rocks. The fault at locality A projects southwestward to locality B where sheared felsite of the lower member is in contact with polydeformed black phyllites, impure limestones, and thin quartzites of the Saint Daniel Formation that form a fault sliver between the two members. The faults that bound the sliver and separate the members at locality B strike about N50°E and cut the local bedding and foliation trends of the lower member felsites and graywacke beds. The faults are considered to have been formed, together with the Rocky Mountain fault, after the main compressional phase of the Acadian orogeny. At present, therefore, stratigraphic continuity between the members of the Depot Mountain cannot be demonstrated.

DISCUSSION AND CONCLUSIONS

It is now clear that in northwestern Maine and adjacent Canada, the transition from rock units contemporaneous with late phases of the Taconian orogeny to units deposited in a post-orogenic successor basin is complex and not generally represented by an angular unconformity. The Taconian is rather elegantly interpreted as the closing of an oceanic basin in which one or more volcanic arcs closed with the early Paleozoic continental margin of North America (St-Julien and Hubert, 1975; Stanley and Ratcliffe, 1985; Bradley and Kusky, 1986). The arcs, possibly with "cores" of continental crust, developed some unknown distances offshore of the continent and moved toward the continent, beginning by at least the Arenigian of the Early Ordovician and probably earlier. Interaction of the arcs with the continent took place in the Middle-to-Late Ordovician as continental margin sedimentary rocks, oceanic sedimentary rocks, and ophiolite were thrust onto the edge of the continent to form the Taconic allochthons. The multiple allochthons were accompanied onto the continental edge by a complex of elongate fore-arc basins that represented the arc-trench gap provinces of the system. These basins were filled with flysch and olistostromes derived largely from the allochthons and were deformed by overriding ("higher") allochthons. The final phases of the obduction of arc and accretionary wedge material were completed during the Caradocian in the "classical" Taconian terrane along the western margin of the orogen.

The volcanic rocks of the arc (or arcs) in Quebec and Maine are commonly thought to be represented by the Ascot and Weedon Formations in the Eastern Townships of Quebec and the Winterville and Munsungun Formations of northeastern Maine. The formations in Maine are fossiliferous and almost entirely of Caradocian age (Hall, 1970; Roy and Mencher, 1976), but locally volcanic rocks as old as Arenigian are present (Shin Brook Formation, Neuman, 1967); the Ascot and Weedon Formations are not fossiliferous, but are inferred to be of a similar age range. Although the Ascot-Weedon and Winterville-Munsungun volcanic belts are similar in both lithology (basalt-to-rhyolite) and age, it is not possible to be certain that they are parts of a single volcanic terrane because they are separated by a wide belt of Devonian cover rocks. The volcanic rocks of the Munsungun-Winterville belt rest unconformably on polydeformed formations composed largely of phyllite and quartzite of probable Cambrian-Early Ordovician age. These pre-volcanic arc rock units are generally along strike from, and are temporal/lithologic equivalents of, the Hurricane Mountain Formation of the Lobster Mountain anticlinorium, which displays mélange fabrics and exotic blocks (Boone, 1983; Boone et al., 1984). Collectively, these pre-volcanic units appear to form a foundation for the volcanic arc. They are lithologically similar in many ways to the Saint Daniel Formation and the Caldwell/Rosaire Groups of the Eastern Townships of Quebec and northwestern Maine as pointed out by Boone (1983).

The St. Victor synclinorium and the Depot Mountain belt in northwestern Maine lie between the volcanic rocks assigned to the arc and the Baie Vert-Brompton line which might be thought of as the northwestern limit of the accretionary complex that formed over a subducting oceanic crust. The ophiolite masses, together with the Saint Daniel mélange, might therefore be analogues to the Rowe thrust zone of western New England which is envisioned by Stanley and Ratcliffe (1985) to have formed during a long history of subduction beneath the arc prior to the collision of the arc with North American continental crust.

The flysch of the St. Victor synclinorium, including the Depot Mountain Formation, is located in the correct position and is of the appropriate age to be the last-formed deposits in a fore-arc basin as the arc completed its movement onto the edge of the continent (Cousineau and St-Julien, 1986). As a basin in an arc-continent collisional zone, the Middle-Late Ordovician basin was located in a position analogous to the Plio-Pleistocene coastal range collisional basin of eastern Taiwan (Lundberg and Dorsey, in press) which developed between the Luzon volcanic arc to the east (the Ascot-Weedon/Munsungun-Winterville analogue) and the Central Mountains of Taiwan to the west (the analogue of the polydeformed continental margin and oceanic crust sequences of the Notre Dame anticlinorium of Fig. 1). The fore-arc collisional basin received detritus from both the arc and the uplifted fold-thrust belt of the Central Mountains.

Figure 5 summarizes the correlations proposed here for Ordovician through Middle Devonian units from the St. Victor synclinorium in the Eastern Townships of Quebec, through the Depot Mountain terrane in northwestern Maine, to the Lake Temiscouta region. In northwestern Maine and Quebec to the northeast, the Ordovician and Silurian sequences are bracketed by major faults or fault systems: the Middle Devonian-or-younger La Guadeloupe/Rocky Mountain fault zone on the southeast and the Caradocian-or-younger Dead Brook fault system on the northwest. The La Guadeloupe and Rocky Mountain faults are commonly speculated to be east-over-west thrust faults. Published detailed structural analyses of these faults are, however, lacking. The unnamed extension of the these faults in the Temiscouta Lake area has recently been shown as a right-lateral strike slip fault by David and Gariépy (1986, 1987)

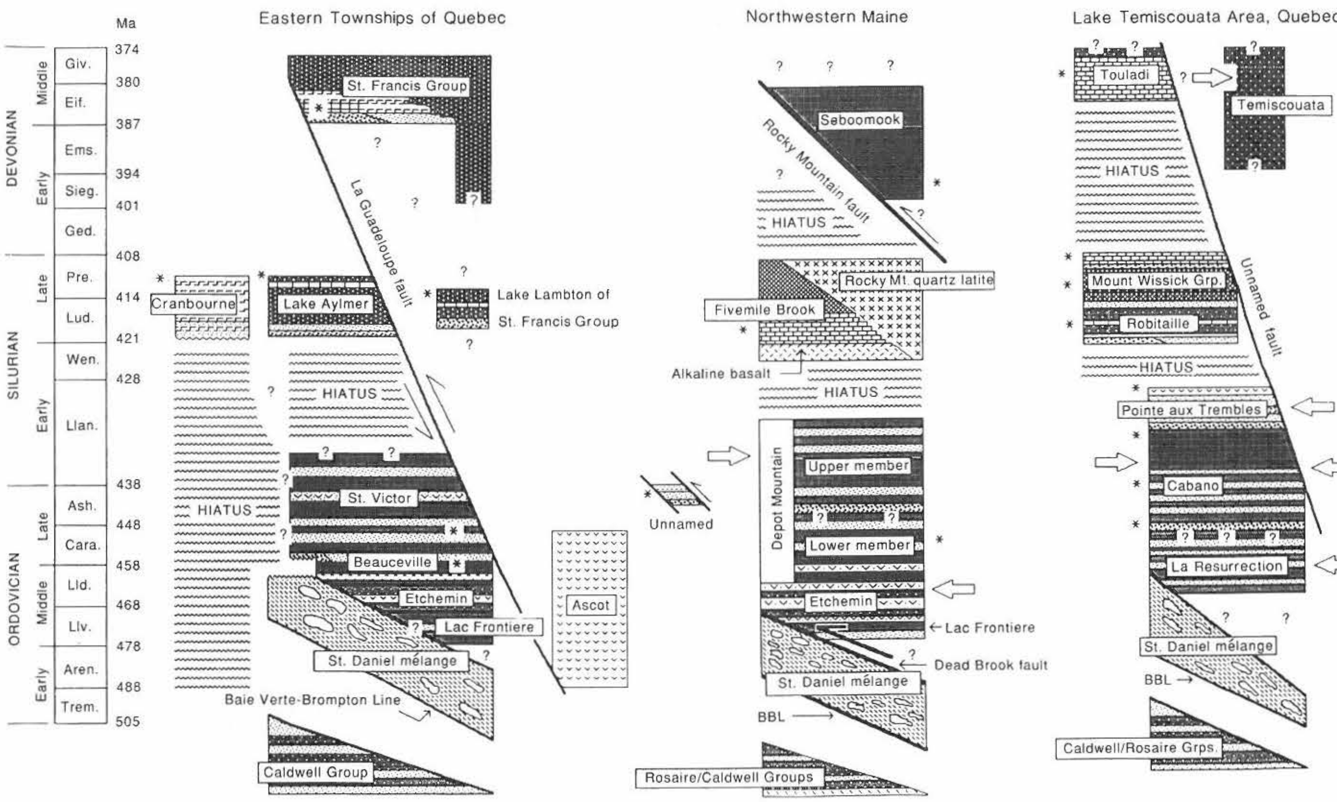

Figure 5. Correlation of the Ordovician-through-Middle Devonian units in northwestern Maine and adjacent Quebec along strike to the northeast (Temiscouta Lake area) and southwest (Eastern Townships). The unnnamed unit in northwestern Maine is the problematic unit discussed in the text. Open arrows indicate speculative sediment transport directions from either the northwest (left) or the southeast (right) in the northwestern Maine and Temiscouta Lake sections. Age picks come from the DNAG time scale (Palmer, 1983). Asterisks indicate stratigraphic position of age control based on fossils.

without a detailed rationale. The ages and nature of displacements along the steeply dipping faults, such as the Dead Brook fault, that separate the Depot Mountain Formation and its correlatives from the Saint Daniel Formation and other Cambro-Ordovician units are also little understood. To complicate matters, the contact between the units of the Saint Victor synclinorium and the Saint Daniel Formation in the Beauceville and Saint Victor/Thetford Mines areas of the Eastern Townships is shown as an unconformity by St-Julien (1987), but as an east-over-west thrust by Slivitsky and St-Julien (1987). Although Slivitsky and St-Julien (1987) show a thrust fault along the northwestern margin of the St. Victor synclinorium, they map synclinal "keels" of Magog rocks within the Saint Daniel terrane near St. Methode and indicate that the Magog stratigraphy is unconformable on the Saint Daniel Formation beneath the thrust fault just north of Magog. Present information along the northwestern margin of the St. Victor synclinorium-Depot Mountain belt therefore suggests that the Depot Mountain Formation was deposited in a basin that was underlain by the Saint Daniel Formation and that the sedimentary sequence of the basin was at least locally unconformable on the mélange. The Dead Brook fault and its equivalents along strike probably postdate the initiation of sedimentation in the fore-arc basin, but may have had a long and complicated displacement history. It is possible that the early movements along the Dead Brook fault were associated with the Taconian orogeny and latest mélange development.

The provenance of the sandstones of the lower member of the Depot Mountain Formation together with the water-laid tuffs in the member are consistent with deposition near an active volcanic arc. The active volcanism of the arc appears to have ceased in the latest Caradocian or early Ashgillian judging by the well defined age limits on the volcanic units in the Munsungun-Pennington Mountain anticlinorium in northern Maine (Hall, 1970; Roy and Mencher, 1976). Termination of the volcanism is likely related to the cessation of subduction and possibly to the movement of North American crust beneath the arc (Zen, 1983). Thus the transition from the lower to the upper member of the Depot Mountain (and the Cabano) Formation approximately in the late Caradocian or Ashgillian seems to coincide with the termination of arc volcanism and of arc-continent collision.

The sandstones and shale of the upper member also show sedimentological features indicative of deep-water deposition.

The Cabano Formation is similarly found to be of deep-water origin (Lajoie et al., 1968; David et al., 1985). Taken together, the two units suggest that the fore-arc basin, begun earlier, continued into the Llandoverian of the early Silurian. Though the part of the basin in Maine remained deep, the provenance of the sandstones changed from largely volcanic to predominantly metasedimentary. To the northeast, where rocks similar to the lower member of the Depot Mountain Formation have not been recognized within the Cabano Formation, the "new source" seen in the upper member appears to have been important as early as the Caradocian since the metasedimentary source seems to have been the more important source for the entire Cabano Formation. Taking the present age information on the two formations at face-value, it is necessary to postulate either, (1) a single complex source terrane that was capable of supplying sand rich in either volcanic or metasedimentary detritus, or (2) multiple source terranes composed largely of either volcanic or metasedimentary rocks.

At the moment, neither provenance hypothesis can be substantiated or eliminated. The sandstones of the Cabano Formation have long been thought to have come from the northwest, based on paleocurrents and clast similarity to the older metasedimentary rocks of the Quebec Group (Lajoie et al., 1968). More recently, David et al. (1985) concluded, based on lithofacies variations and post-Cabano Formation stratigraphy, that the Cabano Formation could have had metasedimentary sources from either the northwest or southeast with sediment transport also within the basin along its northeast-trending axis. The difficulty with proposing southeastern sources has been establishing the specific source rocks. These source rocks should be broadly similar to those of the Cambro-Ordovician to the northwest of the basin. As suggested previously, the source rocks are indeed present beneath the volcanic arc units in the anticlinoria in central and eastern Aroostook County, Maine, and along strike to the southwest. These rocks are seen in thick successions of variegated phyllites with interbedded quartz-rich sandstones and siltstones of the Chase Brook, Grand Pitch, Hurricane Mountain, and Dead River Formations, for example. These largely metasedimentary sequences are commonly polydeformed and locally show mélange features. In a complicated arc source terrane these prevolcanic metasedimentary rocks might have formed extensive upland areas that could have shed substantial non-volcanic detritus into parts of the Depot Mountain-Cabano basin while volcanic detritus was being delivered to other parts of the basin.

The change in sandstone provenance seen in the Depot Mountain Formation could therefore have resulted for either of two reasons. First, a change in sediment transport patterns could have brought sands with metasedimentary detritus from northwestern uplands located in the Notre Dame anticlinorium. This change from "outboard" arc to continentward accretionary wedge sources would be very analogous to upward provenance changes observed in the latest Miocene to early Pleistocene fore-arc basin of eastern Taiwan by Dorsey (1988). Alternatively, the change in Depot Mountain provenance could have been due to the dissection of the southeastern arc terrane to expose the underlying older metasedimentary units while the same sediment-transport patterns were maintained. A long-lived and large sedimentary basin could have been filled with a complicated pattern of sandstone lithofacies. The pattern would have been produced by evolving canyon-fan complexes combined with uplift and erosion of both a decaying volcanic arc and an uplifted continentward accretionary belt analogous to the Central Range of Taiwan. A precise understanding of the evolution of patterns of sediment transport within the basin await more widespread paleocurrent measurements which have thus far proven to be difficult in northwestern Maine.

An interesting complication to the above picture of a progressive upward loss in volcanic detritus is provided by the deposition of the volcaniclastic sandstones and pyroclastic rocks of the Pointe-aux-Trembles Formation in the Lake Temiscouata region and the laterally equivalent Lac Raymond Formation farther northeast (Lajoie et al., 1968; David et al., 1985). The Late Llandoverian Pointe-aux-Trembles Formation overlies the Cabano Formation gradationally with an upward increase in bed thickness and is capped by a succession of tuff, volcanic breccias and conglomerates, and rare andesite lava flows. In addition, the Lac Raymond Formation contains gabbro sills. Lithofacies analysis suggests that the Pointe-Aux-Trembles Formation was derived from the southeast with turbidity currents moving down at least two submarine canyons (David et al., 1985). The Pointe-aux-Trembles Formation therefore represents not only the transportation of volcanic detritus into the basin, but also indicates renewed or continued volcanic activity at the site of deposition and also possibly in the general direction of the arc during the Late Llandovery. This volcanism is younger than any that can be documented in the volcanic units generally assigned to the arc. Because of the coarseness of the volcanic detritus and pyroclastics, David et al. (1985) infer that the volcanism during deposition of the Pointe-aux-Trembles Formation was nearer to the basin than the volcanism of the late Ordovician. Major and trace-element geochemical analyses (including REE) of the volcanic rocks of both formations suggest probable calc-alkaline magmatic affinities to David and Gariépy (1986). The gabbros proved to be either high-alumina or alkali basalts and are not considered to be comagmatic with the volcanic rocks. Though fractional crystallization is favored by David and Gariépy (1986) to produce the geochemical variations seen in the volcanic rocks, they are unable to rule out the possiblity that magma mixing produced the variations. If the late Llandovery volcanism was a continuation of arc volcanism, then it suggests that the movement of the arc toward, and onto, the North American margin continued into the late Early Silurian. However, it is also possible that the late Llandoverian volcanism is an early representation of the late bimodal Silurian volcanism. This bimodal volcanism is seen in the Fivemile Brook Formation, the Rocky Mountain quartz latite, and volcanic units unconformably overlying the Ordovician arc volcanic units in the anticlinoria on the

southeastern side of the Connecticut Valley-Gaspé synclinorium. In this second possibility, the Pointe aux Trembles/Lac Raymond volcanism would be unrelated to the Taconian arc and could have been produced by mixing of peralkaline felsic and alkalic basaltic magmas similar to those seen in the post-Taconian volcanic rocks of slightly younger age (Ludlovian) along strike in Maine (Schwartz et al., 1984).

The late Llandoverian volcanism may be related to a widespread disconformity that separates the Pointe-aux-Trembles Formation and the Depot Mountain Formation from younger, generally shallow-water, units of the upper Silurian (Fig. 5). A hiatus representing the Wenlockian of the Silurian (Fig. 5) was apparently caused by uplift and "draining" of the Depot Mountain-Cabano basin which was accomplished without significant compressional deformation. This occurred during the inferred Middle Silurian highstand of sea level (Vail et al., 1977). Invasion of marine water took place, possibly from the northeast, during the Ludlovian. Restoration of marine conditions was accompanied in northwestern Maine by deposition of the calcareous shales and limestones of the Fivemile Brook Formation associated with bimodal volcanism. The alkalic basalts suggest an extensional tectonic environment (Schwartz and Hon, 1983; Schwartz et al., 1984) that may have eventually led to the development of a deep and widespread basin (back arc ?) in which the Devonian flysch was deposited.

Although it is widely perceived that the Siluro-Devonian basins in New England and Maritime Canada are everywhere "post-Taconian" and possibly even "post-closure" of Iapetus, I consider it likely that some of the deeper and more widespread of these basins began in the Middle Ordovician. This is probably especially true of the basins that contain thick, deep-water Early Silurian flysch sequences such as the Kearsarge-central Maine basin and the Depot Mountain-Cabano basin. Therefore, while allochthons of the Taconian foreland were advancing over the North American continental margin in the Middle Ordovician, deep-water basins were present in outboard locations within an arc-basin complex or beyond the arc on oceanic crust. Along and southeast of the Taconian suture, some of these basins continued during the tectonically more stable Early Silurian and were later affected by diachronous tectonic instability beginning in the Late Silurian and continuing through the Acadian orogeny (Roy, 1980b; Bradley, 1984).

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