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THE CAMBRIAN PLATFORM IN NORTHWESTERN VERMONT

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INTRODUCTION

Cambrian and Lower Ordovician clastic and carbonate sediments in the Vermont portion of the northern Appalachians were deposited on a passively subsiding shelf following late Precambrian rifting of the Iapetus Ocean (Rodgers, 1968). These sediments must have accreted at a rate which kept pace with subsidence as the shelf assumed the morphology of an accretionary rimmed platform (Read, 1985) during the Lower Cambrian. Distribution of facies indicates that the shallow water interior of this platform was affected by tidal fluctuations, and it passed laterally into open shelf regions and ultimately into deeper water basins (Mazzullo and Friedman, 1975). This general sequence of facies has been summarized for the Cambrian and Lower Ordovician of the Appalachians by several authors (Rodgers, 1968; Palmer, 1971). The facies associated with the pericontinental portion of the sequence have been described by Myrow (1983), Rahmanian (1981), Chisick and Friedman (1982), Braun and Friedman (1967) and Speyer (1982). Outer shelf facies have been described by Keith and Friedman (1977). It is important to note that none of these works document the complete sequence from epicontinental seas through to shelf edge to slope environments; most concentrate on the description of a portion of the platform sequence. In fact, looking at Cambro-Ordovician sequences throughout the entire Appalachians, only Pfeil and Read (1980) describe a platform to basin sequence, but it has been dismembered by faults and cannot provide information on the original geometric relations on the platform.

This field trip guide describes the facies and evolution of a portion of the Cambro-Ordovician carbonate platform in northern Vermont (Figure 1). The Dunham Dolomite represents the first carbonate sediment deposited on the newly formed shelf, and we see that the facies distribution and paleogeography of the Dunham platform controls what develops in subsequent Cambrian units. Study of the Dunham Dolomite can therefore tell us much about the morphologic evolution of the entire Cambro-Ordovician platform. The sediments underlying the Dunham Dolomite (Figure 2) have been described by Myrow (1983) as tidally-influenced shallow shelf clastics (Cheshire Quartzite) which overlie the clastic rift basin fill sediments of the late Precambrian Pinnacle and Fairfield Pond Formations (Tauvers, 1982). The Cheshire Quartzite will not be seen on this field trip.

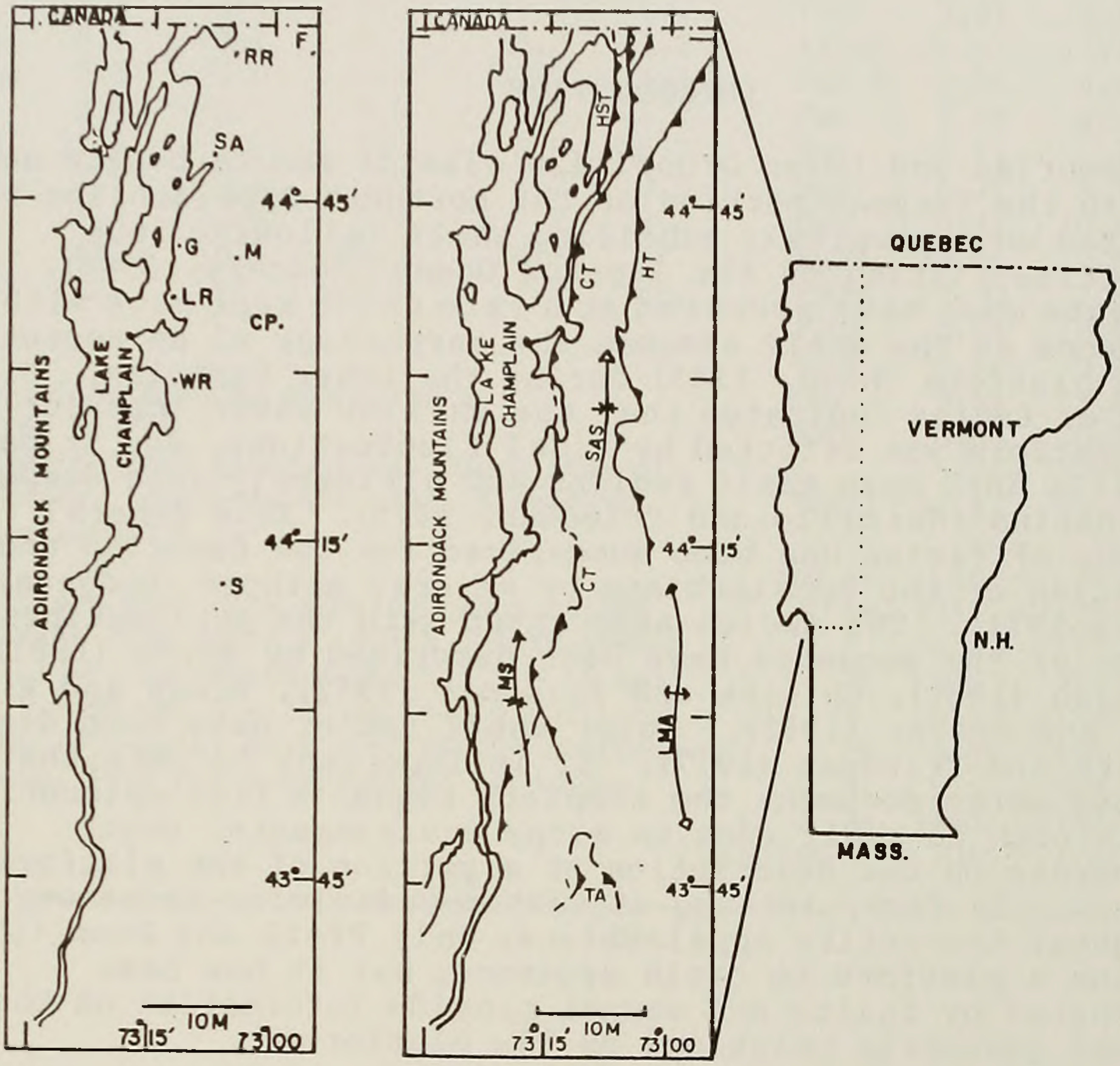

Figure 1. Locality map for some of the **important** outcrops of Cambrian units, and major structural features in the region.
LMA- Lincoln Mountain Anticlinorium; MS- Middlebury Synclinorium; SAS- St. Albans Synclinorium; TA- Taconic Allochthon; CT- Champlain Thrust; HT-Hinesburg Thrust; HST- Highgate Springs Thrust.
S-Shelburn; WR-Winooski River; CP-Colchester Pond; LR-Lamoille River; M-Milton; G-Georgia; SA-St. Albans; RR- Rock River; F-Franklin

Overlying the Dunham Dolomite lies the lower Middle Cambrian Monkton Quartzite (Figure 2), a mixed carbonate and siliciclastic unit which records tidal flat to platform margin sedimentation. The Monkton Quartzite is overlain by the Middle Cambrian Winooski Dolomite, and detailed lithofacies analysis has not been completed on this unit, but the few remaining sedimentary and biogenic structures suggest it also records peritidal to platform margin environments of deposition. The Upper Cambrian Danby Quartzite gradationally and conformably overlies the Winooski Dolomite and Butler (1986) has documented that the Danby records tidal flat to platform margin sedimentation with significant storm overprinting.

This field trip will look at each of these units and examine some of the evidence for the environmental interpretations. The field trip will examine the Dunham, Monkton and Winooski Formations in the Milton area and the Monkton, Winooski and Danby Formations in the Burlington/Winooski regions.

GEOLOGIC SETTING AND STRATIGRAPHY

The Cambrian to Lower Ordovician stratigraphic sequence in western Vermont outcrops in a north-south trending belt (Figure 1), a region bordered on the east by the Green Mountain Anticlinorium, a belt of Precambrian rocks thought to represent the easternmost occurence of the North American craton in the Lower Paleozoic (Rodgers, 1968). The north-south trending outcrop belt consists of several major fold belts (St. Albans Synclinorium, Middlebury Synclinorium) and thrust sheets (Champlain, Hinesburg, Pinnacle, Highgate Springs). The northwestern portion of the outcrop belt is ideally suited for sedimentologic studies of the Cambrian to Lower Ordovician stratigraphic sequence because it lies within the Quebec Reentrant (Williams, 1978, Thomas, 1978), which kept deformation and metamophism associated with the Taconic and Acadian Orogenies to a minimum. The most complete exposures of the Lower Paleozoic are contained within thrust sheets in this region. Stratigraphy within the thrust sheets is coherent, which enables us to reconstruct original geometric relationships.

Cambrian and Lower Ordovician clastics and carbonates in the northern Appalachians were deposited on a tectonically stable shelf which developed following late Precambrian rifting of the Iapetus Ocean. This shelf was undergoing thermal subsidence throughout the interval when Cambro-Ordovician sediments were being deposited.

STRATIGRAPHIC TERMINOLOGY

The Cambro-Ordovician stratigraphic sequence in northwestern Vermont was divided into two sequences by Dorsey (1983): a western shelf and an eastern basinal sequence (Figure 2). The western shelf sequence is composed of alternating siliciclastic (Cheshire, Monkton, Danby Formations) and carbonate (Dunham Winooski and Clarendon Springs Formations) units. The stratigraphy of the basinal sequence which corresponds to the shelf sequence but deposited in deeper water, consists of shale units (Parker, Skeels Corners, Morses Line) with isolated breccia units (Rugg Brook, Rockledge Formations). Unlike the western shelf sequence, correlations are relatively well developed within the basinal deposits. The stratigraphic nomenclature for these units was developed by Shaw (1958), revised by Palmer (1970) and Palmer and James (1980), and most recently revised by Mehrtens and Dorsey (1987) and Mehrtens and Borre (in press) and is presented in Figure 2.

DEPOSITIONAL ENVIRONMENTS OF THE WESTERN SHELF SEQUENCE

Pre-Cheshire Units

The Pinnacle and Fairfield Pond Formations underly the Cheshire Quartzite in central Vermont. The stratigraphy and structure of these units was studied by Tauvers (1982) and their depo-tectonic setting described by Dorsey and others (1983). The Pinnacle and Fairfield Pond Formations are interpreted as representing rift basin fill sediments deposited following initial rifting in the Eocambrian. Doolan and others (1982) has suggested that this rifting may have occured at approximately 560my before present. The topography of the rift basin resulted in a basal unit of coarse-grained clastics, possibly alluvial fan in origin (Tauvers, 1982) overlain by finer-grained siliciclastic sediments of the Fairfield Pond Formation, interpreted as forming in marginal marine basins. The contact of the Fairfield Pond Formation with the overlying Cheshire Quartzite was shown by Tauvers to be conformable. These units will not be seen on this field trip.

Cheshire Quartizte

The Cheshire Quartzite will also not be seen on this field trip as the best exposures of this unit occur in west-central Vermont. A detailed field and petrographic study of the lithofacies of the Cheshire Quartzite was completed by Myrow (1983). The Cheshire is an important unit because it represents the transition from the siliciclastic rift basin fill sediments to those of the newly developing platform (rift-drift transition).

Myrow recognized eight distinct lithofacies within the Cheshire. The lower unit of the Cheshire is arkosic to subarkosic in composition; it is similar to the Gilman Quartzite

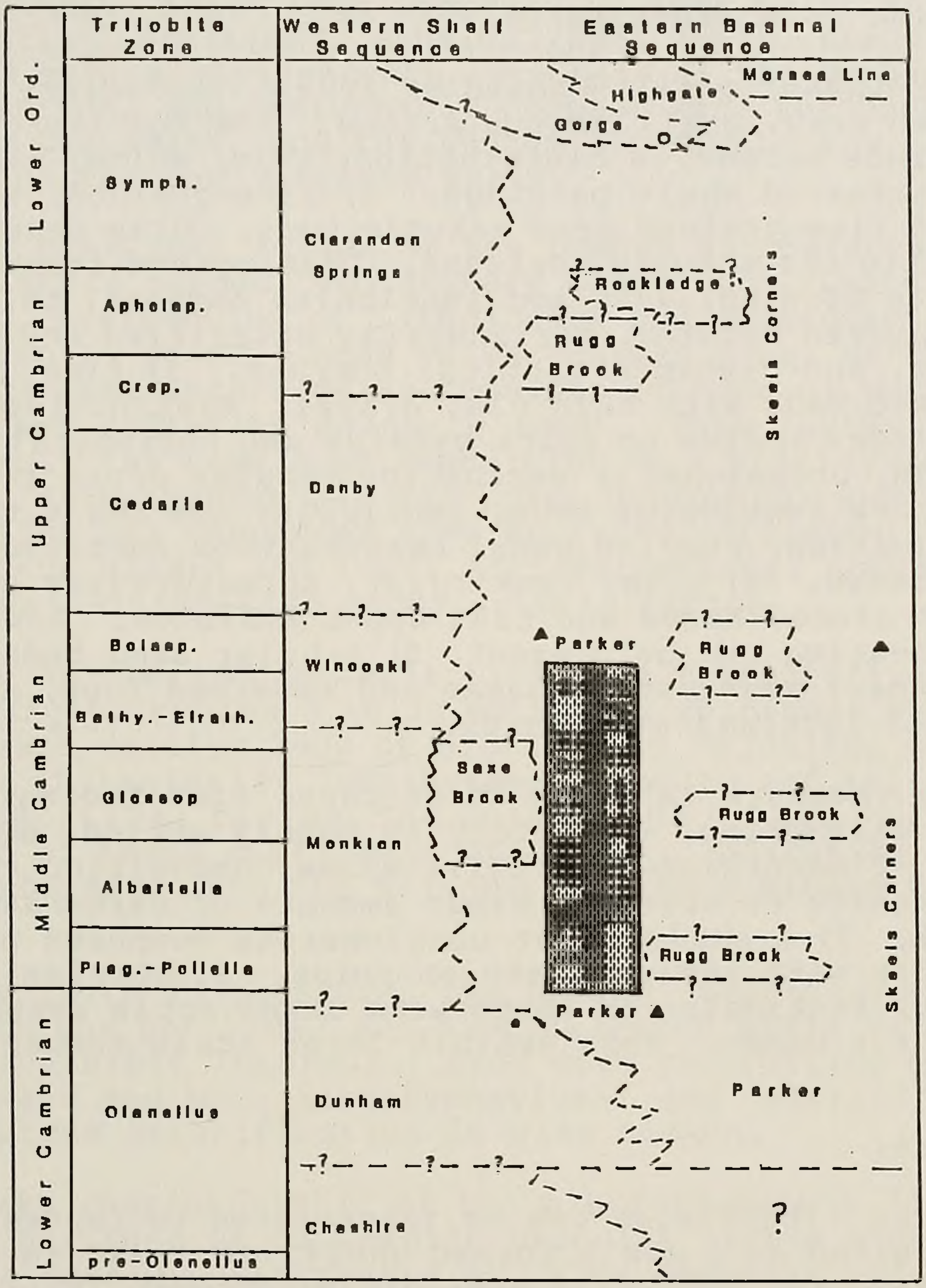

Figure 2. Correlation chart for the Cambro-Ordovician strata of northwestern Vermont. Chart is based on biostratigraphic data by Palmer (1970), Palmer and James (1980), Landing (1983) and Mehrtens and Gregory (1983), and physical stratigraphic relationships by Mehrtens and Dorsey (1987) and Mehrtens and Borre (in press). Age relationships on the platform are approximate because they are based on intertonguing relationships with the basinal units. The Hawke Bay event is illustrated by the shaded bar within the Parker Slate. Pods of Rugg Brook Dolomite extend from post-Dunham to Rockledge time. The Skeels Corners Slate has been dated as Bolaspidella zone in age but mapping relationships suggest it has a much broader age range.

exposed in nearby southern Quebec. The upper unit of the Cheshire is a quartz arenite and is similar to the Cheshire at its type section in Massachusetts.

The lower Cheshire is composed of five lithofacies: 1) fine-grained mottled grey, argillaceous arkose. Distinctive characteristics include extensive bioturbation; thin, white, rippled beds and disseminated shale partings. 2) fine-grained, white subarkosic and fine-grained grey arkosic beds. Clay drapes commonly overlie the arkosic horizons. Distinctive features include: ripple bedding, wavy and lenticular bedding, thick and thinly interlayered bedding, horizontally stratified and cross laminated beds, and U-shaped vertical burrows. 3) fine-grained, white subarkosic beds with thin clay drapes. Distinctive characteristics include: medium to thick massive and horizontally stratified beds, occasionally exhibiting tabular cross stratification, massive lenticular beds, lenticular low angle trough cross stratification, rippled beds, reactivation surfaces and erosional surfaces. 4) thin, lenticular, structureless sand bodies with erosional bases and flat upper surfaces. Low angle cross stratification can be present. 5) tabular sand beds characterized by planar, non-erosive bases and reworked tops, and a notable lack of internal structures.

The upper Cheshire is composed of three lithofacies: 1) a pink to white weathering, moderately to poorly sorted, massive, structureless, fine-grained quartzite whose composition ranges from quartz arenite to arkose. Minor amounts of carbonate cement can be present. 2) a shale clast conglomerate composed of interbedded quartzite with shale clasts or chips. 3) massive quartzite beds, lenticular in shape with large scale erosional surfaces at their bases. Beds exhibit large scale trough cross stratification.

Interpretations:

These eight lithofacies can be interpreted to represent sediments deposited on a newly formed shelf, at least in part within wave base, and partially tidally influenced. The Cheshire Quartzite is thought to represent the marine shelf sand blanketing the underlying rift basin topography. Shelf sediments of the lower Cheshire exhibit periodic storm sedimentation, and are capped by the prograding strandline sands of the upper Cheshire. This interpretation is based on: 1) position within the Cambrian stratigraphic sequence; 2) absence of any lithofacies characteristic of the supratidal environment; 3) comparison to stratigraphic sequences of similar rock units elsewhere in the Appalachians/Caledonides (Swett and Smit, 1972).

Dunham Dolomite

The Dunham Dolomite will be the first unit seen on this field trip.

The lithofacies and depositional environments of the Dunham

Dolomite were studied by Gregory (1982) and Mehrtens and Gregory (in review). These authors recognized that the Dunham Dolomite is a 400 meter thick unit composed of four major lithofacies representing peritidal, subtidal/open shelf, channel and platform margin environments. The base of the Dunham Dolomite is in gradational and conformable contact with the underlying Cheshire Quartzite, and the Dunham represents the first carbonate deposit on the newly formed shelf.

The peritidal facies of the Dunham is characterized by a bedding style termed "sedimentary boudinage", which describes the rhythmic interbedding of lithologies and subsequent differential compaction to produce beds which contain pods, or boudins. In the Dunham the interbedding consists of beds of pure dolomite (white) and silt-rich dolomite (red). This rhythmic interbedding is probably the result of deposition in a tidally-influenced regime. Bioturbation has disrupted burrowing, and early cementation has compacted some horizons sufficiently enough to form rip-up clasts and local intraformational conglomerates. Cryptalgalamintes also occur in this facies.

The subtidal/open shelf facies is characterized by shallowing-up cycles 6 to 10 meters in thickness which have at their bases massive beds of bioturbated dolomites which pass up into the rhythmically interbedded dolomite and silt-rich dolomite of the peritidal facies. The bulk of the Dunham Dolomite is composed of these shallowing-up cycles, indicating that the tidal flats prograded into the adjacent platform almost to the shelf margin.

The third lithofacies, the channel deposits, are interbedded with both the peritidal and subtidal/open shelf facies. The channels exhibit lenticular beds with downcutting bases, abundant quartz sand and both intraformational and "exotic" clasts. Trough cross stratification is also common.

Rocks characteristic of the platform margin lithofacies exhibit horizons of polymictic breccias within a quartz sand-rich dolomite matrix, interpreted as talus deposits and debris flows accumulating off the Dunham carbonate bank. In the Burlington and Winooski regions the Dunham is gradationally overlain by the Monkton Quartzite, but in the Georgia area the breccias grade conformably into clast-rich horizons of the Parker Slate, preserving the platform-to-basin transition (Mehrtens and Borre, in press).

Analysis of the distribution of the platform margin lithofacies is important in developing a model for the geometry of the Lower Cambrian carbonate platform, since these deposits very accurately place the position of the platform-to-basin transition. The distribution of the platform margin deposits indicate that the Dunham passed eastward, down-dip into the Parker Slate, (for example, in the vicinity of Arrowhead Mountain). This down-dip facies change is related to the passage into the shale basin and deeper water sediments of the Iapetus Ocean. Platform margin deposits also indicate that the shallow water deposits of the Dunham pass northward into a basin termed the St. Albans Reentrant (Mehrtens and Dorsey, 1987), which represents a foundered graben within the shelf. Based on outcrop patterns of the platform margin facies, shale units, and breccia deposits within the shales, Mehrtens and Dorsey (1987) and Mehrtens and Borre (in press) defined the margins of the St. Albans Reentrant and suggested that it was a major intrashelf basin accumulating basinal shales which influenced the distribution of the shallow water platform deposits of the Dunham and post-Dunham facies.

Monkton Quartzite

The lithofacies and environments of deposition of the Monkton Quartzite were studied and summarized by Rahmanian (1981), who recognized seven lithofacies, three of which consist of mixed siliciclastic and carbonate sediments, three of which are pure siliciclastic deposits and one is an oolitic dolomite facies. The 300 meter thick Monkton Quartzite is composed of cyclic shallowing-up cycles characterized by repetitive packages of: 1) basal subtidal siliciclastic sand shoals and channels overlain by, 2) interbedded siliciclastic sand, silt, and carbonate intertidal flat sediments, capped by, 3) carbonate muds of the high intertidal and supratidal flat. These cycles are interpreted to represent prograding tidal flat deposits. Two siliciclastic lithofacies have been recognized: 1) sand bars and tidal channels and, 2) mixed rippled sands with mud drapes of the intertidal. These supra-, inter-, and shallow subtidal sediments pass downdip to the east and north (into the St. Albans Reentrant) into subtidal oolitic dolomites and platform margin breccias.

The high degree of similarity between the environments of deposition and facies distribution between the Dunham Dolomite and Monkton Quartzite (Mehrtens, 1985) suggests that the morphology of the Cambrian platform was established in Dunham time and maintained through Monkton deposition. Although the composition of the platform sediments changed from dominantly carbonate (Dunham) to mixed siliciclastic/carbonate (Monkton), the environments of deposition in which these sediments were deposited, and the distribution of these environments, remained the same. Whatever generated the source for the Monkton sands did not effect the geometry of the platform on which they were deposited.

On the shallow water platform the Monkton Quartzite is gradationally overlain by the Winooski Dolomite. This can be seen, for example, in the Winooski region. In the Milton and Georgia areas (eastward and northward) the Monkton is overlain by undifferentiated Parker and Skeels Corners Slates (Mehrtens and Borre, in press).

Winooski Dolomite

The environments of deposition and lithofacies of the

Winooski Dolomite have not yet been studied in detail, but initial studies suggest that it is approximately 300 meters thick and is composed of the following lithofacies: 1) interbedded rippled fine-grained sand and silt with minor clay, 2) dolomite with planar cryptalgalaminite structures; 3) dolomite with LLH stromatolites reaching a height of 50cm; 4) dolomite with disseminated quartz sand; 5) quartz arenite beds with a dolomite matrix, and 6) polymictic breccia beds with a matrix of dolomite and quartz sand-rich dolomite. No shallowing-up cycles have yet been recognized within the Winooski.

Lithofacies 1 through 5 are arranged in a vertical stratigraphic sequence in an active quarry in Winooski, and are characteristic of the base of the unit. Lithofacies (1) and (2) are interbedded with the underlying Monkton Quartzite and are interpreted to represent peritidal deposits. Lithofacies (3), (4), and (5) overlie facies (1) and (2) and they make up the bulk of the stratigraphic sequence seen along the Winooski River (Stop 6). Due to an absence of any obvious sedimentary structures, and stratigraphic position overlying the peritidal facies, lithofacies (3), (4), and (5) are interpreted as shallow subtidal in origin. Lithofacies (4), (5) and (6) are recognized as composing the uppermost horizons of the Winooski Dolomite, and are interpreted to represent subtidal and platform margin deposits, respectively. As seen in the Dunham and Monkton Formations, the Winooski Dolomite also exhibits significant facies changes parallel to depositional strike. The platform margin breccias of the Winooski pass northward into the shales and breccia horizons of the Rugg Brook Formation (Mehrtens and Borre, in press) in the St. Albans Reentrant. To the south, well up onto the adjacent shallow water platform, the Winooski Dolomite passes gradationally upward into the Danby Quartzite.

Danby Quartzite

The Danby Quartzite is a 35-80 meter thick mixed siliciclastic-carbonate unit. Near its type section in southern Vermont the Danby is characterized by a siliciclastic basal unit and an upper carbonate unit termed the Wallingford Member. To the north, in this study area, the Danby thins and becomes a mixed siliciclastic-carbonate unit composed of interbedded quartz arenite, pure dolomite, dolomitic sandstone and sandy dolomite. Four lithofacies have been identified by Butler (1986): 1) intertidal to shallow subtidal, 2) subtidal, 3) open shelf and 4) platform margin. The inter-to shallow subtidal facies is characterized by interbedded sandy dolostone, quartzose sandstone and shales with mudcracks, vertical burrows, wave and current ripples, cryptalgalaminites and oncolites. The subtidal sediments are compsed of thick bedded sandy dolostones and pure dolostones with herringbone cross stratification. The open shelf facies is characterized by thick bedded, coarse-grained dolomitic sandstones and quartzose sandstones with large scale tabular cross stratification. Platform margin deposits include polymictic breccias in a dolomite matrix, and cross bedded sands interpreted as platform margin sand bodies.

The Danby Formation is interpreted to represent sediments deposited on the Cambrian platform in a complex mosaic of deposits recording both fairweather and storm processes. Evidence for storm deposition is best exhibited in the inter-to shallow subtidal facies, where laterally discontinous bedding, erosional downcutting surfaces, hummocky cross stratification, and graded bedding are common.

PLATFORM GEOMETRY

Figure 3, taken from Dorsey and others (1983) summarizes the geometry of the Cambrian platform in northwestern Vermont. Several important features are shown on this diagram, constructed from a view looking southeast. The St. Albans Reentrant, the shale basin lying along depositional strike in the shelf, is shown. Note also the north-to-south, and west-to-east facies changes present within every Cambrian platform deposit. The shallow water facies are present in the south, and they pass northward and eastward into subtidal and platform margin deposits, and ultimately into the shale basin. The diagram also shows the localization of the platform margin from Dunham through Danby time. This is important because it indicates that the platform was characterized by vertical aggradation, or upward building, throughout the Cambrian. Platform facies did not build out into the basin, nor did the platform founder and experience significant onlap of basinal shales. What could have caused the pronounced localization of the platform margin? If the St. Albans Reentrant is indeed a graben within the shelf which foundered as a result of movement on underlying Eocambrian rift block terrain (Mehrtens and Dorsey, 1987), in other words, a lystric fault, then these localized deposits accumulated along the fault scarp. Sedimentation on the platform itself was able to keep pace with thermal subsidence on the young, hot, recently-rifted margin, and the sediment built vertically, with an abrupt pinchout into the adjacent basin. The timing of initial movement of the graben which formed the St. Albans Reentrant is thought to be late-to-post-Dunham time, based on the fact that the Dunham Dolomite is the only shelf unit which continues across what becomes the shale basin. Following deposition of the Dunham, the facies on the northern rim of the Reentrant are different than those to the south (Mehrtens and Dorsey, 1987).

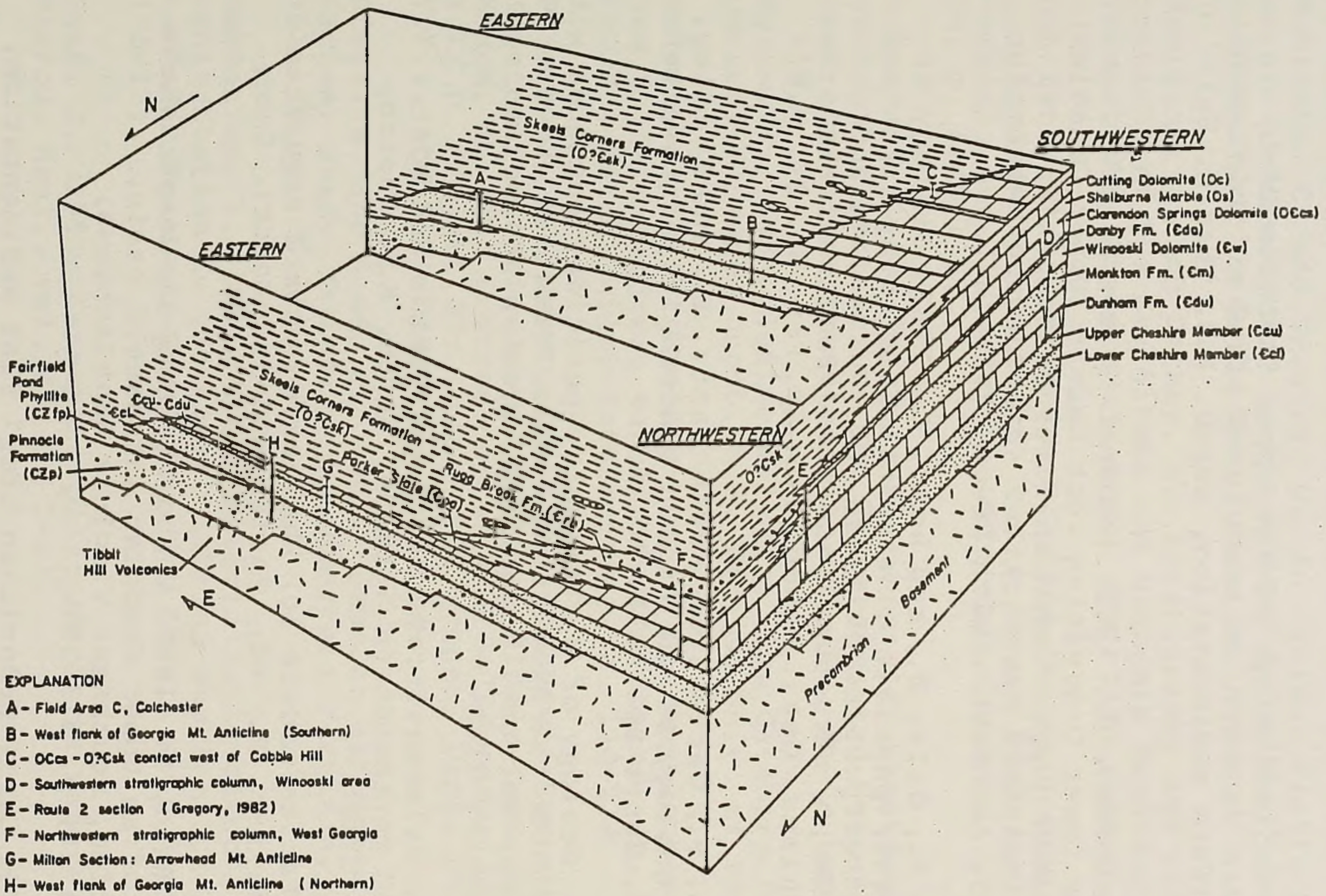

Figure 3. Block diagram from Dorsey and others (1983) illustrating the proposed paleogeography of the southern margin of the St. Albans Reentrant. Diagram shows the platform deposits pinching out to the east, into the marginal Iapetus Ocean, and to the north, into the St. Albans Reentrant. This field trip will be viewing the sections E (Route 2) and D (Winooski River).

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FIELD TRIP ITINERARY

This field trip will stop at exposures of all of the Cambrian units with the exception of the Cheshire Quartzite. All outcrops lie on the upper plate of the Champlain Thrust, and the geographic distribution of facies represents original relationships. Bedding dips gently to the east, north-east. For convenience the trip starts in the north, where the subtidal and platform margin facies occur and ends in the Burlington/Winooski region where tidal flat and shallow subtidal deposits are exposed. Hopefully at the end of the trip you will be able to see the south-to-north facies changes which occur, the localized platform margin facies, and the general features of the Dunham through Danby Formations.

Assembly point: Sand Bar State Park on Route 2 (mileage 0.0)

<u>Mileage</u>

1.6 Stop 1- Abandonned quarry on north side of Route 2

Park on the southwest (right) shoulder, cross Route 2, and ascend overgrown driveway into quarry.
The Dunham Dolomite exposed here is the basal facies of the Dunham, characterized by the rhythmic interbedding of dolomite (white) and silt-rich dolomite (pink). This bedding style is thought to be the product of alternating deposition of carbonate and clastic laminae in a tidal flat setting, producing "ribbon bedding". Subsequent differential compaction produces "sedimentary boudinage". There is local imbrication of clasts. Irregular-shaped pods of dolomite are interpreted to be burrows. The white dolomite pods are often cored by calcite. Greiner (1982) has documented occurences of gypsum. Cryptalgalaminites

resembling LLH stromatolites are present within the red silty-dolomite horizons.

Return to cars and continue east on Route 2.

2.4 Stop 2 Shallowing-up cycles

This roadcut on the left (north shoulder) exposes 3 shallowing-up cycles within the Dunham Dolomite. One SUC can be studied in detial on the northwest corner of the outcrop. The SUC is composed of a basal subtidal dolomite overlain by sedimentary-boudinaged beds of the peritidal facies seen at Stop 1. These cycles are similar to "muddy shallowing-up cycles" of James (1983), and they consist of 6-10 meters of bioturbated, sandy dolomite pasing up into ribbon-bedded dolomite and silt-rich dolomite, local intraformational conglomerates and cryptalgalaminites. Note the color change (white to pink) which results from increasing amounts of silt accompanying the change from sub- to peritidal sediments. The contact of the peritidal with the next overlying cycle is sharp and scoured, but there is no sedimentologic evidence of subaerial exposure.

Return to cars and continue driving east on Route 2.

3.1 Stop 3- Dunham subtidal and platform margin facies

Pull off about 100 yards beyond the speed limit sign on this long roadcut. At the base of this outcrop (west end) there are good exposures of the subtidal facies of the Dunham with the characteristic mottled texture produced by burrowing. Burrow mottles are irregular in shape and devoid of quartz and feldspar sand. Burrows are generally about 1 cm across but may be as large as 8cm. Between the white burrows the matrix is very clay-rich and variable in color. Stone and Dennis (1964) attribute this color variation to differing concentrations of trace metals. Specimens of <u>Salterella conulata</u> (Mehrtens and Gregory, 1983) were found in this facies.

The platform margin facies is exposed on the east end of the same outcrop. This facies is composed of chaotically-bedded, laterally discontinuous horizons of breccia in a sand-rich dolomite matrix. Clast composition is highly variable, and includes chert pebbles, sandstones, sandy-dolostones and dolomitic sandstones. Breccia beds are structureless and poorly sorted by graded beds are present in dolomitic sandstone horizons.

Return to cars and continue east on Route 2.

3.8 Stop 4-Monkton Quartzite, subtidal and shelf edge facies

This roadcut exhibits the subtidal and shelf edge facies of the Monkton, as evidenced by the overall thickness of individual beds, increasing amounts of shale between sandstone beds, presence of relict oolites in some dolomite horizons, and occurences of large scale tabular cross stratification. Many of these beds probably represent shelf edge sand shoals. Features at this outcrop can be compared to those seen at Stop 6.

Walk east 0.3mi to the small knoll beyond the road sign. Here the polymictic breccia of the platform margin facies is exposed. The clasts are floating in a matrix of sandy dolomite and are interbedded with cross bedded sandstones.

Return to cars and continue east on Route 2.

4.7 T-insection with Routes 2 and 7 at Chimney Corners. Turn left.

4.8 Pull off into commutor parking lot.

Stop 5- Winooski platform margin facies

Walk from the parking area back to the intersection, looking first at the outcrop on the southwest side. This is an exposure of recrystallized dolomite, cross bedded, and in places oolitic, of the uppermost Winooski. Cross the road to the low-lying outcrop on the east side of Route 7. Note the variable clast composition and abundance of sand in the dolomite matrix in this platform margin breccia. These outcrops of Winooski at Chimney Corners and the I-89 exit ramps to the west are the northernmost outcrops of Winooski in northwestern Vermont. Along routes I-89 and 7 to the north are exposures of the Rugg Brook Dolomite (a basinal breccia deposit).

Return to cars and head for Burlington.

5.1 Southbound entrance ramp on I-89
Outcrops of the Monkton Quartzite occur as roadcuts all along Route 89

11.1 First outcrop of Winooski Dolomite on the median of I-89

11.3 Exit of i-89, southbound onto Routes 2 & 7.

12.5 Intersection in Winooski with Routes 2, 7,& 15. Continue straight ahead on Routes 2 & 7.

12.7 Bridge over the Winooski River (Stop 6 is below). Bear right at "Y".

12.9 Park in the small pull-off on the right or across the street in store parking lots.

Stop 6 Salmon Hole- Tidal flat facies of the Monkton,

Winooski and Danby Formations

Descend the pathway down to the broad bedding planes of the Monkton in the south bank of the river. This beautiful outcrop of Monkton is in danger of going underwater from a soon-to-be-constructed dam, in which case these excellent examples of tidally-bedded sands, shales and dolomite of the supra- and intertidal Monkton would go under! Examine the multitude of rippled surfaces, note that flow directions are highly variable. Look also at the numerous bedding traces, both vertical and horizontal. Mudcracks can also be found. Buff colored dolomite beds here are interpreted to be supratidal in origin, so the uppermost bedding planes are an example of a shallowing-up cycle in the Monkton.

The Monkton/Winooski contact is under water here but can be seen at a quarry near the I-89 exit. It is gradational over about 10 meters, with progressively decreasing amounts of sand up section into the Winooski. To view the Winooski climb up out of the river, walk north across the bridge to the north bank and descend. The Winooski Dolomite does not exhibit many features but cryptalgalaminites are present as thin wisps of carbonaceous material with sand grains concentrated along the laminae. Quartz sand is disbursed throughout the unit (eolian?) and becomes progressively more abundant up section as the contact with the Danby is approached. During low water levels the entire section up into the Danby can be walked, but otherwise climb up out of the river again, this time cross Routes 2 & 7, walk past the Champlain Mill shopping arcade and descend to the river on the upstream (east) side of the building. You are now on bedding planes of the shallow subtidal facies of the Danby Quartzite. There are many excellent sedimentary structures exposed at this outcrop, including hummocky cross stratification, complexly-interwoven ripple bundles, bedding planes with interference ripples and graded beds. Biogenic structures include small LLH stromatolites and oncolites. Most of these features suggest that the sediments of the Danby were frequently reworked by storm action, resuspending and reworking the substrate, and rapidly depositing sediment during post-storm surge ebb.

Return to cars. End of trip.

Stratigraphic Definition of the Piermont Allochthon, Sunday Mountain to Albee Hill, New Hampshire

Robert H. Moench and Katrin Hafner-Douglass

(Trip cancelled 4-15-87, by necessity, with regrets)

The Piermont allochthon, whose existence was not expected prior to our 1985 field season, is a fault-bounded tract composed mainly of Silurian metasedimentary and metavolcanic rocks and probably associated mafic dike swarms that extend at least 100 km from Sunday Mountain, near Orfordville, to a few kilometers north of Greoveton, New Hampshire, and possibly an additional 200 km northeast to northern Maine. In an area that was previously mapped almost entirely as the Albee Formation (Upper Cambrian? and Lower Ordovician) south to Groveton, the allochthon contains recognized equivilents of all the Silurian formations of the Rangeley-Phillips area of western Maine, in ascending order: Greenvale Cove, Rangeley (three members recognized), Perry MOuntain (plus a volcanic-bearing member), Smalls Falls, and Madrid. Small remnants of the Quimby (Upper Ordovician?) and Littleton (Lower Devonian) are exposed as well. These formations are juxtaposed against an autochthonous sequence in which the Silurian is represented only by discontinuous lenses of Clough Quartzite, and locally by the Fitch Formation. Rocks of the allochthon are interpreted to have originated 15-25 km to the southeast near the Silurian tectonic hinge of western Maine and east-central New Hampshire, and to have been transported to their present position prior to about 400 Ma. This trip will examine the autochthonous and allochthonous sequences, the pertinent localities of isotopically dated rocks, and at least one exposure of the Foster Hill sole fault, which is the inferred base of the Piermont allochthon.