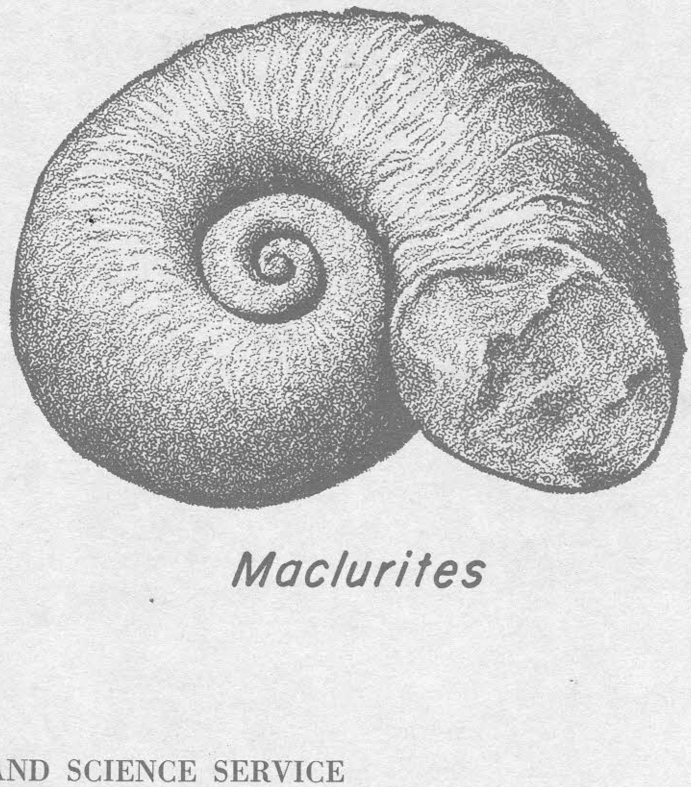
Geology of the Plattsburgh and Rouses Point, New York-Vermont, Quadrangles

DONALD W. FISHER

The gastropod, *Maclurites magnus* Le Sueur (x1) from the Chazyan Crown Point Limestone.



Maclurites

NEW YORK STATE MUSEUM AND SCIENCE SERVICE

MAP AND CHART SERIES NUMBER 10

The University of the State of New York/The State Education Department/Albany, 1968

Figure 1

WORLD PHANEROZOIC TIME SCALE

	Era	Period	Epoch	Millions of Years	Description
PHANEROZOIC EON	Cenozoic		PLEISTOCENE	1/2-2	Man
			PLIOCENE	7	Large carnivores
		TERTIARY	MIOCENE		Abundant grazing mammals.
				26	
			OLIGOCENE		Large running mammals.
				37-38	
			EOCENE		Many modern types of mammals.
				53-54	
			PALEOCENE		Earliest placental mammals.
				65	
	Mesozoic	CRETACEOUS	UPPER		Earliest flowering plants. Climax of dinosaurs and ammonites–followed by extinction. Great decline of brachiopods. Great development of bony fishes.
				100	
			LOWER		
				136	
		JURASSIC	UPPER		Earliest birds and mammals. Abundant dinosaurs and ammonites
				162	
			MIDDLE		
				172	
			LOWER		
				190-95	
		TRIASSIC	UPPER		Earliest dinosaurs. Abundant cycads and conifers.
				205	
			MIDDLE		
				215	
			LOWER		
				225	
	Paleozoic	PERMIAN	UPPER		Extinction of many kinds marine animals, including trilobites. Little change in terrestrial animals.
				240	
			LOWER		
				280	
		CARBONIFEROUS	PENNSYLVANIAN		Earliest reptiles. Great coal-forming forests.
				*310	
			MISSISSIPPIAN		Abundant sharks and amphibians. Large and numerous scale trees and seed ferns.
				345	
		DEVONIAN	UPPER		Earliest amphibians and ammonites. Extinction of armored fishes, other fishes abundant.
				359	
			MIDDLE		
				370	
			LOWER		
				395	
		SILURIAN			Earliest terrestrial plants and animals. Peak development of eurypterids.
				430-40	
		ORDOVICIAN	UPPER		Earliest fishes. Invertebrates dominant–coelenterates and mollusks become abundant, echinoderms expand in numbers and kinds.
				445	
			LOWER		
				500	
		CAMBRIAN	UPPER		Earliest abundant record of marine life. Trilobites dominant.
				515	
			MIDDLE		
				540	
			LOWER		
				570	
PRECAMBRIAN EON					Fossils extremely rare, primitive aquatic plants.
ORIGIN OF THE EARTH				4500	

RANGE OF INVERTEBRATE FOSSILS IN NEW YORK STATE ROCKS (Devonian through Cambrian)

DATES (except *) FROM: *Quarterly Jour. Geol. Soc. London*, v.120, p. 260-262 (1964)

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ILLUSTRATIONS

FIGURE 2. *Eurystomites kelloggi* (Whitfield), a coiled nautiloid from the Fort Cassin Formation at Chellis Bay, Rouses Point quadrangle

Geology of the Plattsburgh and Rouses Point, New York-Vermont,[1] Quadrangles

by Donald W. Fisher [2]

ABSTRACT

Twenty rock-mapping units and one tectonic-mapping unit (mélange) are depicted at a scale of 1 inch = approximately 1 mile (1:62,500) on a colored geologic map of the Plattsburgh and Rouses Point quadrangles, New York-Vermont. This area lies in the northeasternmost corner of New York and northwesternmost Vermont within the northern Lake Champlain Valley.

The exposed metamorphic and sedimentary rocks range in age from Precambrian (1105 ± 15 m.y. (million years) ago) to Late Ordovician (ca. 440 m.y. ago) (figures 1 and 37). Described rock-mapping units, their lithologies and faunas, include:

GROUP	FORMATION	MEMBER
Paleozoic Era		
Trenton	Iberville Shale	
	Stony Point Shale	
	Cumberland Head Argillite	
	Glens Falls Limestone	Montreal Limestone Larrabee Limestone
Black River	Isle La Motte Limestone	
	Lowville Limestone	
	Pamelia Dolostone	
Chazy	Valcour Limestone	
	Crown Point Limestone	
	Day Point Limestone	basal Ste. Thérèse Siltstone
Beekmantown	Providence Island Dolostone	
	Fort Cassin Formation (limestone, dolostone)	
	Spellman Limestone	
	Cutting Dolostone	
Saratoga Springs	Theresa Formation (dolostone, sandstone)	
	Potsdam Formation	Keeseville Sandstone Ausable Arkose
Precambrian Eon	diabase dikes	
	metagabbro	
	metanorthosite	

Except for the Cambrian Potsdam Formation, all Paleozoic strata are Ordovician in age. Lamprophyre dikes, of probable Late Jurassic-Early Cretaceous (136 million years ago) age, transect the youngest strata.

The so-called Lacolle Conglomerate is reinterpreted as a mélange (after the usage of Hsu, 1966). It is a series of disconnected, heterogeneous bodies composed of angular pebble- and cobble-sized blocks derived from the Potsdam through Cumberland Head Formations, and has an unfossiliferous fine-grained matrix. The

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Lacolle's origin is attributed to stripping from a lithologically varied but chiefly carbonate autochthon by a westwardly overriding pelitic allochthon during the acme of the Taconian Orogeny, some 430 m.y. ago.

A brief résumé of the Pleistocene history is presented, with maps denoting approximate positions of the ancient water bodies (Lake Vermont, Champlain Sea) which occupied the Champlain Lowland. With emphasis on paleoenvironmental settings, geologic and tectonic events are chronologically traced. An extensive bibliography to Champlain Valley geology is listed.

Résumé

Une carte géologique colorée des " quadrangles " de Plattsburgh et de Rouses (États de New York et du Vermont) a été préparée à l'echelle approximative de 1 pouce = 1 mille (1:62,500). Vingt unités pétrologiques et une unité tectonique (mélange) y sont représentées. Cette région est située dans le coin le plus au nord-est de l'état de New York et au nord-ouest de l'état de Vermont, dans la partie septenrionale de la vallée du lac Champlain.

Les roches sédimentaires et métamorphiques exposées varient en âge du précambrien à l'ordovicien supérieur, de 1105 ± 15 à environ 440 millions d'années.

Les unités pétrologiques décrites avec leur lithologie et leur faune comprennent:

GROUPE	FORMATION	MEMBRE
Ere Paléozoique		
Trenton	Schiste agileux Iberville	
	Schiste agileux Stony Point	
	Argilite Cumberland Head	Calcaire Montreal
	Calcaire Glens Falls	Calcaire Larrabee
Black River	Calcaire Isle la Motte	
	Calcaire Lowville	
	Dolomie Pamelia	
Chazy	Calcaire Valcour	
	Calcaire Crown Point	
	Calcaire Day Point — Schiste silteux de base Ste. Thérèse	
Beekmantown	Dolomie Providence Island	
	Formation Fort Cassin (Calcaire, Dolomie)	
	Calcaire Spellman	
	Dolomie Cutting	
Saratoga Springs	Formation Theresa (Dolomie, Grès)	
	Formation Potsdam	Grès Keeseville Arkose Ausable
Eon Précambrien	Dykes de diabase	
	Métagabbro	
	Métanorthosite	

A l'exception de la formation cambrienne de Potsdam, toutes les strates paléozoiques sont d'âge ordovicien. Des dykes de lamprophyre probablement d'âge jurassique supérieur-crétacé inférieur (136 millions d'années) traversent les plus jeunes couches.

Le soi-disant conglomérat Lacolle est réinterprété comme étant un mélange (d'après l'usage de Hsu, 1966). Celui-ce se trouve en masses discontinues et hétérogènes constituées de cailloux et de bloc angulaires enrobés dans une matrice non fossilifère à grain fin; les cailloux et les blocs proviennent de toutes les formations à partir du Potsdam jusqu'à la formation Cumberland Head. L'origine du Lacolle est attribuée à l'arrachement d'un autochtone de lithologie variée mais principalement carbonaté par le chevauchment d'un allochtone pélitique se deplaçant vers l'ouest; ceci se serait produit à l'apogée de l'orogénie taconique, il y a quelque 430 millions d'années.

Un court résumé de l'histoire du pléistocène est accompagné de cartes indiquant la position approximative des anciens lacs ou mers (lac Vermont, mer Champlain) qui ont occupé les basses terres Champlain. Une reconstitution chronologique des événements géologiques et tectoniques porte une attention particulière à la situation et aux conditions des palémillieux. La rapport se termine par une vaste liste bibliographique de la géologie de la valée Champlain.

Introduction

HISTORY AND GEOLOGIC SETTING

HISTORICALLY, THE LAKE CHAMPLAIN VALLEY has functioned as an area where early inhabitants of the continent eked out a livelihood, as an avenue for invading and withdrawing armies, as a proving ground for an embryonic American Navy, as a transportation corridor vital in our national economy, and as a summer vacationland. In a large measure, its historic importance has been dependent upon its geologic configuration — a lowland connecting the St. Lawrence and Hudson Valleys.

Perhaps the earliest documentor of the geology of the valley was the Swedish adventurer Peter Kalm (1770) who, on October 15–16, 1749, noted fossils (coiled nautiloids) in limestones along the shore of Lake Champlain. And among "firsts," it is noteworthy that the first New York fossil to receive Linnaean (Latinized binomal) nomenclature — the gastropod *Maclurites magnus*, named by Charles Alexandre Le Sueur (1818) — came from the Chazy Limestone of Clinton County.

The nineteenth century pioneers who labored to unravel the geologic history were Ebenezer Emmons, Geologist with the First Geological Survey of New York (1842); Edward Hitchcock, Professor of Geology at Amherst (1861) and State Geologist of Vermont (1856–1864); Ezra Brainerd, President, and Henry M. Seely, Professor of Geology, at Middlebury College (1890, 1896). Fossil investigations were conducted by Robert P. Whitfield (1886, 1889, 1890, 1897), Curator of Paleontology at the American Museum of Natural History; Charles D. Walcott (1891), Director of the Smithsonian Institution; Percy E. Raymond (1902, 1905a, 1905b, 1906, 1908, 1910a, 1910b, 1910c, 1911, 1916, 1924), Professor of paleontology at Harvard University; and Rudolf Ruedemann (1906), State Paleontologist of New York. Glacial deposits and Pleistocene history were studied by Herman Leroy Fairchild (1919) and Jay B. Woodworth (1905). All these names are now revered in American geology.

Geologically, the Champlain Valley occupies the site of a long-enduring geosyncline — a sinking basin in which a prism of sediments (sands, silts, muds, marls) was deposited in front of a rising and eroding eastern land mass. These sediments were afterward consolidated into sandstones, siltstones, shales, limestones, and dolostones. Subsequently, the Champlain region has been the locus of earthquakes, been ruptured by crust-rending fractures (faults), and penetrated by exceedingly hot liquid rock (magma). It has been overridden by hundreds of feet of foreign deformed rock, originally laid down tens of miles to the east, has experienced millions of years of quiescence, and more recently, has served as a drain for melting continental ice. Such a succession of events, deciphered from the rock record, stamp this region as arousing more than average geologic interest.

Furthermore, Champlain Valley rocks (particularly within the area here described) have played a prime role in the development of stratigraphic nomenclature for the Lower Paleozoic rocks (figure 10) and have long been regarded as part-standard for the Ordovician System in North America. Actually, the name Champlainian (which has priority over the name Ordovician by some 40 years) was utilized, by some, in a systemic sense. The name is now sometimes employed as "Champlainian series," synonymous with the American usage of Middle Ordovician, a term unused in Europe. Clinton County, in particular, is somewhat of a "classical region" for within its boundaries occur outcroppings of rock units — Potsdam, Beekmantown, Chazy — which are legend in American stratigraphy. Students of geology will not fail to recognize these names. Hundreds have visited the region to study the Potsdam Sandstone, superbly displayed in celebrated Ausable Chasm, the geographically widespread but somewhat poorly exposed Beekmantown Group, and the geographically restricted but well exposed Chazy Group.

From the foregoing remarks it is understandable why I chose to study this area. Aside from the principal aim — mapping the distribution of bedrock units — some vexing problems which received special attention were:

1. To explore the feasibility of a Beekmantown subdivision in the northern Champlain Valley,
2. The unraveling of several stratigraphic nuances,
3. The quest for additional paleoecologic data so as to improve the interpretation of the relationships of the rock formations.

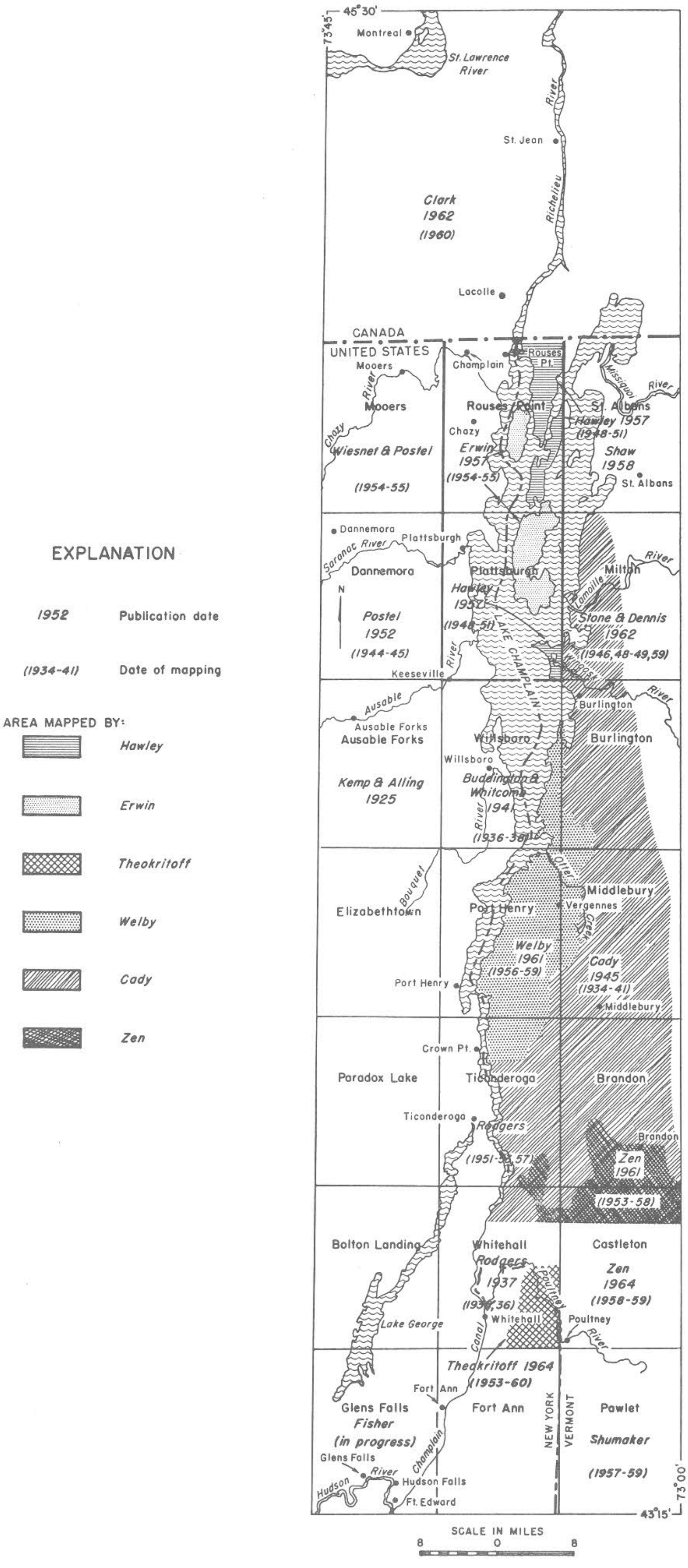


FIGURE 3. *Index map, showing mapped area with respect to adjacent mapped and unmapped areas.*

These were accomplished to varying degrees and, fortunately, not without a serendipitous outcome; a new Fort Cassin (Early Ordovician) ostracode faunule and a Cumberland Head (Medial Ordovician) fossil assemblage were discovered. Field work, conducted intermittently during the summers of 1954, 1955, 1957, and 1958 was concluded in 1965. Bedrock mapping in the Vermont portions of the quadrangles was performed by Erwin (1957) and Hawley (1957). As only minor modifications of their work has been made, the reader is referred to their articles for a detailed discussion of the Vermont geology of these quadrangles. Detailed mapping in nearby quadrangles (figure 3) has been performed by Kemp and Ruedemann (1910) [Elizabethtown and Port Henry], Kemp and Alling (1925) [Ausable], Buddington and Whitcomb (1941) [Willsboro], Postel and Rogers (1951) [Dannemora], Shaw (1958) [St. Albans], Welby (1961) [Willsboro, Port Henry], and Stone and Dennis (1964) [Milton]. Generalized geology of the region is depicted on Centennial Geologic Map of Vermont by Doll and others (1961) and Geologic Map of New York by Broughton and others (1962). In the St. Lawrence Lowlands of Canada, T. H. Clark has for many years (1934, 1952, 1962) been engaged in bedrock mapping of the Paleozoic rocks.

ACKNOWLEDGMENTS

Charles G. Doll, State Geologist of Vermont, read the entire manuscript and offered welcome suggestions. Charles S. Denny, of the U.S. Geological Survey, has kindly read and commented on portions of this article dealing with the Pleistocene. William Hobba, of the U.S. Geological Survey, Albany Office, has willingly supplied unpublished data on water wells in Clinton County. The article is enhanced by the line drawings, skillfully prepared by John Skiba of the Geological Survey, New York State Museum and Science Service. All photos, except figure 12 (courtesy of Ausable Chasm Company), were taken by the author.

GEOGRAPHY AND TOPOGRAPHY

The Rouses Point and Plattsburgh quadrangles are situated in the northern Champlain Valley and are the northeasternmost and northwesternmost 15-minute quadrangles in New York State and Vermont (figure 3); about half of each quadrangle lies in Vermont. The New York portion lies almost wholly within Clinton County, but Chesterfield Township in the extreme southern part of the Plattsburgh quadrangle is within Essex County. In New York, the largest communities, according to the 1960 census, are Plattsburgh, 20,172; Keeseville, 2,213; Rouses Point, 2,160; and Champlain, 1,549; Clinton County's total population is 72,722.

Numerous roads traverse the area. Interstate 87 (Adirondack Northway), U.S. 9, and N.Y. 22 are the chief north-south highways and U.S. 11, N.Y. 9N, N.Y. 3 and N.Y. 191 are the major roads from the west. Vermont is accessible by the bridge at Rouses Point to Alburg via U.S. 2, or by the car-ferrys from Cumberland Head or Port Kent. Provincial route 9 is a direct road to Montreal from whence Provincial routes 2 or 3 may be taken to Quebec City. The Delaware and Hudson Railroad services the area from the south and north. Commercial airplanes are accommodated at the Plattsburgh Airport, west of the city. U.S. Air Force bases at the southern edge of Plattsburgh and near Burlington are other good landing fields. Burlington, Vermont's largest city, lies in the extreme southeastern corner of the Plattsburgh quadrangle. It is serviced by a commercial airport, the Rutland Railroad (now the Vermont Railway, Inc.) U.S. 7 to Middlebury, Rutland, and Bennington in southern Vermont, by U.S. 2 and Interstate 89 to Montpelier and the east and by U.S. 7 and Quebec 7 north to Montreal. The New York State Conservation Department maintains two parks within the area, Cumberland Head State Park and Ausable Point Campsite, both with sandy beaches and camping facilities.

The Lake Champlain Valley is a lowland of very little relief, developed on glacial lake and marine sediments which rest in turn on eroded and bevelled strata of Cambrian and Ordovician ages. This graben-like valley is wedged between the intensely metamorphosed Precambrian rocks of the domical Adirondack Mountains on the west and the lesser metamorphosed, severely compressed Cambrian strata of the Green Mountain Anticlinorium on the east (figure 4). On the north, in the Province of Quebec, is a featureless plain underlain by the northeast-trending St. Lawrence Basin of unmetamorphosed strata, ranging through latest Ordovician age. On the south are an additional 70 miles of progressively narrowing Champlain Valley, in which there are localized areas of higher relief caused by westward overthrusting of imbricate blocks of Cambrian and Ordovician strata, and finger-like extensions of the Precambrian Adirondack massif which reach the lake shore.

GENERALIZED GEOLOGIC
and
TECTONIC MAP
of the
CHAMPLAIN VALLEY

EXPLANATION

Thrust fault; spurs on overriding block

Normal fault; hachures on downthrown block

Anticlinal axis

Synclinal axis

CRETACEOUS

Basic and ultrabasic intrusive rocks of the Monteregian Hills, including Mount Royal at Montreal.

ORDOVICIAN

Shales, limestones, dolostones of the miogeosynclinal sequence.
Where diagonally ruled, shales of the eugeosynclinal sequence.

CAMBRIAN

Sandstones, quartzites and dolostones of the miogeosynclinal sequence.
Where diagonally ruled, shales, quartzites, graywackes of the eugeosynclinal sequence.

PRECAMBRIAN

Metanorthosite, metasedimentary gneisses, quartzite, marble, charnockitic and granitic gneisses, metagabbro, diabase

SCALE IN MILES

8 0 8 16

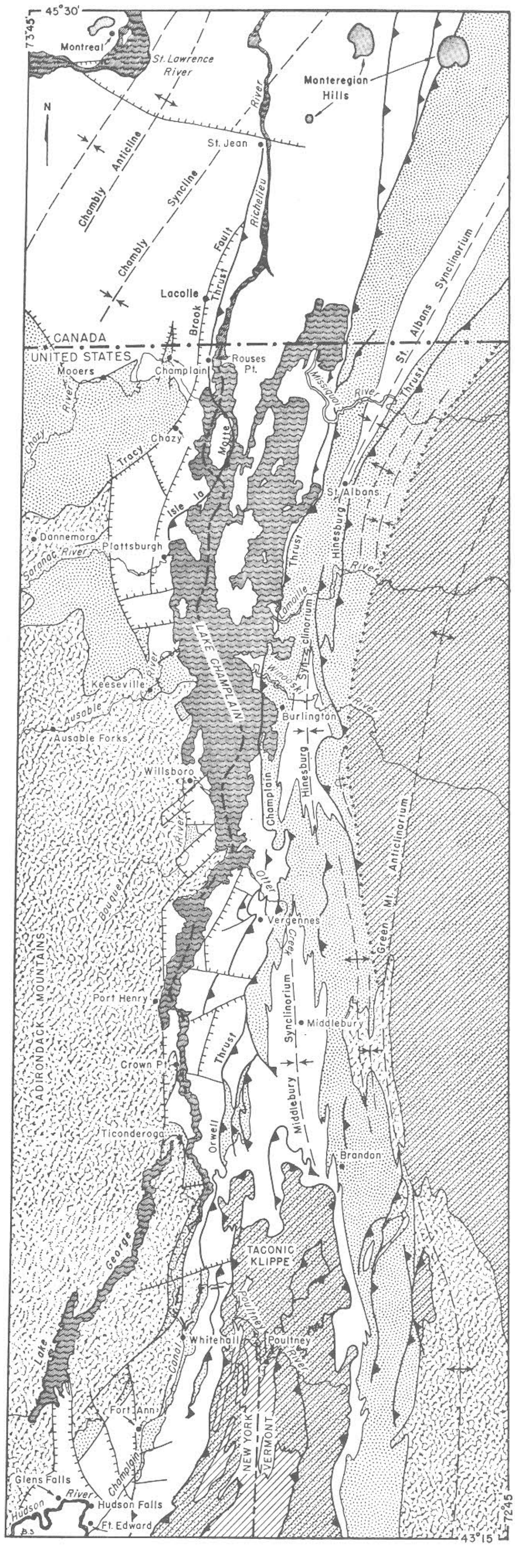


Figure 4

Adapted from Broughton, et al. (1962) and Doll, et al. (1961)

FIGURE 5. *Vista, looking north, from Trembleau Mountain (Precambrian) across Paleozoic lowland; Port Kent in center (on Potsdam Sandstone)*

Lake Champlain (439 square miles; maximum depth, 399 feet; maximum length, 125 miles; maximum width, 11 miles) drains to the north through the Richelieu River, thence to the St. Lawrence. The major New York tributaries to the lake are, from north to south, the Great Chazy, Saranac, Ausable, and Bouquet Rivers with main stream lengths of 48, 86, 57, and 43 miles, respectively, and their Vermont opposites, the Missisquoi, Lamoille, Winooski, Otter, and Poultney Rivers with main stream lengths of 47 (Vt.), 78, 82, 106, and 35 miles, respectively. In general, these rivers occupy their preglacial channels. By contrast, the smaller streams entering the lake are almost wholly in postglacial channels. The extensive, flat Pleistocene sediments are well suited for agricultural purposes, among which dairying and apple growing are foremost.

The highest elevation within the mapped quadrangles is Trembleau Mountain, south of Port Kent and N.Y. 373, which reaches 980 feet above mean sea level. Exceptional panoramic vistas of the mapped area may be viewed from here (looking north) and from Rand Hill (elev. 1500 feet) 4.5 miles NNW of West Plattsburgh on the Mooers quadrangle (figures 5 and 6). Most of the area, however, seldom exceeds 300 feet; relief is generally very low. Mean lake level is 95 feet above sea level. Aside from Trembleau Mountain, there are few notable topographic features. Ausable Chasm, along the Ausable River north of Keeseville, is a much publicized and splendid example of a late-glacial gorge carved into horizontal layers of Potsdam Sandstone. Yet another proof that a continental glacier passed this way is the Ingraham Esker, a long sinuous ridge of stratified sand and gravel, extending for about nine miles on the Rouses Point sheet, from MacBride Road on the north to Spellman Road on the south. Cumberland Head is a prominent peninsula projecting into the Lake opposite Plattsburgh; Point au Fer and Point au Roche are smaller peninsulas, north and south projecting, and simulate vise jaws around Isle La Motte. The numerous Lake islands display a north-south linear trend and characteristically show numerous promontories and shallow bays. Four islands lie within the New York limits: Crab, Valcour, Garden, and Schuyler. The major topographic features (except for the Ingraham Esker) are, in part, structurally controlled by three systems of normal faults and low-angle overthrusts.

On the geologic map (Plate 1), the projection of bedrock distribution beneath Pleistocene cover, admittedly

FIGURE 6. *Panorama, from the top of Rand Hill, looking south-south-east. Precambrian Trembleau Mountain on center horizon, metamorphosed Cambrian and Ordovician Green Mountains in left haze, and*

a risky undertaking, must be understood as depicting a probable, but not necessarily the correct solution, to the structural pattern (Plate 2). Based on attitude and age of the scattered bedrock exposures, a minimum of inferred faults are inserted; doubtless more are concealed. No evidence could be found for some of Hudson's (1933) faults and his alleged pattern of faulting does not appear to be as rigorously systematic as was conceived.

Outcroppings in general are uncommon, but locally where soil cover is veneer-like, they are apt to be expansive. Along the lake shore, bedrock is extensive but sometimes inaccessible because of precipitous cliffs or owner's refusal of access. With few exceptions, the streams are lacking exposures because the Pleistocene cover has not been excavated sufficiently. Old quarries and highway cuts are the most rewarding.

GEOCHRONOLOGY

Geochronology is that branch of geology which deals with the " absolute " measurement of geologic time. Like the endlessness of space the vastness of geologic time is difficult to comprehend, hence analogies create for us a " yardstick " which can more readily fix ancient happenings and ourselves in proper perspective. For example, if the height of the Empire State Building is taken to represent all of geologic time, then the thickness of a coin would depict man's duration on this earth. Or, if we were able to view the sequence of events and the parade of life on a continuously running film starting on New Year's Eve, life would not appear until early July, dinosaurs would dominate the land during November but late-comer man would not make his entrance until one hour before midnight of the succeeding New Year's Eve.

Relative ages of adjacent rocks, or contained fossils, and the sequence of deformation may usually be determined without difficulty. As sediments are deposited on existing ones in a horizontal fashion, it is obvious that the oldest sediments are those at the bottom of an undeformed sedimentary pile, becoming progressively younger until the surface is reached. Utilizing igneous intrusions which penetrate older rocks or sediments and undulating contacts or angularity of bedding with subjacent strata which portrays extended periods of erosion, orogenic events may be plotted in the rock record. As a corollary, fossils entombed in older sediments or rocks are older than those in younger ones. Accumulation of such data on an inter- or intra-continental basis discloses that groups of fossil plants and animals have succeeded each other in a definite and determinable order, and the strata of each division of time (system, series, stage) can be recognized by their respective fossils. To cite broad

Precambrian high peaks of Adirondacks on right horizon. Lake Champlain Valley floored by foreland rocks of Cambrian and Ordovician ages

examples, fossil trilobites will never be found with fossil dinosaurs nor will the latter ever be found with fossil horses or man, for their respective geologic ranges did not overlap.

But the previous-named devices only produce a *relative* chronology, one lacking time spans of definite duration. Precise "absolute age" determinations have only been made possible within the past two decades; refinements are and will modify the current time scale (figure 1). With the discovery of disintegration of radioactive isotopes of certain elements, and the knowledge that this radioactive decay proceeds at a constant rate independent of external conditions, "absolute age" determinations are possible by comparing the measured amounts of original or "parent" isotope and new or "daughter" isotopes in a mineral. The most utilized minerals containing one or more of these radioactive isotopes are micas (chiefly biotite and muscovite), potassium-rich feldspars, hornblende, pyroxene, glauconite, zircon, and several uranium minerals. Obviously, if such analyzed minerals were formed subsequent to deposition or consolidation, an erroneous answer will result — the "absolute age" will be too young. In the case of sedimentary rocks, orogenic or other thermal events are dated instead of the time of deposition of the sediments. Metamorphism reconstitutes minerals and establishes new parent-daughter relationships; any prior relationship is completely obliterated. Some of the more common natural radioactive "parent-daughter duos" employed for geologic dating are uranium $(U)^{238}$-lead $(Pb)^{206}$, uranium^{235}-lead^{207}, thorium $(Th)^{232}$-lead^{208}, rubidium $(Rb)^{87}$-strontium $(Sr)^{87}$, and potassium $(K)^{40}$-argon $(Ar)^{40}$. The isotopes of carbon (C^{14}-C^{12}) are useful for backdating only to about 50,000 years owing to the relatively rapid decay rate of C^{14}. Nevertheless, it is our most useful tool for dating the most recent geologic and anthropologic events.

In general, the more recent the date, the more reliable the date because the stratigraphy of the later periods is more firmly established and there is less masking by metamorphic overprint. Furthermore, some potassium-argon is apt to yield ages that are too young when compared with other isotopic determinations on the same rock, since K-Ar undergoes more "leakage" of decay products.

To date, seven radiometric dates on the geologic calendar have been determined for the Champlain Valley and environs.

1. A radiocarbon date (W–1109: C. S. Denny, written comm. 9/23/65) of 10,500 ± 350 years B.P. (before the present) has been obtained by analyzing mollusk, crustacean, foraminifera, and ostracode shells from a sand layer resting on the boulder-gravel core of the Ingraham Esker 0.5 mile south of the Miner Institute in Clinton County. These sands were laid down in the Champlain Sea

— a marine flooding actuated by crustal sagging below mean sea level due to the tremendous weight of continental ice during the Pleistocene Period.

2. Some 110 m.y. ago (the Lower-Upper Cretaceous boundary), the Monteregian intrusives were emplaced. These hills are a lineal eastward belt of differing ultrabasic intrusive igneous rocks extending from Mt. Oka, 25 miles west of Montreal to Megantic, about 115 miles east of Montreal.

   Fairbairn (1912, p. 55) determined that the rubidium-strontium isotopic analyses of 17 rock samples from 10 localities (Fairbairn, 1962) show an age of 109 ± 5 m.y. Similar investigations of nine biotites show a range of ages from 95–114 m.y. Five K–Ar biotite ages range from 85–126 m.y. The average Rb–Sr biotite age is 106 m.y.; the whole rock age is 116 m.y. and the average K–Ar age is 114 m.y.

3. A recent K–Ar date (1967) on biotite from a lamprophyre dike on the west shore of Grand Isle, 1.5 miles west of the hamlet of South Hero gives an age of 136 ± 7 million years. This would fix the time of crystallization as virtually on the Jurassic-Cretaceous boundary. Contemporaneity of this and related lamprophyres and bostonites of the Champlain Valley with the Monteregian ultrabasics is implied; this intrusive event may have spanned as much as 20 million years, initiating in the Late Jurassic and terminating during the Early Cretaceous.

4. Prof. Donald Miller of Rensselaer Polytechnic Institute has kindly furnished the following on the "bostonite" at Cannon's Point, $5\frac{3}{4}$ miles south-southeast of Willsboro. "A whole rock Rb–Sr analysis on the Willsboro Trachyte Porphyry gives a Sr–87/Sr–86 ratio of 0.714 ± 0.002. The rate of change of Sr–87/Sr–86 is 0.007 per 100 m.y. (based on a half-life of 47 billion years) in this particular rock due to a Rb–Sr ratio of 1.7. If we assume the rock started with an initial ratio of 0.706 (Hills and Gast, 1954) it would take 140 m.y. to produce a Sr–87/Sr–86 ratio of 0.716. Until further whole rock analyses are done the best age estimate is that the Willsboro Trachyte Porphyry is most probably less than 140 m.y."

5. An Ordovician date of 480 m.y. was obtained by Poole, Beland, and Wanless (1963) by the K–Ar method on muscovite in a granite which pierced the graptolite-bearing Beauceville Group in the Thetford Mines-Black Lake area of southern Quebec. Berry (1962) has determined that the graptolites belong to the *Climacograptus bicornis* zone (Wilderness Stage) of the Mohawkian Series; this would equate with the Black River Group limestones of Clinton County.

   However, this 480 m.y. date appears too old in the light of another, allegedly reliable one from Tennessee. Edwards, et al. (1959), utilizing U^{238}–Pb^{206} isotopes from zircons in three volcanic ash beds (bentonites) within the Carters Limestone, obtained ages of 452, 446, 438 m.y. Another bentonite from the Bays Formation yielded a 452 m.y. age. The Carters and Bays are correlated with the Glens Falls Limestone on trilobite evidence.

6. The most ancient date relevant to the discussed area is 1105 ± 15 m.y. (Silver, 1963). This was derived from U–Th–Pb isotope ratios in zircon from an undeformed syenitic pegmatite cutting intensely granulated Marcy Metanorthosite (similar to that comprising Trembleau Mountain) east of Jay, New York, in the Ausable Forks quadrangle. This fixes the end of the last important Precambrian event affecting the Adirondacks.

7. A date with the same order of magnitude was obtained at Lake George in the Glens Falls quadrangle where Hills and Gast (1964), employing whole-rock Rb–Sr analyses, determined the age of the igneous intrusion (batholith-sized complex of pyroxene-hornblende gneisses and hornblende granitic gneisses) to be 1035 ± 20 m.y., based on 6 samples. Whole-rock Rb/Sr analyses of gneisses of the mantling sequence yield 1100 ± 125 m.y. and 1040 ± 40 m.y., and minerals from a pegmatite in the mantling gneiss are 1060 ± 75 m.y. old.

Precambrian Rocks

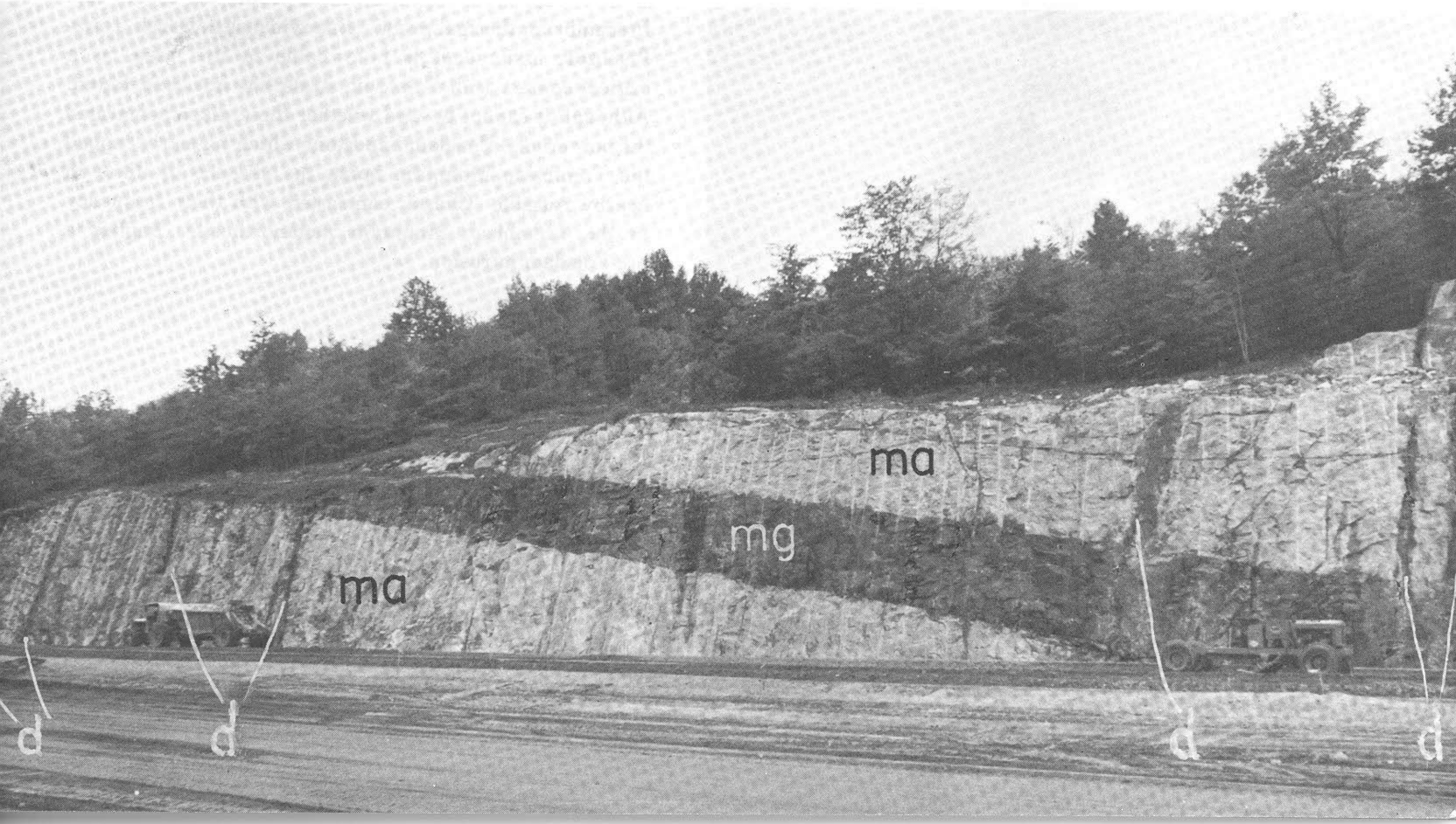
THOUGH NOT THE OLDEST ROCKS in New York State, the oldest rocks in this area are those which comprise Trembleau Mountain, a spur of the ancient Adirondack massif which reaches the lakeshore at the southern limit of the mapped area. Here, faintly gneissic metanorthosite, similar to that of the Adirondack high peaks area, boldly rises upward to form rounded hills of moderate relief (figure 6) covered with soil veneer — a marked contrast to the exceptionally low relief of the remainder of the quadrangles.

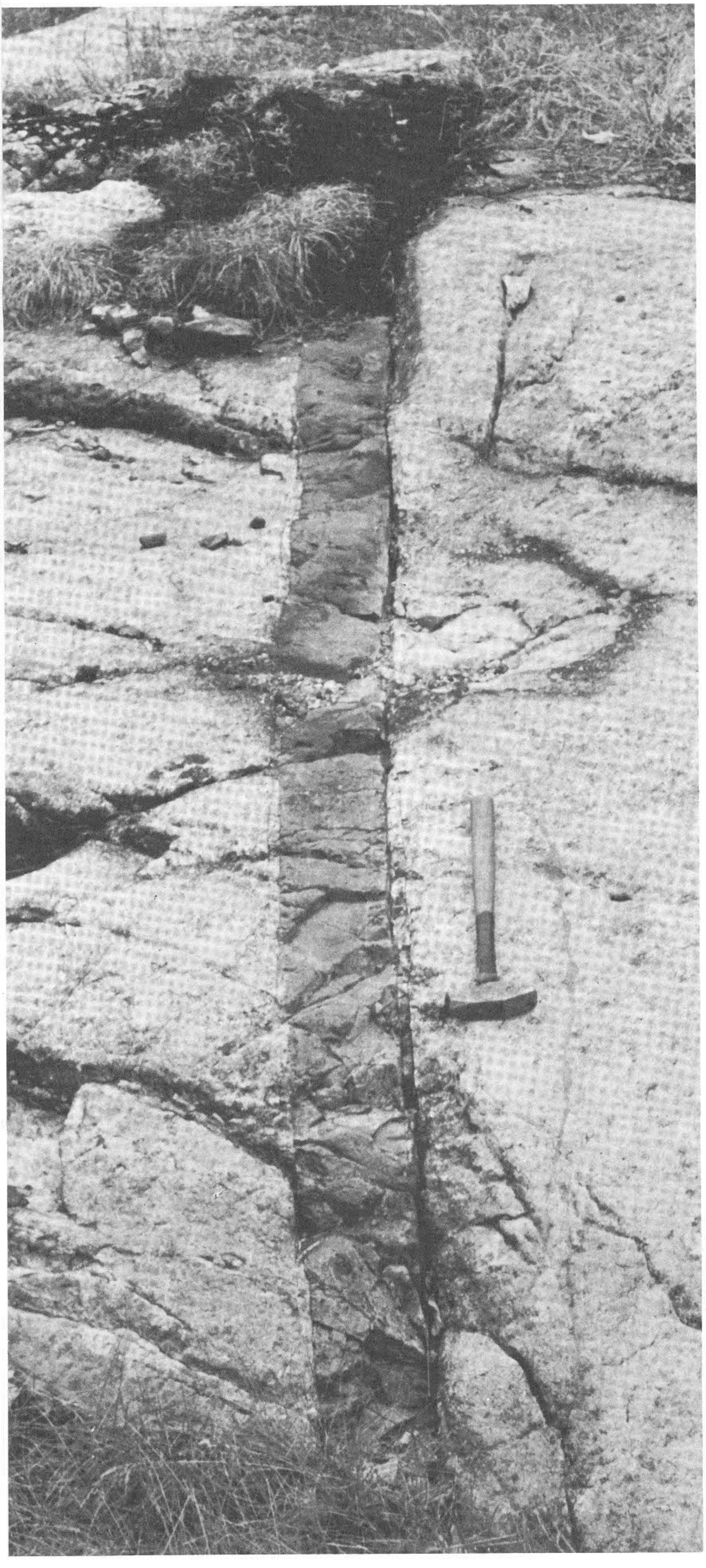
The **metanorthosite** at Trembleau Mountain is essentially a coarse, inequigranular, pale to light greenish-gray (5 G 6/1)* metamorphic rock composed principally of megacrysts of plagioclase feldspar with subordinate amounts of hornblende, augite, biotite, and ilmenite in a crushed or granulite matrix; sometimes an orange-rind weathering (due to decomposition of feldspar to kaolin) is in evidence. Because it is hypersthene-rich, the Trembleau Mountain type may be termed noritic metanorthosite. Furthermore, it is more gabbroic than, for example, the greener-gray variety so well exposed along the Northway, south of the Ausable River, in the northwestern portion of the Willsboro quadrangle where diabase dikes, cutting metagabbro, in turn cutting metanorthosites, are advantageously shown (figure 7). Most Adirondack Precambrian workers believe that anorthosite was intrusive into older sedimentary rocks (quartzose shales, sandstones, limestones), now converted to metanorthosite, gneisses, quartzites, and marbles by subsequent metamorphism. This metamorphic event has been radiometrically dated, via lead-uranium isotopes in zircons, as having occurred 1100 million years ago during the late Precambrian (Silver, 1963); the beginning of the Cambrian is currently placed at 570 m.y. ago (*fide.* Geological Society Phanerozoic Time-scale, 1965).

The metanorthosite along the Northway, 2 miles south of Keeseville, differs from the Trembleau Mountain type in that it has less than 10 percent dark minerals — the dividing line between gabbroic metanorthosite and metanorthosite. It is an incompletely, inequigranular, granu-

* Rock colors given in this article are selected from the standard Rock Color Chart (Goddard and others, 1963, the Geological Society of America).

FIGURE 7. *Vertical narrow diabase dikes* (d), *cutting metagabbro* (mg) *which had earlier cut metanorthosite* (ma). *On west side of Northway (Interstate 87), one mile south of Keeseville*





lated metanorthosite showing dark greenish-gray megacrysts (uncrushed relicts) of plagioclase in a matrix of granulated and recrystallized plagioclase. The dark gray color of the uncrushed grains is due to the presence of microscopic inclusions of iron and titanium oxides (magnetite, ilmenite) which have been expelled during recrystallization of the finer matrix, thus accounting for its lighter color. Such metanorthosite constitutes the host rock for the ilmenite-magnetite ore at the National Lead Company's mine at Tahawus.

Relatively small, dike- or sill-like bodies of **metagabbro** penetrate the metanorthosite of Trembleau Mountain. This metagabbro is now a medium-grained, brownish-weathering, somewhat speckled granulite (not gneissic or banded). Initially, this was intruded into the older anorthosite and both were metamorphosed, along with the still older sedimentary rocks, during the Grenville Orogeny of some 1100 m.y. ago. The constituent major minerals are: plagioclase, pyroxenes, ilmenite, magnetite, garnet, and possibly hornblende. Readily accessible exposures of metagabbro may be observed along and to the north of a recently improved town road to Trembleau Park, a collection of summer cottages along the lake at Trembleau Point, and along the west side of the Northway, 2 miles south of Keeseville (figure 7).

Diabase dikes, dark greenish gray (5 G 4/1) to grayish black (N 2), up to 12 feet wide but usually less than 2 feet wide (figure 8), are numerous in the 3 miles of railroad cut south of Port Kent. Along the aforementioned town road to Trembleau Point, some of these dikes enclose metanorthosite inclusions, termed xenoliths (figure 9). Elsewhere within the Adirondacks, these unmetamorphosed dikes are thought to be the product of a very late Precambrian thermal event. But evidence for such a pre-Paleozoic assignment is unavailable in this area, as a critical contact with Paleozoic strata has not been found. Although it cannot be said whether these dikes penetrated the now eroded Potsdam Sandstone which formerly capped the Trembleau Mountain horst, the absence of dikes in nearby Ausable Chasm, contrasted with their frequency in the Trembleau Mountain metanorthosite, implies a pre-Potsdam intrusion.

FIGURE 8. *Narrow diabase dike cutting metanorthosite along Delaware and Hudson Railroad, near Trembleau Point*

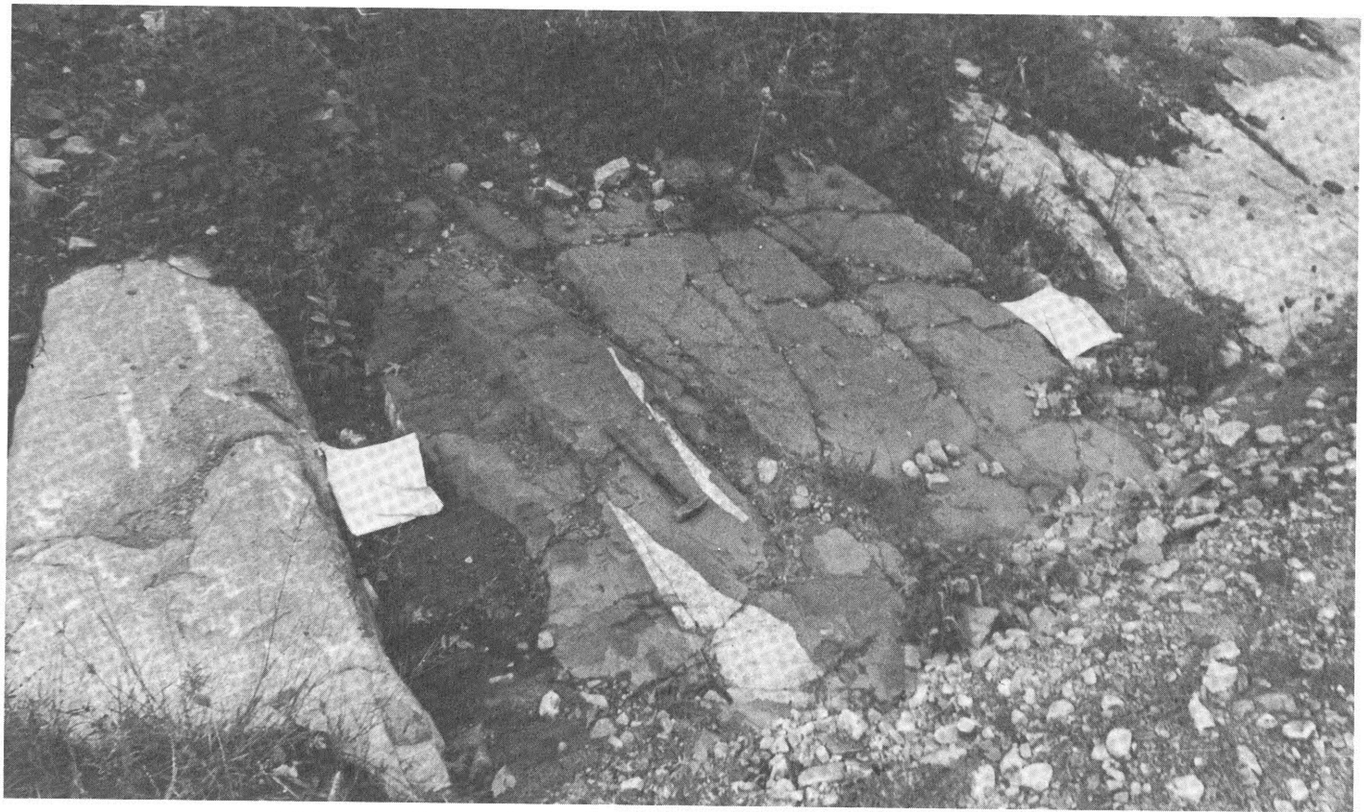


FIGURE 9. *Metanorthosite inclusions (white slivers) in diabase dike which has penetrated the metanorthosite, along road to Trembleau Point*

Summary of development of nomenclature of foreland rocks in the Champlain Valley

Emmons 1842 Champlain Valley	Brainerd and Seely 1888-1896 Champlain Valley	Cushing 1905 Clinton County, N.Y.	Ruedemann 1910 Port Henry quad, N.Y.	Whitcomb 1941 Willsboro quad, N.Y.	Cady 1945 West-central Vt.	Erwin and Hawley 1957 Vermont Islands	Oxley and Kay 1959 Chazy rocks only N.Y. and Vt.	Welby 1961 Central Champlain Valley	Clark and Hoffman 1952-1962 Southern Quebec	Flower 1964 Ft. Ann N.Y. region	Fisher 1967 Rouses Point and Plattsburgh N.Y. quads
CHAMPLAIN GROUP: Utica Slate	Utica Slate	Utica Slate Cumberland Head Shale	*unexposed*	Canajoharie Shale	Hortonville Slate (400'±)	Iberville Shale Stony Point Shale (1000'-1500') Cumberland Head (150'+)	not discussed	Iberville (1000'±) Stony Point (1000'±)	Utica: Lachine Shale (300'+) Tetrauville Ls+Sh (190'-270')	Snake Hill Shale (600')	Stony Point Cumberland Head Ls+Sh (150' -300'?)
Trenton Limestone	"Trenton"	Trenton (300'-350')	Trenton (314')	Trenton	Glens Falls Limestone (115'±)	Glens Falls: Shoreham (45') Larrabee (70')		Glens Falls (450'±)	Trenton: Montreal Ls. (350'-480') Mile End Ls. (25')	Glens Falls	Glens Falls: Montreal (150'+) Larrabee (25'±5')
Black Marble of Isle la Motte Birdseye Limestone		Black River Limestone Lowville Limestone	Black River (62') Lowville (5')	*unexposed*	Orwell Limestone (50'+)	Isle la Motte Limestone Lowville		Orwell (40')	Black River: Leray (21-24') Lowville (9'-17') Pamelia (8'-22')	Orwell	Isle la Motte Limestone (12'-22') Lowville Ls. (6'-15') Pamelia Dolo.
Chazy Limestone	Chazy: C (270') B (150') A (223')	Chazy: Valcour Limestone Crown Point Limestone Day Point Limestone	Chazy (50'±)	Chazy (Crown Point only)	Middlebury Limestone (600') Beldens Limestone (0-700') Crown Point Limestone (0-150')	Valcour (270') Crown Point (150') Day Point (233')	Valcour: Beech Ls. (85'-123') Hero Ls. (40'-100') Crown Point (88'-350') Day Point: Fleury Ls. (115'-220') Wait Ss. (5') Scott Ls. (44'-86') Head Ss. (0'-20')	Valcour (20'-95') Crown Point (100'-200') Day Point (35'-75')	Laval calc. sh.; arg. Ls. (76'-410') basal member is Sainte Thérèse Ss. (42')		Valcour (90'-220') Crown Point (50'-250') Day Point (80'-300')
Calciferous Sandrock Fucoidal Layers	Div. E (450') dolostone Div. D (375') limestone Div. C (350') dolostone Div. B (295') limestone Div. A (310') dolostone	Beekmantown: Cassin Formation	Beekmantown (300'+)	Beekmantown	Bridport Dolomite (0-500') Bascom Formation (375'+) Cutting Dolomite (350'+) Shelburne Marble (0-600') Clarendon Sprgs. Dolomite (50'-200')	Providence Island Dolomite (74') *base unexposed* *unexposed*	not discussed	Bridport Dolostone (450') Cassin Formation (210') Cutting Dolostone (440') Whitehall Dolostone (210') Ticonderoga Dolostone (300'+) *base unexposed*	Beekmantown: Beldens Dol.-Ls. (0'-275') Beauharnois Dolostone (0-1000') March Formation dol.+ss. (0-250')	Providence Island Dolomite (300') Fort Cassin Formation (150') Fort Ann Fm. (formerly Smith Basin Limestone) (100') Smith Basin Ls. (formerly Fort Ann) Great Meadows Fm. (110') Baldwin Corner Dol. (120') Whitehall Fm. (110') Dewey Bridge Dol.-Ss. (200')	Providence Island Dolostone (60'+) Fort Cassin Formation (45'+) Spellman Formation (25'+) Cutting Dolostone (200'±) concealed dolostone (75'-275') Theresa dol.-ss. (90'+)
Potsdam Sandstone	Potsdam Sandstone	Potsdam (1000')	Potsdam (100')	Potsdam	Danby Formation (400'-800') Winooski Dolo. Monkton Qtzte. Dunham Dolo. Cheshire Qtzte. Mendon Series				Potsdam (= Nepean of Wilson) (0-1700')	Potdam Ss. (300')	Potsdam Ss.: Keeseville (470'+) Ausable feld.ss.35'+
Primary gneisses, etc.	Precambrian								Gneiss, quartzite, anorthosite	Gneiss	Metanorthosite, metagabbro, diabase

FIGURE 10

Cambrian-Ordovician Rocks

SARATOGA SPRINGS GROUP

The **Potsdam Sandstone,** one of the most referred-to stratigraphic units in our literature, was named (Emmons, 1838) from its type exposure at Hannawa Falls near Potsdam, St. Lawrence County, where it is imperfectly and, ironically, atypically exposed. In New York, the unit rims the Adirondack Mountains, except on the southwest in the Black River Valley, and is sporadically exposed along the southern margin. The sections displaying the greatest stratigraphic thickness extend from the Fort Ann area (300 feet) northward to Ausable Chasm (455 feet +); Chateaugay Chasm (200 feet +) in northern Franklin County and the Covey Hill area on the International Boundary in northern Clinton County similarly reveal long sections of Potsdam. West of the Chambly Arch, to the St. Lawrence River, outcrops expose little thickness and stratigraphic placement of field ledges within the Potsdam is exceedingly difficult. Adding to this difficulty is the fact that sandstone beds within the overlying Theresa facies may be mistaken for part of the Potsdam if seen in an isolated outcrop. However, in the Mooers quadrangle, Wiesnet (1961) suggested that the Potsdam and Theresa sandstones may be distinguished by the presence of feldspar in the former and its absence in the latter. Moreover, he demonstrated greater sphericity for the quartz-sand grains of the Theresa. Whether these criteria hold in other areas is unproved. Furthermore, as the base and summit of the Potsdam are usually unexposed, relative stratigraphic placement of field ledges is usually impossible. Because of these limitations, the Potsdam's thickness in Clinton County is difficult to determine. Ausable Chasm shows about 455 feet with neither base nor summit evident. The Morrisonville Well, drilled in 1898–99 as a test for natural gas, in the Dannemora quadrangle, penetrated 775 feet of Potsdam without reaching the base. Wiesnet (1961, p. 6) reported 1750 feet for the Potsdam in the neighboring Mooers quadrangle. In the Beauharnois vicinity of southern Quebec, 2000 feet have been allotted to the Potsdam in a few wells. Therefore, it is reasonable to assume that the Potsdam attains 1500 feet in the northern Champlain Valley.

Three lithologic types (facies) of Potsdam may be recognized in Clinton County. From bottom to top, they are:

1. **Basal member**—[Allens Falls of Krynine (1948); Nicholville of Postel, Nelson, and Wiesnet (1959)] — maroon or dusky red (5 R 3/4) hematitic, feldspathic, micaceous, quartzose sandstone having high accessory mineral content; some maroon shale interbeds.
2. **Ausable Member**—highly crosslaminated orange-pink (5YR 8/4) to pale red (5R 6/2) very coarse- to medium-grained arkose (feldspathic sandstone) with quartzose green shale seams and conglomeratic lenses.
3. **Keeseville Member** — pinkish-gray (5 YR 8/1) to very pale orange (10 YR 8/2) regular-bedded, clay-deficient, quartz-sandstone, only slightly feldspathic.

The first facies is not exposed in the Plattsburgh and Rouses Point quadrangles but does crop out sporadically near Jericho in the adjacent Mooers quadrangle, and westward through the Churubusco, Chateaugay, Malone, Moira, and Nicholville quadrangles. It is patchy and does not everywhere constitute the basal Potsdam. In some places it is a conglomerate of quartzite and gneiss boulders and cobbles, displaying characteristics of terrestrial alluvial fans accumulated in a tectonically unstable area. Its age is uncertain.

Within the mapped area, two members may be distinguished. The **Ausable Member**, named by Alling (1919, p. 144), is a heterogeneous rock. The lithology becomes progressively but irregularly more uniform upward in the section. For example, in some sections arkose occurs as high as 250 feet above the lowest exposure, whereas in others, only the lower few feet are arkosic. Although long stratigraphic sections are unavailable for verification, it appears that locally, the Ausable Arkose is relatively high within the Potsdam Formation and its configuration seemingly reflects the distribution of Precambrian feldspar-rich source rocks.

The Ausable Arkose is a highly cross-laminated (figure 11), coarse- to medium-grained, orange to pink to pale red, hematitic, feldspathic, quartzose sandstone with well-rounded quartz grains. There are occasional thin seams of quartzose green shale and lenses of ill-sorted and nonoriented conglomerate of flat pebble (up to

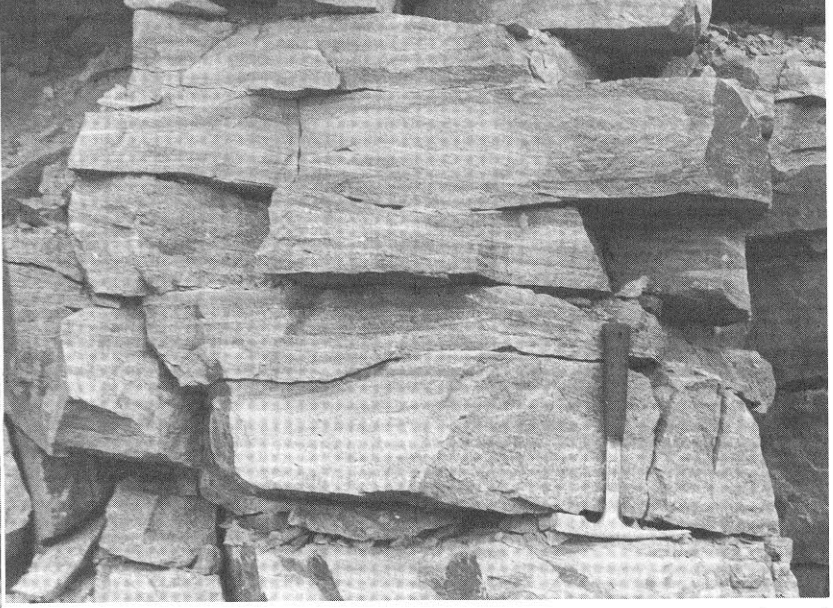


FIGURE 11. *Closeup of Ausable Arkose Member of Potsdam Formation at Laphams Mills; note cross-laminations*

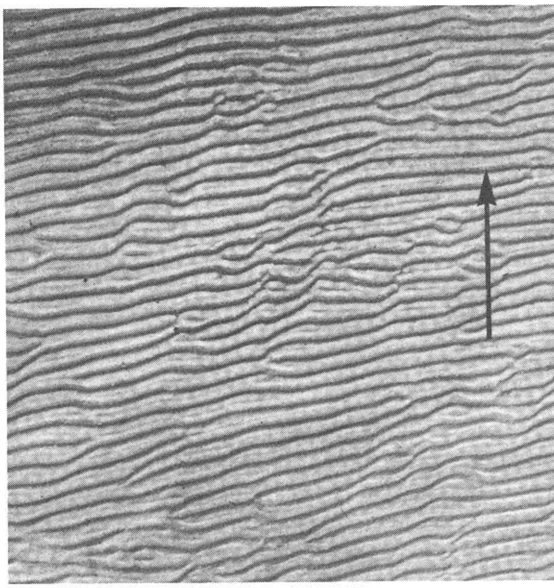
10 cm.) quartzite. The feldspar may reach 50 percent; it is predominantly orthoclase with subordinate equal amounts of plagioclase and microcline. Accessory minerals are zircon, magnetite, hematite, biotite, pyroxene, and hornblende.

An instructive exposure crops out along both lanes of the Adirondack Northway (Interstate 87) at Laphams Mills at the west edge of the Plattsburgh quadrangle. Here, cut-and-fill structures have developed from cross-lamination; shale interbeds, conglomerate seams, and a shaly fault zone are all visible. Parallel straight rulings (striations) atop the mall exposure, trending N 3° W, attest to the scouring of bedrock by foreign rocks imbedded in the sole of moving ice. The Ausable Arkose conceivably represents the initial rapidly laid clastic debris derived from a mechanically and chemically eroded Precambrian terrane which accumulated on an estuarine shoreline of moderately low relief. The sedimentary structures denote that the sediments came to rest in high energy river channel-river bank (fluvial) and tidal channel-tidal bank (intertidal) environments.

The **Keeseville Member**, named by Emmons (1841, p. 130–131), is a more homogeneous rock. It is a pinkish-gray (5 YR 8/1), fine- to coarse-grained, better sorted quartz sandstone, with substantial frosting and well-rounding of quartz grains. Feldspar is subordinate, seldom exceeding 10 percent. The cement is silica and calcite. Laminations, due to limonite or hematite veneers, parallel the regular bedding, which varies from thin- to medium-bedded; intrabed crossbedding and current-produced ripple marks with wave lengths of 2–8 cm. are not uncommon (figure 12). Chocolate brown specks and general overall yellow-iron oxide staining are ubiquitous. As wave churning and persistent currents would eliminate laminations, the Keeseville Sandstone is believed to record deposits in low-energy outer intertidal and inner subtidal shelf zones, and bays and lagoons protected by barrier beaches. In view of the postulated low-energy environment it is puzzling that the Keeseville is so clay-poor. Some sedimentary mechanism such as clay bypassing may account for this omission. Occasional beds with polygonal desiccation cracks (mudcracks) attest to brief periods of subaerial exposure. A magnificent section may be seen in Ausable Chasm, north of Keeseville (figure 13). Widespread field exposures occur on the northwest side of the Tracy Brook Fault north and northeast of Chazy. The Potsdam facies-settings outlined here agree with those independently determined by Otvos (1966).

The Potsdam is of differing ages (figure 28). The lowest maroon member lacks fossils; it may be late Precambrian, Early Cambrian, or, at the youngest, Medial Cambrian. The Ausable Member lacks diagnostic fossils; it is probably Early Cambrian or early Medial Cambrian. It has yielded the enigmatic *Climachtichnites*, probably an arthropod trail. The Keeseville Member, in Clinton County, is late Medial Cambrian (Dresbachian) as the trilobites *Komaspidella seelyi* and *Lonchocephalus minutus* have been collected in Ausable Chasm about 120 feet from the lowest beds; the probable mollusk, *Hyolithes* and the inarticulate brachiopods, *Lingulella* and *Obolella* have also been found here. The planispiral gastropod *Ophileta*, indicative of an Early Canadian age

FIGURE 12. *Current ripple marks (arrow denotes current direction) in Keeseville Sandstone Member of Potsdam Formation above falls at Ausable Chasm*



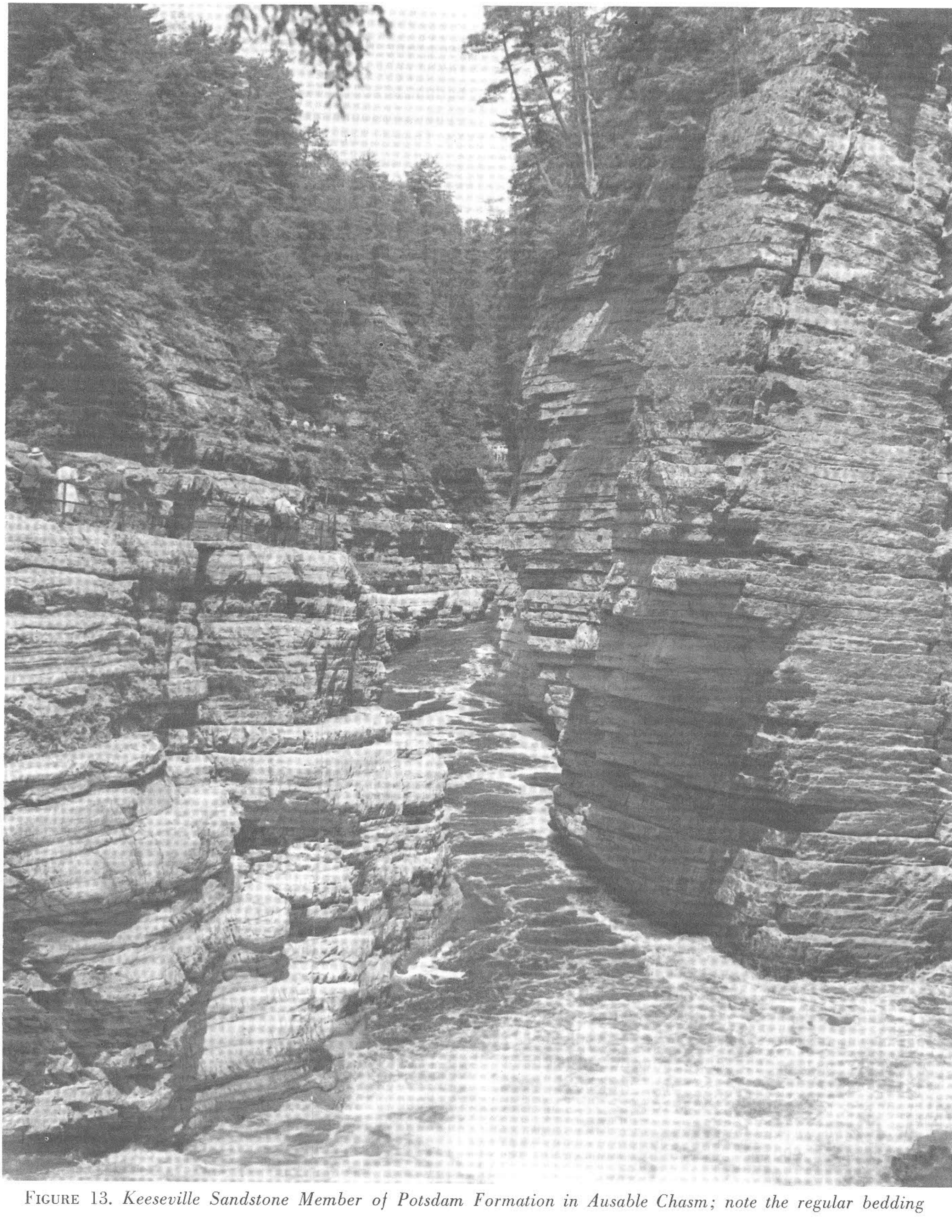


FIGURE 13. *Keeseville Sandstone Member of Potsdam Formation in Ausable Chasm; note the regular bedding*

madoc), has been reported (Walcott, 1891) from the uppermost Potsdam sandstones (Theresa?) in the splendid section along the Saranac River from Cadyville to Kent Falls, in the Dannemora quadrangle.

In the Fort Ann-Whitehall area, northern Washington County, the Potsdam (Keeseville Member) is demonstrably Medial Cambrian (Dresbachian) and Late Cambrian (Franconian), as it yields the trilobites *Komaspidella, Lonchocephalus, Conaspis, Elvinia, Camaraspis* and *Berkeia* (Flower, 1964, p. 156). In Chateaugay Chasm, northern Franklin County, the Potsdam (Keeseville Member) is later Late Cambrian (Trempealeau), yielding the trilobites *Prosaukia* and *Ptychaspis*. In St. Lawrence County, diagnostic trilobites have not been reported, but in view of the progressive northwestward chronologic transgression, the Potsdam is likely Early Canadian (Tremadoc). Placement of the Tremadoc within either the Cambrian or Ordovician is unfixed (figure 28) as the position of the Cambrian-Ordovician boundary is controversial in the British type section. Pending decision by committee action on the Cambrian-Ordovician boundary, the New York Potsdam is tentatively assigned to the Cambrian. In eastern Ontario, the Potsdam (Nepean) of Wilson (1954) was assigned by her to the Ordovician.

Theresa Formation (termed Ticonderoga Formation in southern Champlain Valley)

Described by Cushing (1908, p. 159), the Theresa Formation is well represented in this area. Where exposed, as from Champlain Village north to the International Boundary (Plate 1), it consists of interlayered medium- to thick-bedded quartzose dolostone and ferruginous, dolomitic, quartz sandstone; the quartz grains are frosted and exceptionally well rounded. Textures are invariably coarse to medium and laminated beds are common. Rare ripple marks trend N 80°W. The sandstones (sometimes "fucoidal") are light brownish-gray (5 YR 6/1) to light bluish-gray (5 B 7/1) and the dolostones are shades of light- (5 B 7/1) to medium bluish-gray (5 B 5/1). Weathering hues are light brown-(5 YR 6/4) to yellow-gray (5 Y 8/1). The more dolomitic strata may be somewhat vuggy; the vugs are lined chiefly with the mineral dolomite. In the early 1960's a cylindrical excavation by the U.S. Air Force for a missile silo (now abandoned) exposed, 1.9 miles northwest of Champlain, an unexposed amount of silty, gray-black shale interbedded with ferruginous sandstone. To illustrate the porosity and permeability of this unit, all water was lost at a depth of 200 feet; at 225 feet some water returned.

Lithologically similar strata fringe the Adirondacks, occupying the stratigraphic position between the relatively pure quartz-sandstones below and the dominantly carbonate strata above. The thickness of the intermediate transitional facies varies; in the Fort Ann area, the Theresa facies is 180 to 200 feet thick (Flower, 1964, p. 157) and may approach 300 feet, whereas in Clinton County it is relatively thin. The Morrisonville Well penetrated 50 feet of Theresa and a composite of the outcroppings in northern Champlain Township agrees with this figure; two abandoned quarries (Plate 1) north and northeast of Champlain Village reveal a composite of 45 feet. Certainly no more than 85 feet are present in Clinton County; at Shoreham, Vermont, in the southern Champlain Valley, 100 feet have been recorded (Rodgers, 1937). Westward across the northern flank of the Adirondacks, the thickness remains fairly constant but the Theresa's outcrop belt broadens due to reduced relief and a small dip (1° to 3°). The combined Potsdam-Theresa in St. Lawrence County measures 150 to 200 feet thick. Published thicknesses for the Theresa may fluctuate owing to arbitrary placement of the lower and upper contacts because the Theresa displays both lateral and vertical transition between quartz-sand and carbonate facies. Similarity with the older Potsdam Sandstone has already been commented on.

The age of the Theresa is disputable in Clinton County; the sole fossil discovered was a loosely coiled ecculiomphalid gastropod, too poorly preserved for generic assignment. In neighboring Quebec, the same unit [March Formation of Wilson (1946)], was regarded as Early Ordovician, although the faunal evidence is likewise inconclusive. Tremadocian gastropods (*Ophileta, Helicotema uniangulata*) occur in the Theresa at Theresa, Jefferson County (type locality) and in the Bucks Bridge Formation (Theresa facies) at Bucks Bridge, St. Lawrence County. In contrast, the Theresa near Saratoga Springs along the southeastern Adirondack flank is Late Cambrian (Franconian), as demonstrated by the trilobites *Elvinia* and *Berkeia* (Fisher and Hanson, 1951). Thus, the Theresa, like the Potsdam, becomes progressively younger northwestward with sedimentation fairly continuous from Croixian into Tremadocian time. In view of the *Ophileta* reported by Walcott (1891) from the uppermost Potsdam at Kent Falls, it seems best to class the Theresa in Clinton County with the Tremadocian. Supporting evidence for a Tremadocian age may be found at the St. Clothilde quarry in southern Quebec (Clark, 1962) where there are Early Canadian fossils within the lower somewhat quartzose Beauharnois Dolostone, a few feet above the March Formation (= Theresa).

BEEKMANTOWN GROUP

Of especial stratigraphic significance is the site of Clarke and Schuchert's (1899) "type" Beekmantown within the mapped area — the Beekmantown, New York, vicinity. Many stratigraphers and teachers erroneously have regarded the field ledges there, such as Kirby Ledge north of Beekmantown, as the type Beekmantown and have bemoaned the fact that the section is most imperfect. But Clarke and Schuchert were explicit in pointing out that although the name was selected from Beekmantown, the type section was at East Shoreham, Vermont, some 60 miles to the south, where the section is essentially complete. Here, Brainerd and Seely (1890) distinguished five divisions of the carbonate "Calciferous" with the letter designations A, B, C, D, E (fig. 10, p. 14). Divisions A, C, and E were overwhelmingly dolostone (calcium-magnesium carbonate) and B and D dominantly limestone (calcium carbonate), somewhat dolomitic, with fossils. Past workers (Rodgers, 1937; Wheeler, 1942; Cady, 1945; Welby, 1961; Flower, 1964) have attempted to extend these divisions into neighboring regions and have met with limited success. One of the difficulties in applying these divisions too rigidly is that lateral and vertical transition from dolostone to limestone is apt to be abrupt. This produces a condition where a certain division may have quite different stratal limits and/or composition from its type section at differing localities.

A resolute effort was exerted to map divisions of the Beekmantown in the Rouses Point and Plattsburgh quadrangles. Some success was achieved, but owing to scattered exposures of small vertical extent and large areas of masking Pleistocene sediments it is certain that the total thickness of the Beekmantown Group is unexposed; unit boundaries are admittedly ill-defined. Nevertheless, five subunits were distinguished with some confidence. They are, in ascending order:

B_1 **Theresa** — some would include the Theresa in the Beekmantown Group. I have no strong feelings one way or the other. Traditionally, it has been excluded from the Beekmantown, the disposition it is here accorded.

B_2 **Cutting** — These are massive light (N 7) gray and very pale orange (10 YR 8/2) or buff weathering, medium- to fine-grained bluish-gray (5 B 6/1) to dark gray (N 3) cherty dolostones, only slightly calcitic. Generically indeterminable faint loosely coiled gastropods were found. The base of the unit is unexposed.

B_3 **Spellman** — Very light gray (N 8) weathering, thin- to medium-bedded, medium (N 5)- to dark-gray (N 3) dolomitic calcilutites and calcisiltites with fewer medium- to thick-bedded tan- to buff-weathering cherty dolostones; the lower portion is almost entirely calcitic dolostone, often with reticulose weathering. The gastropods *Lecanospira* (figure 14) and *Rhombella* and the trilobites *Bolbocephalus seelyi* and *Hystricurus conicus* are indicators of a Medial Canadian (= Early Arenig) age (figure 28).

B_4 **Fort Cassin** — (figure 16) Lithologies of B_5 with interbedded, massive gray (N 6) weathering, medium gray (N 5) to grayish black (N 2) slightly dolomitic, occasionally cherty, fine- to medium-grained banded limestone (calcilutite, calcisiltite) within which occur small pods or lenses of coarse-grained limestone (calcarenite). These dolomitic limestones display a characteristic reticulated or fretwork weathering surface (figure 15). Occasional thin beds of argillicalcilutite hold abundant lingulid brachiopods. The calcilutites and calcisiltites con-

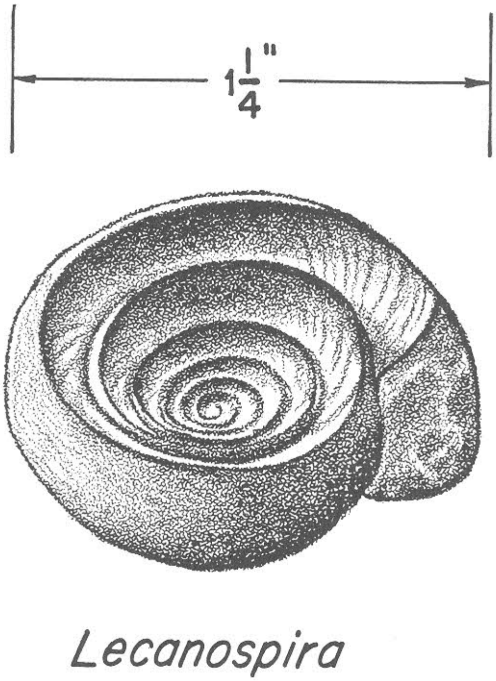


FIGURE 14. *Lecanospira compacta (Salter), a depressed-spire gastropod and indicator of a medial Canadian age, Spellman Limestone, Kirby Ledge, Beekmantown, New York*

FIGURE 15. *Closeup of reticulated surface produced by differential weathering of dolomitic limestone; Fort Cassin Formation south of Chellis Bay*

tain a nautiloid cephalopod fauna of which the coiled *Eurystomites* (figure 2) and *Tarphyceras* are most striking. Along the lakeshore, south of Chellis Bay, a profuse ostracode (*Isochilina*) fauna occurs in the calcarenites, together with a low-spired gastropod. Trilobite fragments are profuse throughout the limestones. The fauna is a typical Fort Cassin one as described by Whitfield (1897) and is assigned to the Late Canadian (= Late Arenig).

B_5 **Providence Island** — (figure 17) Very pale orange (10 YR 8/2) or buff-weathering massive, thick- to medium-bedded, light blue-gray (5 B 7/1) fine- to medium-grained dolostone (dolomilutite, dolomisiltite); locally vuggy. No fossils found. This is the most prevalent Beekmantown unit in the mapped area.

FIGURE 16. *Fort Cassin limestone and dolostone of the Beekmantown Group, along lake shore south of Chellis Bay*

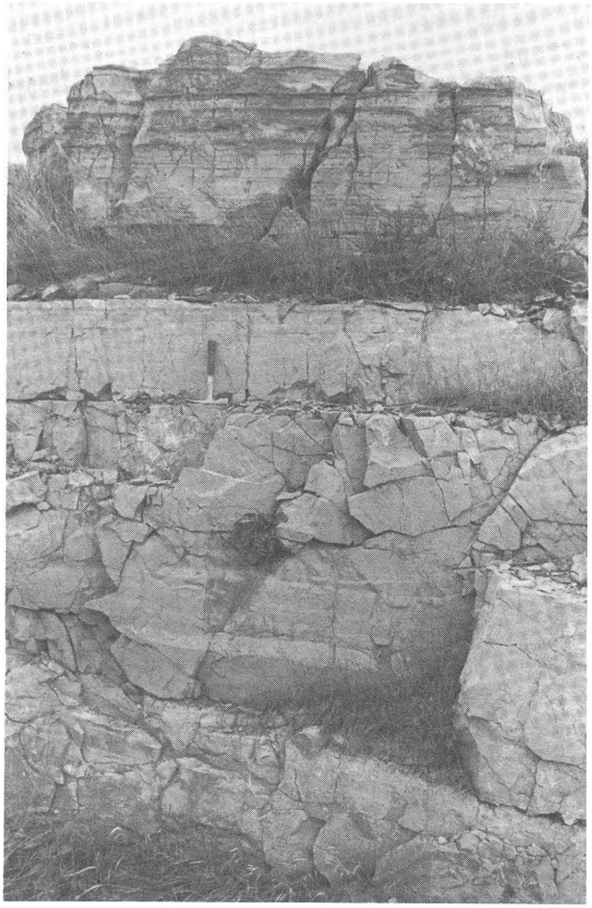


FIGURE 17. *Providence Island Dolostone, along east side of U.S. 9, 4 miles north of Plattsburgh*

Aside from Kirby Ledge (B_3), paralleling New York 22 north of Beekmantown, instructive exposures of the Beekmantown Group may be found (Plate 1) in a broadly exposed area 2 miles east-northeast of Champlain Village (B_1), field ledges near the County Home 4 miles north-northwest of Plattsburgh (B_2), Northway cut at South Plattsburgh (B_5), lake shore (figure 16) from Point au Roche south (B_4), lake shore from Valcour south for 0.4 mile(B_4), roadcut along U.S. 9 (figure 17) and the old quarry to east to road, 2 miles north of Plattsburgh (B_5).

Because of insufficient exposure and subsurface data the total thickness of Beekmantown strata in Clinton County is indeterminable.

CHAZY GROUP

Undoubtedly, most paleontologists, stratigraphers, teachers, and students that have visited this area have done so to examine and collect from the Chazy limestones. In a geologic sense, one thinks automatically of the Champlain Valley when speaking of Chazy — the two names go hand in hand. And little wonder, for splendid easily accessible exposures of Chazy rocks dot the lowland in Clinton County, particularly in Chazy Township, (Plate 1). Southwest of Chazy Village, between the Tracy Brook Fault and New York 348, the type section is about 740 feet thick (Oxley and Kay, 1959) with about 10 to 15 percent of the section concealed. A thickness of approximately 890 feet has been reported (Hudson, 1931) on Valcour Island, but the Day Point is exposed most imperfectly and numerous faults unquestionably both repeat and omit parts of the section; other partial but good sections occur at the northwestern edge of Plattsburgh extending north from Boynton Avenue (Day Point, Crown Point, Valcour), the lake shore north of Valcour to Day Point (Day Point), the Bluff Point area south of the Cliff Haven Fault (Day Point, Crown Point). A north-south section (Day Point thru Valcour) crossing Sheldon Lane discloses an abnormally thin section of no more than 300 feet, with the lowest Day Point unexposed. Additional exposures occur along the Tracy Brook Fault 1.5 miles northeast of Chazy (Crown Point and Valcour), and the abandoned Bechard quarry west of Kings Bay (Valcour). In Vermont, extensive outcroppings occur on South Hero Island southwest of Keeler Bay and on the southeastern third of Isle La Motte (Oxley, 1951; Erwin, 1957; Oxley and Kay, 1959).

Ever since Emmons assigned the name Chazy (1841), these rocks have received more than average attention. Despite this, much remains to be learned about their fauna and stratigraphic relations. In the past, Brainerd and Seely (1890), Cushing (1905), Oxley (1951), Erwin (1957), and Oxley and Kay (1959) have prepared the major stratigraphic contributions whereas Raymond has studied many faunas (1905a, 1905b, 1906, 1908, 1910b, 1910c, 1911, 1916, 1924); Flower (1947, 1952, 1957, 1961) has described the nautiloids, G. A. Cooper (1956) the brachiopods, Swain (1957, 1962) the ostracodes, and J. R. P. Ross (1963a-e, 1964) the bryozoans. Pitcher (1964) has carefully studied the organic reefs (bioherms). F. C. Shaw (in press, as New York State Museum Memoir 17) has recently restudied the trilobites.

Cushing (1905) distinguished three divisions of the Chazy, called by him substages — Day Point, Crown Point, Valcour — but his usage was not in the modern sense of the term substage. More recently, Oxley and

Kay (1959) offered a system of terminology in which these divisions were classed as stages, — the Dayan, Crownian, and Valcourian within the Chazyan Series. The Dayan stage consisted of the Day Point Formation, which was divided into four members (Head, Scott, Wait, Fleury). The Crownian consisted of the Crown Point Formation, and the Valcourian accommodated the Valcour Formation, divided into two members (Hero, Beech). Whereas such a complete separation may be applicable to southern Isle La Motte, I have found it to be generally unworkable in New York. Admittedly, the Valcour can be subdivided into a lower reefoid, calcarenitic unit, and an upper non-reefoid, argillicalcilutitic unit northeast and southwest of Chazy, at Sheldon Lane, and on Valcour Island. But these do not fit the descriptions of the Hero and Beech of Oxley and Kay (1959).

As in the Beekmantown, lateral and vertical lithologic transition is widely apparent and some alleged faunal restrictions have proved erroneous. For example, the gastropod *Maclurites magnus* is not restricted to the Crown Point facies, nor is the trilobite *Glaphurus pustulatus* restricted to the basal Valcour. F. C. Shaw, utilizing trilobites, has independently, failed to obtain evidence of a threefold faunal division or any trilobite zonation within the Chazy Group. Similarly, Welby (1961), while writing on the central Champlain Valley in Vermont, failed to utilize Oxley and Kay's (1959) stage and member divisions. Utilizing both lithologic and paleontologic criteria, and acknowledging lateral and vertical gradations, the three units of Cushing may be retained, but with more flexibility of definition.

Accordingly, the **Day Point Formation** (80–300 feet) consists of a basal quartz-rich unit (not exposed in the New York portion of the mapped quadrangles) with fucoidal markings and lingulid brachiopod fragments, — the Ste. Thérèse Member of Clark (1952) (Head, Scott, and Wait Members of Oxley and Kay, 1959). From 6 to 18 feet of crossbedded sandstone and siltstone are superbly displayed at the southern tip of Isle La Motte, resting with sharp lithologic change on the Providence Island Dolostone. Erwin (1957, p. 13) reported an easterly dip of 21° for the crossbeds, indicating a western source. The upper 10 feet yield the bryozoan *Phylloporina incepta*, the ostracode *Eurychilina latimarginata*, and the trilobites *Basilicus marginalis* and *Isotelus harrisi*. *Lingula brainerdi* is abundant in the lower 10 feet. On South Hero Island, a prominent knob $\frac{3}{4}$ mile east of Beech Bay reveals 53.5 feet of Ste. Thérèse; the lower 25 feet is siltstone (Head Member of Oxley and Kay, 1959), the next 19 feet is quartzose calcarenite (Scott Member of Oxley and Kay, 1959) and the next 9.5 feet are a coarse quartz sandstone (Wait Member of Oxley and Kay, 1959) with *Lingula brainerdi*. The succeeding 61 feet of crossbedded calcarenite (Fleury Member of Oxley and Kay, 1959) is the *Mimella* (brachiopod) zone of the upper Day Point.

The upper member of the Day Point (Fleury Member of Oxley and Kay, 1959) is easily recognized by the preponderance of light- (N 7) to medium-gray (N 5) calcarenites, both crossbedded (figure 18) and regular bedded. Dome-like reefs of bryozoans, corals, sponges, and algae are frequent within 50 feet of the Crown Point contact; these organic mounds seldom exceed 20 feet in diameter. Typical Day Point bioherms may be studied atop the abandoned quarry north of Boynton Avenue at the north edge of Plattsburgh (figure 19). Brachiopods, showing evidence of mechanical size sorting, are particularly abundant in the reef-flanking calcarenites. Near the middle of the Day Point is a moderate red (5 R 4/6) zone, about 8 to 20 feet thick, formerly quarried as "Lepanto" marble. Pelmatozoan debris accounts for the bulk of the rock, and *Bolboporites americanus* is common. This red calcarenite was formerly quarried near Bellarmine College, 3 miles south of Chazy, and is well exposed at the intersection of U.S. 9 and Slosson Road. Between 60 and 200 feet of gray crossbedded calcarenite intervene before the fine textured Crown Point Limestone is encountered.

In the pastures south of Sheldon Lane, about 45 to 55 feet of highly crossbedded light gray calcarenite with abundant *Maclurites magnus* and small reeflets (1 to 3 feet in diameter) probably equates to much of the Crown Point at the type section southwest of Chazy Village. No more than 50 feet of Crown Point lithology occurs in this section. Basal Valcour reefs and calcarenite enter the section some 200 feet south of the road.

The overlying **Crown Point Limestone** (50 to 250 feet) is primarily an argillaceous medium-fine textured, medium- (N 5) to dark-gray (N 3) limestone (argillicalcisiltite to argillicalcilutite), molluscan-trilobite facies replete with the large planispiral gastropod, *Maclurites magnus* (figure 20 and cover illustration). Shale partings are rare. Relatively small reefs or reeflets, principally of stromatoporoids, are locally present, but flanking strata of crossbedded calcarenites are virtually absent; this absence of coarse limestones serves to separate the Crown Point lithofacies from the underlying Day Point calcarenites and overlying Valcour basal calcarenites and reefs. Regular bedding ranges from 1 to 16 inches thick.

Galloway (1957, p. 401) reported, "The oldest authentic stromatoporoid known, *Cystostroma vermontense*,

FIGURE 18. *Crossbedded coarse grained limestones (calcarenites) of Day Point Formation, in pasture one mile south of Sheldon Lane*

FIGURE 19. *Reef topography in uppermost Day Point Limestone, atop abandoned quarry north of Boynton Avenue, Plattsburgh*

FIGURE 20. *View illustrating the abundance of the gastropod Maclurites magnus Le Sueur in the Crown Point Limestone, Northway cut 2.5 miles southwest of Chazy*

occurs in a reef of large accumulation of stromatoporoids and calcareous algae, in the middle Chazyan, 1 mile southeast of Isle La Motte village, Vermont, collected by Dr. Marshall Kay, 1954." *Pseudostylodictyon kayi* Gallawoy and St. Jean also occurs here. I have, however, observed stromatoporoids in the lower Chazy Day Point Formation. Instructive exposures of the Crown Point Limestone may be examined in the type section of the Chazy, southwest of Chazy Village, south of Sheldon Lane, Plattsburgh Rock Products quarry, southern Isle La Motte and Valcour Island (figure 21).

The **Valcour Limestone**, the youngest unit of the tripartite Chazy, is the most argillaceous. Although the lower 40 to 55 feet exhibit reefs constructed of bryozoans, sponges, algae, and stromatoporoids associated with flanking and inter-reef medium light gray (N 6) calcarenites, the upper 80 to 125 feet are dark gray (N 3) argillicalcilutites with shale partings. The topmost 10 to 40 feet of the Valcour are argillaceous dolostones which are indistinguishable from Pamelia lithology (Johnsen and Toung, 1960). In fact, in Quebec, this dolostone interval is referred to as Pamelia. Brachiopods, among which *Rostricellula* is diagnostic, and bryozoans are especially common in the Valcour calcilutites and calcarenites. Splendid Valcour reeflets (bioherms) and calcarenites of the lower Valcour occur in the pasture south of — and in the water-filled quarry north of —

FIGURE 21. *Crown Point Limestone at southern end of Valcour Island; cliff marks trace of an east-west trending normal fault of the latitudinal fault system*

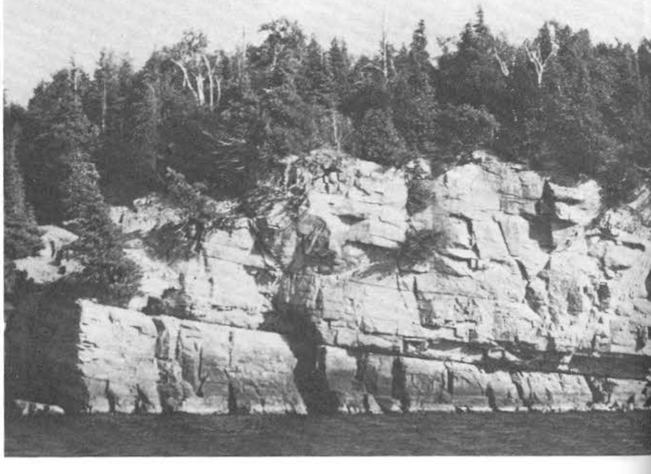
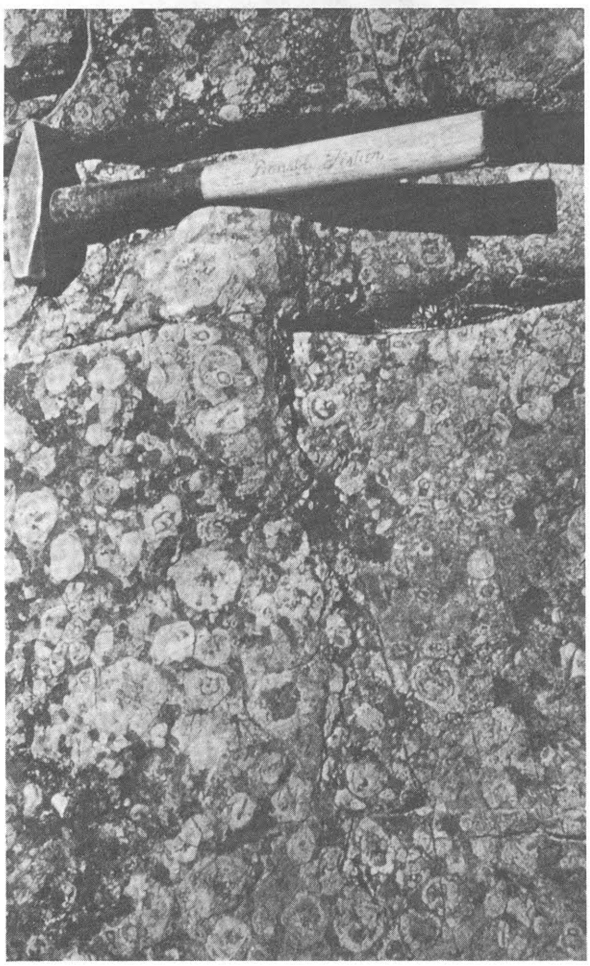


FIGURE 22. *Reef rock (light areas) and flanking calcarenites (darker areas) in basal Valcour Limestone at abandoned quarry on Bechard Farm, west of Kings Bay*

FIGURE 23. *Sponges and algal nodules in reeflet in basal Valcour Limestone at type locality, 1.3 miles southwest of Chazy*



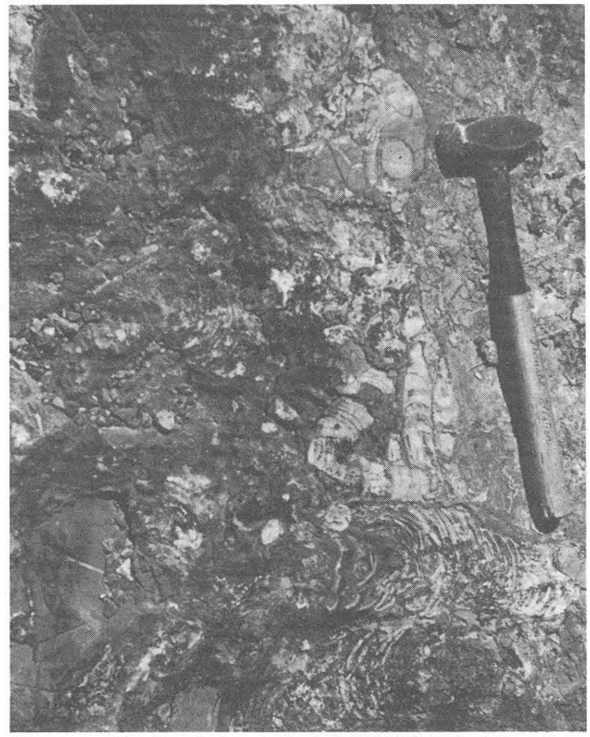


FIGURE 24. *Straight-shelled nautiloid debris abutting reef rock at Bechard quarry reef complex*

Sheldon Lane, in the abandoned quarry on the Bechard Farm 0.5 mile west of Kings Bay (figure 22), and at Tiger Point on Valcour Island where a rare conularid was found. These organic mounds are constructed primarily of sponges and algae (figure 23), bryozoans, and stromatoporoids with exquisite straight nautiloids nested in reef re-entrants (figure 24). The trilobite *Glaphurus pustulatus*, formerly considered a guide to the basal Valcour, but which I found in the upper Crown Point, is confined in the Valcour, probably by ecologic control, to the basal calcarenite.

There is an unrivaled exposure of the summit of the Chazy Group in the abandoned quarry southeast of Chazy Village (figure 25) where buff-weathering argilli-dolostones (Pamelia, in part), carrying *Rostricellula*, grade upward through about 10 feet into white weathering " dove " gray (Lowville) calcilutite; no physical break is obvious. A similar situation is present along the east side of the road 2 miles southwest of Rouses Point, and along the northern tip of Valcour Island, though here there is a short concealed interval below the Lowville.

FIGURE 25. *Valcour-Pamelia-Lowville-Isle La Motte transition in south face of abandoned International Lime and Stone quarry, one mile southeast of Chazy*

BLACK RIVER GROUP

In its type area, the Black River Valley west of the Adirondacks, the Black River Group (Pamelia, Lowville, Chaumont) is well developed, exhibiting several lithofacies in complete and frequent sections. In the Champlain Valley, however, the Black River Group is infrequently exposed and, accordingly, less can be said concerning its facies relations. In the southern Champlain Valley at Crown Point, where the Black River Group embraces 70 to 75 feet, the Lowville, Chaumont, Amsterdam, and Isle La Motte Limestones are present (Raymond, 1902; Kay, 1937). Northward, the Chaumont and Amsterdam disappear (probably merging into the Isle La Motte) — the Lowville and Isle La Motte persist and the Pamelia, though thin, is introduced at the base. In Clinton County, the Pamelia attains a thickness of 40 feet but may be missing; the Lowville averages 12 feet, and the Isle La Motte 25 feet.

The **Pamelia Dolostone** consists of medium- to thick-bedded yellowish-gray (5 Y 8/1) weathering, conchoidal to sub-conchoidal fracturing, greenish gray (5 G 6/1) argillaceous dolostones with quartz sand. Some greenish-gray dolomitic shale with fucoidal markings also occurs, and some of the lower dolostones have numerous cross sections of what appear to be the brachiopod *Rostricellula.* The argillaceous dolostones referred to the Pamelia were formerly included within the upper Valcour Formation of the Chazy Group.

The **Lowville Limestone** is very light gray (N 8)- to light-gray (N 7) weathering, massive, light olive gray (5 Y 6/1) (" dove ") or light gray (N 7) with a pronounced conchoidal fracture. The rock customarily yields less than 3 percent insoluble residue. No fossils, except trails and burrows, have been noted. With little doubt the Lowville was an intertidal deposit. Only three exposures are known to me in Clinton County (Plate 1); at the northern tip of Valcour Island (at low water only), in the abandoned International Lime and Stone Company quarry southeast of Chazy (figure 25), and an abandoned shallow quarry 1.5 miles southwest of Rouses Point. The Lowville and Isle La Motte are laterally and vertically transitional; this "mixing" is splendidly displayed in the old Chazy Marble Company quarry 500 feet east of U.S. 9, south of Chazy. Because of the interlayering of Lowville and Isle La Motte lithologies, and the resultant subjectiveness of placing formational contacts, the respective thicknesses vary appreciably.

The **Isle La Motte Limestone** is a medium light gray (N 6) weathering, massive, medium dark gray (N 4) to dark gray (N 3) calcilutite with a conchoidal to subconchoidal fracture; bedding plane separations are absent or, at best, indistinct. Locally, as at the old Chazy Marble Company quarry, the Isle La Motte's summit displays small patches of fossiliferous calcarenite to subcoquinite petrologically and faunally like the overlying Larrabee Limestone, but in a calcilutite matrix. These patches are largely accumulations of fossil debris, perhaps mechanically concentrated along mud bars slightly beneath the lower tidal limit. By contrast, the fossils in the calcilutite are different genera, nonfragmental, rare, and exceedingly difficult to extract because of the compactness of the rock. The following fossils have been observed: the stromatoporoid *Stromatocerium*, the horn coral *Streptelasma*, the gastropod *Maclurites logani*, and the colonial tabulate coral *Columnaria*, the trilobites *Bumastus*, *Thaleops*, and *Bathyurus spiniger*, the brachiopods *Strophomena* and *Zygospira*, the pelecypods *Ambonychia* and *Cyrtodonta*, and undetermined orthoconic cephalopods and leperditicopid ostracodes. The gray calcarenite patches, because of the badly broken fossils, contain few recognizable forms. The brachiopods *Sowerbyella*, *Paucicrura*, and *Parastrophina*, the gastropods *Helicotoma* and *Raphistomina*, trilobite fragments (*Ceraurus*), and crinoid columnals have been identified. The most suitable exposures for study (see Plate 1) are at the old Chazy Marble Company quarry southeast of Chazy, along the Little Chazy River at Chazy, and field ledges 2 miles northeast of Chazy.

TRENTON GROUP

In Clinton County, the Trenton Group is represented by the Glens Falls Limestone below and the Cumberland Head Argillite above. Their mutual contact is concealed. Exposures of the Glens Falls are customarily small whereas Cumberland Head exposures are larger, but, because of the infrequency of the former and the deformed character of the latter, thicknesses are difficult to ascertain. So as not to leave the Stony Point and Iberville Shales without a group assignment, and for consistency, they are here treated as units of the Trenton Group.

The **Glens Falls Limestone** embraces a lower coarse-grained, medium- to thick-bedded, medium light gray (N 6) limestone termed the **Larrabee** (Kay, 1937); this is, and has priority over, the Mile End Limestone of Clark (1952). Brachiopods and much pelmatozoan debris are particularly abundant. Rafinesquinid and dalmanellid brachiopods outnumber the other types. *Sowerbyella*, *Dinorthis*, *Zygospira*, and *Lingula* have also been found. The pelecypods *Ctenodonta*, *Cyrtodonta*, and *Whitella*, the trilobite *Ceraurus*, and the ostracode *Eurychilina* are also common. The best exposures of the Larrabee (see Plate 1) are on the north wall of the abandoned International Lime and Stone Company quarry southeast of Chazy (20 feet) and along the Little Chazy River northeast of Chazy (25 to 30 feet).

The upper Glens Falls is a medium- to fine-grained, thin-bedded, very pale orange (10 YR 8/2) weathering, medium dark-gray (N 4) to dark gray (N 3) argillaceous

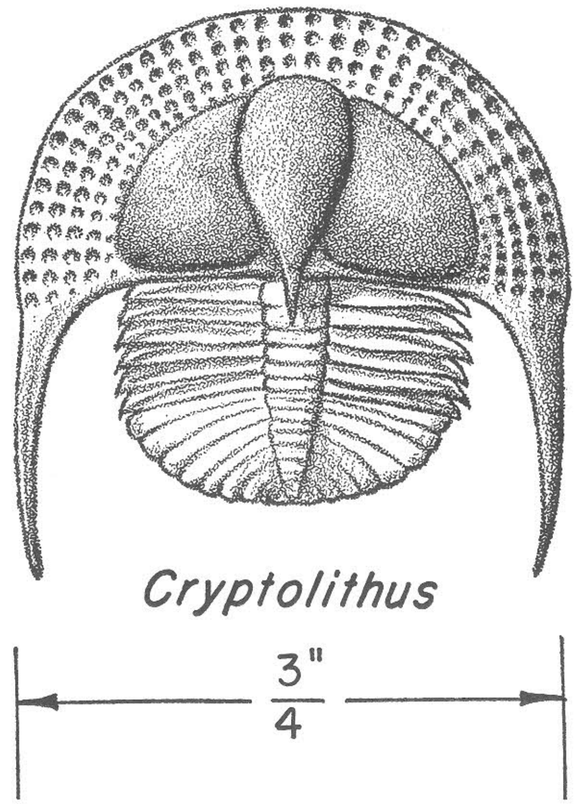
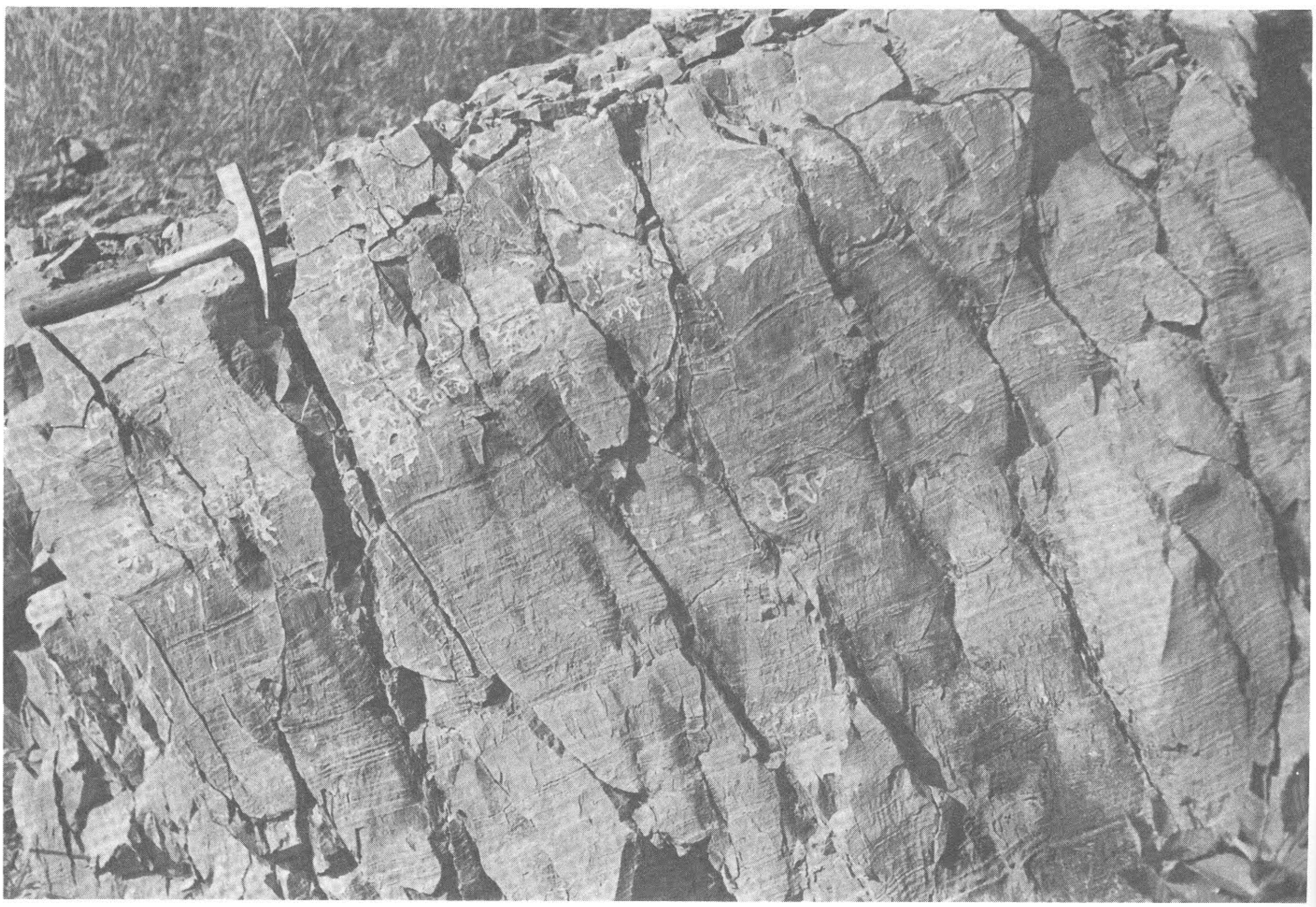


FIGURE 26. *The trilobite Cryptolithus tesselatus (Green), an indicator of Barneveld age and common in the Montreal Limestone Member of the Glens Falls Limestone and in the Cumberland Head Argillite*

limestone with grayish black (N 2) shale partings, and is transitional with the Larrabee below and presumably with the Cumberland Head above. Kay (1937) named this the Shoreham Limestone, defining it not as a rock unit, but as a biostratigraphic unit — the zone of *Cryptolithus tesselatus*, a trilobite. At least in the northern Champlain Valley, I prefer to use Clark's (1952) name **Montreal** for this rock unit. The Montreal's fauna is more varied and abundant than the underlying Larrabee. Trilobites are dominant; *Cryptolithus tesselatus* (figure 26), *Isotelus gigas, Flexicalymene senaria, Ceraurus,* and *Proetus* are present. Dalmanellids (*Paucicrura?*), *Lingula, Pholidops trentonensis, Rafinesquina alternata, Sowerbyella,* and *Strophomena* complete the brachiopod assemblage. Among mollusks, the pelecypod *Ctenodonta* and orthoconic nautiloids are most prevalent; gastropods are strangely missing. Many genera of bryozoans occur, among which *Prasopora* is most prevalent. Unusual in limestones, the graptolites *Dicranograptus* and *Orthograptus truncatus* aid in placing the Montreal Limestone chronologically in the Barneveld Stage of the Mohawkian Series (figure 28).

About 100 feet of Montreal Limestone are displayed in a north-south trending anticline on Crab Island (so named for the notable abundance of the trilobite *Isotelus*, popularly known as " fossil crabs "). Other favorable exposures (Plate 1) are: in the bed of the Saranac River near the Catherine Street bridge within Plattsburgh, where thin lamprophyre dikes transect the upturned strata; along the lake shore at Cliff Haven two miles south of Plattsburgh, where it appears on the northern or downdropped side of the Cliff Haven Fault; along N.Y. 191 west of Chazy landing, where Evitt (1953, p. 34) described silicified trilobites; and along the Little Chazy River northeast of Chazy (graptolite-bearing). The Montreal's precise thickness, not obtainable from measured sections, is likely 150-200 feet in Clinton County.

FIGURE 27. *Bedding (dipping to left) and cleavage (dipping steeper to the right) in Cumberland Head Argillite, along U.S. 9, 4 miles north of Plattsburgh*



CORRELATION CHART

CAMBRIAN-ORDOVICIAN OF THE ADIRONDACK BORDER REGION

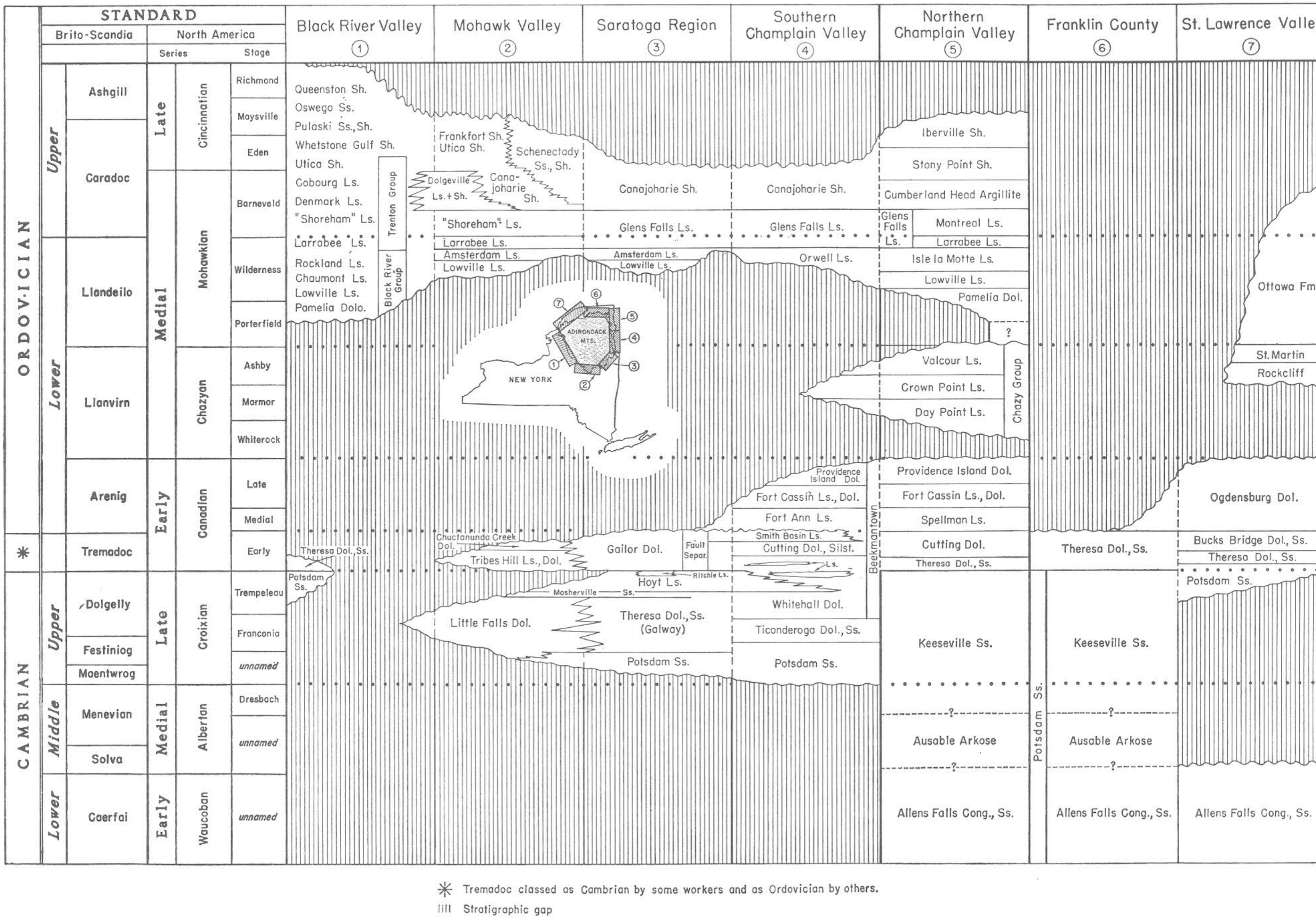


FIGURE 28

The **Cumberland Head Argillite**, named by Cushing (1895, p. 555, 560), is a yellowish-gray (5 Y 7/2) weathering, calcareous, slightly quartz-silt bearing, medium bluish-gray (5 B 5/1) argillite alternating with very pale orange (10 YR 8/2) weathering medium gray (N 5) argillicalcilutites, producing a banding similar to varves. The Cumberland Head is, perhaps, the most regionally restricted rock unit discussed. Always found east of the Isle La Motte Thrust (except on Isle La Motte) it is unknown in the Willsboro quadrangle to the south and the Vermont mainland to the east (it occurs on Isle La Motte and South Hero Island); to the north it is, lithologically, the Tetreauville and Terrebonne Formations of Clark (1952). Cleavage is well developed and is as prominent as, or dominant over, bedding (figure 27). Because the upper and lower contacts of the Cumberland Head Argillite have not been observed, its accurate thickness cannot be given; its minimum thickness is probably about 200 feet.

Fossils are uncommon, fragmentary, and generally smaller than in the other Paleozoic strata. The fauna resembles that of the Montreal Limestone. Articulate (*Zygospira, Paucicura?*) and inarticulate (*Schizocrania, Trematis, Lingula, Leptobolus*) brachiopods, the pelecypod *Ctenodonta*, orthoconic nautiloids, *Conularia trentonensis*, and *Dicranograptus* are uncommon. Trilobite debris is most abundant; *Flexicalymene senaria, Cryptolithus tesselatus, Isotelus gigas, Ceraurus*, and *Triarthrus becki* are present. The co-existence of *Cryptolithus tesselatus* and *Triarthrus becki* is of especial interest; a similar co-occurrence occurs in the middle Canajoharie Shale near Tribes Hill in the Mohawk Valley. Formerly, these two trilobite genera were thought to occupy separate faunal zones. A Barneveld age is indicated.

Drumlin-like topography, produced by a combination of slaty cleavage and folding is characteristic for the area underlain by the Cumberland Head Argillite. This unit is admirably shown on the Cumberland Head peninsula shores (type locality) and the hummocky area north of Treadwell Bay; an isolated exposure occurs at the southern tip of Point au Fer and fresher outcroppings are shown along Interstate 87, north of Plattsburgh. In Vermont, outcroppings occur on Isle La Motte and South Hero Island (see Plate 1).

The **Stony Point** and **Iberville** are dark gray (N 3) to grayish black (N 2) shales well exhibited on the Vermont Islands, where they undoubtedly exceed 1,000 feet in thickness (Hawley, 1957). Lithologically, they are identical except that the Stony Point is calcareous and the Iberville is not. The Stony Point has been seen at only three places on the New York side (Plate 1) — at Stony Point, 1.5 miles south of Rouses Point, at a now covered roadside cut along U.S. 2, 0.3 mile east of N.Y. 9B at Rouses Point, and on Schuyler Island; the Iberville does not occur in New York.

At Stony Point, the graptolites *Climacograptus spiniferus, Glossograptus quadrimucronatus*, and *Lasiograptus eucharis* have been found as well as the brachiopod *Leptobolus insignis*, the trilobite *Triarthrus becki*, and an undetermined orthoconic cephalopod. The fauna, identical to that of the upper Canajoharie Shale of the Mohawk Valley and the Lachine Formation of the Montreal area, signifies a Barneveld age.

In Vermont, for additional details on the limestones see Erwin (1957), and for the shales and younger Hathaway Formation see Hawley (1957).

LACOLLE MÉLANGE

Named the Lacolle Conglomerate and described as a sedimentary formation by Clark and McGerrigle (1936), the unit is a polymict array of Potsdam, Theresa, Beekmantown, Chazy, Black River, and Trenton pebble, cobble, and boulder size angular blocks in a pulverized rock powder matrix. Earlier, this rock at some sites had been called fault breccia. Stone (1957) rejected a sedimentary origin on several well chosen points and proposed a tectonic origin for the mound-like masses, interpreting them as klippen remaining from the erosional retreat of a complex pelitic overthrust sheet. My mapping supports Stone's views.

As the Lacolle fragments (phenoclasts) reveal insufficient attrition attributable to erosional transport and all are angular, Clark and McGerrigle's (1936) usage of Lacolle Conglomerate is a misnomer; Lacolle Breccia is factually descriptive, but to some may imply a sedimentary genesis. Mélange of Hsu (1966), denoting unequivocal tectonic origin, is preferred because field evidence does not support a sedimentary origin. Corroborative tectonic evidence exists in that some mounds include fragments from formations with up to 2,500 feet of stratigraphic separation. This implies a derivation from steeply inclined strata or from a moderate transportation distance in gently tilted strata; the overridden strata (autochthon) seldom have dips exceeding 8° and we have already remarked on the lack of transportive evidence. Lack of sorting, a rock powder matrix (devoid of fossils), and disproportionately great range in size of fragments and blocks eliminates an erosional transportive device, making a sedimentary origin impossible.

Hsu (1966) has recently proposed the mélange concept in which mélanges are defined as mappable bodies of deformed rocks characterized by the inclusion of tectonic blocks in a pervasively sheared, commonly pelitic matrix. The Lacolle of this area, the " Bald Mountain Limestone " of the Schuylerville quadrangle, and a " blocks in shale " unit rimming the west margin of the Taconic klippe all seem to fit this concept and, accordingly, are classed as mélanges.

Outcroppings of the Lacolle Mélange exist as small, elongated mounds in an otherwise flat terrain. When grouped, they display a marked north-south linear trend as, for example, 1 mile west of Rouses Point. The breccia consists of angular to sub-angular fragments of a few millimeters up to slab-like blocks 50 feet long; most are less than 2 feet long. The largest blocks were observed on Cloak Island where all three Chazy formations are represented. Lack of sorting is everywhere apparent. The matrix is paste-like fine, unfossiliferous gray powder. Among the blocks, the youngest rocks found are slabs of Cumberland Head Argillite; no black shale was discovered, although Clark and McGerrigle (1936) report some from Quebec. Though disconnected from the Lacolle residuum, the Stony Point Shale and Cumberland Head Argillite comprise the closest overthrust units. Precambrian fragments have not been identified in the mélange, denoting that the thrusting was confined to the Paleozoic strata.

Parallelism to fault traces is striking; there is a restricted relationship to the Tracy Brook (normal) Fault and the Isle La Motte (thrust) Fault. It seems plausible that the debris picked up from the sole of the allochthon was concentrated against low scarps produced by earlier block faulting. The composition of each mound reflects the stratigraphic terrain over which the allochthon moved; thus, some exposures are essentially monolithologic (comprising Providence Island Dolostone) as the breccias in southeastern Beekmantown Township and those west of Rouses Point (Beekmantown Dolostone) near the Golf Course. Where the allochthon moved over many formations in a relatively short distance, a heterogeneous constituency resulted, as the exposure along N.Y. 9B east of Cooperville, where there is a greater percentage of Black River and Trenton pieces (figure 29).

FIGURE 29. *Lacolle Mélange, along south side of N.Y. 9A east of Cooperville. Note angularity and disparity in size of varied rock fragments*

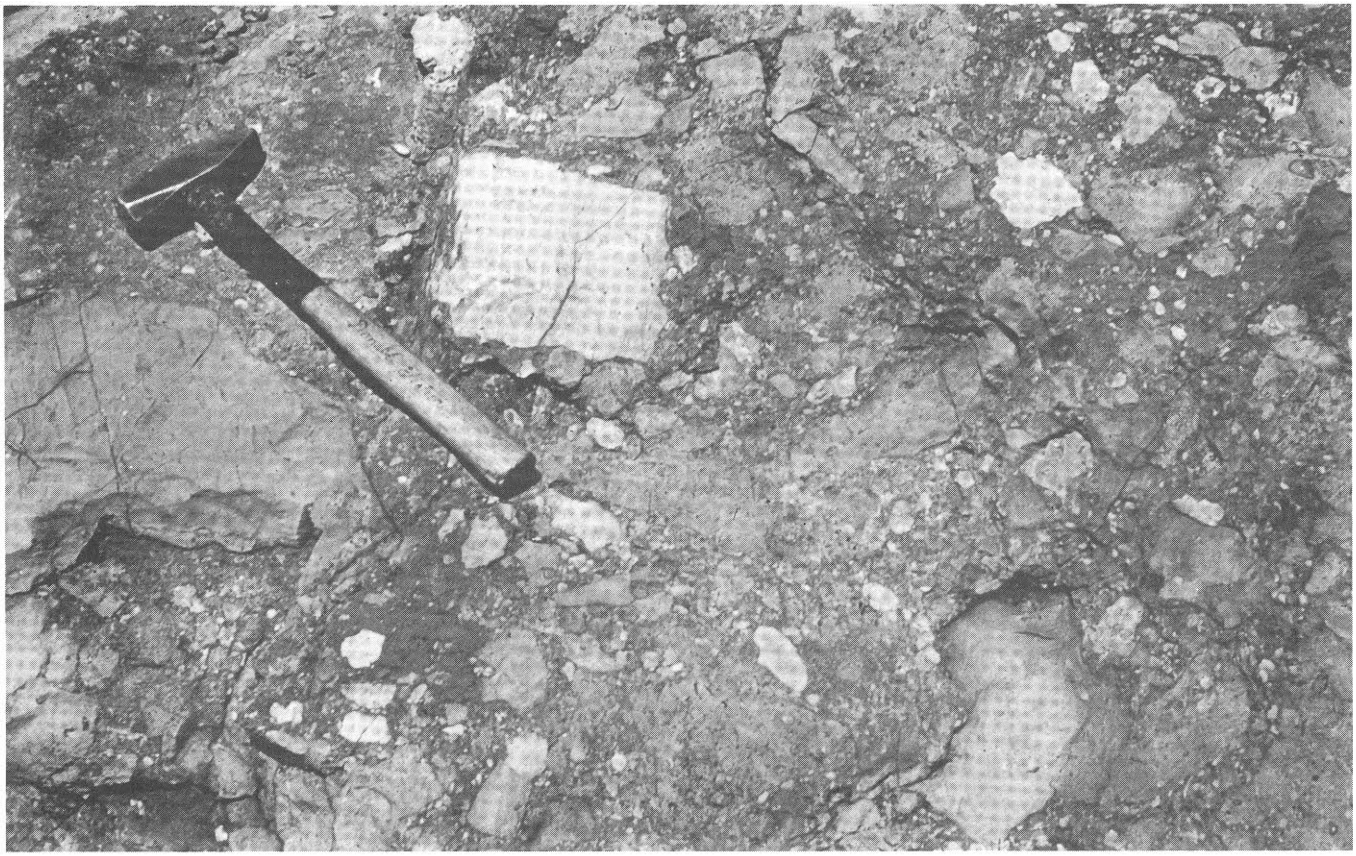


FIGURE 30. *Fault breccia along Tracy Brook Fault, on west side of U.S. 9, north of railroad underpass in village of Chazy. The rock is entirely crushed Potsdam (Keeseville) Sandstone*

Conceivably, the "Lacolle" may represent a talus deposit accumulated at the base of a high sea cliff coincident with a fault line. But known talus deposits contain rounded cobbles and boulders and no such rounding is evident in the "Lacolle Breccia." Whereas the shape of the "Lacolle" bodies are not talus-like, subsequent modification by glacial erosion could explain the linear mound configuration. Derivation from a 2,500 foot scarp of Potsdam through Cumberland Head Formations seems highly improbable unless concurrent faulting and sedimentation, akin to the development of the Triassic basins, were in effect.

Resistant residues of an eroded pelitic allochthon best satisfies the derivation and distribution of the Lacolle Mélange, although admittedly some breccia patches from pre-existing normal fault zones, such as from the Tracy Brook Fault at Chazy (figure 30) may have become incorporated into the overriding thrust mass.

Late Jurassic-Early Cretaceous Igneous Rocks

NO ATTEMPT HAS BEEN MADE TO SAMPLE and systematically describe the numerous mafic dikes that penetrate the rocks of the region. The reader is referred to Kemp and Marsters (1893), and Hudson and Cushing (1931) for a more complete discussion of them.

In the mapped area, the observed dikes range in width from a few inches up to about 12 feet (one of the diabases near Trembleau Point). Owing to inadequate exposure, they usually cannot be traced overland very far, but some, as the Cliff Haven and Tiger Point dikes, have been projected so as to extend more than one mile.

Petrographically, the dikes fall into two groups — the **diabases** (discussed under Precambrian rocks) and the **lamprophyres**. These lamprophyres are represented by varieties termed *fourchite, monchiquite,* and *spessartite*; the last-named are the augite-camptonites of Hudson and Cushing (1931). Both diabases and lamprophyres are basic and dark colored. But south of the mapped area, in the Willsboro quadrangle, both in New York and Vermont, another light colored, acidic high-quartz type, called bostonite (trachyte, rhyolite) is extensive. Whereas the diabases and lamprophyres are thin and nearly perpendicular to bedding (figure 31), bostonites are usually thicker, both crosscutting and paralleling bedding. A few, like the reddish porphyritic trachyte at Cannon's Point, 6 miles south-southeast of Willsboro, are laccolithic or lens-like (see reference under Geochronology).

Lamprophyres are dark dike rocks in which dark minerals occur both as phenocrysts (crystals visible to the naked eye) and in the groundmass, whereas light-colored minerals occur only in the groundmass. The essential constituents of lamprophyres are biotite, horn-

FIGURE 31. *Lamprophyre dike, 0.5 mile north of Valcour, cutting Day Point Limestone and trending toward another dike (shown by arrow) near southern tip of Valcour Island*

blende, or pyroxene, or combinations of the three, and feldspar or feldspathoids. All carry much iron, lime, magnesia, and alkalies, and almost all are comparatively rich in MgO compared with diabase. *Monchiquite* contains phenocrysts of titanaugite with some biotite and barkevikite, phenocrysts of olivine and titanomagnetite, and a glassy matrix of labradorite and nepheline, rich in pyroxene, barkevikite, iron ore, apatite, calcite, aragonite, and zeolites. *Fourchite* is a monchiquite devoid of olivine and rich in porphyritic titanaugite. *Spessartite* (the augite-camptonites of Kemp and Marsters; of Hudson and Cushing) is an augite- or hornblende-rich lamprophyre with plagioclase as its principal feldspar, and 25 to 50 percent of the rock consists of slender prismatic phenocrysts and microlithic needles of green and brown hornblende. Olivine and biotite are common, though minor, constituents along with iron ore and apatite. The characteristic plagioclase is andesine, sometimes rimmed with more sodic feldspar. A little orthoclase and quartz may occur interstitially. Spessartites are extremely similar to diabases and, in fact, grade into them. For example, the Spoon Island dike is a diabase, but its extension on Valcour Island is a spessartite. Hudson and Cushing (1931, p. 97) believed that the dikes widened downward at the rate of 8 to 10 inches per thousand feet. Field evidence would seem to substantiate this, for the wider dikes have been observed only in the older units.

It has long been recognized that the lamprophyres and bostonites of the Champlain Valley are post-Ordovician black shale deposition and pre-Pleistocene glacial deposits, but there has been little unanimity as to the precise time of intrusion within these broad limits. Some workers (Kemp and Marsters, 1893; Cady, 1945, p. 580–581) have thought that they were contemporaneous with the Taconian Orogeny during the Late Ordovician. Still others have assigned a Devonian (Hudson and Cushing, 1931) or Carboniferous (Cushing, 1905, p. 287, 397) age to them. Welby (1961, p. 190) referred to them as post-Devonian. Ascertaining whether faulting predated or postdated the igneous bodies is meaningless, since faulting unquestionably occurred at different periods along the same lines of weakness. Field evidence bears this out, for there are instances where faults cut dikes, and some where dikes cut faults.

The advent of radiometric dating in recent years has provided data which enables us to restrict the dike invasion within the Late Ordovician-Pleistocene interval. The nearest unmetamorphosed basic to ultrabasic intrusives are the Monteregian Hills, the westernmost of which lies near Montreal. These have been radiometrically dated at 110 m.y. ago, or at the end of the Early Cretaceous Period (figure 1). If we assume that the lamprophyres are related to this igneous event and are upward extensions of larger, but buried, basic bodies, then we may say that the Champlain Valley lamprophyres were intruded at the close of Early Cretaceous time. Diment (1963) has discovered local gravity highs paralleling the Monteregian Hills. These anomalies may be the expression of subsurface intrusives of the Monteregian type; one of these is 4 miles north of Plattsburgh at the northern brim of an area of abundant known dikes.

Supportive age evidence may be found at Orchard Point, Vermont (Nash's Point of Kemp and Marsters), where a bostonite dike crosscuts a monchiquitic lamprophyre, denoting that the lamprophyres antedated the bostonite. However, on nearby Barber Hill, a spessartitic lamprophyre crosscuts a bostonite. This seemingly contradictory evidence may be resolved by assigning both the dark-colored lamprophyres and the light-colored bostonites to the same igneous event. Reenforcing evidence may be found in the laccolithic trachyte porphyry (bostonite) at Cannon's Point in the Willsboro quadrangle. This has been radiometrically dated (see chapter on Geochronology) as probably less than 140 m.y. ago, which would denote a post-Jurassic age.

If the Monteregian Hills — lamprophyre dike association is correct, the time of emplacement of the Champlain Valley lamprophyres and bostonites is thus narrowed to a Jurassic-Cretaceous span. It follows that since some of the igneous bodies are broken by faults, at least some movement along existing fault planes occurred later than the Mesozoic Era.

Pleistocene Deposits

SINCE 1963, CHARLES S. DENNY of the U.S. Geological Survey has been mapping the surficial deposits of the Mooers, Dannemora, Rouses Point, and Plattsburgh quadrangles.* A detailed discussion of the Pleistocene events and glacial deposits will be presented in forthcoming papers by him. Furthermore, a State map of Vermont (with text) (scale: 1:250,000) showing glacial deposits is in press. However, for the benefit of those who wish to know something about Champlain Valley Pleistocene events, a résumé of these relatively late geologic happenings will complete this chronicle.

Past workers (Peet, 1904; Woodworth, 1905; Fairchild, 1917; and Chapman, 1937) have studied the features left by the Pleistocene ice and the sequence of events based on the correlation of beaches of former bodies of water which occupied the Champlain Lowland.

The general sequence of " Ice Age " (Pleistocene) events in North America has been known for some time. However, the details of Champlain Valley glacial history are only now emerging.

Pleistocene History began with a cooling of the climate of the Northern Hemisphere and the piling up of ice to form glaciers. These centers of ice accumulation grew to form an ice blanket that covered the northern half of the North American continent to depths of hundreds to thousands of feet of ice. All of what is now New York State was ice-blanketed except a small portion in southwestern New York State in Cattaraugus County. It is known that there were four major separate advances of ice blankets, separated by warmer inter-glacial periods during which the ice front withdrew. In New York and Vermont, only the last, or Wisconsin glaciation is well known, for the effects of the earlier glaciations were masked by the last one.

Wisconsin glaciation, at its southernmost extent, reached Long Island; the Island itself is partially composed of terminal moraines (dumping ground features) where the ice front remained stationary for a longer period. Similar end moraines mark interruptions in the ice front withdrawal. Later, and farther north, the large amount of meltwater created extensive but temporary bodies of water into which sediments were rapidly deposited.

The water-laid sediments are more or less sorted, whereas the ice-laid material is unsorted or poorly sorted. During ice wastage, the pre-Pleistocene valleys were widened, deepened, blocked, or filled. In many cases, new channels were carved where previous major streams did not exist. Linear lakes occupied the Hudson, Mohawk, and Champlain Valleys. As the continental ice front receded toward Canada and uncovered the northward draining " new " Champlain Valley, an open body of water grew northward, ultimately flooding most of the lowland and continuously bathing the nose of the

* Since this paper was submitted, the " Surficial Geologic Map of the Dannemora quadrangle and part of the Plattsburgh quadrangle " by Denny (1967) has appeared.

FIGURE 32. *Glacial striations, trending north-south, on Larrabee Member of the Glens Falls Limestone; atop north wall of abandoned International Lime and Stone Company quarry, one mile southeast of Chazy*

diminishing fingerlike ice lobe with meltwater. Highlands flanking the Valley were uncovered first and were probably completely devoid of ice when the last fingerlike dirty ice withdrew north through the Valley. This initial temporary body of water, named Lake Vermont (figure 33) (Woodworth, 1905), at first was dammed by a rock barrier at Coveville, near Schuylerville, Washington County, and was termed the Coveville Stage. Simultaneously, an earlier formed Lake Albany extended south to Rhinebeck in the Hudson Valley. LaFleur (1965, p. 17) has recently suggested that Lake Vermont was controlled by Lake Albany levels rather than by spillways at Coveville or Schuylerville. During the Coveville Stage, lake beaches were constructed in the Plattsburgh quadrangle between 660 and 740 feet while the Rouses Point quadrangle was probably still buried under sediment and boulder-laden ice. When the ice front was in southern Quebec, the levels of Lake Vermont dropped to elevations of 570 to 660 feet in the Plattsburgh quadrangle and 660 to 740 feet toward the International Boundary; this lower level has been termed the Fort Ann Stage.

When the ice uncovered the St. Lawrence Valley, marine waters spilled over the Richelieu sill and invaded the Champlain Valley, owing to a combination of elevated oceanic levels and a depressed St. Lawrence-Champlain Lowland. However, marine water never reached as far as the Hudson Valley (figure 34). Woodworth (1905, p. 220) termed this marine body of water the Hochelaga Sea (more frequently referred to as the Champlain Sea), named from the ancient Indian site now occupied by Montreal. Marine shells, a fossil seal, and a fossil whale suggest its oceanic designation. By faunal analysis, Goldring (1920), who used the more common name Champlain Sea, has shown that the salinity decreased southward. Better sorting of Lake Vermont (lacustrine) sands and silts suggests that lake levels were more static than those of the, perhaps, oscillating Champlain Sea, whose deposits are less well sorted (figure 35). On the basis of different beach levels, six stages (Woodworth, 1905) of this sea have been recognized, of which the youngest is below the present level of Lake Champlain in the area mapped (data from Chapman, 1937).

Because the tremendous weight of ice depressed the crust, equilibrium has been maintained since ice disappearance by a progressively increased northward rising of the continent. Thus, correlative beaches and features in the north stand at higher present day levels than synchronous ones in the south (they were initially at the same elevations).

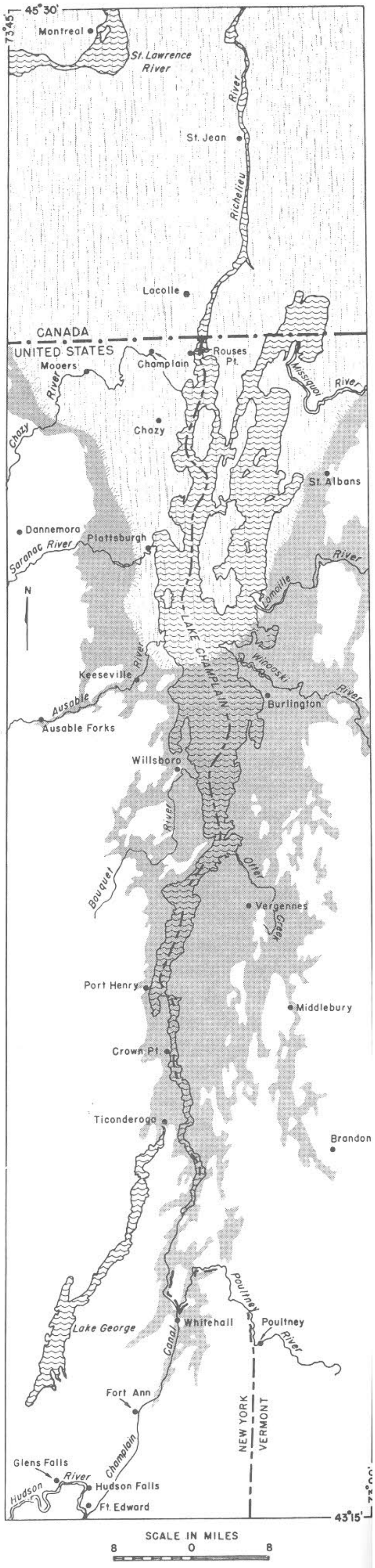


FIGURE 33. *Map showing extent of Lake Vermont* (data from Chapman, 1937)

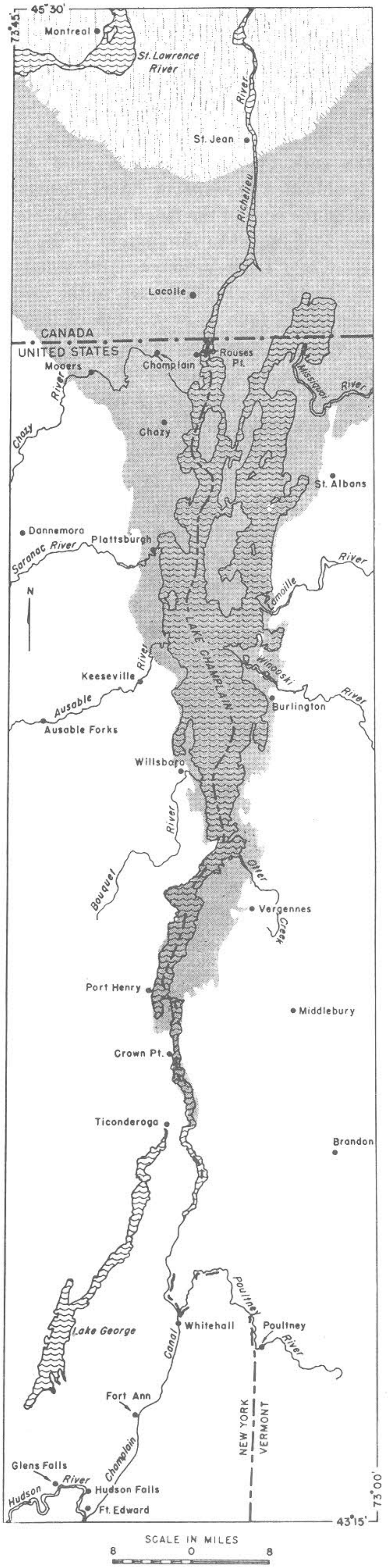


FIGURE 34. *Map showing extent of Champlain Sea* (data from Chapman, 1937)

Beach Levels of major water bodies in Champlain Valley (in feet)	Platts-burgh	Rouses Point
	FEET	FEET
Present day Lake Champlain ...	95	95
Hochelaga or Champlain Sea		
Port Henry stage	89	?
Plattsburgh stage	130-170	170-220
Burlington stage	200-240	240-280
Port Kent stage	250-300	300-360
Beekmantown stage	300-370	360-440
Upper marine stage	370-460	460-530
Lake Vermont		
Fort Ann stage	540-590	590-650
Coveville stage	630-680	680-750

Hochelagan deposits in the mapped area include:

Port Henry stage	submerged terraces at head of Cumberland Bay and off Ausable delta
Plattsburgh stage	delta of the Little Ausable River (150 feet), delta of the Saranac River (170 feet), Chazy beaches, beach along Great Chazy River (170 feet)
Burlington stage	Corbeau deposits (200 feet), Port Kent delta (part), Fuller St. Beach (200-240 feet)
Port Kent stage	Port Kent delta (220-260 feet), beaches west of Plattsburgh (240-300 feet), West Chazy beach (320 feet)
Beekmantown stage	West Chazy beach (400 feet)
Upper marine stage	Ausable delta (380 feet), Ausable wave-cut terraces (370 feet)

One wonders if some crustal adjustment along the ancient ruptures may even have taken place relatively recently, subsequent to the melting of the great Pleistocene ice sheet, as compensation for the tremendous weight of ice which depressed the crust. Some "joints" in the Beekmantown along the Saranac River display 2 to 5 inches of vertical displacement, possibly related to post-Pleistocene rebound of the crust.

Pleistocene snails (*Cylichna albe, Utriculus pertenuis*) and clams (*Saxicava rugosa, Mya arenaria, Macoma groenlandica, Mytilus edulis, Yoldia arctica*) and barnacles (*Balanus crenatus*) have been found both south and north of Port Kent; northwest and south of Laphams Mills; along the Salmon River near South Plattsburgh; north and south of the Saranac River 2 miles from its mouth; on Valcour Island; on Cumberland Head; and throughout the length of the Ingraham Esker (see map symbol on Plate 1). North, in the Montreal-Quebec region, foraminifers, sponges, bryozoans, brachiopods, and echinoderms have been found. Salinity increased northward from near freshwater at Crown Point through brackish water at the latitude of Burlington, changing to a "normal" marine sea at Plattsburgh. The reader is referred

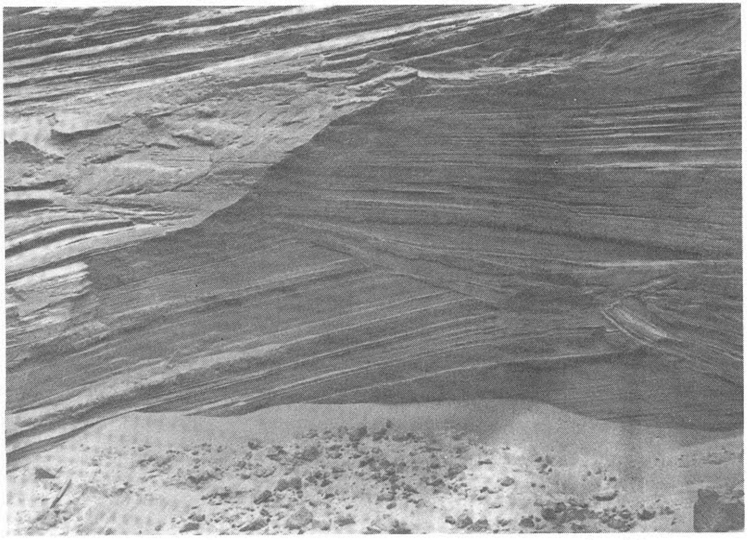


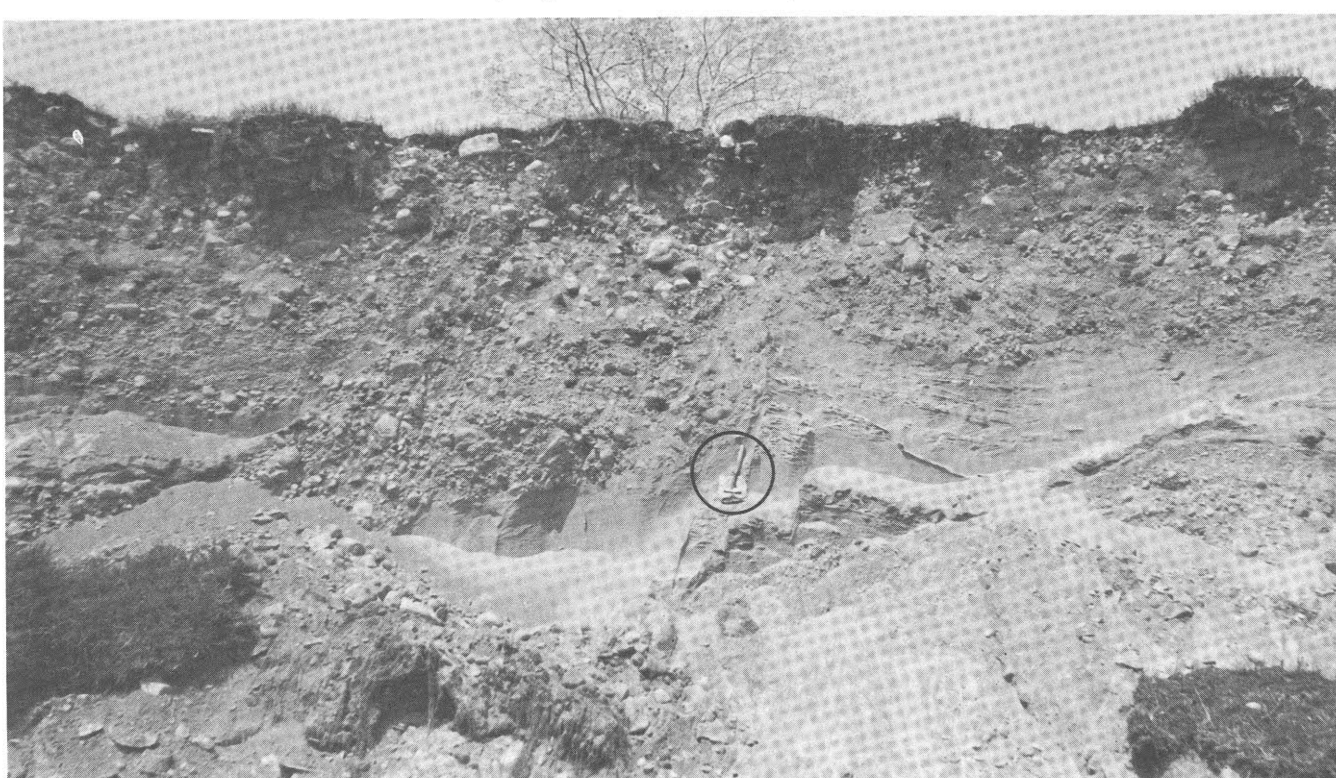
FIGURE 35. *Crossbedded, laminated Pleistocene sands of the Champlain Sea in sand pit south of N.Y. 373, 1 mile east of Ausable Chasm*

to Goldring (1920) for additional details on the Champlain Sea and its fossils.

The **Ingraham Esker** (figure 36), first recognized by Baldwin (1894, p. 177), is a topographic feature of sufficient prominence to be shown on a map with a 20 foot contour interval, and resembles an abandoned railroad bed. On the Rouses Point quadrangle, it traverses the lowlands from Spellman Road on the south to Macbride Road on the north. C. S. Denny (Pers. Comm.) reports that the esker has a core of boulder gravel overlain by fossiliferous sand and gravel deposited in the Champlain Sea. In some places the marine beds are separated from the core by unfossiliferous sand and gravel, probably fresh-water deposits of Lake Vermont. The stratified gravel in the core of the ridge was deposited by a stream, flowing in a tunnel in the bottom of the ice sheet that discharged into Lake Vermont. Informative stratigraphic profiles are presently shown where the esker lies east of, and paralleling, route U.S. 9, south of Ingraham. *Saxicava* is especially frequent here.

Ausable Chasm, its "dogleg" course partly controlled by closely spaced parallel joints in the Potsdam Sandstone, post-dates any delta building. If it was in existence earlier, it would have been filled with sand and gravel. The preglacial course of the Ausable River was probably west of the Chasm, conceivably occupying the area where the Paleozoic and Precambrian contact would be exposed — a naturally weak zone susceptible to rapid erosion. Both the ancient and modern deltas of the Ausable River are correspondingly larger than those of the Saranac and Chazy Rivers due to steeper gradient and greater load.

FIGURE 36. *Ingraham Esker; profile illustrating sand and gravel, and laminated sands (yielding the clam Saxicava) of the Champlain Sea resting on a lower sand and gravel core, deposited in Lake Vermont. Pit 0.5 mile south of Ingraham on east side of U.S. 9*



Geologic and Tectonic History

(Refer to figures 1, 4, and 37)

THE STORY OF THE CHAMPLAIN VALLEY and environs began over 1.5 billion years ago when shallow primeval seas received perhaps thousands of feet of sand, silt, and clay from erosion of a primordial land (exact whereabouts unknown). Accumulating in an ancient geosyncline (sinking basin), these sediments were subsequently consolidated in varying proportions into sandstones, siltstones, shales, and limestones. Intruded by granite, anorthosite, and gabbro during one or more mountain-making episodes which involved intense folding, the original sedimentary rocks were deeply buried, melted, and reconstituted to quartzites, gneisses, and marbles. This last metamorphic overprint in the Adirondacks occurred some 1100 m.y. ago (see chapter on Geochronology). During the late Precambrian, diabase dikes penetrated the older metamorphic rocks; late Precambrian sedimentary rocks are unknown in New York.

Millions of unrecorded years ensued. In northern New York, the next known event was a westward marine flooding upon a deeply eroded lateritic (iron-oxide rich) soil-covered ancestral Adirondacks and a partial reworking of these thick residual soils (Allens Falls and Nicholville Members). The resultant poorly sorted (Ausable Member) Potsdam deposits, of supratidal beach and fluvial origin, are without diagnostic fossils and therefore their age is uncertain; they could be very late Precambrian but are more probably Early or Medial Cambrian—deposits of which are well represented in Vermont.

Oscillating but slowly transgressive quiet seas redistributed existent quartz-rich soils. These Medial and Late Cambrian intertidal and inner-shelf Potsdam sands (Keeseville Member) are dated by key trilobites. Continental shelf-type sedimentation was destined to continue for another 100 m.y. with an increase in the amount of carbonate, notably scarce clay deposition, and only sporadic accumulation of quartz deposits.

The eve of the Cambrian and the dawn of the Ordovician witnessed sands alternating and mixing with carbonates (Theresa) until the sand supply was reduced to the point where the accumulating sediments were essentially carbonate (Beekmantown Group). Brief periods of local sand introduction were mingled with carbonates on the shallow shelf. These Early Ordovician (Canadian) seas were apparently physically uniform and widespread, for there is little evidence of localized environments and restricted faunas. Nautiloid cephalopods, gastropods, and trilobites dominate this period of time, and ostracodes appear in the Late Canadian seas. Brachiopods are noticeably subordinate — an unusual condition in normal marine Paleozoic seas. Algal mats are locally important. The situation of few species in large numbers suggest cool (boreal) waters. Regional uplift (accompanied by block faulting?) brought the Early Ordovician (Canadian) to a close, for there is evidence of erosion of higher Beekmantown units elsewhere in New York prior to deposition of the next younger Ordovician units (figure 28).

Returning epicontinental seas during Chazyan time differed from their predecessors in many ways. Chazyan seas were physically more variable and they were relatively warmer and conducive to warm-water reef builders (algae, sponges, bryozoans, stromatoporoids, and corals). Snails, nautiloids, and trilobites colonized the reef "supermarkets." Hosts of brachiopods dotted the sea floor among gardens of yet another new phylum — the echinoderms. Whereas most groups were more numerous and diversified than before, cephalopods were proportionally less numerous and diverse, judging by the known fossils. The basal unit of the subsequent Chazy Group is a dolomitic siltstone replete with lingulid brachiopods and "fucoids," implying an intertidal paleoenvironment. There is prevalent evidence of agitated waters, in the form of abundant crossbedded calcarenites, in Early and early-late Chazyan Seas. Great variation in attitudes of crossbedding favors the view that Chazyan seas were geographically restricted with more irregular shorelines, estuaries, and offshore islands. Sea floors were presumably firmer, supporting an abundant and diverse bottom-dwelling fauna. Many types of localized limestone facies exists — a marked contrast to the comparatively homogeneous blanket-type carbonates of the earlier Canadian.

Although there is no obvious physical discordance atop the Chazy rocks, there is a pronounced faunal change between the Chazyan (early Medial Ordovician) and the overlying Mohawkian (late Medial Ordovician) strata. This difference has caused paleontologists to place an evolutionary gap of several million years between these two series. As no marked crustal instability at the close of Chazyan sedimentation has been advocated, a gentle uplift could produce a featureless coastal plain capable of supplying only a minimal amount of fine lime and clay to the initial Mohawkian transgressive sea. Basal Mohawkian sediments are quartz-poor carbonates, only locally somewhat argillaceous or arkosic (Pamelia). These thin early Mohawkian carbonates (Black River Group) possess an impoverished fauna of mud-loving worms, snails, and a few types of brachiopods, undoubtedly reflecting the softness of the sea bottom and probable absence of clay-scattering currents. Later, the Mohawkian seas supported more cosmopolitan faunas replete with untold numbers of brachiopods, bryozoans, mollusks, ostracodes, and trilobites. Among Ordovician rocks, the Glens Falls Limestone holds one of the most abundant and variable faunas.

But a much greater influx of clay minerals made bottom life more difficult. The succeeding Cumberland Head Argillite has a fauna of diminutive brachiopods, mollusks, and trilobites. Inarticulate brachiopods rivaled their articulate cousins for numerical supremacy, an unusual situation. With the gradual decrease of calcium carbonate and an enduring soft mud bottom, the shelled bottom dwellers (brachiopods, snails, clams, corals, bryozoans) diminished drastically, and floaters (plankton), swimmers (nekton), and animals attached to them (epiplankton, epinekton) assumed dominancy. Accordingly, graptolites and clinging-type brachiopods and snails with a few straggling scavengers (trilobites, cephalopods) occupied the Stony Point seas. The introduction of black sulfur-bearing muds, products of an intensified erosion, heralded the oncoming of a mountain building orogeny. These soft black oozes were inhospitable to life — especially to filter feeders like brachiopods. Great quantities of erosive debris were dumped into the rapidly filling basin. To the east in New England emerged new lands domed with volcanoes. The entire area east of the Adirondacks became most unstable and was rocked by earthquakes and displacements of the crust. As a climax, westward overthrusting (along, for example, the Champlain, Hinesburg, or Isle La Motte Thrusts) of imbricated blocks of older rock into a mud-laden sea filled up the geosyncline. These imbricated slices are thought to have become activated by gravity sliding down the west flank of a rising Green Mountain Precambrian ridge (figure 28). External continental compression from the east may also have produced buckling and overriding, by which mechanism blocks or sheets or rock were torn up and incorporated into transported blocks (klippen). The Taconic Mountains (the Taconic Klippe) of eastern New York and southwestern Vermont are constructed of these thrust blocks. Subsequent erosion of the Ordovician alpine-like Taconics spread clastics as far west as Ohio and built up a widespread coastal plain — the late Ordovician Queenston Delta — from Quebec (St. Lawrence Basin) to Virginia.

Coincident with the doming of the Adirondack Mountains (during the Early and Late Ordovician) and the establishment of a southern peninsular extension, the Adirondack Arch, a series of northeast trending high-angle wrench faults (for example, the Tracy Brook Fault) ruptured the western margin of the Champlain Trough and the southern flank of the Adirondacks (the Mohawk Valley region of today). Most of these certainly reflect older lines of weakness in the Precambrian basement. In some areas, it can be shown that Taconic thrusting postdated normal faulting; in other areas, normal faults cut thrusts or the allochthon. This aptly illustrates that ancient fracture planes have been planes of adjustment at different times throughout geologic history, or intermittently active many times. Customarily, faults with the greatest vertical displacement are down-dropped on the east. Secondary ones are down-dropped west. This produces a block-type high and low plateau effect known as horst and graben topography — well exemplified in the Mohawk Valley. In the Champlain Valley, however, a slightly different condition was created (Plate 2.) Only the western portion of the down-dropped Champlain Trough or Rift, with its westerly upthrown faults cutting autochthonous strata, is now visible. The eastern part of the Rift is concealed by overriding slices of allochthonous rocks. One of these slices, the Cumberland Head Allochthon (termed the Isle La Motte slice by Stone, 1957), is now the westernmost exotic block and has spilled over onto the western flank of the endemic rift valley, effectively concealing the eastern flank. That this is an exotic rock mass is affirmed by a water well (200 D 20) which passed through the Cumberland Head Argillite and pierced the overriden Beekmantown Dolostone; the Chazy, Black River, and Trenton Groups are absent from their accustomed position. The Cumberland Head Allochthon and other thrust slices developed when regional folding and shearing could no longer accommodate the pressure buildup. Thus, the high-angle north-south wrench or longitudinal faults, low-angle thrusts, and primary north-south folds (St. Albans, Hinesburg, and Middlebury Synclinoria and Green Mountain Anticlinorium) can be explained together as caused by compressional deformation. Most of the east-west transverse or latitudinal faults (e.g., Cliff Haven and Valcour Faults) probably came into being as compensation for differential stresses exerted upon the underlying sole rocks.

Customarily, an older or synchronous allochthon is emplaced upon a younger autochthon. In order to explain how *younger* allochthonous strata (Cumberland Head Argillite) overrode *older* autochthonous strata (Beekmantown Dolostone), suppose we employ the mechanism of tectonic stripping. By this action less competent shales, previously downthrown along earlier high-angle faults, were torn from the more competent Glens Falls Limestone (or older carbonate) beneath and thrust westward varying distances, ultimately coming to rest on differing older strata. Exposed, structurally loosened segments of previously upthrown fault blocks might be incorporated into the overriding shale. Mono- or polylithologic breccias would be manufactured, depending on the variety of lithologic units exposed in these upthrown blocks. Block dumping in a linear trend would result where the allochthon encountered a major topographic obstacle such as a partly eroded fault scarp; this would produce a concentration of stripped fragments and blocks at or near the scarp's base — the Lacolle Mélange.

Post-orogenic relaxation (tension) along old normal fault planes or closely spaced joints may have produced apparent straightness of portions of the thrust trace, such as the west shore of Treadwell Bay or along the east shore of Isle La Motte. In addition to this "trimming" by renewed movement, other factors controlling the present pattern of the allochthonous rocks are thickness variations of the overriding mass and relative rock susceptibility to erosion (*i.e.* Cumberland Head Argillite is more resistant than Stony Point Shale).

Good field evidence supports the trace of the low-dipping Isle La Motte Thrust which roughly bisects the quadrangle at 44°45′ latitude. East of the fault trace, the allochthonous Cumberland Head, Stony Point, and Iberville Formations display tight folding (overturned to the west or northwest), steep dips (up to verticality) averaging 25° to 30°, fracture cleavage, slickensiding, widespread calcite veining, and large-scale brecciation. West of the Isle La Motte trace, older autochthonous Late Cambrian, and Early and Medial Ordovician formations are block faulted, only gently undulating, and have dips seldom exceeding 8°.

High-angle longitudinal wrench faults (*e.g.*, Tracy Brook Fault) predated the low-angle thrusting, though subsequent post-Taconic gravity faulting occurred, especially along these older weaknesses in the crust. Latitudinal faults, well exemplified by the Cliff Haven Fault, transect the previous faults and are thus the youngest major fault system — clearly a response to strains exerted by the westwardly transported allochthon.

For the next 335 million years, from the end of the Ordovician to within the Cretaceous Period (figure 1), there is an unfilled gap in our knowledge of the happenings in the Champlain Valley. What transpired during these unrecorded years? Did fish swim in ancient lakes or seas? Did prehistoric birds feed amidst flowering plants? Did dinosaurs thrive and die as primitive mammals struggled to inherit the Earth? Although the story of the parade of life is an enigma, some crustal disturbances may be inferred. During this interim, there may have been adjustments along older fault planes accompanied by regional uplifts. It is reasonable to assume this because to the east (Maine, New Hampshire, eastern Vermont) there is evidence of plutonic activity and folding during the Devonian (Acadian Orogeny), and to the south (southern New York) there is dike intrusion, sill extrusion, and block faulting during the Triassic (Palisades Orogeny). Carboniferous folding, too, affected the entire Appalachian Geosyncline from Nova Scotia to Alabama.

With the intrusion of the Monteregian Hills at the close of the Early Cretaceous, there was probable adjunct dike activity in the Champlain Valley (see chapter on Geochronology); some of this may have persisted into the Tertiary (Miocene and Pliocene Epochs); the lands were standing relatively high and our major drainage patterns were undoubtedly established. But these were due for modification by an erosive and depositional agent not known to have been active in this region before — a continental glacier.

About 1.5 m.y. ago, the climate began a slight but steady cooling trend, culminating in accumulations of ice which began to flow. A continuance of these conditions caused the ice to amasss to several hundreds to thousands of feet thick, covering the northern half of North America. Four major separate continental ice advances are known, of which the last, or Wisconsin glaciation, is best documented. With the exception of a small segment in southwestern New York, all of the State was buried under millions of tons of ice and incorporated rock and sediment which was eroded and assimilated as the ice sheet moved out of Canada southward across the Plattsburgh and Rouses Point quadrangles. This was, indeed, a prodigious weight and, as a consequence, depressed the crust. Finally, following a long warming trend, the ice sheet wasted and melted. The growth and death of the sometimes plow-like, sometimes conveyor-like moving ice caused New York's pre-Pleistocene residual soils to be virtually eliminated, its river valleys widened, deepened, or filled, and its mountains subdued. Great quantities of foreign material were dumped, some of which was watersorted by enlarged or temporary rivers and lakes. New bodies of water, such as fresh water Lake Vermont (figure 33) and the marine Champlain or Hochelaga Sea (figure 34) came into being and entire new surface features (eskers, drumlins, moraines, etc.) were created. The geologist can thank Pleistocene glaciation for stripping away the masking residual soils of millions of years accumulation, for without this excavation the deciphering of our bedrock geology would have been exceedingly difficult. Complete wastage of ice (the Greenland ice sheet is but a remnant) eliminated the water supply and the ice dams for the newly formed water bodies, and they gradually receded to the levels at which we see them today — or, as in many cases, to abandonment.

Economic Geology

FACTORS CONTROLLING ECONOMIC USEFULNESS OF ROCK MATERIALS

THIS SECTION DISCUSSES THE PAST, PRESENT, and potential mineral resources in the Plattsburgh and Rouses Point quadrangles. Usability of rock materials, each of which possesses obligatory specifications for contemplated use, is influenced by the following properties:

1. Chemical composition
2. Mineral composition
   a. essential ingredient(s)
   b. nonessential or accessory ingredients
3. Texture — size, form, and spacing of mineral particles
4. Strength — resistance which rocks offer to stress
5. Color — largely personal taste for stone exposed in building construction, although some colors warn of undesirable mineral impurities
6. Specific gravity — the weight of the sample compared with the weight of an equal volume of water
7. Weight of rock per unit volume — determined by multiplying the specific gravity of the sample by 62.4 pounds (weight of a cubic foot of water)
8. Porosity — percentage of pore space in a rock
9. Absorption — ratio between weight of absorbed water and dry weight
10. Hardness — hardness of constituent minerals compared with a standard, such as Moh's Scale of Hardness
11. Toughness — resistance to rupture by impact
12. Abrasion resistance — dependent on hardness, toughness, and strength
13. Resistance to fire damage
14. Susceptibility to frost breakage — ability to resist alternate freezing and thawing (to some extent dependent on porosity)

The mineral resources that have been tested in the area of this report are: limestone (and dolostone), sandstone, metanorthosite, natural gas, sand and gravel.

LIMESTONE AND DOLOSTONE

Quarries, past and present — Innumerable long-inactive quarries dot the countryside. Many prominent field ledges show evidence of rock removal, but most sites unquestionably were worked only briefly and consequently little rock was extracted. A list, in order from oldest to youngest rock, of selected quarry sites follows on page 44 (see Plate 1 for locations):

As of this writing, there is but one active bedrock quarry (Table 1–15) within the Plattsburgh and Rouses Point quadrangles — Plattsburgh Quarries, Incorporated, — in the Chazy (Crown Point) Limestone, at the northwestern edge of Plattsburgh just north of Interstate 87. Here, the limestone is used chiefly for roadbedding (sometimes referred to as road metal) and concrete aggregate.

In the category of a semi-active quarry (Table 1–13) is the one 0.9 mile southwest of Jordan Point on Isle La Motte. This is the source for the Vermont Marble Company's "fossil marble," a bluish to gray-black crystalline limestone with included large snails, straight cephalopods, brachiopods, and stromatoporoids all replaced to varying degrees by white crystalline calcite. Infrequent quarrying here is based on demand for the "fossil marble" for table tops, in particular. Latest information indicates that this quarry will be re-activated to full-time use.

"Marble" — Much of the rock from the aforementioned list of quarries was employed for dimension stone and ornamental facing stone, and sold as marble. To quarrymen, crystalline, granular limestones which take a high polish and which are adaptable to decorative work (table tops, facing, etc.) are classed as marbles. This usage is in contrast to the geologic definition of marble — a metamorphosed limestone or one changed by heat and/or pressure so as to effect a recrystallization of the calcium carbonate with, perhaps, an introduction and formation of new metamorphic minerals. None of the rock west of the Champlain Thrust (figure 4) in the Champlain Valley, formerly (or presently) sold as marble, is true marble; in addition to not fulfilling the geologic definition, *i.e.*, that they be metamorphosed, they lack the glint and translucency of true marbles.

One of these "trade marbles" or "pseudo-marbles" was marketed as "Lepanto Marble," a coarse-textured,

Table 1. Selected present and past quarry sites.

Location	Maximum working face	Rock unit	Uses
1. 0.6 mile north of Champlain	15 Feet	Theresa Dol.	roadstone, riprap
2. 1.8 miles east-northeast of Champlain	20 Feet–25 Feet	Theresa Dol.	roadstone, riprap
3. 2.5 miles northwest of downtown Plattsburgh	25 Feet	Beekmantown Dol. (Cutting)	roadstone
4. 2.3 miles west of downtown Plattsburgh	10 Feet + (flooded)	Beekmantown Dol. (Cutting)	roadstone
5. 1.2 miles west of St. Armand Beach	25 Feet	Beekmantown Dol. (Providence Island)	roadstone, riprap
6. 0.5 mile north of Wool Point	20 Feet	Day Point Ls.	dimension stone, riprap, roadstone
7. 0.3 mile southwest of Holcomb Point, Isle La Motte	20 Feet	Day Point Ls.	dimension stone, roadstone
8. 0.1 mile east of Scott Point, Isle La Motte	35 Feet–40 Feet	Day Point Ls.	dimension stone
9. 1.1 miles northeast of downtown Plattsburgh	30 Feet	Day Point Ls.	roadstone, dimension stone, riprap
10. 0.3 mile south of Cliff Haven	20 Feet	Day Point Ls.	dimension stone, riprap,
11. 0.8 mile south of Cliff Haven at Bluff Point	15 Feet	Day Point Ls.	dimension stone, roadstone
12. 1.2 miles southwest of Cliff Haven	20 Feet + (flooded)	Day Point Ls.	dimension stone, facing, roadstone
13. 0.9 mile southwest of Jordan Point, Isle La Motte	25 Feet	Crown Point Ls.	dimension stone, facing
14. 0.5 mile east-southeast of Fisk Point, Isle La Motte	25 Feet + (flooded)	Crown Point Ls.	dimension stone, facing
15. 1.5 miles northwest of downtown Plattsburgh	40 Feet	Crown Point Ls.	roadstone
16. 2.3 miles north-northwest of downtown Plattsburgh	10 Feet + (flooded)	Crown Point Ls. Valcour Ls.	roadstone, dimension stone, facing
17. 1.3 miles east of Cooperville	25 Feet + (flooded)	Valcour Ls.	dimension stone, lime
18. 2.1 miles southeast of Chazy	30 Feet + (flooded)	Valcour Ls.	lime, roadstone
19. 1.1 miles southeast of Chazy	35 Feet + (flooded)	Valcour Ls. through Larrabee Ls.	lime, roadstone
20. 0.7 mile south of Chazy	15 Feet	Isle La Motte Ls.	dimension stone, facing, lime
21. 1.2 miles south of Chazy	15 Feet	Isle La Motte Ls.	dimension stone, facing, lime

fossil-fragmental limestone within the Day Point Formation, whose red-pink-gray color makes it most attractive. Its vari-colored fossils (fragments of echinoderms and brachiopods) are enclosed in a partially recrystallized gray groundmass that displays countless glistening cleavage faces of calcite; thus, the rock approaches a true marble and as a consequence assumes an unusually prime polish. The "Lepanto" contains 95.96 percent calcium carbonate, 3 percent magnesium carbonate, 1 percent silica, and alumina and iron oxides. Its specific gravity is 2.709 and weight is 168.8 pounds/cubic foot. In the early twentieth century, the stone was quarried at Bluff Point (Table 1–11) by the Burlington Marble Company (later to become the Vermont Marble Company). Unexploited exposures are well exhibited at the intersection of U.S. 9 and Slosson Road and in the field to the northwest.

Light gray, coarse-textured limestone of the Day Point Formation has been utilized extensively for building stone and foundation work for homes and bridges and sold for facing under the trade name of "French-gray marble." Attesting to the Day Point's durability as a building stone is old Fort Montgomery, one mile northeast of Rouses Point, constructed from rock removed from abandoned workings south of the Cliff Haven Fault on the property of Bellarmine College.

The overlying Crown Point Limestone has, similarly, been employed as dimension and ornamental stone and sold, respectively, under the names "Lake Champlain bluestone" and "radio-black fossil marble." Because quartz sand and silt are virtually absent and because of the included fossils, the Crown Point is highly prized as an ornamental stone for tables and walls. It is not as jet black as the younger Isle La Motte Limestone which, in past years, was extensively quarried in the Champlain Valley as "Isle La Motte Marble" or "Glens Falls Marble." Because of its compactness, ease of dressing to any shape, and ability to assume a superior polish, the Isle La Motte has rivalled foreign marbles for shelving and facing; strangely it is not now quarried in New York for these purposes. The Isle La Motte or Glens Falls Marble has a specific gravity of 2.718 and weighs 169.4 pounds/cubic foot.

As a result of high labor costs and ignorance of availability, the Champlain Valley limestones are not being exploited for architectural stone to their full potential. Currently there seems to be an upward trend in the employment of natural stone for architectural purposes and hopefully New York's "marbles" may once again be in production.

Roadstone (road bedding or road metal) — Owing to increased highway construction and improvement of existing roads, road bedding material is in great demand. Requisite qualities are hardness and toughness; where both are unobtainable, the latter is preferred. Limestone is especially desirable since it possesses superior packing qualities and in areas where the ground water table is high, percolating mineralized water charged with carbonic acid produces a natural concrete by partly dissolving a rind on the limestone fragments. Dolostone is a second choice; its detritus acts as a mortar. Fortunately, Clinton County is well endowed with both of these carbonate rocks. Igneous and siliceous rocks, though hard, do not pack well. Gneiss, especially if micaceous, breaks up rapidly and is to be shunned. Shale is to be avoided at all costs as it breaks up rapidly, yielding a sticky clay. Gravel, albeit making a fairly serviceable road, does not pack well (unless vigorously tamped) and, depending on the mineralogic makeup of the pebbles and cobbles, may not endure in this climate of extreme temperatures and frost action. If gravel must be used, quartz gravel should be sought; furthermore, its durability may be improved by breaking the pebbles and cobbles in half.

Riprap — Beekmantown Dolostone and the even more quartzose Theresa Formation, as well as the Chazy limestones, have been utilized for riprap (rock protection for river or lake banks that are especially susceptible to erosion) in order to protect piers and waterfront property. The now abandoned railroad bed at Rouses Point was so protected where it crossed the lake. Similarly, metanorthosite blocks have been used for riprap to fortify the Delaware and Hudson Railroad bed near Port Kent. In addition, Beekmantown Dolostone has been sparingly used for dimension stone; its siliceous content (locally as high as 15 percent) and iron oxide cause it to be less suitable for use as aggregate or road bedding.

Agricultural Lime — Two quarries (Table 1-18, 19) which ceased producing in the early 1960's were operated by the International Lime and Stone Company for agricultural lime and crushed rock. They are located, respectively, 1.1 miles southeast of Chazy (eastward extension of the old Chazy Marble Company quarry whose dilapidated kilns may be seen along U.S. 9) and on the north side of Sheldon Lane, 2.1 miles southeast of Chazy. The former quarry exposes the uppermost Valcour dolostones, Pamelia Dolostone, Lowville Limestone, Isle La Motte Limestone, and lower Glens Falls (Larrabee) Limestone. The latter quarry is entirely within the lower Valcour and consists of coarse-textured fossiliferous limestone with fossil-crowded organic reefs of fine-textured limestone. Due to its high calcium content, a relatively small amount of rock from the active quarry (Table 1-15) of Plattsburgh Quarries, Incorporated, is pulverized as agricultural lime for local needs in neutralizing soil.

SANDSTONE

A rock with great strength and low absorptive properties is aptly suited for structural and street (curbing) work. Such a rock is the upper Potsdam or Keeseville Sandstone. In this area, it was formerly quarried within the limits of the privately owned Ausable Chasm. Many buildings in Keeseville and throughout Clinton, Franklin, and St. Lawrence Counties stand as testimony to the application of this rock as a building material.

ANORTHOSITE (technically METANORTHOSITE)

Discussion of the economic geology of the area would be incomplete without mention of the use to which the Precambrian metanorthosite has been put. Especially south and west of Keeseville, metanorthosite has been extracted as a source of large quantities of building and monumental stone. It has been marketed under the name "Ausable Granite," a misnomer geologically speaking since, technically, granite consists principally of quartz and potassium-feldspar whereas metanorthosite possesses calcic-feldspar and less than 5 percent quartz. The Prospect Hill Quarries were south of Keeseville and formerly owned by the Ausable Granite Company. The Empire State Granite Company opened quarries west of Keeseville and on the west side of Auger Lake. At present, Lake Placid "Granite" is quarried west of Ausable Forks, a few miles southwest of the mapped area. Here, the rock is medium- to coarse-textured, depending on the relative amounts of crushed and uncrushed plagioclase feldspar. The surface is almost unaffected by weathering although a thin rind of kaolin and chlorite — decomposition products of feldspar and ferromagnesian minerals, respectively — is customarily in evidence. Garnet (1 to 2 percent) is ubiquitous as are even lesser amounts of ilmenite (iron-titanium oxide) and pyrite (iron sulfide).

Metanorthosite is superior in hardness to marble and easier to polish than granite. Its specific gravity is 2.75 and its weight is 175 lbs/cubic foot. Because of its essentially monomineralic makeup with resultant fairly uniform chatoyant color (gray-green), it has demonstrated its applicability for dimension and facing stone. The Catholic Church in Keeseville is constructed of metanorthosite — mainly from quarry waste. The sole drawback seems to be the presence of minute fractures which may accelerate surface chipping by acting as avenues for freezing water.

Metanorthosite is the host rock for ilmenite, the source of titanium dioxide — a whitening agent for paint — at the National Lead Company's operation at Tahawus. Ilmenite in economic concentrations has not been found in the mapped area.

NATURAL GAS

Although unproductive, it is noteworthy that two deep tests for natural gas have been conducted in the area. The earlier one, begun in 1898 and completed in 1899, was near Morrisonville in the Dannemora quadrangle. The hole was drilled to 1350 feet, penetrating 20 feet of overburden, 500 feet of Beekmantown, and 50 feet of Theresa, with the remainder in the Potsdam Sandstone; the Precambrian was not reached. A show of oil (presumably in the Potsdam) and a water-bearing zone was found within the Potsdam; no gas was discovered. A more recent deep test near Alburg, Vermont, in the Rouses Point quadrangle was begun in 1964 and drilling ceased in 1965 at a depth of 5,075 feet. Owing to the complex structure and variable dipping strata, the subsurface stratigraphy could not be reliably ascertained. No gas was discovered.

SAND AND GRAVEL

Among the most important mineral resources in New York and Vermont is sand and gravel. Within the mapped area, many pits (not shown on this geologic map, but will be located on the forthcoming Vermont map of glacial deposits) have been opened in the Ingraham Esker, in some places to the extent that this striking feature has been breached. The workings are short-lived, depending upon local needs. The esker holds superior, but very limited, pebble and cobble gravel and coarse sand for concrete aggregate. Larger quantities of sand are available from the former beaches of glacial Lake Vermont and the Champlain Sea at the west edge of Plattsburgh, and also extending from north of Ausable Chasm to Port Kent. More expansive gravel deposits exist in the adjacent Mooers quadrangle to the west.

PRECIOUS METAL

It seems apropos to close with an historic note of an isolated occurrence of precious metal in Clinton County. Peter Collier (1881, p. 123) reported the discovery (a few years earlier) of a nugget of platinum, weighing 104.4 grams, "adjacent to the village of Plattsburgh." Several other specimens were alleged to have been found simultaneously but because their value was unknown, they were mislaid and lost. The slightly magnetic nugget consisted of 46 percent platinum and 54 percent chromite. The platinum designation was verified by the following analysis:

Percent	
82.8	platinum
11.0	iron
3.1	palladium
1.9	alumina
0.6	iridium
0.4	copper
0.3	rhodium
tr	lime and magnesia

This is the sole record of platinum from New York State, and was unquestionably a stray, incorporated with the glacial debris from the north. Eastern Quebec possesses bodies of serpentinite that carry mineable chromite in a requisite geologic setting for platinum. Also, there are serpentinite bodies in north-central Vermont, about 50 miles east of the Plattsburgh area. The ultrabasic Monteregian Hills, too, a few miles north of the International Boundary, possess appropriate mineralogic makeup for the occurrence of platinum. Nevertheless, it should be emphasized that this is a record of a unique find and obviously geologically foreign to its discovery site. The nugget's whereabouts is unknown.

Bibliography

Baldwin, S. P., 1894, Pleistocene history of the Lake Champlain Valley. Am. Geol.: 13: 170–184, maps.

Berry, W. B. N., 1962, On the Magog, Quebec graptolites: Am. J. Sci.: 260: 142–148, 1 fig.

Brainerd, Ezra, & Seely, H. M., 1890, The Calciferous Formation in the Champlain Valley: Am. Mus. Nat. Hist., 3: No. 1, 1–23, 5 maps.

———, 1896, The Chazy of Lake Champlain: Am. Mus. Nat. Hist. Bull.: 8: 305–315, 3 maps.

Broughton, J. G., Fisher, D. W., Isachsen, Y. W., Rickard, L. V., Offield, T. W., 1962, Geologic Map of New York, 1:250,000: (colored map) N.Y.S. Mus. and Sci. Ser., Map and Chart Ser. No. 5. (Adirondack Sheet).

Buddington, A. F. & Whitcomb, L., 1941, Geology of The Willsboro Quadrangle: N.Y.S. Mus. Bull. 325; 137 pp., 46 figs., colored geologic map.

Cady, Wallace M., 1945, Stratigraphy and structure of west-central Vermont: Bull. Geol. Soc. Am.: 56: 515–588, 10 pls., 6 figs., colored geologic map.

———, 1960, Stratigraphy and geotechnic relationships in northern Vermont and southern Quebec: Bull. Geol. Soc. Am.: 71: 531–576.

Chapman, Donald H., 1937, Late-glacial and postglacial history of the Champlain Valley: Am. J. Sci.: 34: 89–124, 16 figs. Bull.

Clark, T. H., 1934, Structure and stratigraphy of southern Quebec: Geol. Soc. Am.: 45: 1–20, 3 figs.

———, 1952, Montreal Area Laval and Lachine Map areas: Can. Dept. of Mines Geol. Rpt. 46, 159 pp., 12 figs., frontispiece and 16 pls., 4 colored maps.

———, 1962, Geologic Map of St. Lawrence Lowlands: Quebec Dept. of Natural Resources, Map No. 1407, colored map.

———, & **McGerrigle, H. W.**, 1936, Lacolle Conglomerate: A new Ordovician Formation in southern Quebec: Bull. Geol. Soc. Am., 47: 665–674, 12 figs.

Clarke, J. M., & Schuchert, C., 1899, Nomenclature of New York series of geological formations: Science, New Ser.: 110: 876.

Collier, Peter, 1881, A remarkable nugget of platinum: Am. J. Sci., 3rd ser., 21: 122: 123–124.

Cooper, G. A., 1956, Chazyan and related brachiopods: Smith. Misc. Coll. 127, 1024 pp. 269 pls.

Cushing, H. P., 1894, Preliminary report on the geology of Clinton County (New York): N.Y. State Geol. Ann. Rpt. 13: 473–489.

———, 1897, Report on geology of Clinton County (New York): N.Y. State Geol. Ann. Rpt. 15: 21–22, 499–573.

———, 1905, Geology of the northern Adirondack region (New York): N.Y.S. Mus. Bull. 95: 271–453.

Denny, C. S., 1967, Surficial geologic map of the Dannemora quadrangle and part of the Plattsburgh quadrangle, New York: U.S. Geol. Surv. Map GQ–635 (colored map).

Diment, W. H., 1963, Gravity and magnetic anomalies in northeastern New York: Geol. Soc. Am. Sp. Paper 76, p. 45.

Doll, C. G., Cady, W. M., Thompson, J. B., Jr. & Billings, M. P., 1961, Centennial Geologic Map of Vermont, 1:250,000: Vt. Geol. Surv. (colored map).

Edwards, G., Heinle, W. K., Osmond, J. K. & Adams, J. A. S., 1959, Further progress in absolute dating of the Middle Ordovician: Bull. Geol. Soc. Am., 70: No. 12, pt. 2 (Dec. 1959). (Abstract).

Emmons, Ebenezer, 1842, Geology of New York, Part 2, Comprising the Survey of the Second Geological District: 437 pp.

Erwin, Robert B., 1957, The geology of the limestone of Isle La Motte and South Hero Island, Vermont: Vt. Geol. Surv. Bull. 9, 94 pp., 20 pls., 3 tables, colored map.

Fairchild, Herman Leroy, 1919, Pleistocene marine submergence of the Hudson, Champlain, and St. Lawrence Valleys: N.Y.S. Mus. Bull. 209–210.

Fisher, Donald W., 1954, Lower Ordovician (Canadian) stratigraphy of the Mohawk Valley New York: Bull. Geol. Soc. Am.: 65: 71–96, 4 pls., 6 figs.

———, 1956, The Cambrian System in New York: Cambrian Symposium, 20th Inter. Geol. Congress, Mexico City, p. 321–351, 4 figs.

———, 1962, Correlation of the Cambrian Rocks in New York State: N.Y.S. Mus. and Sci. Serv., Map and Chart Ser. No. 2.

———, 1962, Correlation of the Ordovician Rocks in New York State: N.Y.S. Mus. and Sci. Serv., Map and Chart Ser. No. 3.

———, & **Hanson, Geo. F.**, 1951, Revisions in the geology of Saratoga Springs, New York and vicinity: Am. J. Sci., 249: 795–814, 3 figs., 2 pls.

Flower, Rousseau H., 1947, New Ordovician Nautiloids from New York: Jour., Paleo., 21, No. 5, pp. 429–433, pl. 59. 1 text fig.

———, 1952, New Ordovician Cephalopods from eastern North America: J. Paleo., 26: 1: 24–59, pls. 5-10, 1 text fig.

———, 1955, New Chazyan Orthocones: J. Paleo., 29: 5: 806–830, pls. 77–81, 1 text fig.

———, 1957, Studies of the Actinoceratida: New Mexico Bur. Mines and Min. Res., Memoir 2, 100 pp., 13 pls.

———, 1961, The phragmocone of *Ecdyceras:* New Mexico Bur. Mines and Min. Res., Memoir 9, 27 pp., 4 pls.

———, 1964, The foreland sequence of the Fort Ann region, New York [in the Nautiloid Order Ellesmeroceratida (Cephalopoda)]: New Mex. Bur. Mines and Min. Resources, Memoir 12: 153–164.

Galloway, Jesse J., 1957, Structure and classification of the stromatoporoidea: Bull. Am. Paleon. 37: 164: 141 pp., 7 pls.

Geological Society Phanerozoic time-scale, 1964: Quart. J. Geol. Soc. London, 120S: 260–262.

Goldring, Winifred, 1920, The Champlain Sea: N.Y.S. Mus. Bull. 239–240: 153–194. 2 figs., 2 maps.

Hawley, David, 1957, Ordovician Slates and submarine breccias of northern Champlain Valley in Vermont: Bull. Geol. Soc. Am., 68: 55–94, map.

Hills, Allan, & Gast, P. W., 1964, Age of pyroxene-hornblende granitic gneiss of the eastern Adirondacks by the Rubidium-Strontium whole-rock method: Bull. Geol. Soc. Am., 75: 759–766, 3 figs.

Hitchcock, Edward, Hitchcock, Edward, Jr., Hager, A. D., Hitchcock, Charles H., 1861, Report on the geology of Vermont, vol. 1, 558 pp., 38 pls., 289 figs.

Hsu, K. Jinghwa, 1966, Mélange concept and its application to an interpretation of the California Cóast Range Geology, Geol. Soc. Am., Sp. paper 101, p. 99.

Hudson, George H., 1904, Contributions to the fauna of the Chazy limestones on Valcour Island, Lake Champlain: N.Y.S. Paleon. Rept. 1903: 270–295.

———, 1907, On some Pelmatozoa from the Chazy Limestone of New York: in N.Y.S. Mus. Bull. 107: 97–102.

———, 1931, The fault systems of the northern Champlain Valley, New York: N.Y.S. Mus. Bull. 286: 5–80.

———, & **Cushing, H. P.**, 1931, The dike invasions of the Champlain Valley, New York: N.Y.S. Mus. Bull. 286: 81–112.

Johnson, John, & Toung, George, 1960, Pamelia east of the Frontenac Axis in New York State, Bull. Geol. Soc. Am., 71: 1898.

Kalm, Peter, Peter Kalm's travels in North America, English version of 1770, 797 pp.

Kay, Marshall, 1937, Stratigraphy of the Trenton Group: Bull. Geol. Soc. Am., 48: 233–302.

Kemp, J. F. & Alling, H. L., 1925, Geology of the Ausable quadrangle: N.Y.S. Mus. Bull. 261, 126 pp., 24 figs., 12 pls., colored map.

———, & **Marsters, V. F.**, 1893, The Trap dikes of the Lake Champlain region: U.S. Geol. Surv. Bull. 107: 11–62.

———, & **Ruedemann, R.**, 1910, Geology of the Elizabethtown and Port Henry quadrangles: N.Y.S. Mus. Bull. 138, 173 pp., 36 figs., 19 pls., colored map.

Krynine, P. D., 1948, Possible Algonkian in New York State (abstract): Geol. Soc. Am. Bull., 59: no. 12: 1333–1334.

LaFleur, Robert G., 1965, Glacial geology of the Troy, New York quadrangle. N.Y.S. Mus. and Sci. Serv. Map and Chart Series no. 7, 22 pp., colored map.

Le Sueur, Charles A., 1818, Observations on a new genus of fossil shells. J. Acad. Nat. Sci, Philadelphia 1: 310–312, pl. 13 (3 figs.)

Otvos, Ervin G., Jr., 1966, Sedimentary structures and depositional environments, Potsdam Formation, Upper Cambrian; Am. Assoc. Petrol Geol. Bull., 50: no. 1: 159–165, 8 figs.

Oxley, Philip, 1951, Chazyan reef facies relationships in northern Champlain Valley; Denison Univ. Bull., 51: 92–106, 5 pls., 2 text figs.

———, & Kay, M., 1959, Ordovician Chazyan Series of Champlain Valley, New York and Vermont and its reefs: Am. Assoc. Petrol Geol. Bull., 43: 817–853, 10 figs.

Peet, C. E., 1904, Glacial and post-glacial history of the Hudson and Champlain Valleys: J. Geol., 12: 415–469, 617–660, maps.

Pitcher, Max, 1964, Evolution of Chazyan (Ordovician) reefs of eastern United States and Canada: Bull. of Can. Petroleum Geol., 12: no. 3: 632–691, 3 pls., 49 text figs.

Poole, W. H., Beland, J. & Wanless, R. K., 1963, Minimum age of Middle Ordovician rocks in southern Quebec: Bull. Geol. Soc. Am., 74: 1063–1064, 1 fig.

Postel, A. W., Nelson, A. E., Wiesnet, D. R., 1959, Geologic map of the Nicholville quadrangle, New York: U.S. Geol. Surv. Geol. Quad. Map GQ–123 (colored map)

———, & Rogers, C. L., 1951, Geologic map of the Dannemora Quadrangle New York: U.S. Geol. Surv. Quadrangle Map [GQ 14], colored map with text.

Quinn, Alonzo, 1933, Normal faults of the Lake Champlain region: J. Geol. 42: 113–143.

Raymond, Percy E., 1902, The Crown Point section: Bull. of Am. Paleo., v. 3, no. 14.

———, 1905a, The trilobites of the Chazy limestone: Annals of Carnegie Mus., 3: 328–386.

———, 1905b, The fauna of the Chazy limestone: Am. J. Sci. Ser. 4, 20: 353–382.

———, 1906, The Chazy formation and its fauna: Annals of Carnegie Mus. 4: 168–225.

———, 1910a, Notes on Ordovician trilobites. II Asaphidae from the Beekmantown: Annals of Carnegie Mus., 7: 35–44.

———, 1910b, Notes on Ordovician trilobites. IV New and old species from Chazy: Annals of Carnegie Mus., 7: 60–80.

———, 1910c, Trilobites of the Champlain Valley: Vt. State Geol. Rept. 7: 213–248.

———, 1911, The Brachiopoda and Ostracoda of the Chazy: Annals of Carnegie Mus., 7: 215–259.

———, 1916, The Pelecypoda of the Chazy formation: Annals of Carnegie Mus. 10: 325–342.

———, 1924, The oldest coral reef: Vt. State Geol. Rept. 14: 72–76.

Rodgers, John, 1937, Stratigraphy and structure in the upper Champlain Valley: Bull. Geol. Soc. Am., 48: 1573–1588, 4 figs.

Ross, June R. P., 1963a, *Constellaria* from the Chazyan (Ordovician), Isle La Motte, Vermont: J. Paleo., 37: 1: 51–56, pls. 5–6, 2 text figs.

———, 1963b, New Ordovician species of Chazyan trepostome and cryptostome bryozoa: J. Paleo., 37: 1: 57–63, pls. 7–8, 2 text figs.

———, 1963c, Chazyan (Ordovician) leptotrypellid and atactotoechid bryozoa: Paleontology, v. 5: pt. 4: 727–739, pls. 105–108.

———, 1963, Ordovician cryptostome bryozoa, standard Chazyan series, New York and Vermont: Bull. Geol. Soc. Am., 74: 577–608, 7 figs. 10 pls.

———, 1963e, The bryozoan trepostome *Batostoma* in Chazyan (Ordovician) strata: J. Paleo., 37: 4: 857–866, pls. 106–109., 6 text figs.

———, 1964, Champlainian cryptostome bryozoa from New York State: J. Paleo., 38: 1: 1–32, 8 pls., 11 text figures, 1 table.

Ruedemann, Rudolph, 1906, Cephalopoda of the Beekmantown and Chazy Formations: N.Y.S. Mus. Bull. 90: 393–611.

Shaw, Alan B., 1958, Stratigraphy and structure of the St. Albans area, northwestern Vermont: Bull. Geol. Soc. Am., 69: 519–568. (colored geologic map)

Silver, Leon T., 1963, Isotope investigations of zircons in Precambrian igneous rocks of the Adirondack Mountains, New York: Geol. Soc. Am. Sp. Paper 76.

Simmons, Gene, 1964, Gravity survey and geological interpretation, northern New York: Bull. Geol. Soc. Amer. 75: 81–98, 8 figs., 4 pls.

Stone, Donald S., 1957, Origin and significance of breccias along the northwest side of Lake Champlain: J. Geol., 65: 85–96, 4 pls., 1 table, 2 figs. (one a map).

Stone, Solon W. & Dennis, John G., 1964, The geology of the Milton quadrangle, Vermont: Vt. Geol. Surv. Bull. 26, 79 pp., 7 figs. 6 pls., colored map.

Swain, Frederick M., 1957, Early Middle Ordovician ostracoda of the eastern United States, Part 1: Stratigraphic data and description of Leperditidae, Aparchitidae, and Leperditellidae: J. Paleo., 31: 3: 528–570, pl. 59–62, 10 text figs.

———, 1962, Early Middle Ordovician ostracoda of the eastern United States, Part II. Leperditellacea (part), Hollinacea, Kloedenellacea, Bairdiacea, and Superfamily uncertain: J. Paleo., 36: 4: 719–744, pls. 109–111, 3 text figs.

Walcott, Charles D.,1891, Correlation Papers-Cambrian, U.S. Geol. Surv. Bull. 81, 446 pp.

Welby, Charles W., 1961, Bedrock geology of the central Champlain Valley of Vermont: Vt. Geol. Surv. Bull. 14, 296 pp., 19 text figs., 13 pls., 5 tables, colored map.

Wheeler, Robert R., 1942, Cambrian-Ordovician boundary in the Adirondack Border region: Am. J. Sci., 240: 518–524.

Whitfield, Robert P., 1886, Notice of geological investigations along the eastern shore of Lake Champlain, conducted by Prof. H. M. Seely and Prest. Ezra Brainerd, of Middlebury College, with descriptions of the new fossils discovered: Bull. Am. Mus. Nat. Hist. Art. 42: 295–345, pls. 24–34.

———, 1889, Observation on some imperfectly known fossils from the Calciferous Sandrock of Lake Champlain, and description of several new forms: Am. Mus. Nat. Hist. Bull., 2: 2: 41–63, pls. 7–13.

———, 1890, Observations on the fauna of the rocks at Fort Cassin, Vermont, with descriptions of a few new species: Am. Mus. Nat. Hist. Bull. 3: 1: 25–39, pls. 1–3.

———, 1897, Descriptions of new species of Silurian fossils from near Fort Cassin and elsewhere on Lake Champlain: Am. Mus. Nat. Hist. Bull., 9: 11: 174–184, pls. 4–5.

Wiesnet, Donald R., 1961, Composition, grain size, roundness and sphericity of the Potsdam Sandstone (Cambrian) in northeastern New York: J. Sed. Petrol., 31: 1: 5–14, 9 text figs.

Wilson, Alice E., 1946, Geology of the Ottawa-St. Lawrence Lowland, Ontario and Quebec: Canada Geol. Surv. Mem. 241, 65 pp.

Woodworth, Jay B., 1905, Ancient water levels of the Champlain and Hudson Valleys: N.Y.S. Mus. Bull. 84, 265 pp., 29 pls, (includes map of Mooers quad.)

Zartman, R. E., Brock, M. R., Heyl, A. V., & Thomas, H. H., 1967, K–Ar and Rb-Sr ages of some alkalic intrusive rocks from central and eastern United States: Amer, J. Sci., 265: 848–870.

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JOHN G. BROUGHTON, STATE GEOLOGIST

BEDROCK GEOLOGY OF THE PLATTSBURGH AND ROUSES POINT QUADRANGLES, NEW YORK AND VERMONT

(PLATE 1)

Base from quadrangles by the U.S.G.S.

Control by USGS and USC&GS

Culture and drainage in part compiled from aerial photographs taken 1939. Topography by planetable surveys 1939

Culture revised by photogrammetric methods from aerial photographs taken 1954. Field check 1956

Hydrography compiled from U. S. Lake Survey charts 171 and 172 (1952)

Polyconic projection. 1927 North American datum

10,000-foot grids based on New York coordinate system, east zone, and Vermont coordinate system

1000-meter Universal Transverse Mercator grid ticks, zone 18, shown in blue

APPROXIMATE MEAN DECLINATION, 1956

SCALE 1:62500

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW LAKE LEVEL 92.5 FEET

QUADRANGLE LOCATION

Williams & Heintz Map Corporation, Washington, D.C. 20027

New York Geology by Donald W. Fisher (1954-55, 57-58, 65)

Subsurface well information by William Hobba, U.S. Geological Survey

Vermont Geology - Isle la Motte and South Hero Island by Robert B. Erwin; (1954-55)
Shales by David L. Hawley; (1951-52)
Some faults modified by Donald W. Fisher

LEGEND

PLEISTOCENE

P — Alluvium and marsh, laminated sands of the Champlain Sea and Lake Vermont; all masking bedrock geology

Pie — INGRAHAM ESKER. Cobble and pebble gravel in crossbedded laminated sands, capped by fossil-bearing Champlain Sea sand.

POST-ORDOVICIAN (UPPER JURASSIC-LOWER CRETACEOUS) DIKES

d — Diabase (some Precambrian)
l — Lamprophyre
lf Fourchite
lm Monchiquite
ls Spessartite
lu undetermined

MIDDLE ORDOVICIAN

lam — LACOLLE MÉLANGE– angular pebble–, cobble–, and boulder-sized blocks of Potsdam through Cumberland Head Formations in an unfossiliferous very fine-grained matrix.

(Color block on left indicates rock outcrop. Color block on right indicates bedrock concealed by thin soil covering.)

Trenton Group

Oi — IBERVILLE SHALE. Dark gray to black, splintery fracturing, noncalcareous shale.

Osp — STONY POINT (CANAJOHARIE) SHALE. Black, fissile, carbonaceous, calcareous shale.

Ocum — CUMBERLAND HEAD ARGILLITE Ashen gray to buff—weathering, medium- to dark-gray, laminated, calcareous argillite with some limy mudstone or argillaceous limestone, (argilli-calcilutite) beds. Characterized by the trilobites *Cryptolithus* and *Triarthrus*.

Ogfm — GLENS FALLS LIMESTONE. *Montreal Member*—thin-bedded fine- to medium-grained, dark gray to black limestone with shale interbeds. *Cryptolithus*-bearing.

Ogfl — *Larrabee Member*— Medium- to thick-bedded, coarse to medium grained, light- to medium-gray limestone.

Black River Group

Oil —

ISLE LA MOTTE LIMESTONE. Conchoidal fracturing, massive, dark gray to black fine-grained limestone (calcilutite), weathering light- to medium-gray. Locally, small, light gray, coarse-grained reeflike fossiliferous masses occur.

LOWVILLE LIMESTONE. Conchoidal fracturing, massive, tan-gray ("dove") calcilutite, weathering white to light gray.

PAMELIA DOLOSTONE. Conchoidal to subconchoidal fracturing, medium- to thick-bedded, buff-weathering, greenish-gray, fine-grained argillaceous dolostones with quartz sand.

Chazy Group

Ova — VALCOUR LIMESTONE. Upper strata are principally argilli-calcilutites, yielding the brachiopod *Rostricellula*. Lower strata are coarse textured limestones (calcarenites) and organic reefs.

Ocp — CROWN POINT LIMESTONE. Chiefly medium-grained limestone (calcisiltite) and fine-grained limestone (calcilutite) with the gastropod *Maclurites magnus* exceedingly abundant. Locally, may be slightly reefy but without good development of calcarenites.

Odp — DAY POINT LIMESTONE. Principally light gray calcarenite, frequently crossbedded; usually quartzose and somewhat argillaceous. A red calcarenite zone occurs near the middle and organic reefs are frequent near the summit. The base, where exposed, is a calcareous, argillaceous silt-sandstone (Sainte Thérèse Member) with fucoidal markings and lingulid fragments.

LOWER ORDOVICIAN

Beekmantown Group

Opi — PROVIDENCE ISLAND DOLOSTONE. Buff-weathering medium-thick bedded, fine- to medium-grained, blue-gray dolostone.

Ofc — FORT CASSIN FORMATION. Alternating buff-weathering dolostones (as above) and massive dark gray to black dolomitic calcilutites; some small lenses and seams of ostracode-rich calcarenite. Nautiloids (including *Tarphyceras*) and gastropods relatively common.

Os — SPELLMAN FORMATION. Thin- to thick-bedded; reticulose weathering fossiliferous (*Lecanospira, Bolbocephalus, Hystricurus*) dolomitic calcilutite with lesser amounts of interbedded calcitic dolostone and cherty dolostone; some flat pebble conglomerate.

Ocut — CUTTING DOLOSTONE. Medium- to thick-bedded, medium-grained, gray to light buff weathering, bluish-gray to dark gray chert-bearing slightly calcitic dolostone; minor amount of quartz (silt).

Saratoga Springs Group

Oth — THERESA FORMATION. Alternating medium- to thick-bedded, medium-to coarse-textured, medium to dark gray, quartzose dolostone and coarse-textured, light to medium gray dolomitic quartz-sandstone.

UPPER AND MIDDLE CAMBRIAN

Єpk — POTSDAM SANDSTONE. *Keeseville Member*—Thin-to medium-bedded, ripple marked, white-buff quartz-sandstone, weathering grayish-tan.

Єpa — *Ausable Member*—Medium- to thick-bedded, highly cross-bedded, tan-pink feldspathic sandstone (arkose) with some green quartzose shale interbeds and quartz-pebble conglomerate lenses.

PRECAMBRIAN

mg — Metagabbro, medium-grained, tan and black speckled, non-banded granulite; as relatively narrow igneous intrusions.

ma — Metanorthosite, gabbroic or noritic, various shades of green to gray, inequigranular with megacrysts of plagioclase.

ROCK-UNIT CONTACTS

Contact observed or approximately located.

Contact inferred; queried where surmised.

FAULTS

Normal fault observed or approximately located; hachures on downdropped side.

Normal fault whose location is inferred.

Reverse or thrust fault observed or approximately located; sawteeth on overriding block.

Reverse or thrust fault whose location is inferred.

Fault whose existence is uncertain.

OTHER SYMBOLS

Strike and dip (in degrees) of strata;

Horizontal strata.

Outcrop area

Quarries

Organic reef (bioherm) complex.

Fossils in Pleistocene deposits.

200 D 20 — Selected water well. Left-hand figure denotes depth of well; letter symbol indicates rock type penetrated (D = dolostone, L = limestone, SH = shale, SS = sandstone); right-hand figure denotes depth to bedrock. (depths are in feet)

O 41 — Adirondack Northway Interchanges

No thru road (dead end at Northway)

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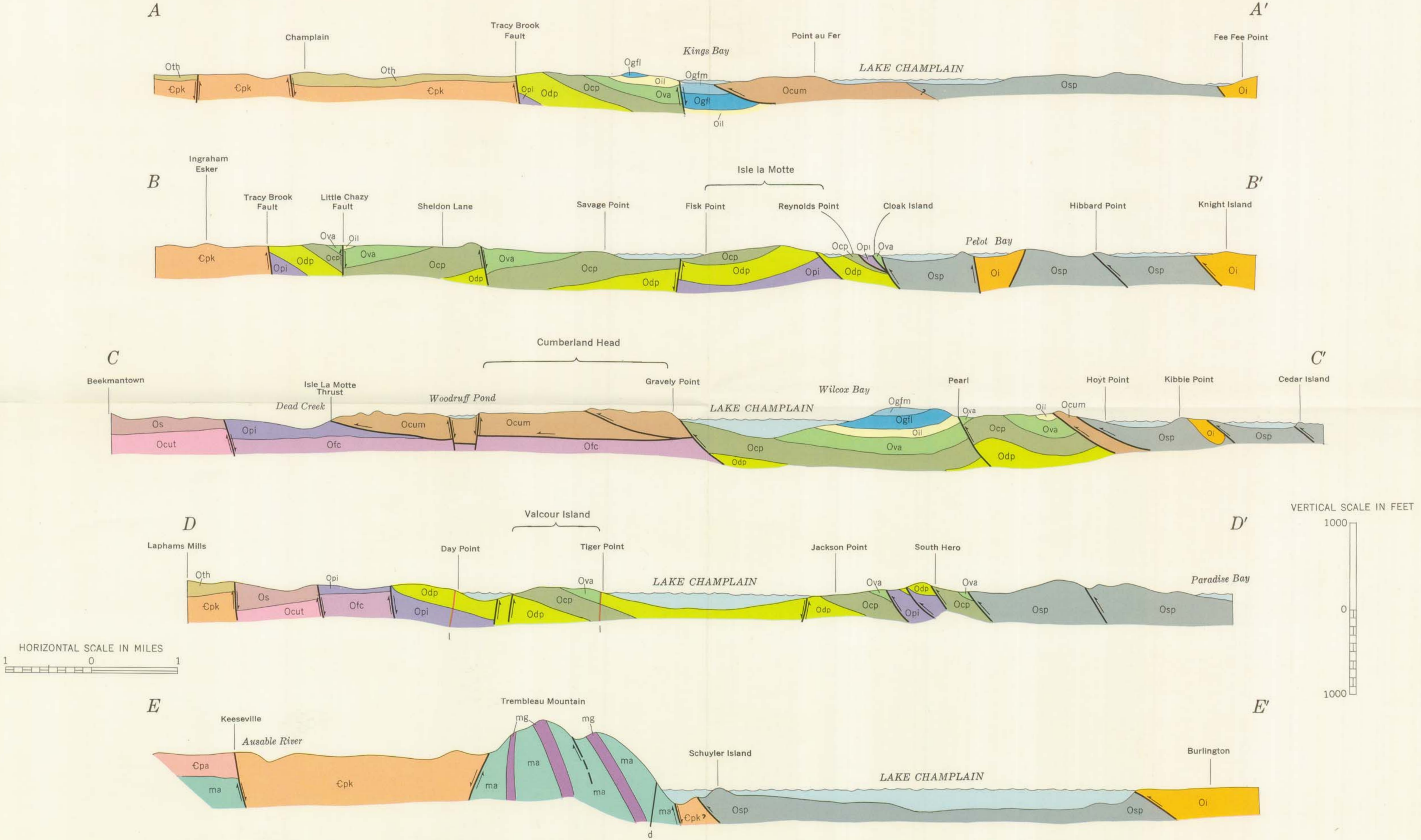

BEDROCK GEOLOGY OF THE PLATTSBURGH AND ROUSES POINT QUADRANGLES, NEW YORK AND VERMONT
(PLATE 2)