GEOLOGIC EXCURSION FROM ALBANY TO THE GLEN VIA LAKE GEORGE

by
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The purpose of this guide is three-fold: to describe very briefly the geology of the Adirondack region as a whole, to offer in the southeastern Adirondack region a smorgasbord of representative Adirondack lithologies and structures, and to discuss features of pre-glacial drainage along the excursion route. Laymen using this guide would profit by first reading a more elementary presentation by Broughton and others (1962).

The present Adirondacks are dome mountains which came into existence during one or more periods of uparching in Phanerozoic, not Precambrian time. This is clear from the quaquaversal dips of bounding Cambrian and Ordovician strata, and from the preservation of Cambrian and Ordovician rocks on the floors of graben within the Adirondack perimeter (Figs. 1,2,3). A profound unconformity separates the mantling Paleozoics from the Precambrian core of the dome. A striking and puzzling feature of the dome is that it exhibits the highest elevations in the Canadian Shield south of the Torngat Mountains which are located nearly 1200 miles distant at the northern tip of Labrador.

To the northwest, the Precambrian core is connected to the rest of the Grenville Province of the Canadian Shield across a narrow arch called the Frontenac Axis, an uplift which is responsible for the "Thousand Islands" region of the St. Lawrence River. On the east, the Adirondack dome is bounded by the down-faulted Champlain basin, beyond which lies the Middlebury synclinorium and thence the Green Mountain anticlinorium with its Precambrian core. Along its eastern and southern flanks, the Adirondack dome is much broken by block faulting, and the Precambrian-Paleozoic contact is a fault, along most of its length (Figs. 2,3). From the latitude of Ticonderoga southward, the central part of the Middlebury synclinorium is occupied by the Taconic Mountains, an elongate mass of Cambrian and Ordovician clastics which are interpreted by most workers to have slid into their present position as a giant klippe from the east during the Taconic disturbance, about 450 m.y. ago (Fig. 5). The Taconic range is clearly visible from the excursion route on auspicious days (Fig. 6).

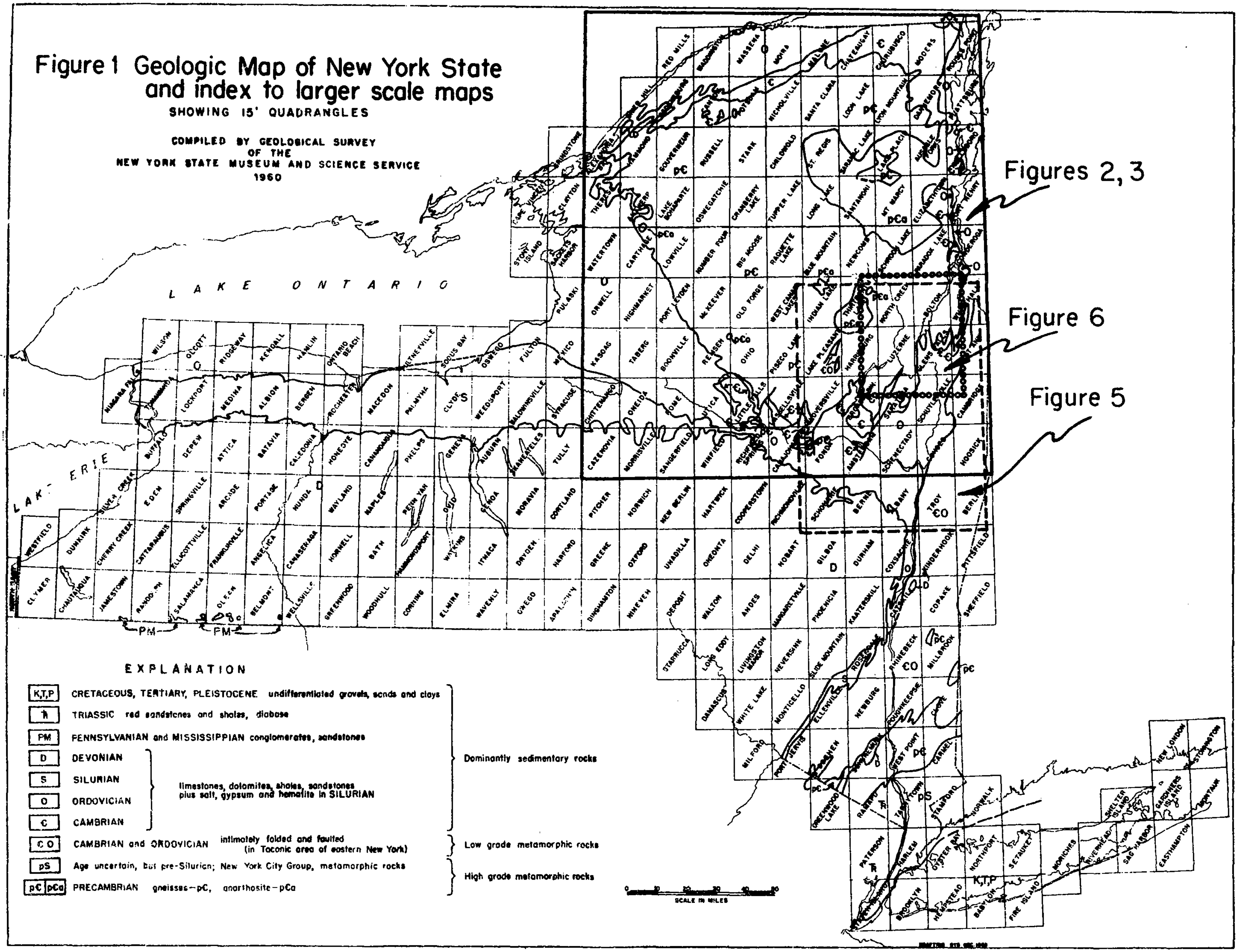
Rock Types and Metamorphism

The Adirondack Precambrian has been conveniently subdivided on the basis of topography and lithology, into two parts: The Central Highlands which comprise 80% of the area, and the Northwest Lowlands. The Highlands are composed dominantly of resistant feldspathic and quartzo-feldspathic rocks, including the extensive sheet of anorthosite which forms the high peaks region. The northwest Lowlands are underlain mainly by less resistant calcitic and dolomitic marbles, biotite-quartz-plagioclase paragneiss, and granitic gneisses. Areal extents of the major rock types are given as follows:

Figure 1 Geologic Map of New York State and index to larger scale maps

SHOWING 15' QUADRANGLES

COMPILED BY GEOLOGICAL SURVEY
OF THE
NEW YORK STATE MUSEUM AND SCIENCE SERVICE
1960



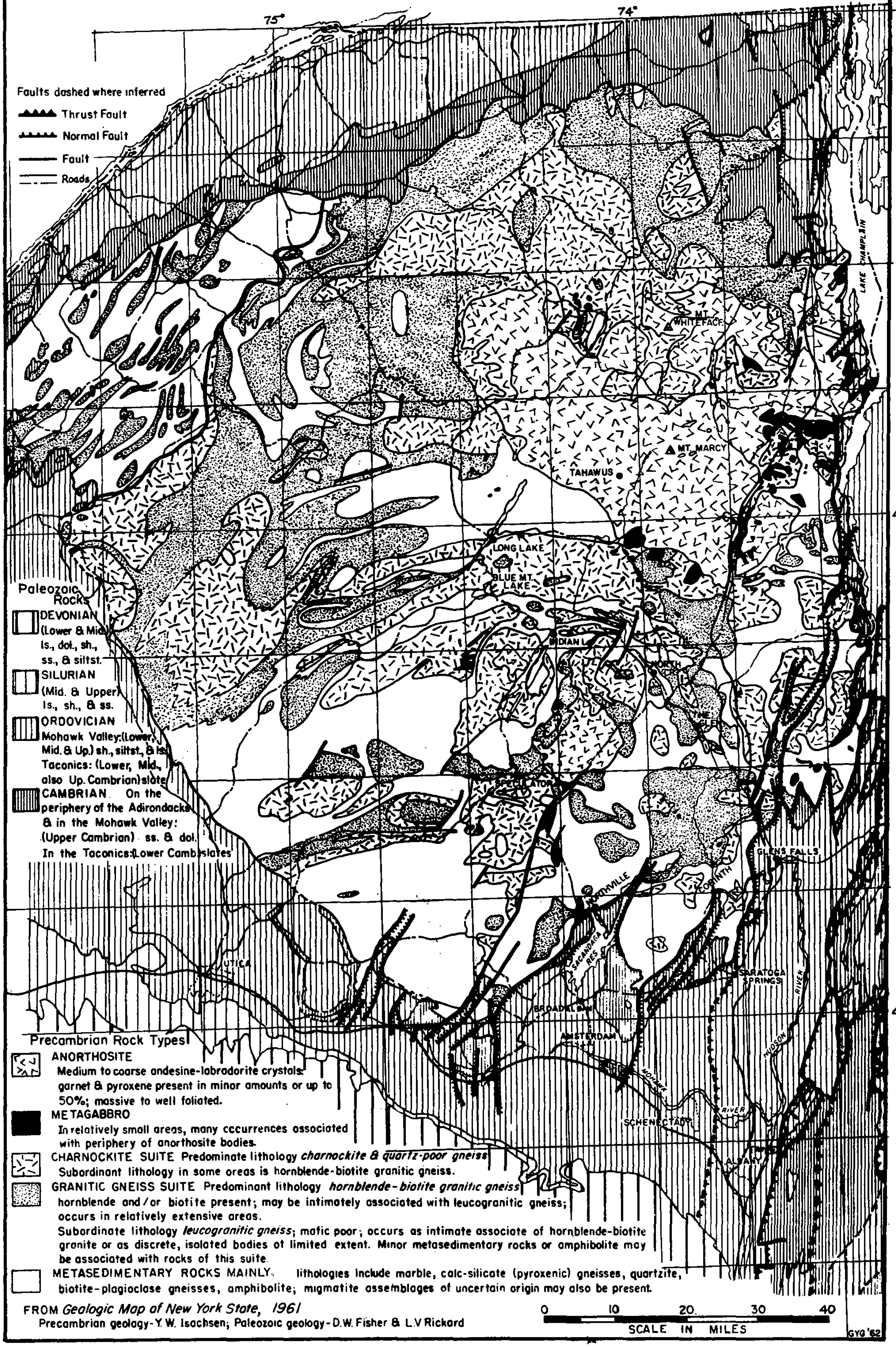
LITHOLOGIC TYPE	Area, Km^2	Area, Mi^2	Area, %
Metagabbro	40	17	0.1
leucogranitic (alaskitic) gneiss	820	320	3.1
hornblende-(biotite)-granite gneiss	6400	2470	23.8
syenitic gneiss	770	300	2.9
charnockitic gneisses	6400	2480	23.8
meta-anorthosite	3750	1450	14.0
metasedimentaries, amphibolite, mixed gneisses	8700	3350	32.4
TOTAL	27x10^3	10x10^3	100.1

Adirondack Precambrian rocks may be classified under three genetic categories: metasedimentary, metaigneous, and metamorphic of complex and/or uncertain origin. Practically all are characterized by metamorphic textures and mineral assemblages, the only notable exceptions being the relatively anhydrous lithologies - metagabbro and meta-anorthosite - which commonly have relict ophitic textures and cores of relict mineral grains. Of the other rocks, the only ones whose parentage is certain are those having diagnostic chemical compositions, namely, marble, calc-silicate rock, quartzite, and pelitic paragneisses. The paragenesis of the remainder, particularly amphibolite and various feldspathic gneisses of syenitic, granitic and charnockitic composition, is still a matter of conjecture inasmuch as matching compositions can be found among sedimentary, volcanic, and plutonic rock types. This dilemma is, of course, not unique to the Adirondacks, but applies to all terranes of deep seated regional metamorphism. The structural patterns of these units does not generally provide a basis for decision either: the rocks are not cross-cutting but occur as folded layers within thick stratigraphic sequences. Hence, the degree to which the parent rocks are interpreted as sediments, volcanics, or concordant intrusives depends at present largely upon the particular area under study and the predilections of the investigator.

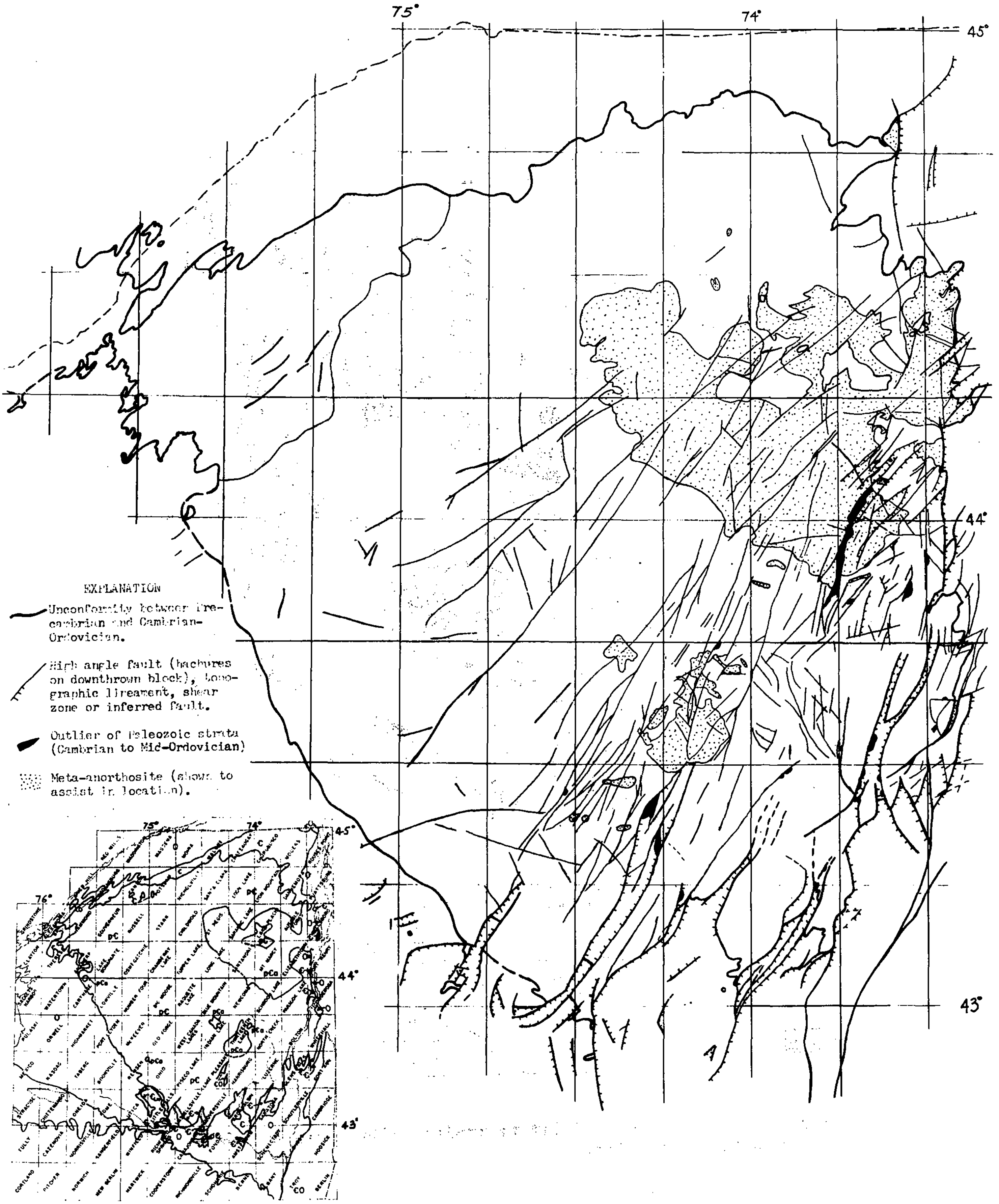
Metamorphic rank in the Adirondacks increases progressively from the upper amphibolite facies in the Northwest Lowlands to the granulite facies in the Central Highlands. Further subdivisions have been made by Buddington (1939, 1963) who has drawn 5 isograds on the basis of first appearance of garnet or orthopyroxene in specified gneisses, and by de Waard (1964; in press) who has subdivided the granulite facies of the Central Highlands into six subfacies.

A variety of geothermometers has been used in the Adirondacks in an attempt to measure the temperatures at which metamorphic recrystallization occurred. From four independent geothermometers temperatures are inferred to have ranged from 525°C for rocks of the sillimanite - almandite-muscovite subfacies of the Northwest Lowlands, to as high as 750°C for rocks of the pyroxene granulite facies in the Central Highlands (Engel and Engel 1958, Buddington, 1963).

GEOLOGY OF NORTHEASTERN NEW YORK STATE



FROM *Geologic Map of New York State, 1961*
Precambrian geology - Y. W. Isachsen; Paleozoic geology - D. W. Fisher & L. V. Rickard



Index to quadrangles

Figure 3. Map showing faults, inferred faults, topographic lineaments and shear zones in the Adirondack-Mohawk Valley region.

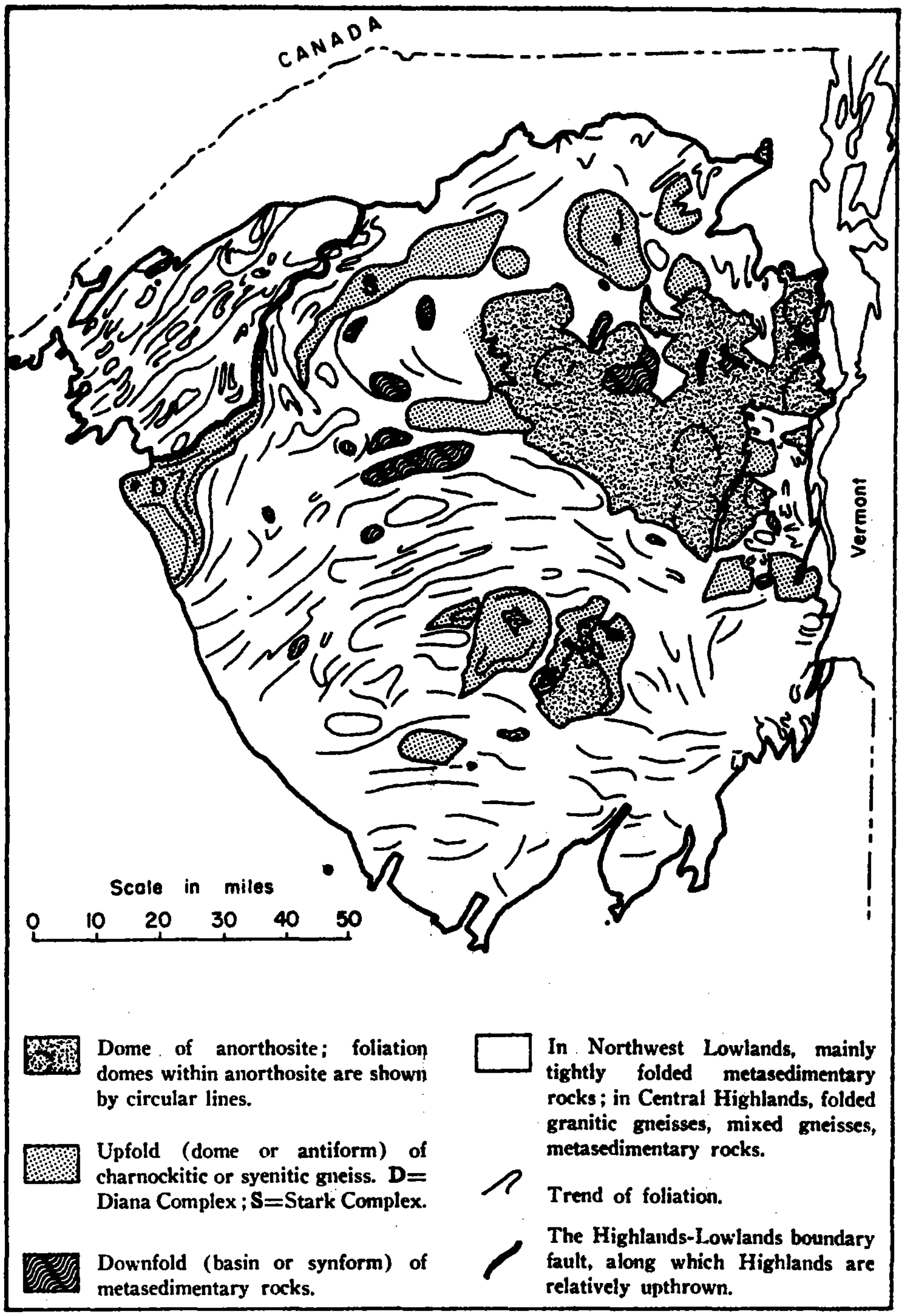
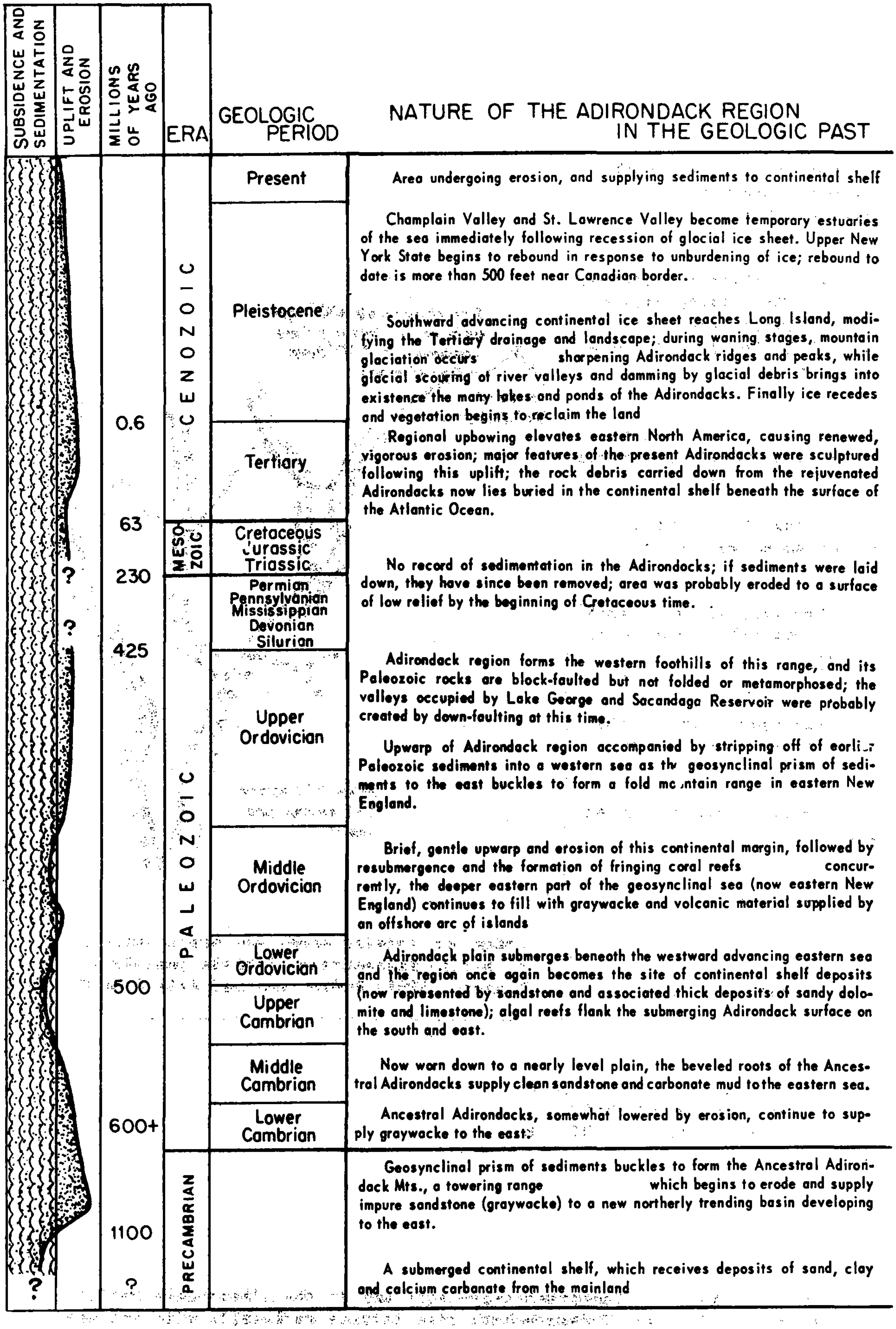


Figure 4. Highly simplified tectonic-geologic map of the Adirondack Precambrian.



MILLIONS OF YEARS AGO	ERA	GEOLOGIC PERIOD	NATURE OF THE ADIRONDACK REGION IN THE GEOLOGIC PAST
	CENOZOIC	Present	Area undergoing erosion, and supplying sediments to continental shelf
0.6		Pleistocene	Champlain Valley and St. Lawrence Valley become temporary estuaries of the sea immediately following recession of glacial ice sheet. Upper New York State begins to rebound in response to unburdening of ice; rebound to date is more than 500 feet near Canadian border. Southward advancing continental ice sheet reaches Long Island, modifying the Tertiary drainage and landscape; during waning stages, mountain glaciation occurs sharpening Adirondack ridges and peaks, while glacial scouring of river valleys and damming by glacial debris brings into existence the many lakes and ponds of the Adirondacks. Finally ice recedes and vegetation begins to reclaim the land
63		Tertiary	Regional upbowing elevates eastern North America, causing renewed, vigorous erosion; major features of the present Adirondacks were sculptured following this uplift; the rock debris carried down from the rejuvenated Adirondacks now lies buried in the continental shelf beneath the surface of the Atlantic Ocean.
230	MESOZOIC	Cretaceous Jurassic Triassic	No record of sedimentation in the Adirondacks; if sediments were laid down, they have since been removed; area was probably eroded to a surface of low relief by the beginning of Cretaceous time.
425	PALEOZOIC	Permian Pennsylvanian Mississippian Devonian Silurian	
		Upper Ordovician	Adirondack region forms the western foothills of this range, and its Paleozoic rocks are block-faulted but not folded or metamorphosed; the valleys occupied by Lake George and Sacandaga Reservoir were probably created by down-faulting at this time. Upwarp of Adirondack region accompanied by stripping off of earlier Paleozoic sediments into a western sea as the geosynclinal prism of sediments to the east buckles to form a fold mountain range in eastern New England.
		Middle Ordovician	Brief, gentle upwarp and erosion of this continental margin, followed by resubmergence and the formation of fringing coral reefs concurrently, the deeper eastern part of the geosynclinal sea (now eastern New England) continues to fill with graywacke and volcanic material supplied by an offshore arc of islands
500		Lower Ordovician	Adirondack plain submerges beneath the westward advancing eastern sea and the region once again becomes the site of continental shelf deposits (now represented by sandstone and associated thick deposits of sandy dolomite and limestone); algal reefs flank the submerging Adirondack surface on the south and east.
		Upper Cambrian	
		Middle Cambrian	Now worn down to a nearly level plain, the beveled roots of the Ancestral Adirondacks supply clean sandstone and carbonate mud to the eastern sea.
600+		Lower Cambrian	Ancestral Adirondacks, somewhat lowered by erosion, continue to supply graywacke to the east.
1100 ?	PRECAMBRIAN		Geosynclinal prism of sediments buckles to form the Ancestral Adirondack Mts., a towering range which begins to erode and supply impure sandstone (graywacke) to a new northerly trending basin developing to the east. A submerged continental shelf, which receives deposits of sand, clay and calcium carbonate from the mainland

Figure 5. Synopsis of geological history of the Adirondack region during the past billion years. (after Isachsen, 1962)

☐ Sand-veneered Tertiary rock terrace(s); Cambrian and Ordovician strata

▨ Dissected Appalachian Plateau, bounded by Helderberg escarpment; horizontal Devonian strata; Silurian present west of Gallupville

░ Taconics; folded and faulted Cambrian and Ordovician strata

▓ Southeastern Adirondacks; Precambrian metamorphics

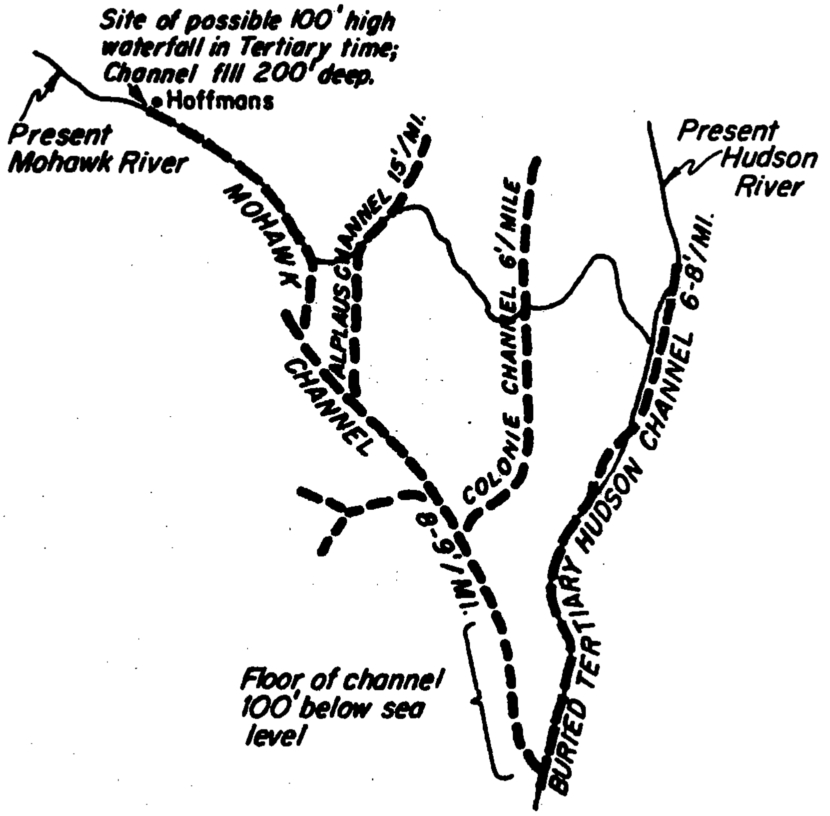
▬ ▬ Buried Tertiary stream channel cut into bedrock; dashed where inferred

╱ High angle fault, topographic lineament, or inferred fault

╱ Thrust fault; teeth on thrust plate

∥ Excursion route

Scale 1:500,000

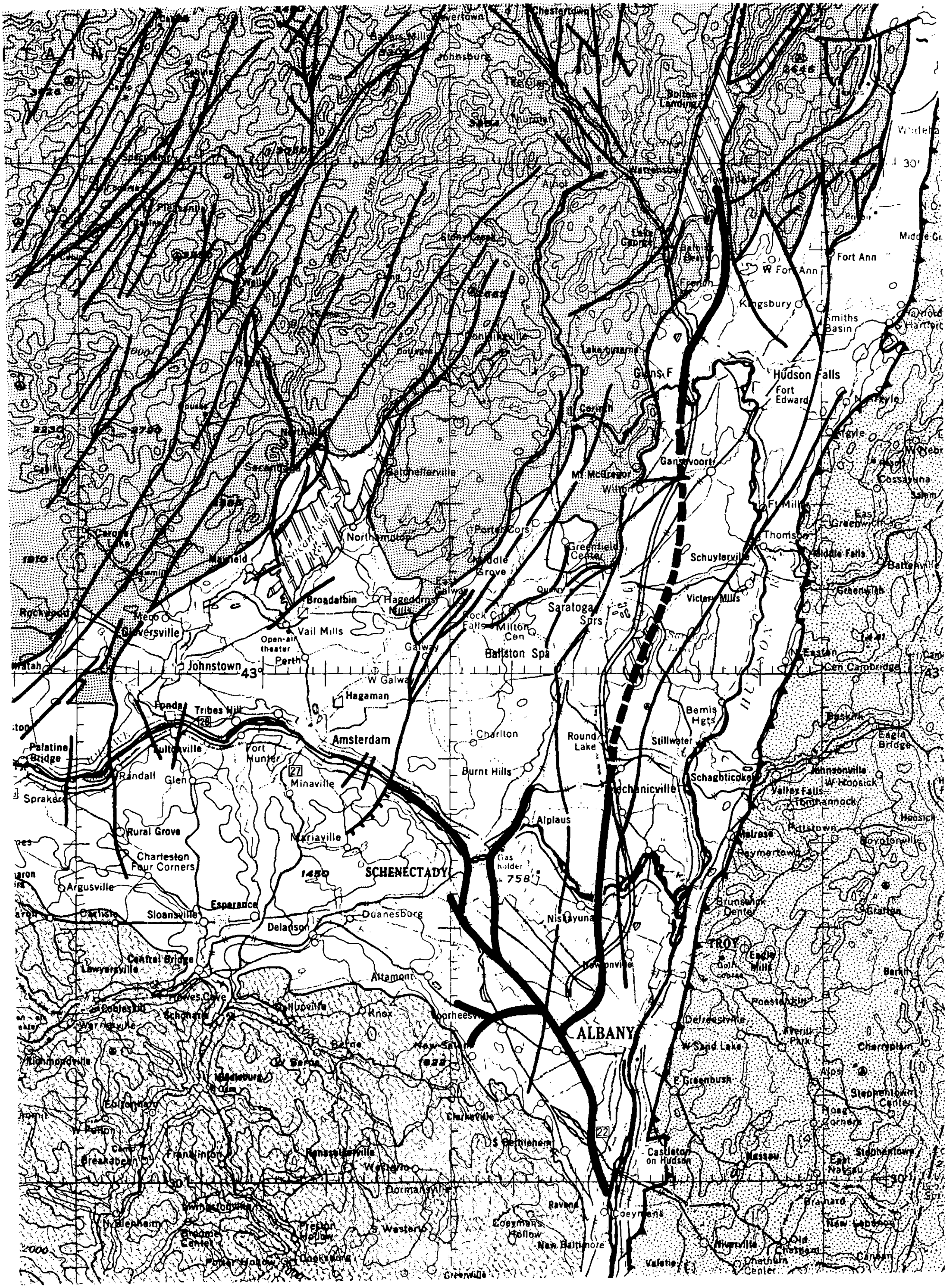


Index map showing names and approximate gradients of buried paleostream channels (mainly after Simpson, 1949; Hudson channel data from Bruehl, 1965.

0 10 20 mi.

0 10 20 30 km.

Explanation for figure 6: Topographic-geologic map of the Albany-Lake George region showing the Tertiary Hudson-Mohawk rock terrace surface(s) with incised Tertiary stream channels, and the bordering upland areas.


Chestertown
Bakers Mills
Johnsburg
Bolton Landing
Thurman
Warrensburg
Cleverdale
Lake George
Fort Ann
W Fort Ann
Kingsbury
Smiths Basin
Hartford
Whiteha
30′
Middle Gr
Lake Luzerne
Glens F
Hudson Falls
Fort Edward
Argyle
Corinth
Gansevoort
Mt McGregor
Wilton
Batchellerville
Northampton
Sacandaga
Porter Cors
Greenfield Center
Middle Grove
Ft Miller
Thomson
Schuylerville
Greenwich
Cossayuna
Salem
Middle Falls
Battenville
Mayfield
Broadalbin
Hagedorns Mills
Vail Mills
Open-air theater
Perth
Rock City Falls
Milton Cen
Saratoga Sprs
Victory Mills
Ballston Spa
Gloversville
Johnstown
43°
Galway
W Galway
Hagaman
Amsterdam
Charlton
Easton
Cen Cambridge
Fonda
Tribes Hill
Fultonville
Fort Hunter
Palatine Bridge
Randall
Glen
Sprakers
Minaville
Burnt Hills
Round Lake
Stillwater
Bemis Hgts
Mechanicville
Schaghticoke
Buskirk
Eagle Bridge
Johnsonville
Valley Falls
Tomhannock
W Hoosick
Hoosick
Rural Grove
Mariaville
Alplaus
Pittstown
Melrose
Raymertown
Boyntonville
Charleston Four Corners
Argusville
1450
SCHENECTADY
Gas holder
758′
Niskayuna
Brunswick Center
Grafton
Carlisle
Sloansville
Esperance
Duanesburg
Delanson
Central Bridge
Lawyersville
Altamont
Newtonville
TROY
Eagle Mills
Golf course
Berlin
Howes Cave
Cobleskill
Schoharie
Knox
Berne
Voorheesville
Poestenkill
Defreestville
ALBANY
W Sand Lake
Averill Park
Richmondville
Middleburg
New Salem
1933
E Greenbush
Stephentown Center
Clarksville
S Bethlehem
22
Castleton on Hudson
Nassau
East Nassau
Stephentown
Breakabeen
Rensselaerville
Westerlo
Dormansville
30′
Ravena
Coeymans
Coeymans Hollow
New Baltimore
S Westerlo
Preston Hollow
N Blenheim
Gilboa
Niverville
Chatham Center
New Lebanon
Brainard
Valatie
Greenville
Cairo
2000
Rockwood
Caroga Lake
1810
Speculator
Wells
Pleasant
Hope
2230
2730
Edinburg
Conklingville
Stony Creek
3250
3340

Pressure during metamorphism can only be roughly bracketed. At a temperature of 750°C, sillimanite is stable between 5 and 14 k.b. (Waldbaum, 1965) which corresponds to depths of burial ranging from about 20 to 50 km. The present boundary between the crust and mantle in the Adirondack region is calculated from seismic velocities to be about 35 km (Katz, 1955).

Structural Geology

In Adirondack metasedimentary rocks and mixed gneisses, compositional layering, most of it relict bedding, is common. Foliation characterizes almost all lithologies except the more pure facies of meta-anorthosite, metagabbros, and certain calc-silicate granulites. Lineation, prevailingly aligned with minor and major fold axes, is fairly common, especially in the axial portions of folds.

The larger structural features of the Adirondacks as defined by trends of foliation are shown in figure 4. In gross manner, the Central Highlands may be subdivided into two major domical areas; the main massif of meta-anorthosite, and the cluster of meta-anorthosite bodies and surrounding charnockitic gneisses south of it. Upfolds in the Adirondacks include domes, doubly-plunging isoclinal anticlines, recumbent folds and nappes. The downfolds range in cross section from open to isoclinal.

Both of the major domical areas correspond to topographic highs. Within them the main grain of the topography is largely determined not by rock foliation, but by accelerated erosion along north-northeast trending high-angle faults which define the present pattern of lakes and drainage in the southeastern half of the Adirondacks (compare figure 3 with any road map). The number of faults and the magnitudes of displacement diminish gradually to the northwest. From topographic relief in the vicinity of Paleozoic outliers, minimum vertical displacements of 3000 feet are indicated. South of the Adirondacks the faults extend into Cambrian and Ordovician strata, but seem to end in the Ordovician of the Mohawk Valley (Fig. 2).

Dating the Adirondack doming and faulting is a major problem; it is not even certain they are related in time. The presence of downfaulted Middle Ordovician carbonate rocks within the Adirondack massif, however, proves that both doming and some fault movement occurred after the Middle Ordovician (Fig. 3). It is not known to what extent the fault movements represent reactivation along Precambrian fracture zones.

Geological History

A simplified synopsis of the geological history of the Adirondack region during Phanerozoic time is set forth in Figure 5. The Precambrian sequence of events is considerably less certain owing to the structural complexity and the high rank of metamorphism. At present, two interpretations are under consideration. That advocated by Buddington (1939, 1952) is based largely on the concept that a unit is younger than any rock it transgresses. Following this premise, the metasedimentary rocks are the oldest in the region, and were intruded successively by 1) the anorthosite series, 2) olivine diabase and gabbro, and 3) concordant sheets of the syenitic and charnockitic series. This was followed in turn by a period of orogenic folding, intrusion of hypersthene diabase, a period of orogenic deformation and metamorphism, intrusion of granite and leucogranite (alaskite), and a final period of orogenic deformation and metamorphism - the Grenville orogeny.

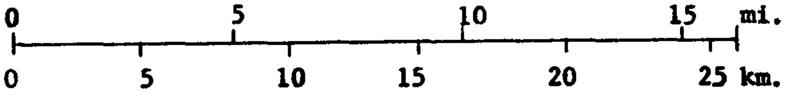
According to a second interpretation (Walton, 1953, Walton and deWaard, 1963) the anorthositic, syenitic, and charnockitic gneisses represent the deeply eroded roots of an earlier mountain system whose beveled roots became submerged and received the sediments which we see today as metasedimentary rocks. Following this sedimentation, the composite terrane was subjected to the deep-seated deformation and metamorphism of the Grenville Orogeny which resulted in partial melting and local remobilization of granitic components in the earlier basement to produce the local transgressive relationships now seen. Relative metamorphic mobilities ranged from slight for anorthosite (which deformed mainly by granulation and recrystallization), through moderate for the syenitic and charnockitic gneisses (which mainly underwent plastic deformation) to maximum for hydrous fractions of granitic composition (which underwent partial or total fusion). Some of the pink granitic gneisses presumably formed in this way.

This sequence of relative mobilities would thus explain, in quite a different way, the intrusive relationships on which Buddington's interpretation of Adirondack geological history was based; namely, the greater the metamorphic mobility, the more transgressive the rock, and consequently, the younger its apparent age. Intrusion of gabbro, which cuts virtually all Adirondack lithologies, is interpreted as the last event before the Grenville Orogeny.

Radiometric dating of minerals and whole rocks from the Adirondacks, totaling more than 30 determinations thus far (Isachsen, 1963; Silver, 1963) indicates that this last major thermal event occurred about 1100± 100 million years ago. As indicated above, the prior geologic history of the region is still a matter of considerable conjecture - despite the fact that the Adirondacks are among the most thoroughly studied of Precambrian terranes.

PHANEROZOIC	Quaternary	Q	Glacial and alluvial deposits, underlying geology unknown
	Middle & Lower Ordovician	Osh, Otbr Ob	Ob: Beekmantown Group carbonates, Otbr: Undifferentiated Trenton and Black River Groups; Osh: Snake Hill Shale
	Upper Cambrian	Єp, Єss	Єp: Potsdam Sandstone; Єss: Saratoga Springs Group
	Lower Ordovician, Upper & Lower Cambrian	ЄO	Undifferentiated Taconic rocks - largely pelites
PRECAMBRIAN		gb	metagabbro
	Relative Ages Uncertain	hbg, lg	hbg: hornblende-(biotite)-granitic gneiss, generally pink; lg: leucogranitic gneiss, generally pink
		ch	charnockitic gneiss, generally dark green
		a	meta-anorthosite
		am, amg	am: amphibolite; amg: interlayered amphibolite and granitic gneiss
		mu	metasedimentaries, mainly distributed as follows: topographic highs: biotite-quartz-plagioclase gneiss, interlayered metasedimentary and granitic gneisses, quartzite topographic lows: calcite marble, calc-silicate rock
		┬┬┬———	high angle fault; where known to be a normal fault, hachures on downthrown side
		---------	topographic lineament, inferred fault, or shear zone

Scale 1:250,000



Explanation for figure 7, Geologic Map of the Lake George Region


hbg
mu
ch
gb
amg
LAKE GEORGE
WARREN COUNTY
Northwest Bay
Brant Lake
322
Glen Lake
Glens Falls
Hudson Falls
Fort Edward
Sacandaga Reservoir
Ob
Otbr
Kingsbury
Smiths Basin
Adamsville
Moreau
Fortsville
Gansevoort
Ballard Corners
Black Pond
Lake Desolation
Snook
1500
1000
2000

ROAD LOG FOR GEOLOGIC EXCURSION FROM ALBANY TO THE GLEN VIA LAKE GEORGE

MILEAGE		
Cum.	B.P.	
0.0	0.0	From the Thruway Motel proceed west on Washington Avenue toward Northway entrance. To the south, Lower Devonian carbonates form the Helderberg escarpment which marks the northern boundary of the Appachachian Uplands (fig. 6).
0.4	0.4	The road cuts through an arrested sand dune developed on a former sand terrace of glacial lake Albany.
		The excursion route between Albany and the Lake George region passes over the floor of this glacial lake. It is marked by lacustrine sand terraces which have, in part, been reworked by wind to form an undulating dune topography. The landscape has been further modified by post-glacial drainage. Beneath the sand veneer, which is generally less than 50 feet thick, is a rock terrace at about 300 feet elevation. This Tertiary erosion surface forms a broad platform extending between the block-faulted scarp of the Adirondack Highlands on the northwest, and the Taconic Mountains on the east and the Appalachian Uplands to the south.
1.2	0.8	Leave Washington Ave. and proceed north onto the Northway (Interstate Highway 87). Avoid continuing westward onto the Thruway (Interstate Highway 90).
9.0	7.8	Road descends toward the Mohawk River cutting through the blanket of lacustrine sands and into the Middle Ordovician Normanskill Formation which is exposed on the right. Lithologies represented are graywacke with mud pellets ("flysch and chips") and overlying shale. The large area of Normanskill of which this is a part has been interpreted alternatively as a thrust outlier of the Taconic klippe and as the core of a north-trending anticline.
9.5	0.5	The attractive pair of tied arch bridges spanning the Mohawk River ahead received honorable mention for design in 1958 by the American Institute of Steel Construction.
9.6	0.1	Cross the Mohawk River which here occupies a post-glacial gorge cut into the Normanskill Formation. Immediately to the west is a deeply buried pre-glacial gorge referred to as the Colonie channel (Fig. 6). Since this paleostream channel has the flattest gradient of the tributaries as presently known, it may have been the major river draining the southeastern Adirondack region in Tertiary times. In contrast, the buried Tertiary Hudson channel probably drained the Hoosic and Batten Kill water sheds, as does the present Hudson River, but did not extend much farther north (Simpson, 1949). Beneath the

MILEAGE
Cum. B.P.

present Hudson River at the foot of Madison Avenue in Albany, the buried Tertiary Hudson channel is almost 100 feet below sea level.

Immediately west of our present location, the floor of this filled channel is about 200 feet below the present Mohawk River which meanders across it at right angles. At the north end of Saratoga Lake it is about 45 feet above sea level, and west of the City of Albany about 80 feet below sea level.

The Northway roughly follows the course of this channel for the next 20 miles or more to a point at the north end of Saratoga Lake (Fig. 6). Beyond this, its extension is largely hypothetical, although supported where drawn across the present Hudson River near Glens Falls by an anomalous lack of outcrop in that short stretch. From Albany north for a distance of about 10 miles where the configuration is best known, it is a relatively steep-walled channel, perhaps owing to glacial scour.

The main tributary to the Colonie channel, the ancestral Mohawk Channel shown on figure 6, has been traced as far west as the Hoffman Fault where a 100 foot high waterfall may have existed in pre-glacial times (Simpson, 1949). There are about 200 feet of channel-fill in the stretch between Schenectady and Hoffmans, and the present Mohawk River meanders over its surface.

Within the next mile the road climbs back up on the Pleistocene cover. Immediately to the east, a bedrock ridge protrudes a hundred feet above the level of the Tertiary terrace. Such relatively rare projections were islands in glacial lake Albany, which had a shoreline at about the present 300 feet contour.

21.5 4.7 Northway crosses one of the glacial meltwater channels which is now occupied by Ballston Creek. Looking down the valley to the southeast the Round Lake depression may be seen. This and Saratoga Lake to the north represent unfilled depressions, perhaps kettle lakes, on the glacial debris occupying the pre-glacial Colonie channel (Woodworth, 1905; Cook, 1930 p. 197).

23.8 2.3 Road descends into the valley of Drummond Creek, and for one-half mile cuts into highly fissile black shale of the Snake Hill Formation.

31.5 7.7 The escarpment which has been intermittently visible to the west extends from Saratoga Springs northward for a distance of 25 miles. It is a fault line scarp produced by differential erosion along the McGregor fault which marks the boundary between the Precambrian (here composed mainly of east-west trending metasedimentary rocks) and the Paleozoics. On the basis of measured Paleozoic sections in the Mohawk and south Champlain

MILEAGE
Cum. B.P.

valleys, it is estimated that the vertical displacement along the McGregor is at least 2200 feet.

It is only possible at present to date the normal faulting of the eastern and southern Adirondacks and the adjoining Mohawk Valley region as post-Frankfort (i.e. post Late Ordovician) inasmuch as these are the youngest rocks known to be involved. All of the faults in the Mohawk Valley region either hinge out before reaching the Silurian at the base of the Helderberg escarpment, or pass beneath it without being recognized. Field relationships do not permit an absolute resolution of this question, but the fault movement is inferred to have occurred during the Taconic disturbance (Kay, 1942, p. 1627).

52.5 7.8 Outcrop of Precambrian; the rock here a quartzo-feldspathic gneiss, similar to that exposed at Stop 1.

52.8 .3
Stop 1 Large scale recumbent folding and related structures in biotitic paragneiss.

55.0 Leave Northway, turn east for 0.1 mile, then proceed north on Route 9 for 1 mile. Note views of Lake George which lies in a graben between two blocks of Precambrian gneiss. Leave Route 9 a short distance beyond the Tiki Motel; turn right on road marked "Lake George Beach" (a State Park), and proceed 0.3 miles to junction of Route 9L.

56.3 0.3 Turn right on 9L for 0.1 miles.

56.4 0.1 Turn right at Park entrance.

Stop 2 You are standing on Paleozoic rocks at the floor of the Lake George complex graben, completely surrounded by Precambrian rocks. The steeply rising valley walls are fault-line scarps which give the region a spectacular relief such as is generally found only well within the Adirondack perimeter; the local relief here reaches 2000 feet. Combining this value with the 500 foot estimated thickness of the Paleozoics here gives a minimum vertical displacement of at least 2500 feet.

The crystal clear waters for which this lake is noted, result from the fact that only short mountain brooks drain into the lake, and hence the very fine clay fraction common to most drainage systems is virtually absent. Most of the lake is not deeper than 50 feet, although measured depths of up to 190 feet are shown on the hydrographic map published by the Lake George Power Squadron. The many islands in Lake George number 184, and of those 154 are State-owned. Most are composed of bedrock but several are gravel drumlins according to Newland and Vaughan (1942).

MILEAGE

Cum.	B.P.	
		Lake George now drains northward into Lake Champlain, with a decent of more than 200 feet (from 319 ft. to 95 ft.). In Tertiary time, however, both lake basins were river valleys separated by a drainage divide. The Lake Champlain valley drained into the St. Lawrence as it does today but the Lake George basin drained southward through the relatively wide graben valley located just east of French Mountain (Fig. 7). This valley is now clogged with glacial debris including a well-shaped drumlin 1 and 1/2 miles long (Fig. 7). The inferred Tertiary drainage course is shown in Figure 6.
		At the close of the last ice advance, a glacial lake occupied the basin as indicated by the presence of sand terraces representing several transitory levels in the lowering of the lake to its present elevation. The highest of the terraces has an elevation of 600 feet, and is well represented 1 and 1/2 miles to the southeast, just uphill from the Northway exit on Route 9L (see mileage 56.3).
		The Paleozoics here are exposed in the railroad bed of an abandoned spur of the Delaware and Hudson Railroad, which carried vacationers from down-state to Lake George via Fort Edward and Glens Falls, until 1957. The exposed dolomite strata are either Little Falls or Beekmantown equivalents; fossils have not been found. A fault breccia in the cut contains fragments of lithographic limestone which are probably down-dragged Beekmantown limestone.
		A brief summary of Colonial history of the Lake George region is given in the appendix.
		Leave Stop 2 and proceed west on 9L for 0.4 miles to Route 9 in Lake George Village.
56.8	0.4	Leave Route 9L and turn north on Route 9.
57.4	0.6	Junction with Route 9N. Stay on Route 9 which bears left.
59.2	1.7	Spheroidally weathered metagabbro is exposed in road cuts on the right.
59.6	0.4 Stop 3	Be alert for falling rock!
		This outcrop is interpretated as an u transported soil (saprolith) formed by weathering during the Tertiary from biotitic quartz-feldspar gneiss. Note the degree which Precambrian structures, textures, and minerals are preserved. Above the Tertiary saprolith, the Pleistocene is represented by two fluvioglacial boulder gravel units. The lower gravel is weathered and hence of probable pre-classical Wisconsin age; the upper gravel is unweathered

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and of presumed classical Wisconsin age.

When the exposure was first created in 1936, a 2 to 3 foot thick layer of varved clay was visible between the boulder gravels. This clay is thought to have accumulated in a local body of water along the ice edge rather than as part of the main glacial lake that occupied the Lake George valley, inasmuch as the clay here is some 180 feet above the highest glacial sand terrace in Lake George Basin (Newland & Vaughan, 1942).

Tertiary saproliths such as this rarely survive Pleistocene glaciation, and are even more rarely exposed, owing to rapid mechanical disintegration and concommitent plant overgrowth. This steep outcrop apparently survives only due to constant removal of material for human use from its base. Similar saproliths have, however, been discovered in a number of localities in the Adirondacks, and in the Hudson Highlands as well, by geologists of the State Department of Public Works in connection with highway construction; they are generally short lived exposures. The structural and topographic conditions that control the preservation of these soils have not been investigated.

Continue northward on Route 9.

60.0 0.5 Where hill starts to level off, note the spheroidally weathered metagabbro cropping out on the right. A fresh outcrop of this lithology will be seen at Stop 5, just north of Warrensburg.

61.0 0.9
Stop 4 New road cuts being made for the Northway here expose pink, gray and green varieties of granitic gneiss. The typical pink granitic gneisses of the Adirondacks are composed chiefly of microcline or microperthite and quartz along with subordinate amounts of oligoclase and one or more of the dark minerals, hornblende, biotite, pyroxene. In most areas, these gneisses are equigranular, but in parts of the southeastern and northwestern Adirondacks they are inequigranular, containing pink microcline crystals (probably porphyroblasts) which measure up to an inch or more in length. This variety is generally considered to have formed by metasomatism of a biotite-quartz- plagioclase paragneiss into which it grades laterally. A

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subordinate lithology in this suite is leucogranitic (alaskitic) gneiss which is most prominent in the Northwest Lowlands, although it appears in the southern and southeastern Adirondacks. In the eastern Adirondacks, several large magnetite ore bodies occur in this gneiss. The granitic gneisses occur as sheets or lenses in a variety of other rock types.

Continue north of Route 9.

The highway follows the flood plain of the meandering Schroon River. Sand terraces at an elevation of about 760 feet may be seen 80 feet above the valley floor. These are representative of Glacial Lake Warrensburg. (Miller, 1923).

62.7 0.2 Village of Warrensburg. Continue on Route 9 to first outcrop north of the village.

64.6 1.9 Drive into parking area on left side of the highway.

Stop 5 Metagabbro sill in biotite-quartz-feldspar gneiss. Both contacts of this thick sill are clearly delimited, and the lower one is actually exposed.

Aside from obvious metasedimentaries, metagabbro is the only metamorphic rock in the Adirondacks whose origin has never been questioned for reasons given earlier.

Although all the minerals of this sill are the product of metamorphic recrystallization, the textures are relict igneous except at the very margin where the rock has been converted to a biotite schist.

The textures are best shown on weathered surfaces. Throughout most of its width, the sill displays a subophitic fabric, but within a few feet of the contact, the rock has a finer-grained chill border with a diabasic texture. The laths of plagioclase that define these relict textures are not single crystals of plagioclase, as originally, but granoblastic aggregates of andesine-labradorite which presumably represents an equilibrium composition for this metamorphic grade and for this bulk chemical composition. In some Adirondack metagabbros, cores of unrecrystallized igneous minerals have survived metamorphism; most notable are "dusty" plagioclase, augite, hypersthene, and olivine.

Primary constituents of the Adirondack metagabbros are plagioclase (labradorite to bytownite), augite, hypersthene, olivine, ilmenite, and magnetite. Reequilibration of this mineral assemblage under conditions of granulite facies metamorphism has resulted primarily in reaction between plagioclase and the mafic minerals to produce less calcic plagioclase plus garnet and/or augite. Where water has entered the system, hornblende is a common metamorphic mineral. In many metagabbros the border zone has been coverted to amphibolite lacking all trace of the parent igneous texture. Aside from the local addition of small amounts of water, however, the metamorphic reconstitution of gabbroic rocks in the Adirondacks has been an essentially isochemical process. In this exposure, the relatively high biotite content of the metagabbro along its lower contact indicates limited influx of K_2O as well as H_2O.

This roadcut clearly shows the metagabbro to be a sill. Commonly, however, the poor outcropping characteristics of the thinner metagabbros make it difficult or impossible to determine shape of the intrusives. This may account in part for the fact that the bodies are commonly shown on the older reconnaissance quadrangle maps as circular masses (Fig. 2).

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Continue driving north and stop at the next outcrop.

65.1 0.5 Stop 6 Fault breccia in chloritic hornblende-biotite granitic gneiss is evidence of an episode of brittle deformation. Rotated angular and tectonically-rounded fragments of the gneiss are cemented by a chlorite paste, and within the gneiss biotite is largely altered to chlorite. This retrograde metamorphism and the local presence of drusy cavities are among the features of Phanerozoic faults that transect the Precambrian.

Dating the normal faulting that is so prevalent in the southern and eastern Adirondacks and in the adjacent Mohawk Valley (Fig. 6) is a major regional problem. The wise adage of mining geologists, "Once a fault always a fault", doubtless applies here and further complicates the problem. Inasmuch as the trends, steep dips, and other structural characteristics of those faults which are wholly confined to Precambrian crystallines do not differ from those which also involve the peripheral Paleozoics, it might be assumed that all are of the same age, namely, post-Frankfort, as mentioned under Mileage 31.5. Some faults, however, are marked by healed breccias whose mineral assemblages are in equilibrium with the regional metamorphic grade of the Precambrian Grenville orogeny. Thus some Phanerozoic normal faulting apparently represents reactivation along Precambrian zones of weakness.

It may be of interest to note in passing that such normal faulting accounts for the rectangular drainage pattern in the Elizabethtown quadrangle to the north. Prior to detailed geologic mapping by Matt Walton, the Elizabethtown quadrangle had been cited for many years as a classic area of rectangular drainage induced by rectangular jointing.

65.8 0.7 On the left are outcrops of paragneiss, and immediately to the north are exposures of intricately contorted and refolded calcite marble and interlayered calc-silicate rock.

66.5 0.7 Junction of Routes 9 and 28: turn left on Route 28. River road joins Route 28 on the left.

69.0 0.6 Road cuts through isoclinally folded beds of calcite marble containing laminae of calc-silicate minerals.

69.6 0.6 Stop 7 At junction of Route 28 and Potter Brook Road. Charnockitic gneiss. This rock is part of a "charnockitic suite" of metamorphic rocks which has widespread occurrence in the Adirondacks (Fig. 2). The suite includes the true charnockites (hypersthene-bearing gneisses of granitic composition) and varieties departing from

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		granitic composition by: 1) having a lower quartz content than the required 10% (or 20%, depending upon rock classification used), and 2) a range in the ratio of plagioclase to K-feldspar of from less than 1 to more than 1. The gneisses are characteristically gray to dark green in fresh exposures, and weather to a maple-sugar brown; pink facies occur also, however. Microperthite is the predominant mineral; mafic minerals may include hypersthene, augite, hornblende, biotite, and garnet. Owing to the variation in percentages of the "essential" minerals, (commonly within a single mapping unit) and the attempt to fit these lithologies into igneous-rock pigeonholes, they have been mapped under at least 12 different names during the past 50 years. They have been most commonly designated "quartz syenite" and "syenite". However, such terms carry a misleading connotation inasmuch as the rocks are at present largely, if not wholly, metamorphic, whatever their ultimate origins.
		In much of the Adirondacks, rocks of this suite occur as unbanded, relatively monolithic layers many hundreds of feet thick. In the southern Adirondacks however, banded charnockitic gneiss with intimately interlayered sedimentary rocks occurs in a number of areas. The monolithic layers are most commonly exposed as the cores of domes and antiforms, as is expectable from their relatively high resistance to erosion.
		The Hudson River, which flows by a few hundred feet to the west, is cut into metasediments.
70.0	0.4	Charnockitic gneiss in road cut on right.
70.7	0.7	Biotite-quartz plagioclase paragneiss in road cuts on right.
70.9	0.2 Stop 8	Quarry on right side of the road in banded, pink and gray paragneisses with scattered biotite schist layers. Breccias occur at northern end of outcrop but more prominent there is a diabese sill with fine-grained chill borders. This is one of many such undeformed diabase intrusives in the Adirondacks. They generally occur as this, steeply-dipping dikes. Inasmuch as they are undeformed they must postdate the Grenville Orogeny. They have been generally interpreted as Late Precambrian.
		Continue northward on Route 28.
71.6	0.7 Stop 9	Roadcut in marble across from junction with road to Friends Lake.

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		The calcite marble and calc-silicate beds here are typically highly deformed, having been isoclinally folded - and probably refolded as well. The relatively competent calc-silicate layers have been stretched, attenuated, and dismembered well beyond the boudinage stage so that they occur as disconnected lenses, hooks, and clots. Such floating fragments have sometimes been picturesquely tagged "tectonic fish", and "dead snakes".
		Minerals which can be readily found and identified include graphite, diopside, brown tourmaline (dravite), pyrite, sphene. Undeformed mafic dikes with fine-grained chill borders may be seen cutting the marble.
		Continue on Route 28 across Hudson River, which here cuts into metasedimentaries.
72.0	0.4	Cross a second bridge, over small tributary to the Hudson River, and immediately park on the left at entrance to closed road.
	Stop 10	Descend to stream, where may be found glacial boulders of most of the resistant Adirondack lithologies. The only major rock type not yet seen on this excursion - anorthosite - is well represented. Both the relatively pure Marcy-type anorthosite and the more mafic Whiteface-type may be found.
		Proceeding upstream a short distance, a wide variety of metasedimentary lithologies may be seen cropping out in the stream bed. These include paragneisses, quartzites of varying purity, amphibolite, marble and calc-silicate rocks.

APPENDIX

History of the Lake George Region

The important historical role played by the Lake George region during Colonial times has been briefly summarized by Newland and Vaughan (1942) and is of sufficient interest to be quoted here:

"The village site was of great strategic importance during the Revolutionary period and earlier Colonial times. Along with Ticonderoga at the north end of the lake it was regarded as a key point for the control of the water route from the St. Lawrence to the Hudson. A nine-mile carry between the head of the lake and the Hudson near the present Glens Falls was the only important interruption to communication by water from the principal settlements in lower Canada and those within the Hudson Valley. Before Colonial times even, there is reason to believe the Indians had followed this route for purposes of war and trade. The Algonquians on the north and the Iroquois who inhabited the main part of what is now New York State were hereditary enemies, given to warlike incursions on each other's territory; but there were times when peaceful pursuits of trade were in order in all probability.

As witness to the military value in which this place was held during the time of early white settlement we have the series of fortifications here erected. Fort William Henry, the first to have been built was constructed by Sir William Johnson in 1755. It was on the terrace between the present railroad station and the Fort William Henry Hotel. It was captured and destroyed by the French under Montcalm in 1757. At present the most interesting relic remaining on the site seems to be the old well which lay within the earthworks, dug in sand and curbed with small stones.

The second fortification to have been erected at the head of the lake was Fort George, half a mile southeast of Fort William Henry on somewhat higher ground, with rock foundation. This was the work of General Amherst (1759) and used by him as a base from which to conduct operations against Ticonderoga then in possession of the French. It was later captured (1775) and its stores seized by a party from Ethan Allen's forces who took Fort Ticonderoga in the same year. There are enough of the entrenchments and building foundations still left on the site to afford a basis for inferring the outlines and general plan of this Colonial and Revolutionary fort. Interesting is the quarry excavation near-by from which stone was obtained for use in building and lime-making; the exposed rock in the open cut consists of a few beds or layers of dolomite, or magnesian limestone, hard and dense.

The last fortification erected here was Fort Gage, named for a British officer of Amherst's army, on the sand terrace back from the lake and some 200 feet above it. It was designed apparently to command the approach to the lake from the south. There are few marks of the fort now visible."

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