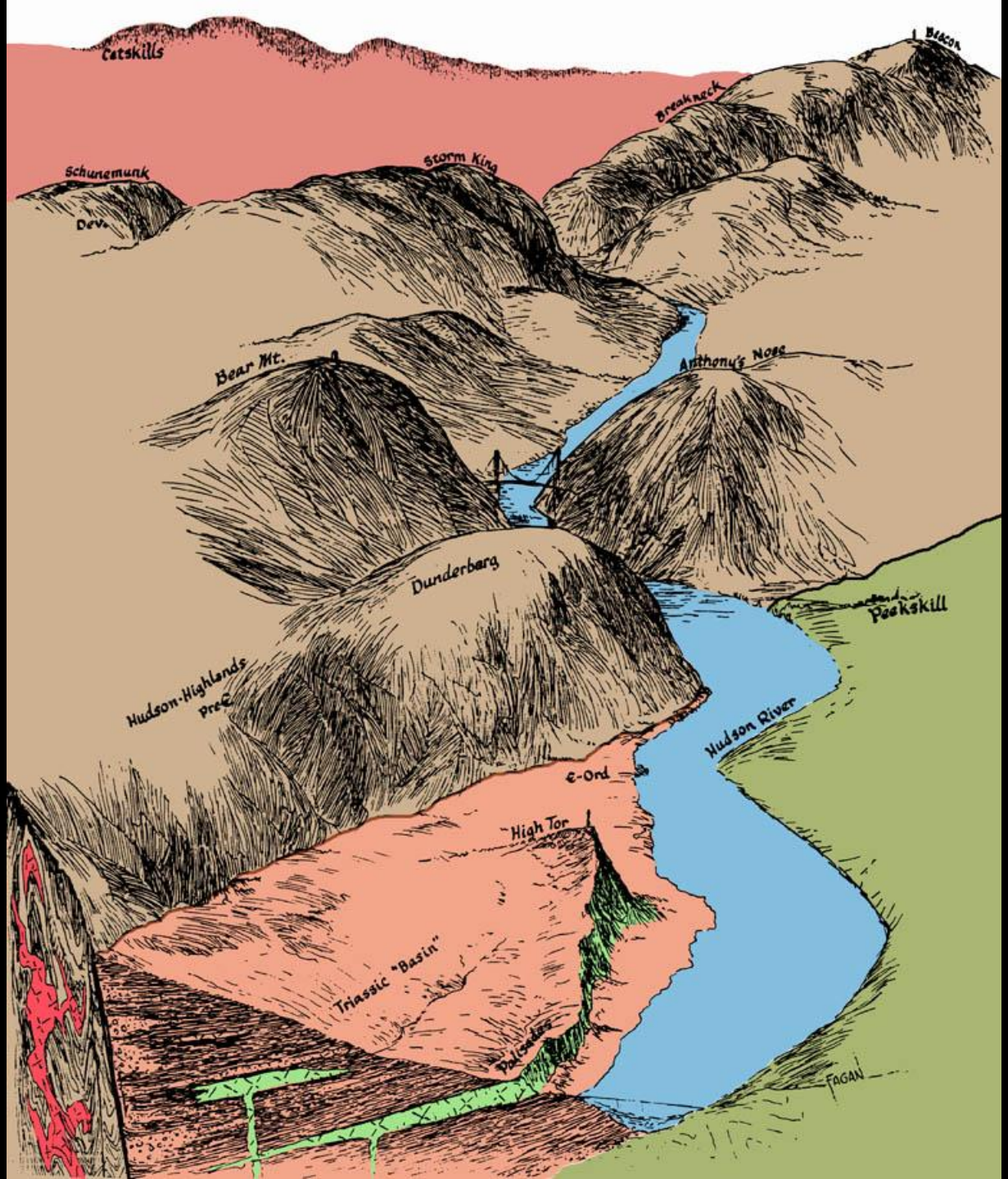
Inquiry Teaching in New York City Parks

Charles Merguerian

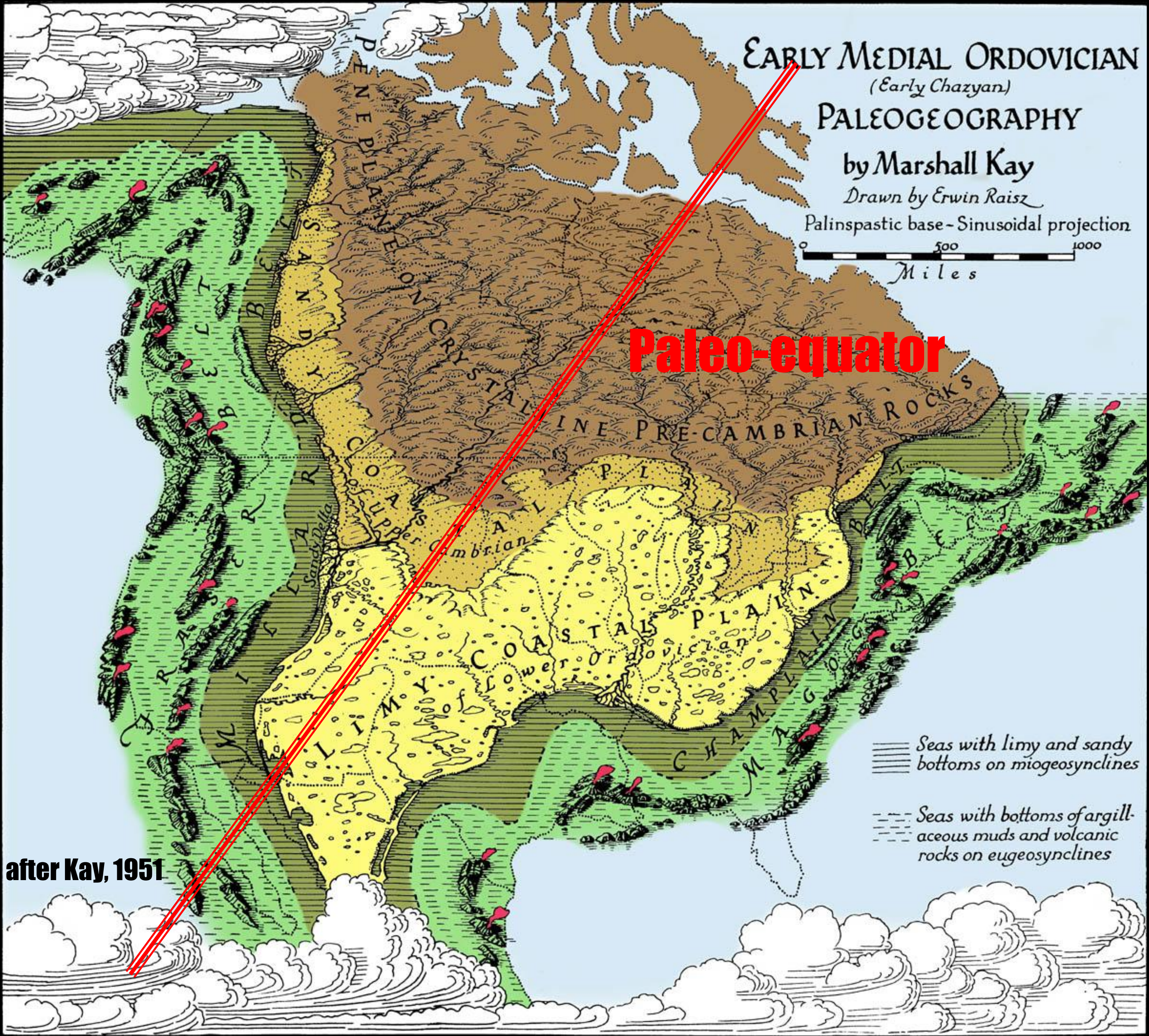
HOFSTRA UNIVERSITY

The Scientific Method of Inquiry

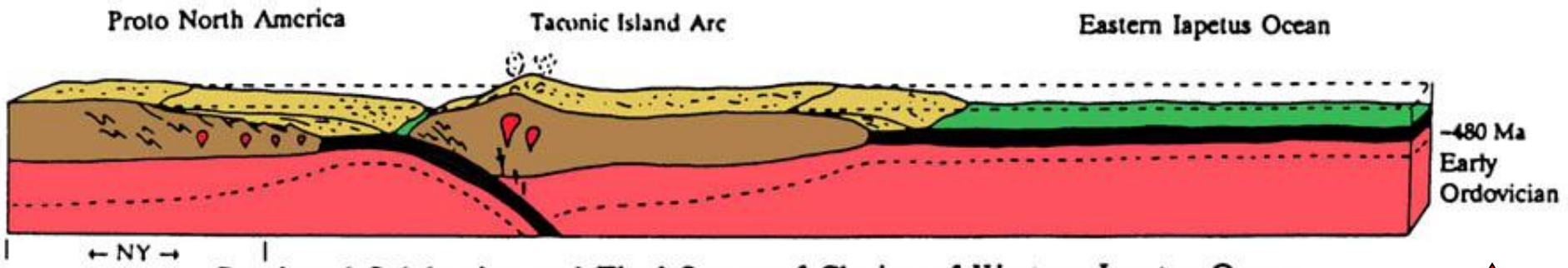
- OBSERVE
- RECORD
- TEST
- PREDICT
- CONTROL



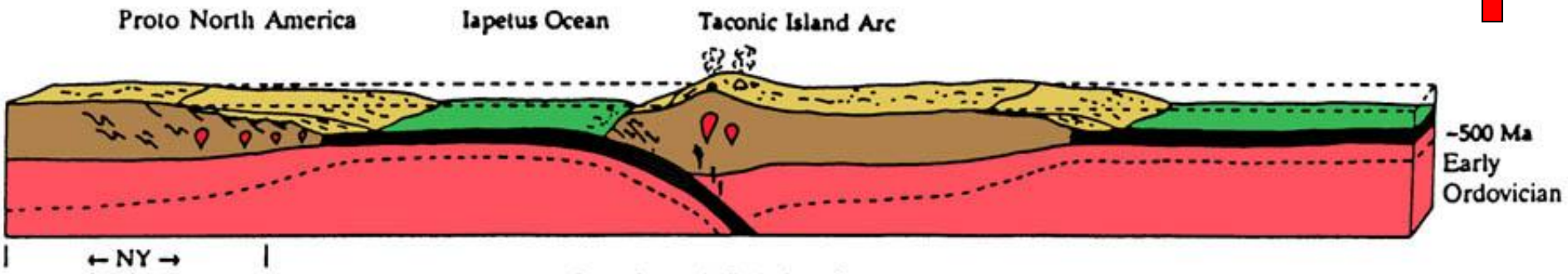
after Fagan 1958



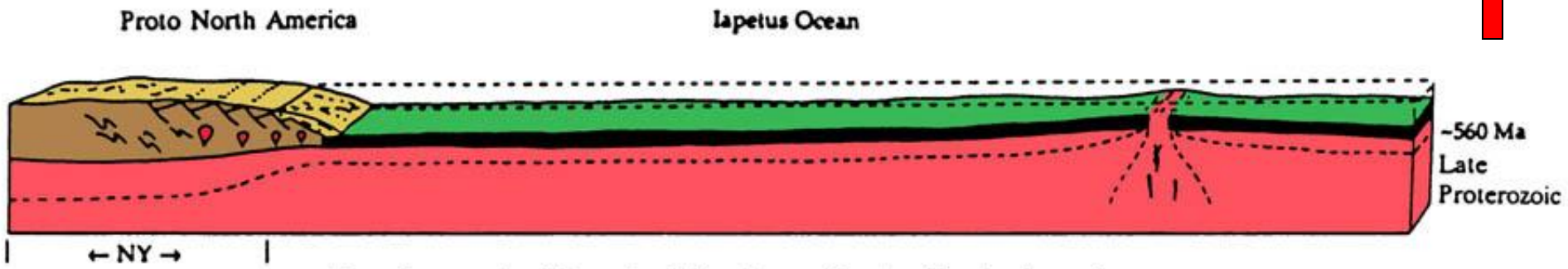
EARLY MEDIAL ORDOVICIAN
(Early Chazyan)
PALEOGEOGRAPHY
by Marshall Kay
Drawn by Erwin Raisz
Palinspastic base - Sinusoidal projection
0 500 1000
Miles
Paleo-equator
PENEPLANE ON CRYSTALLINE PRE-CAMBRIAN ROCKS
SANDY COASTAL PLAIN of Upper Cambrian
LIMY COASTAL PLAIN of Lower Ordovician
Sandy Delta
MILLARD BELT
CORDILLERAN BELT
CHAMPLAIN BELT
MAGOG BELT
Seas with limy and sandy bottoms on miogeosynclines
Seas with bottoms of argillaceous muds and volcanic rocks on eugeosynclines
after Kay, 1951



Continued Subduction and Final Stages of Closing of Western Iapetus Ocean

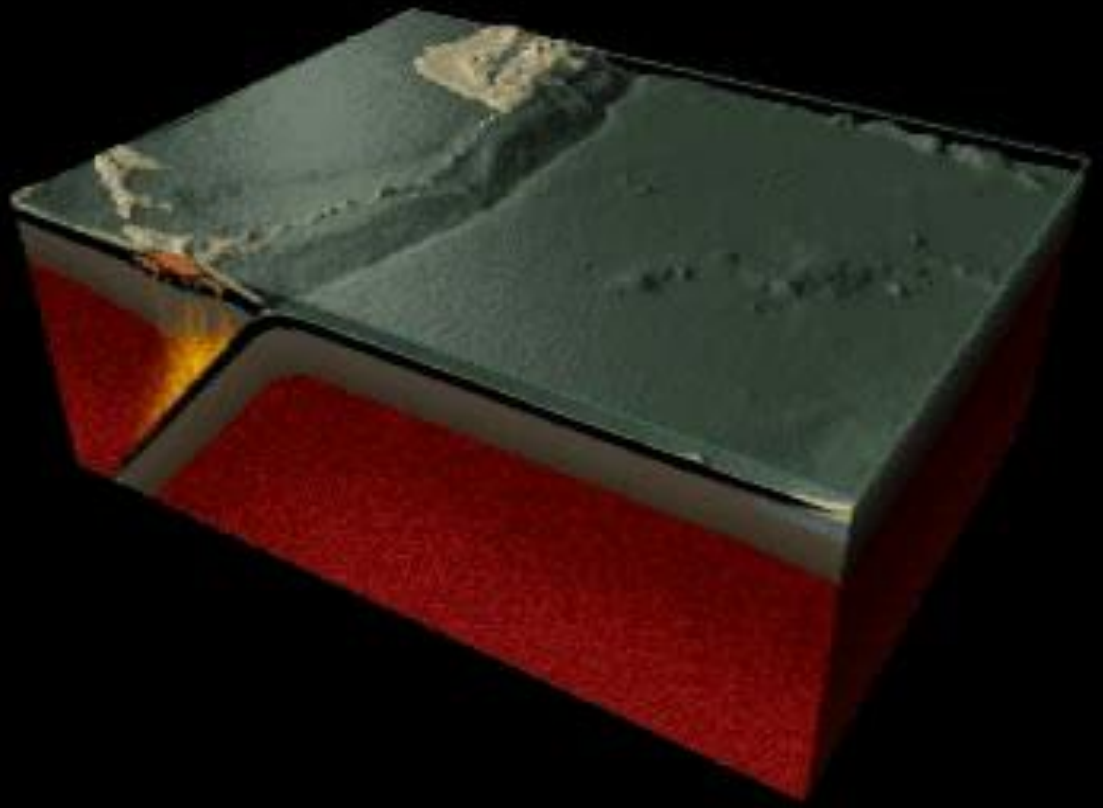


Continued Subduction

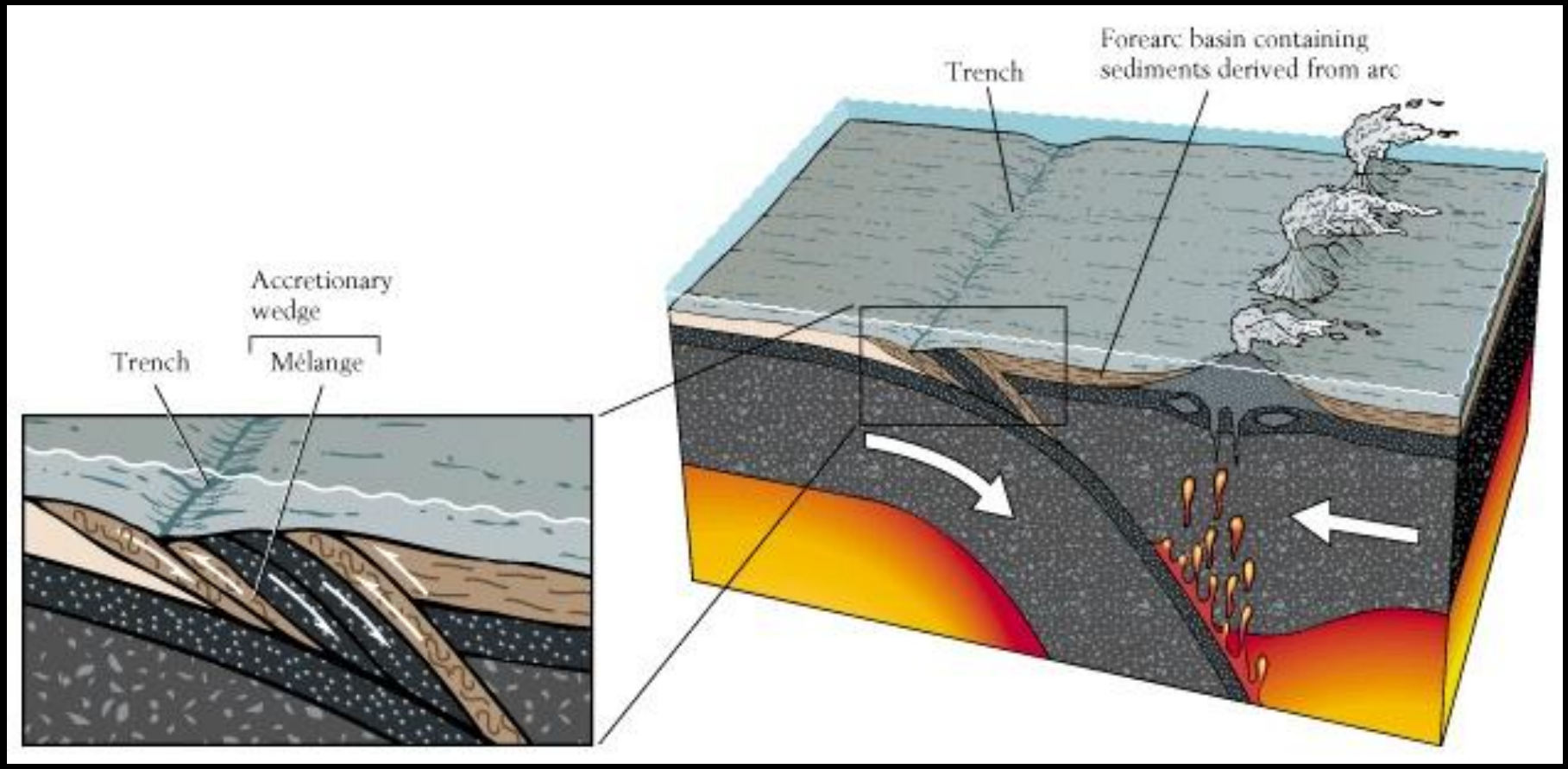


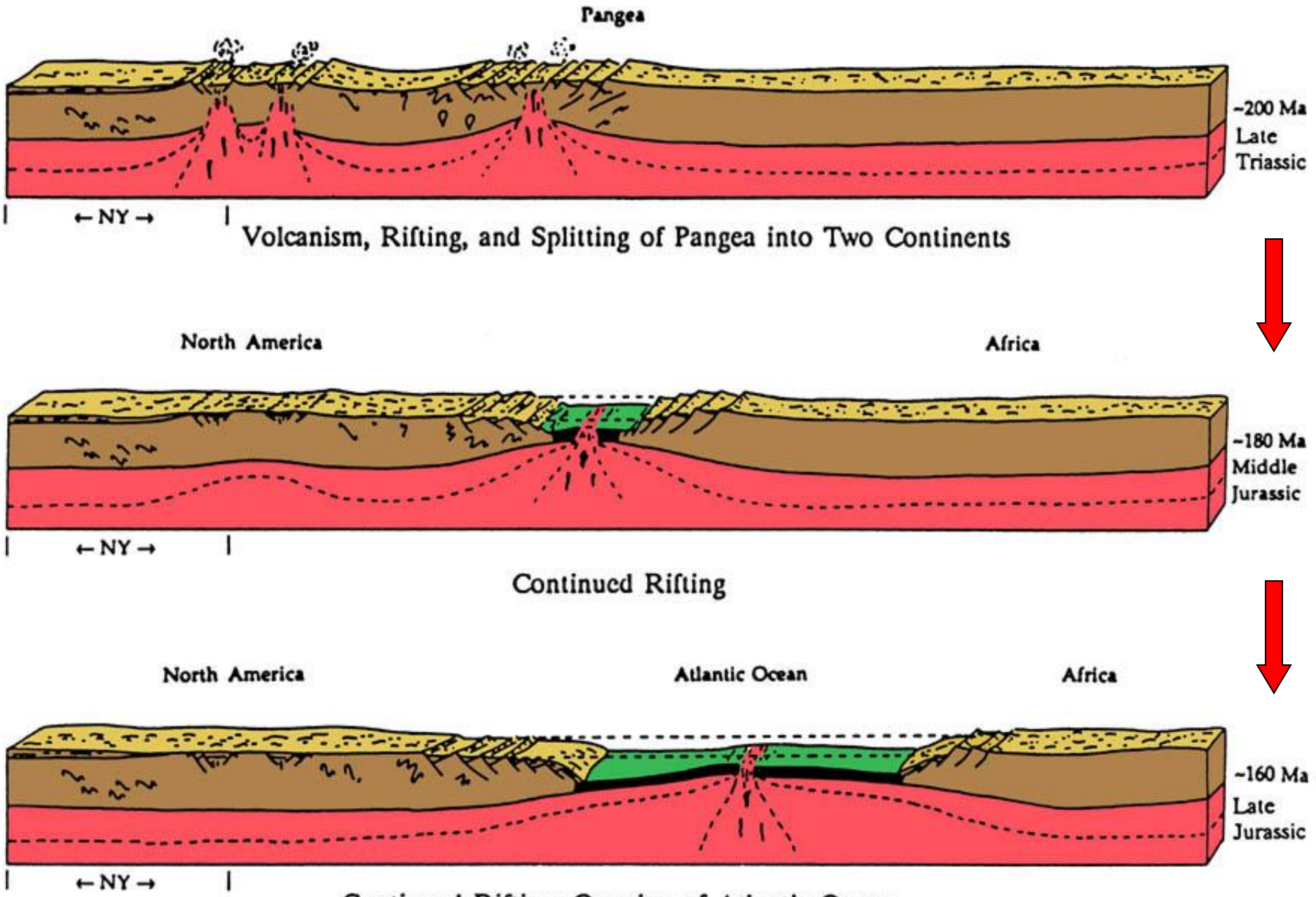
Development of Passive Margin on Proto North America

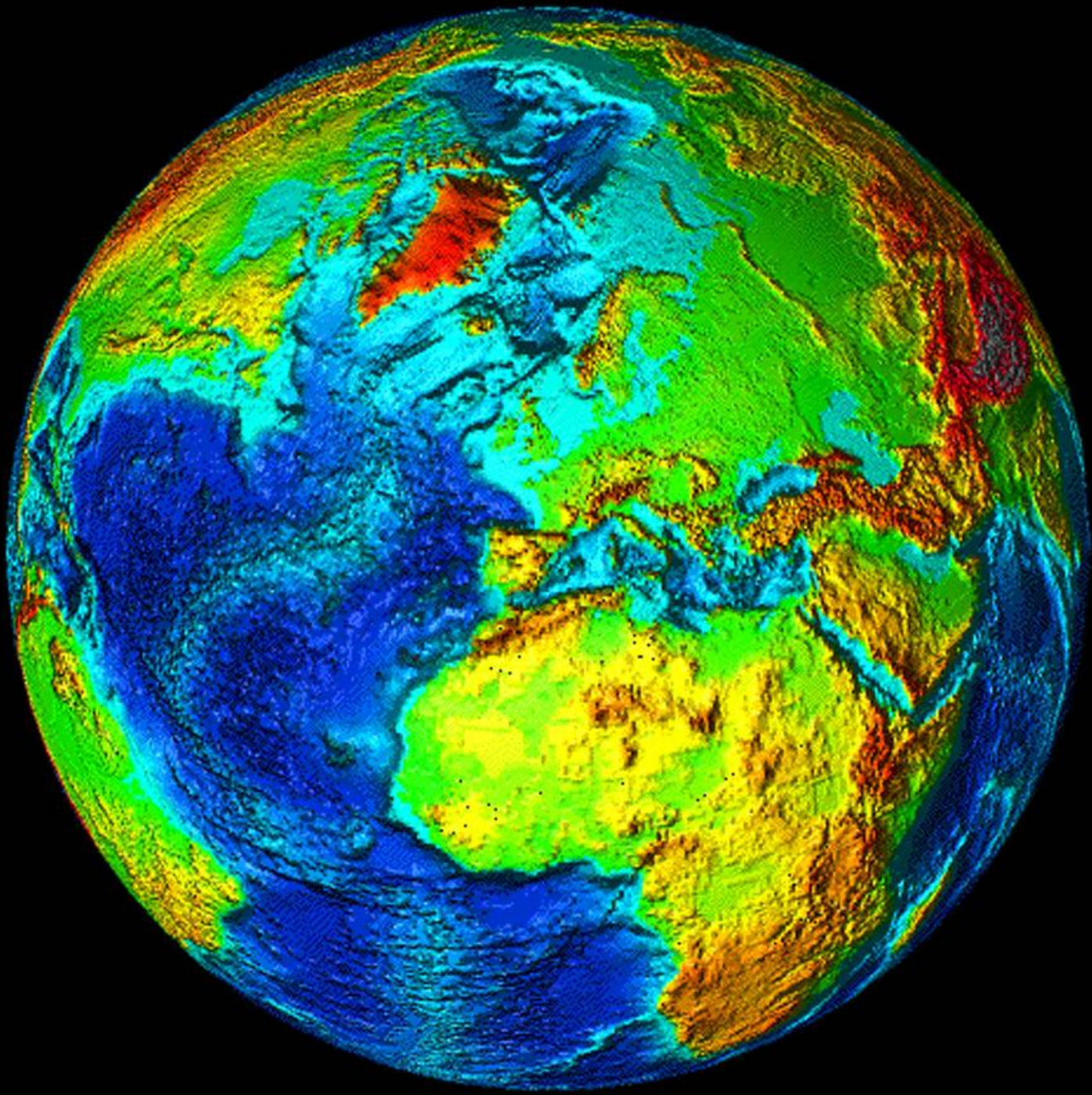
Taconic Arc – Passive Margin Collision

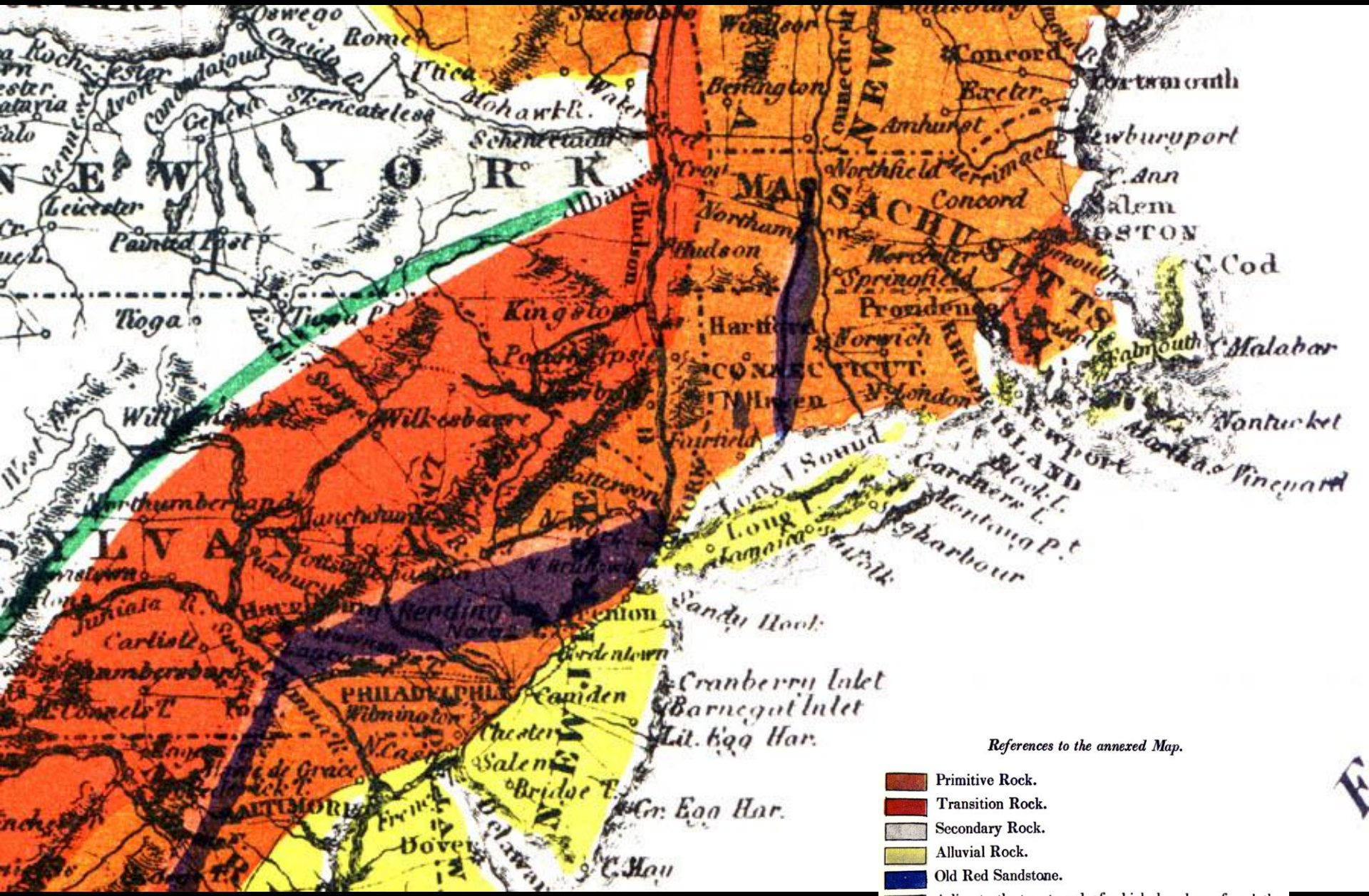


Taconian Accretionary Wedge




Pangea
~200 Ma
Late
Triassic
← NY →
Volcanism, Rifting, and Splitting of Pangea into Two Continents
North America
Africa
~180 Ma
Middle
Jurassic
← NY →
Continued Rifting
North America
Atlantic Ocean
Africa
~160 Ma
Late
Jurassic
← NY →
Continued Rifting; Opening of Atlantic Ocean

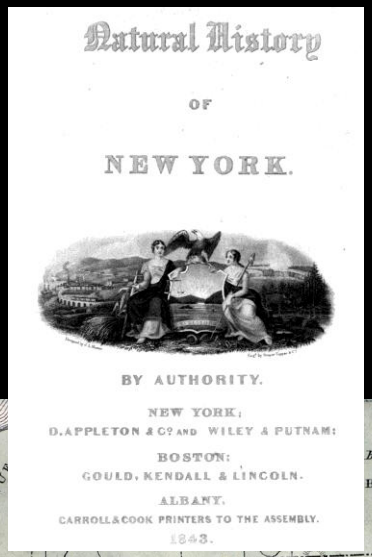




References to the annexed Map.

- Primitive Rock.
- Transition Rock.
- Secondary Rock.
- Alluvial Rock.
- Old Red Sandstone.
- A line to the westward of which has been found the greatest part of the Salt and Gypsum.

Maclure, 1817


Natural History

OF

NEW YORK.

BY AUTHORITY.

NEW YORK:
D. APPLETON & Co. AND WILEY & PUTNAM:

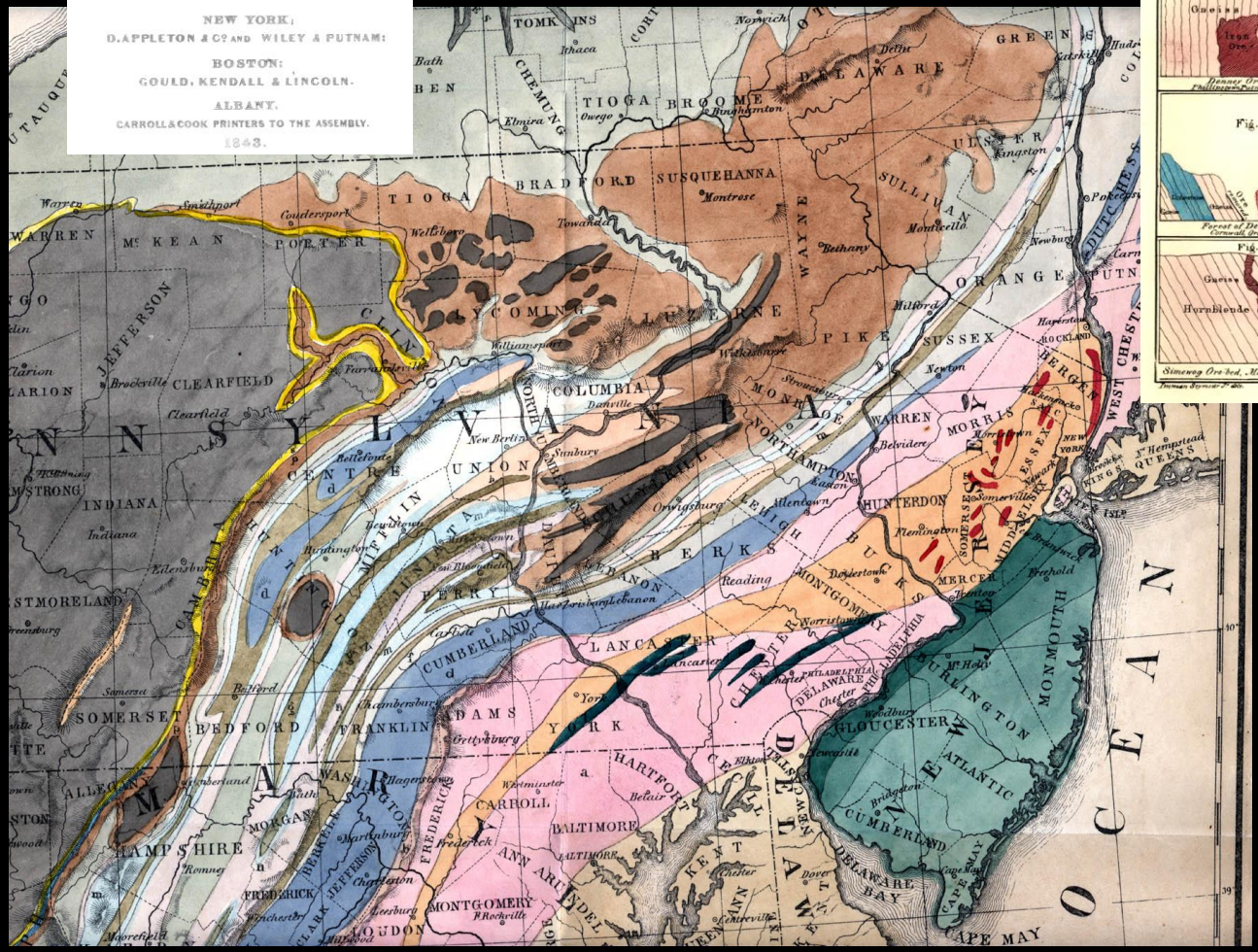
BOSTON:
GOULD, KENDALL & LINCOLN.

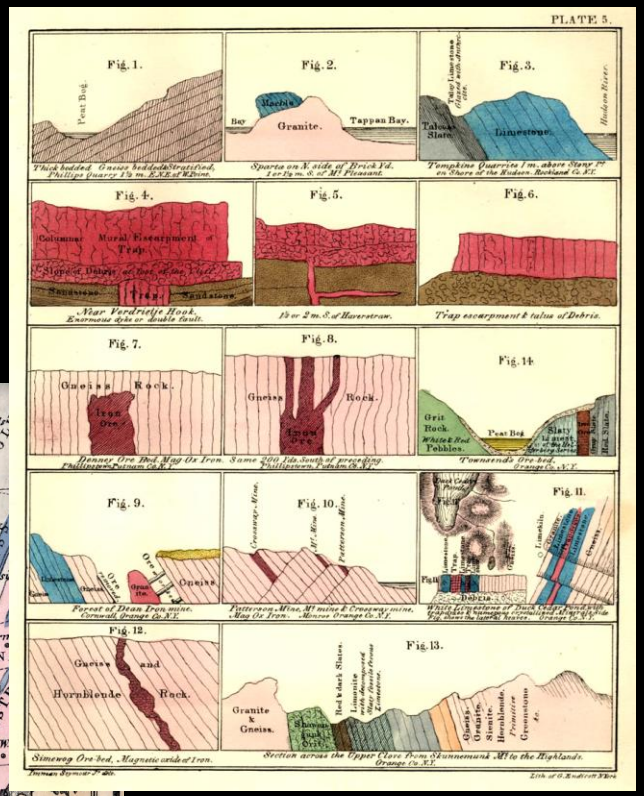
ALBANY.
CARROLL & COOK PRINTERS TO THE ASSEMBLY.

1843.

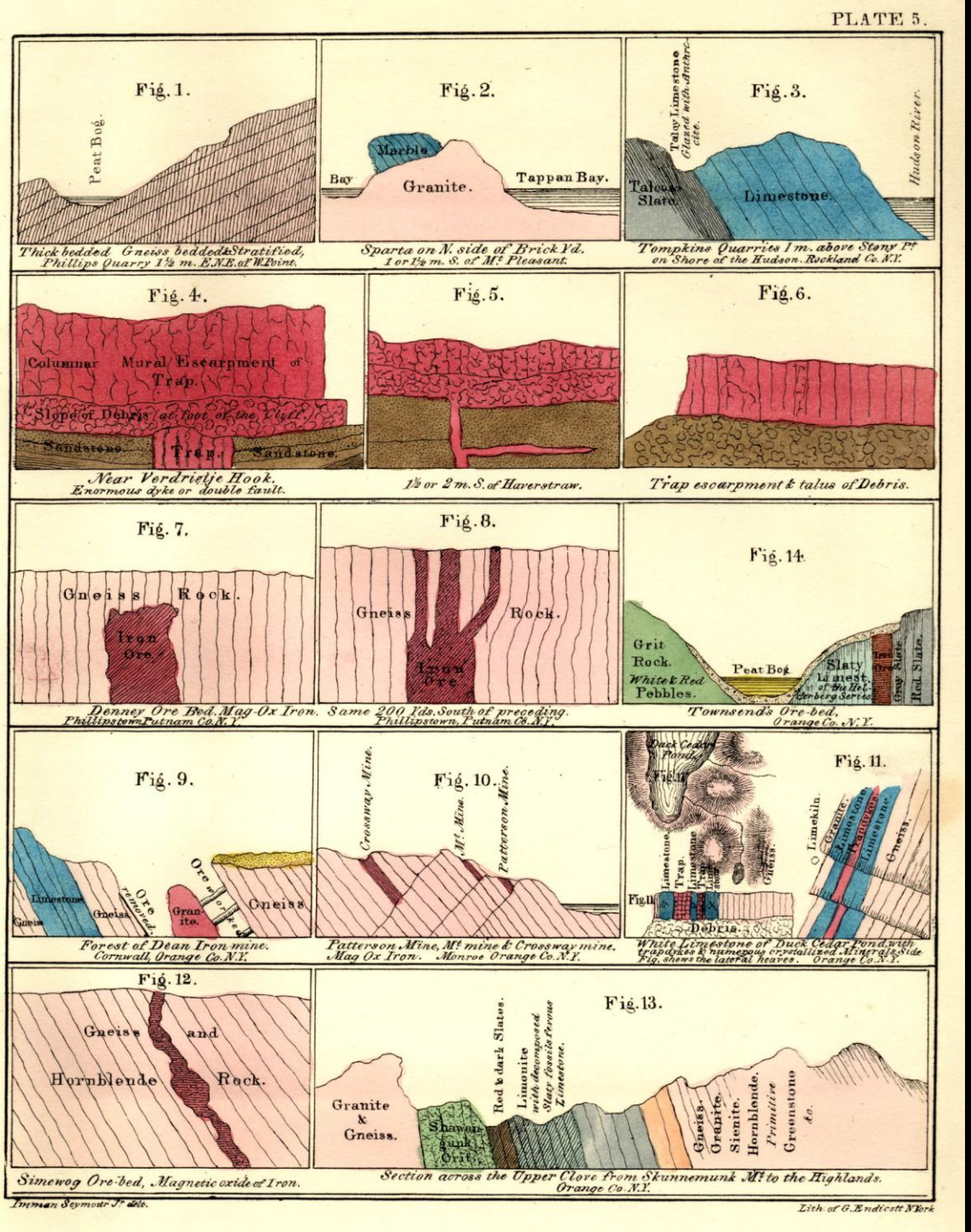
Natural History of New York

1843





Hall
Mather
Emmons
Beck
Vanuxem

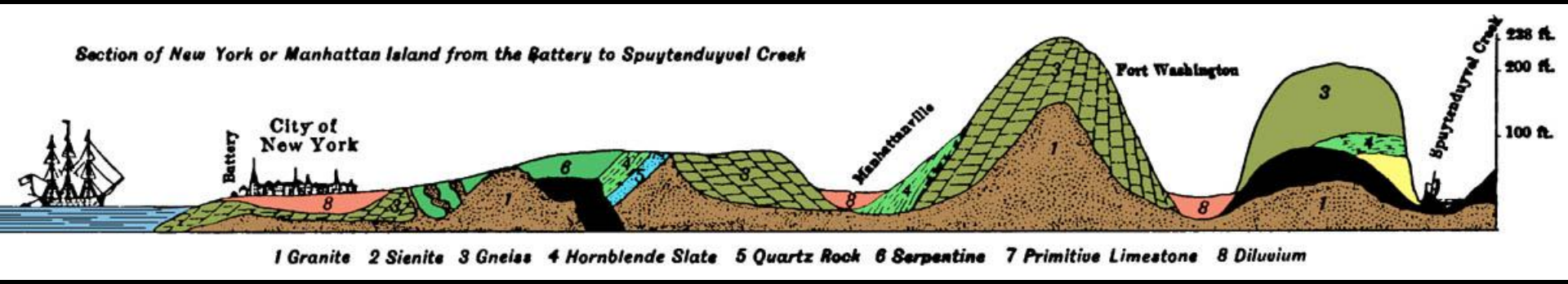


Geologic Sections

New York State

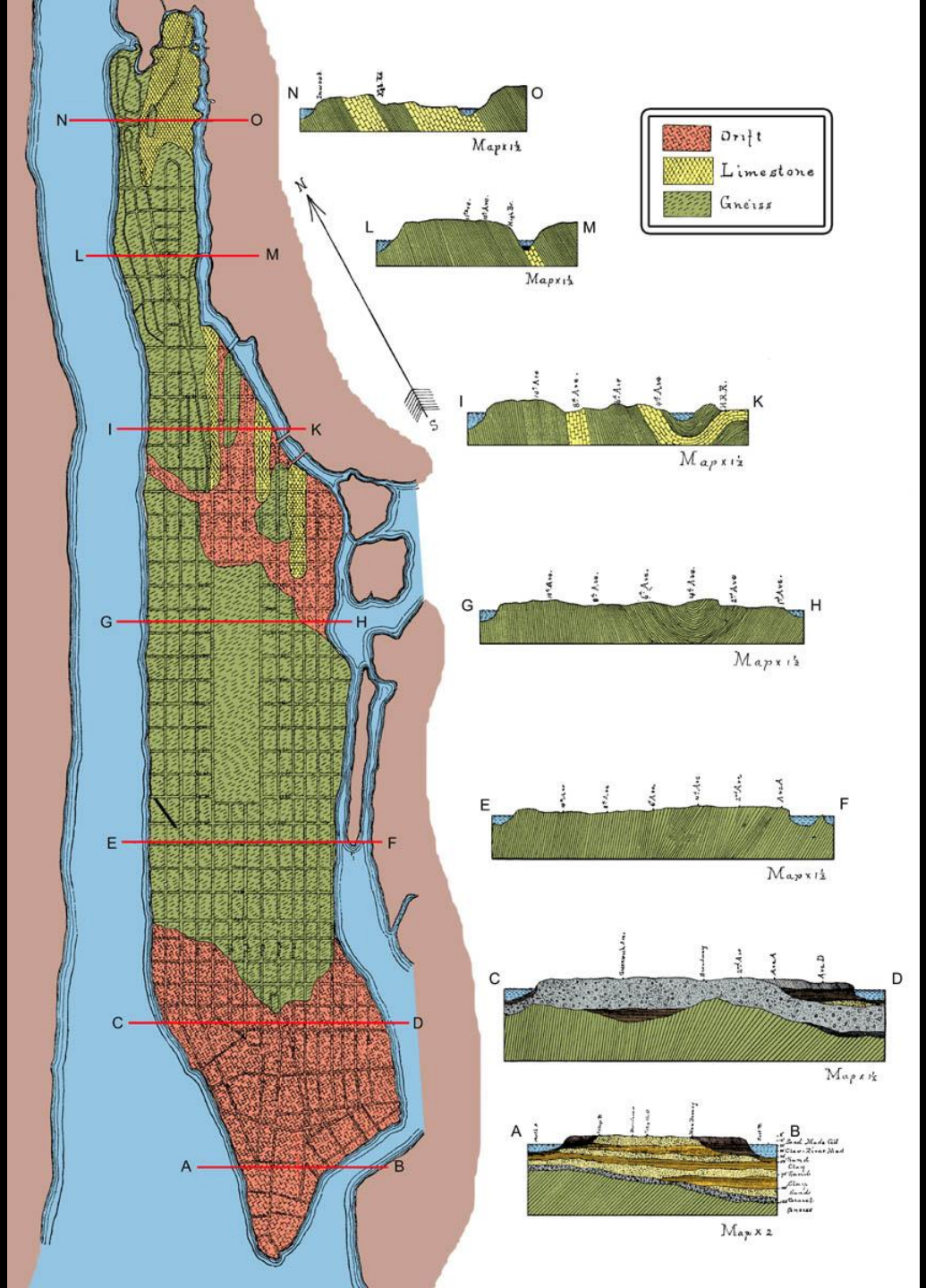
Mather, 1843

Geological Section – Manhattan Island



after Cozzens, 1848

First Geologic Map of Manhattan



after Kemp, 1887

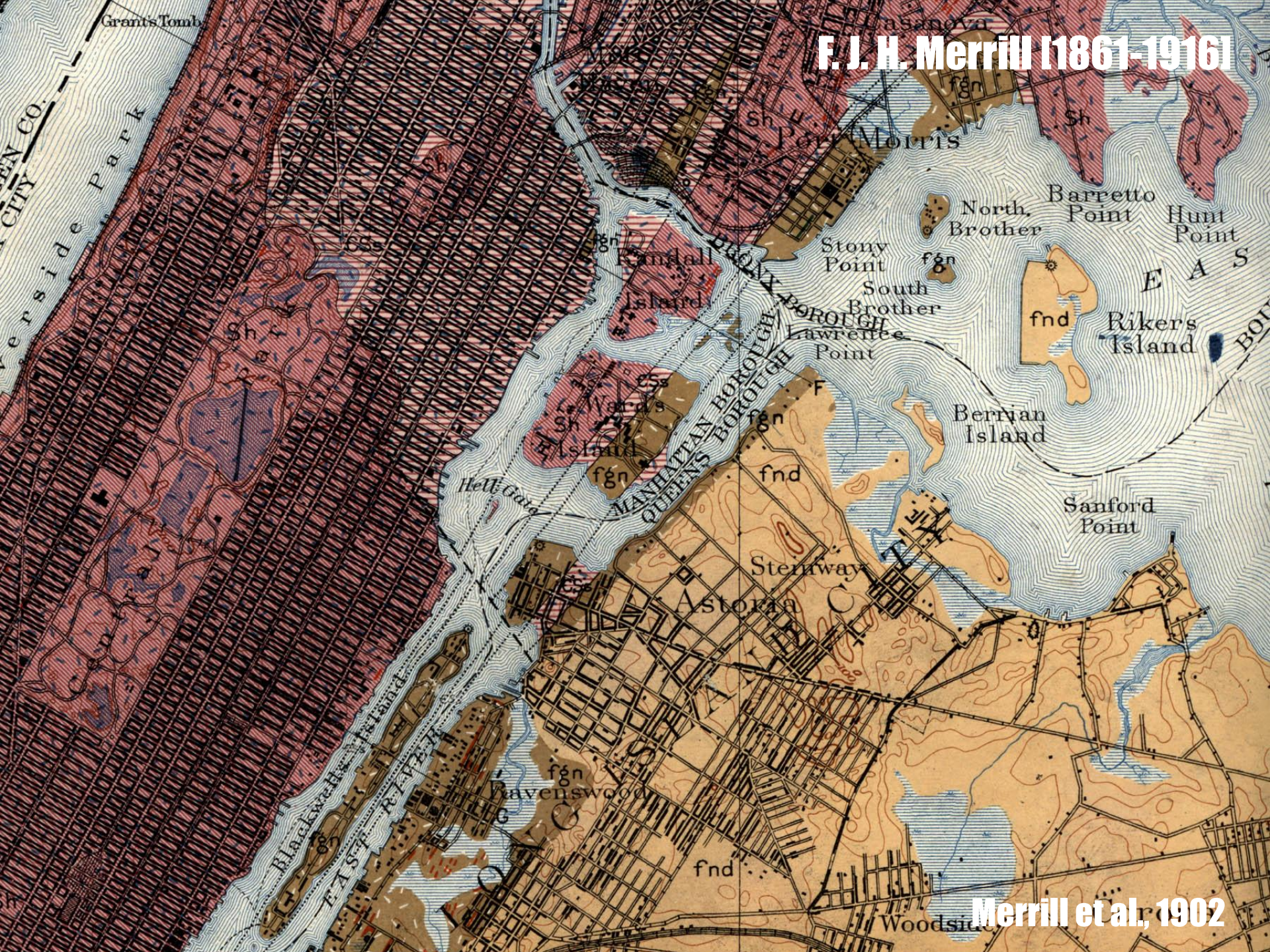
Kemp's Early Field Work on Manhattan Island

W. G. LEVISON, PHOTO. PLATE No. 89 (1901)

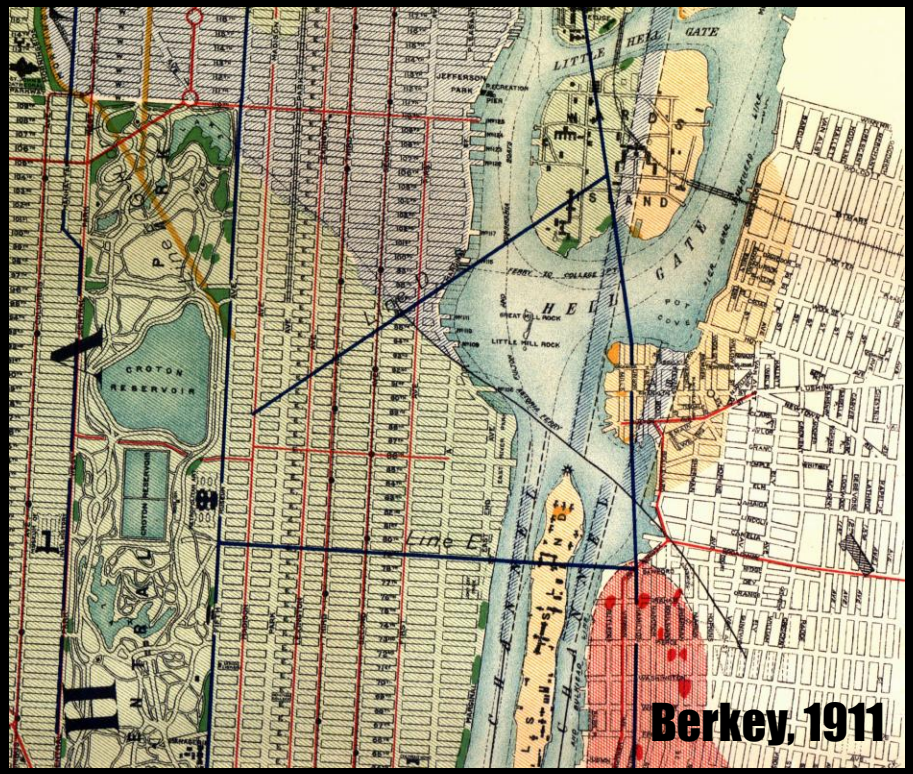
EXCAVATION IN MANHATTAN SCHIST

Riverside Drive, 92nd to 93rd St., Manhattan Island, New York City

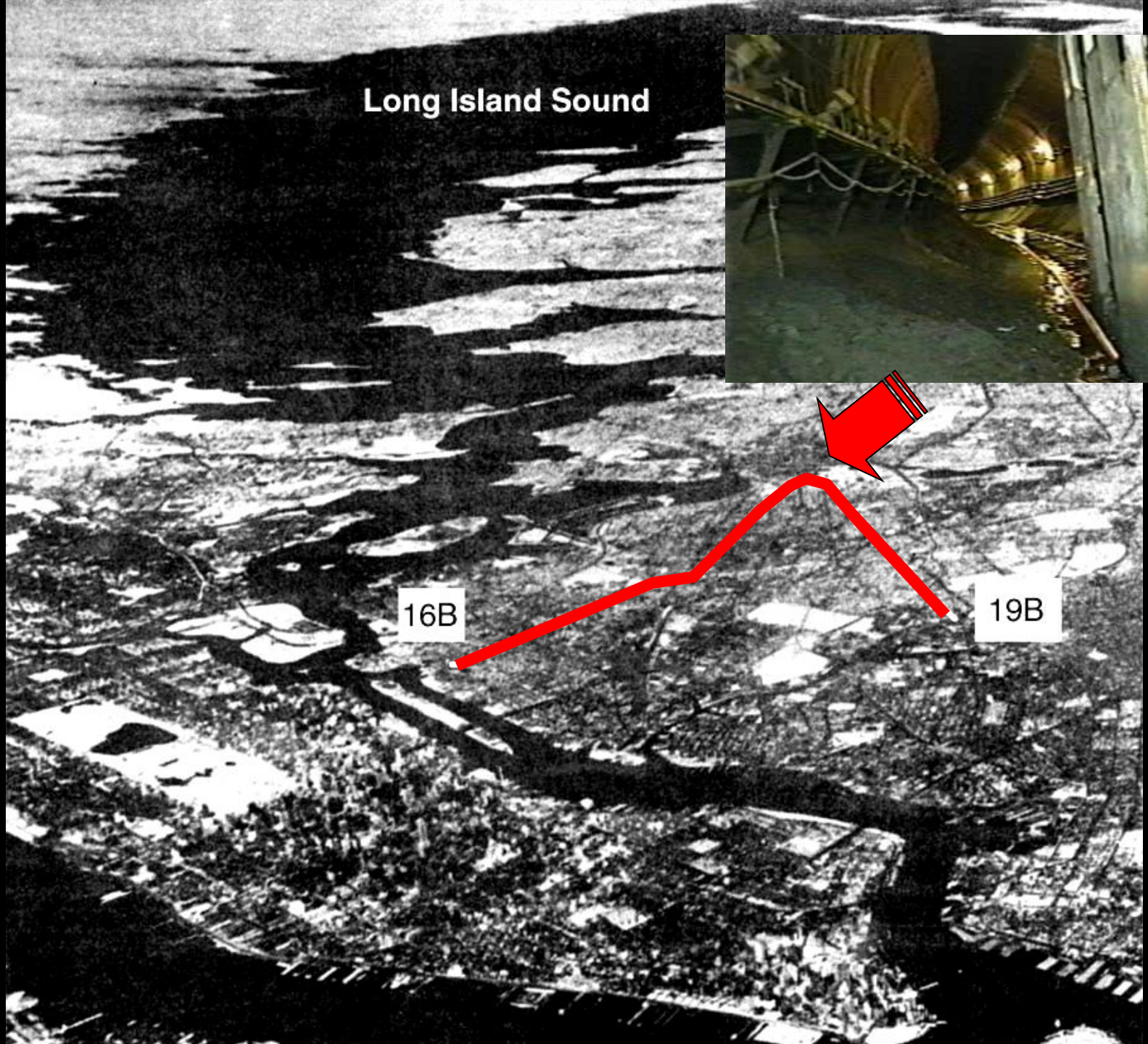
BIRD'S EYE VIEW OF NEW YORK CITY.


F. J. H. Merrill [1861-1916]
Grant's Tomb
Riverside Park
Port Morris
North Brother
Barretto Point
Hunt Point
Stony Point
South Brother
Randall Island
Lawrence Point
Rikers Island
Ward's Island
Berrian Island
Hell Gate
MANHATTAN BOROUGH
QUEENS BOROUGH
Sanford Point
Steinway
Astoria
Ravenswood
Blackwell Island
Woodside
Merrill et al., 1902

Professor Charles P. Berkey [1867-1955]

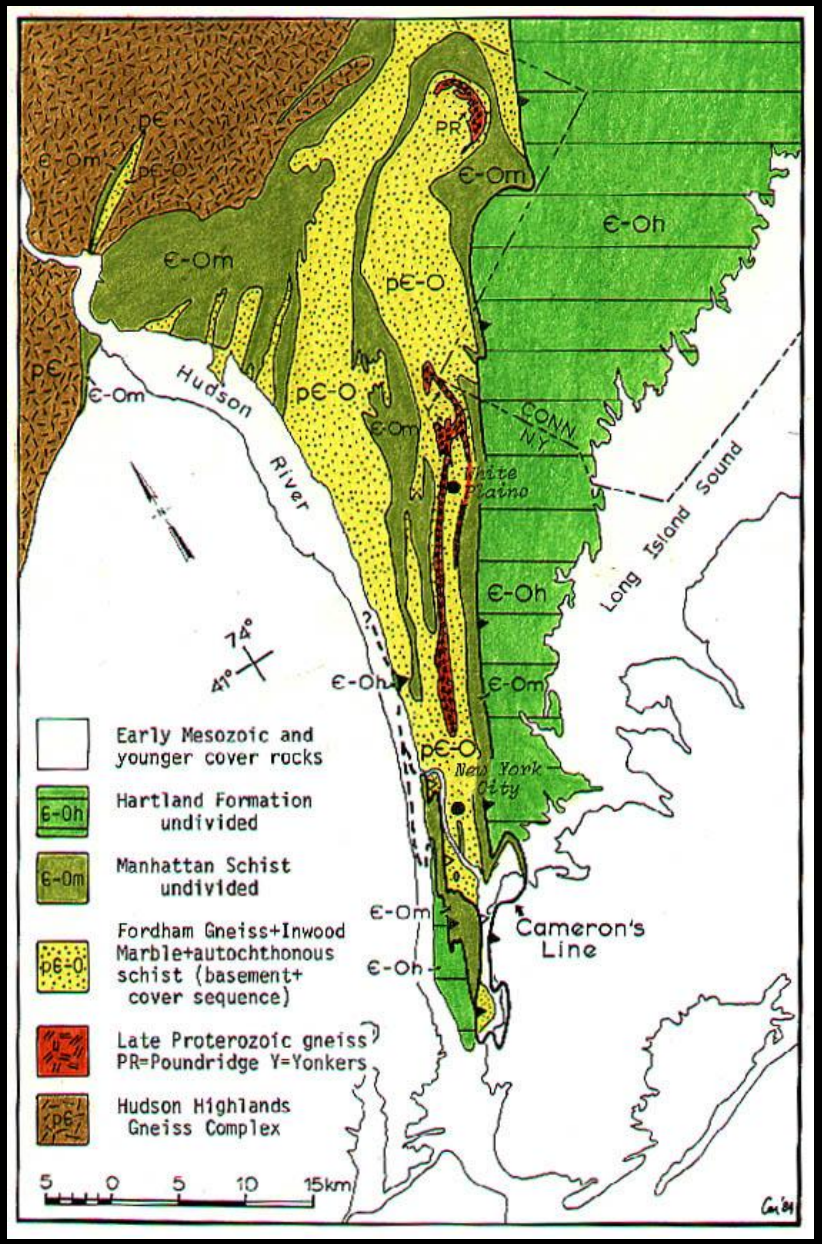


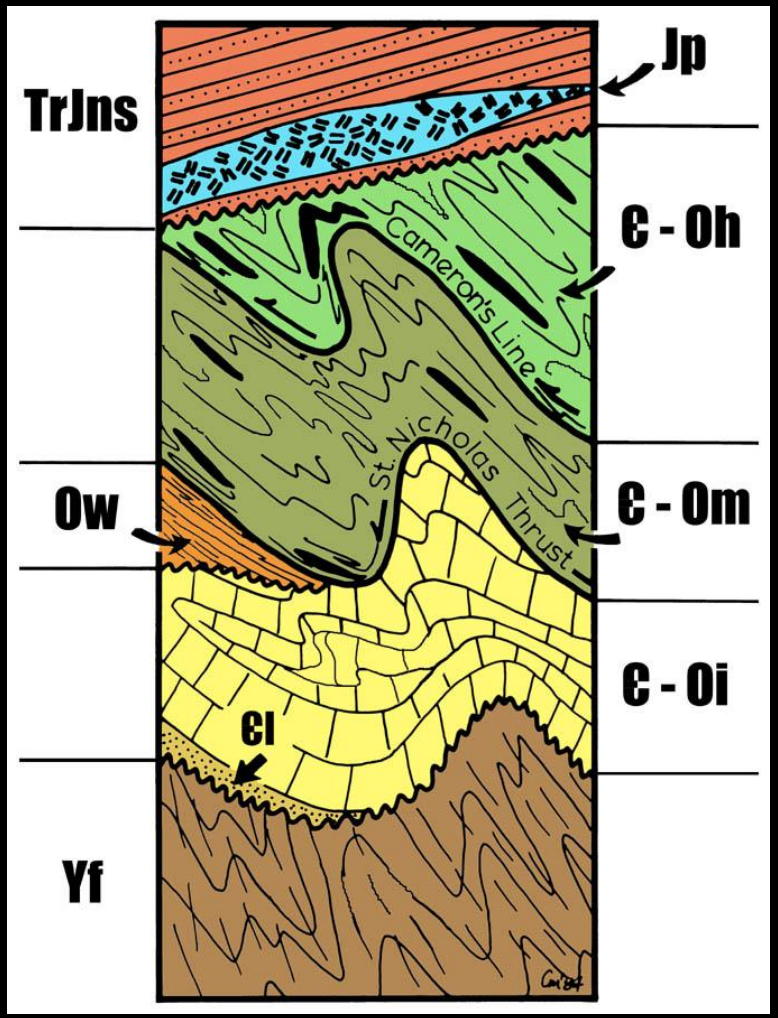
Proper Field Attire For NYC


Long Island Sound
16B
19B

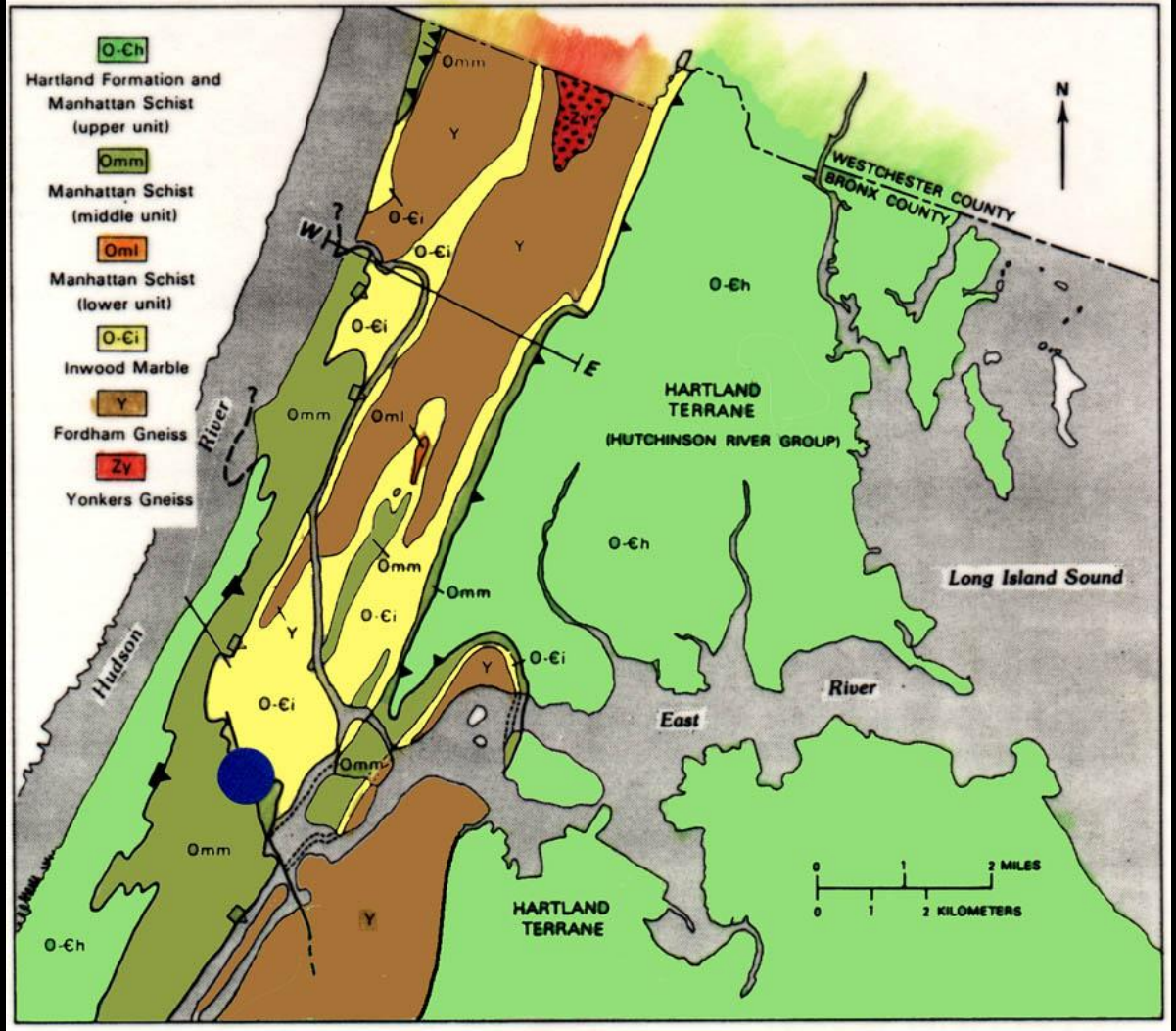
Merguerian's Field Office

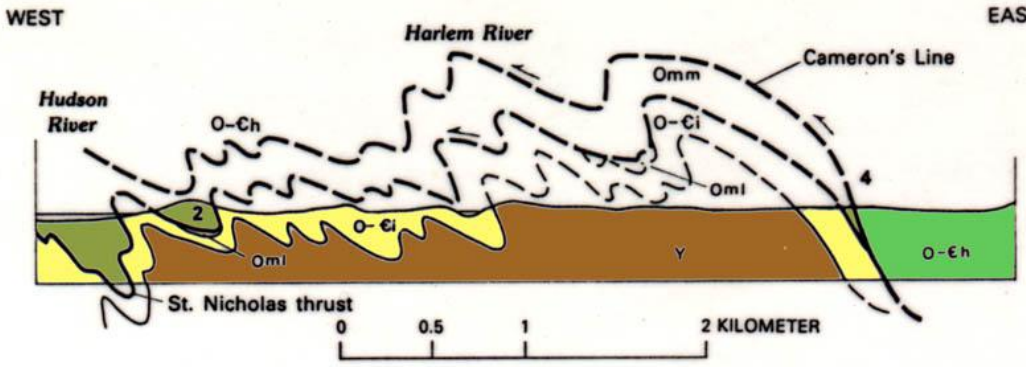
Geology of the New York City Area





after Mose and Merguerian, 1985

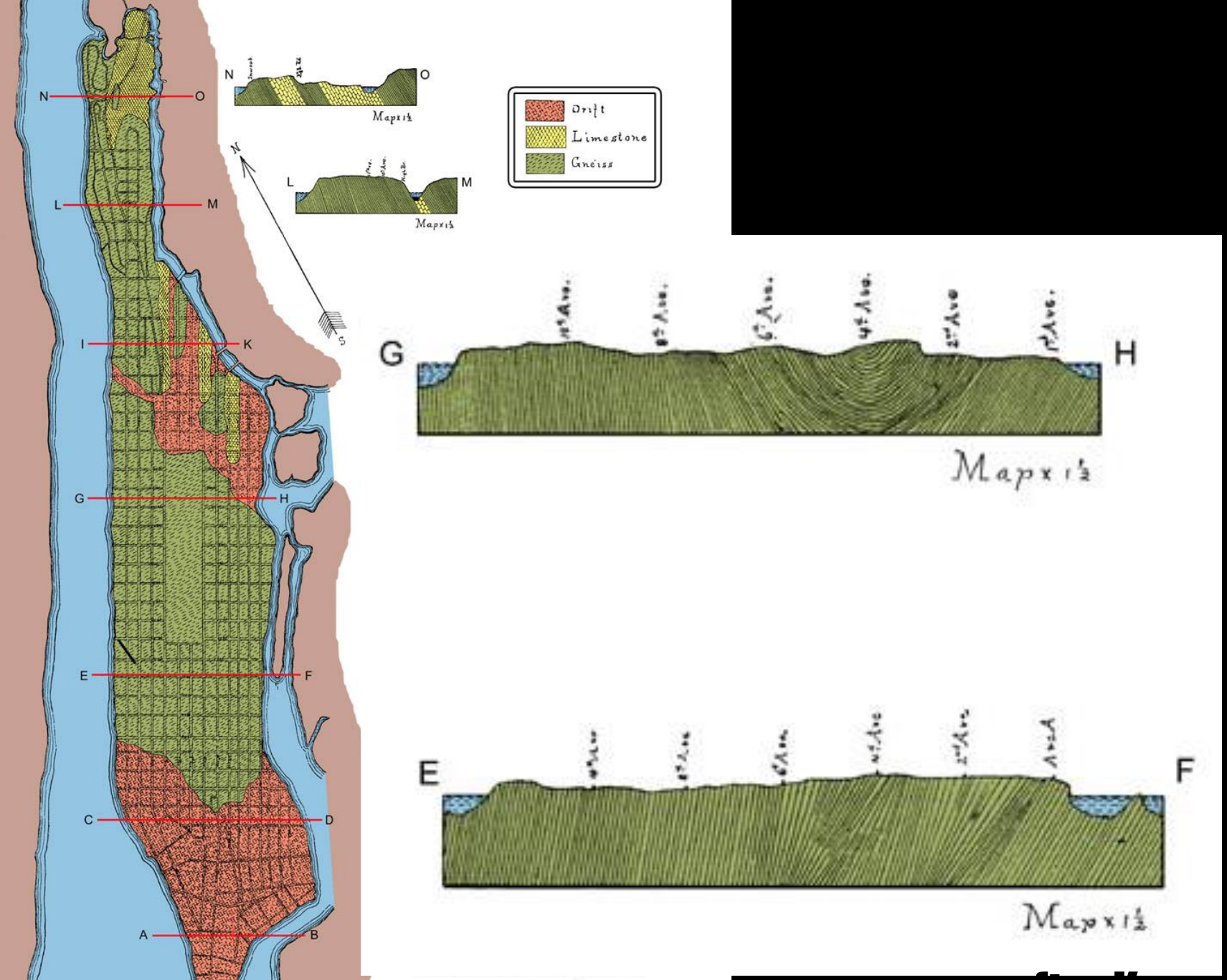




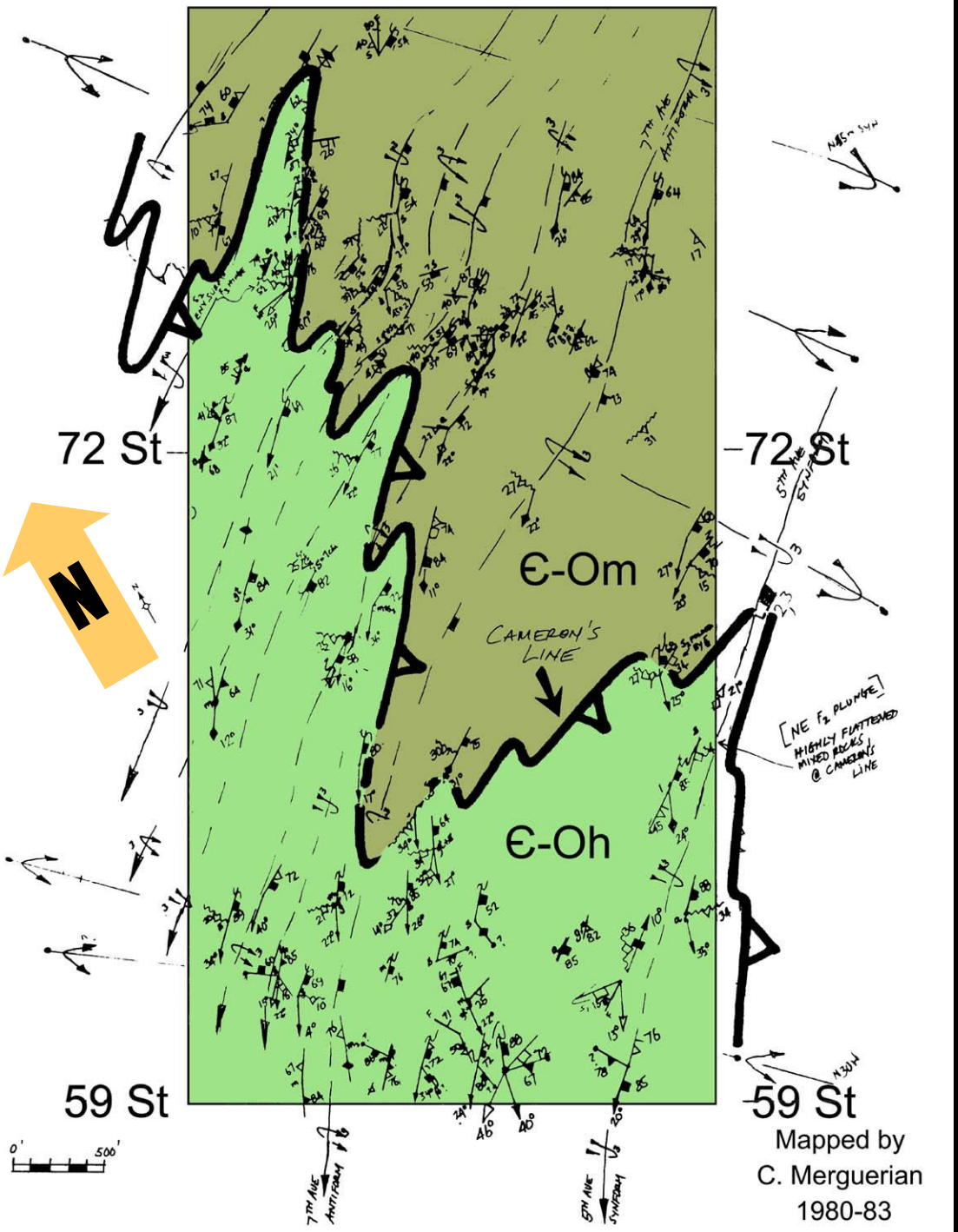
New York City

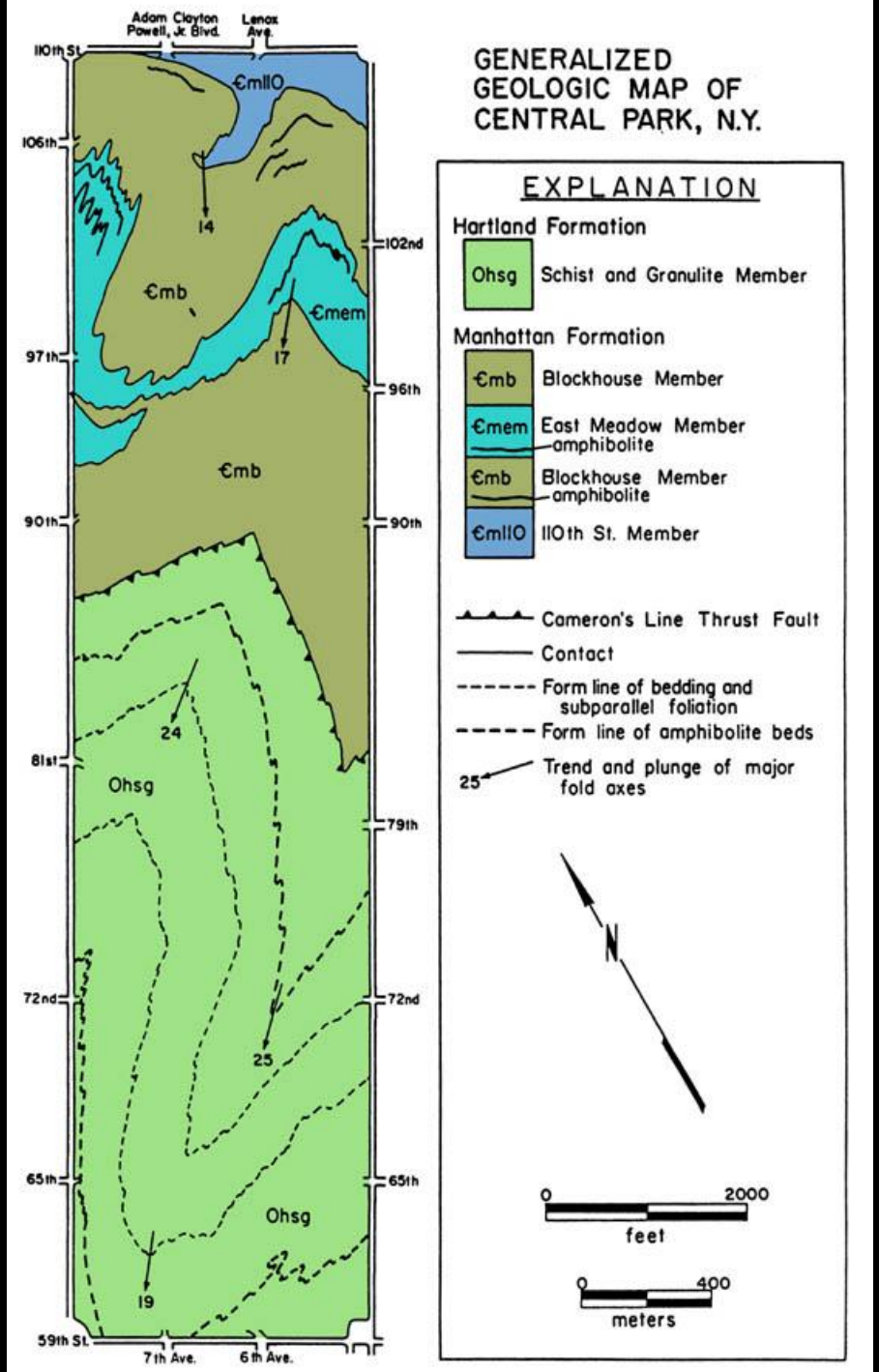
Merguerian, 2001

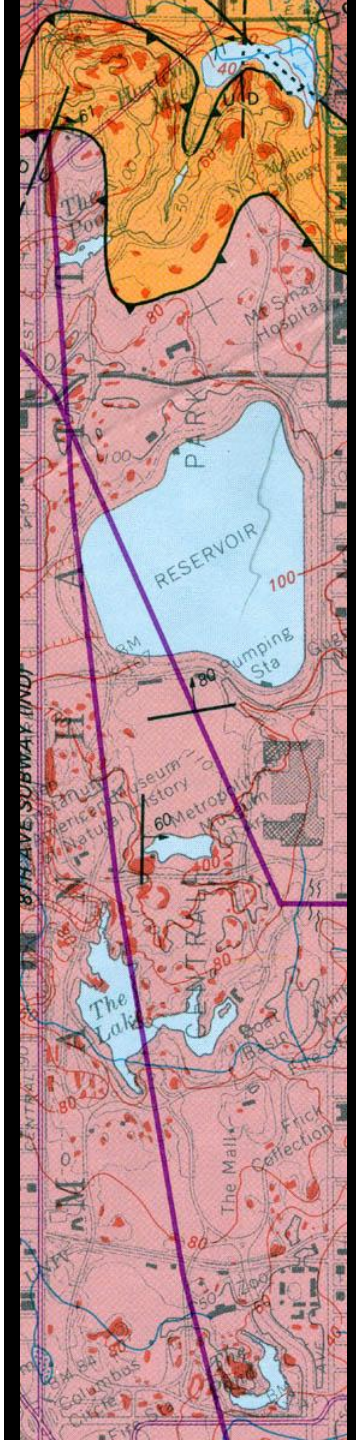
Geology of Central Park
From Rocks to Ice


N
O
L
M
I
K
G
H
E
F
C
D
A
B
Drift
Limestone
Gneiss
Map x 2

Cameron's Line in Central Park



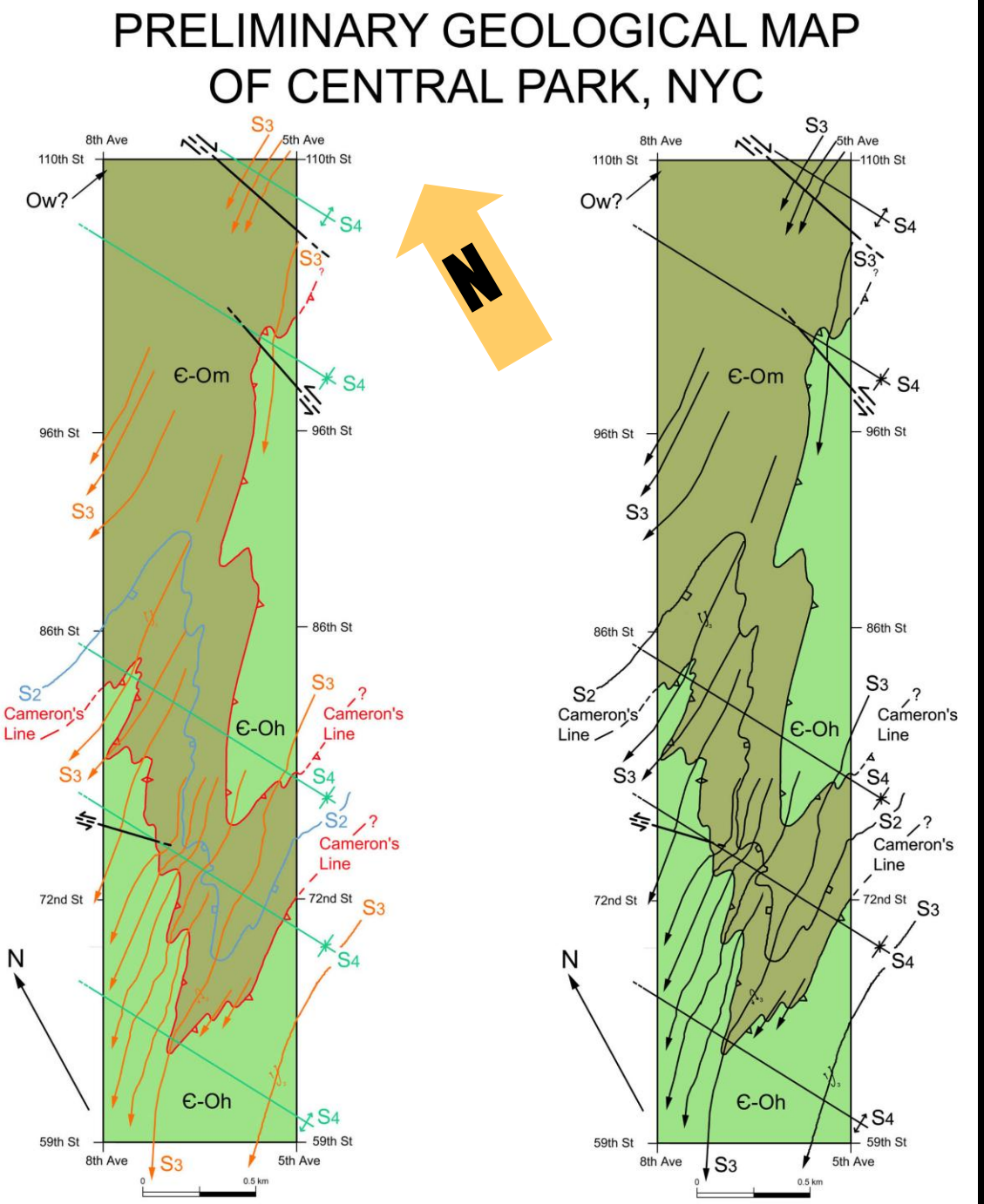




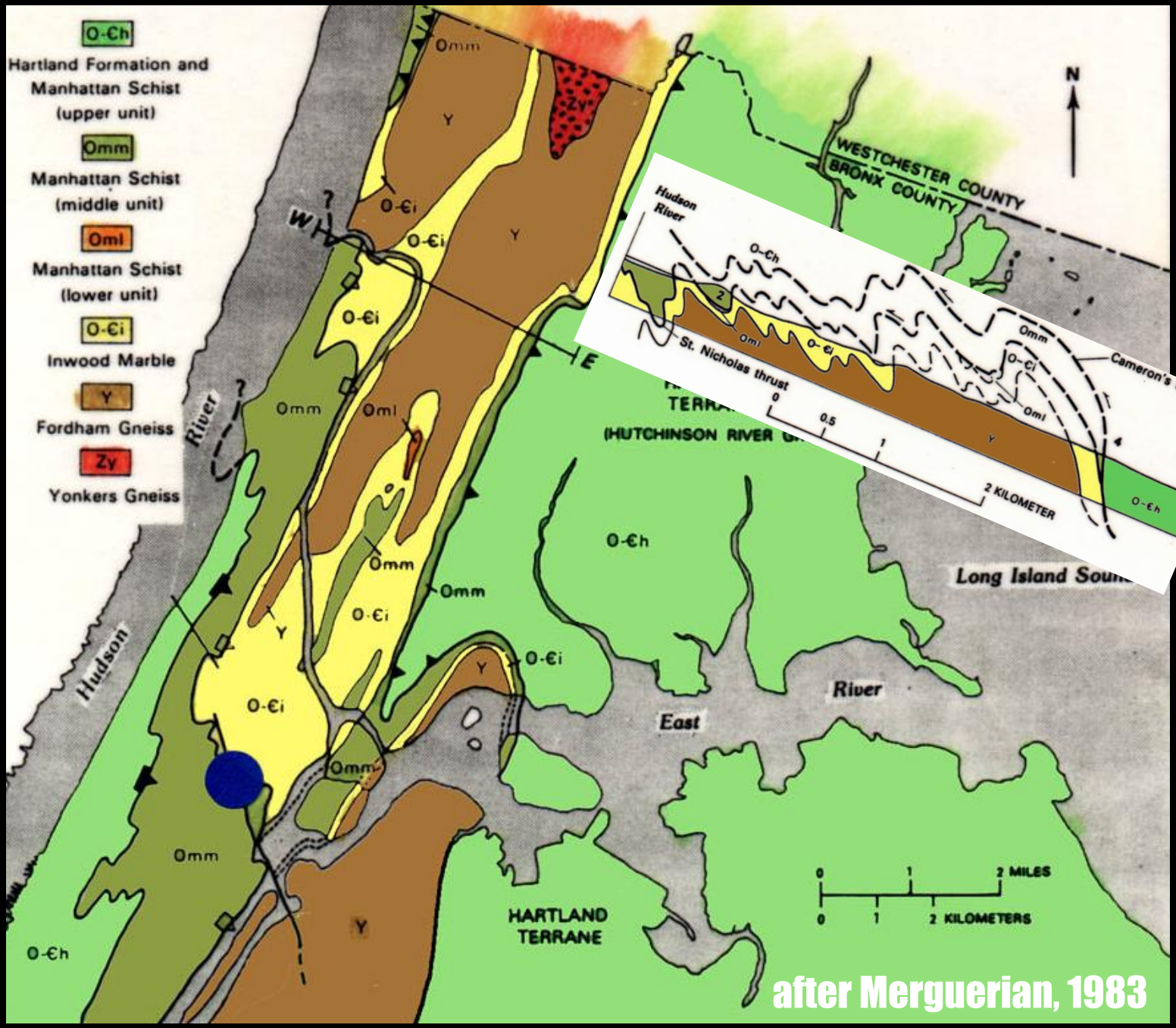
Geologic Maps Of Central Park

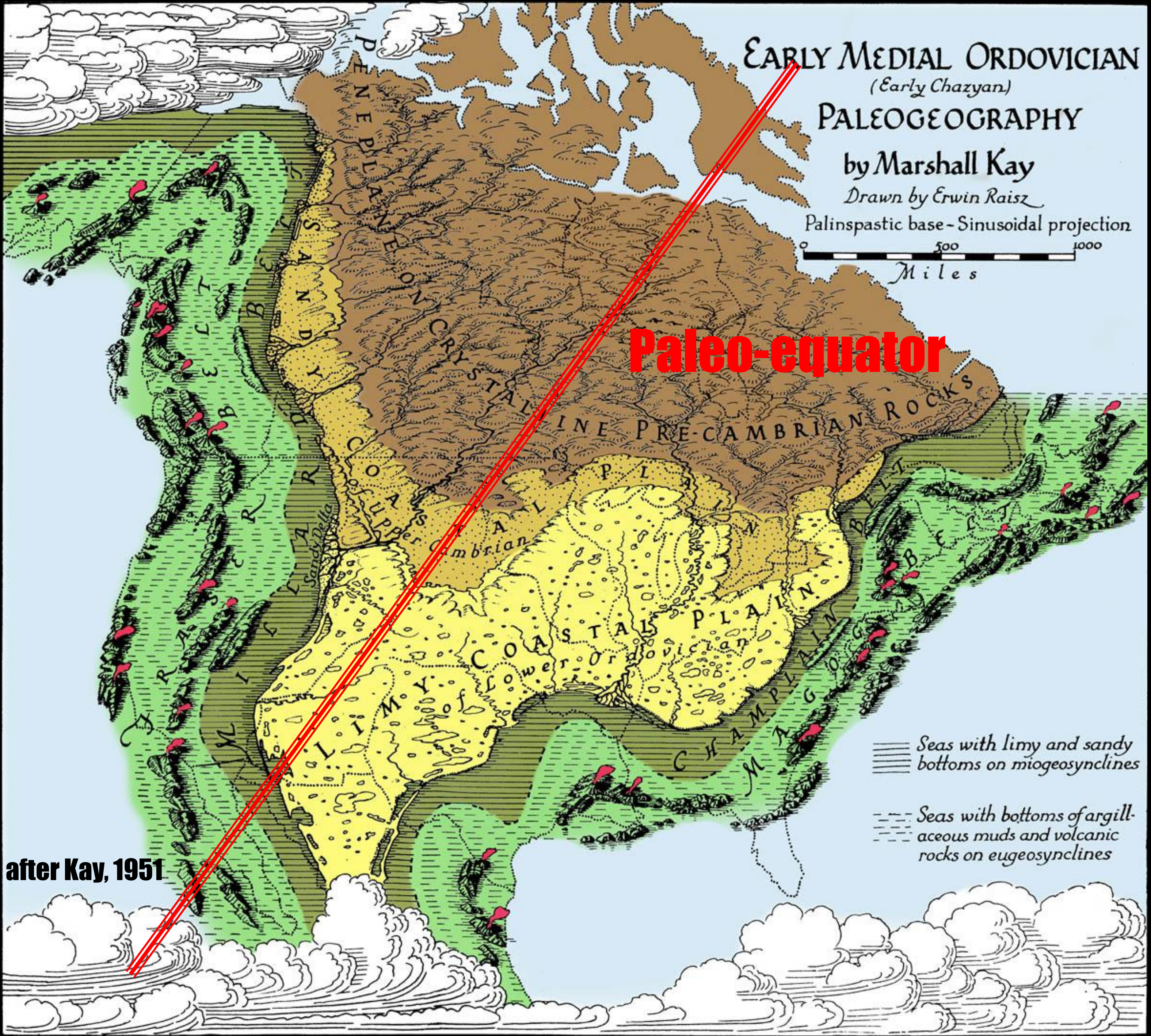
after Taterka, 1987 and Baskerville, 1994

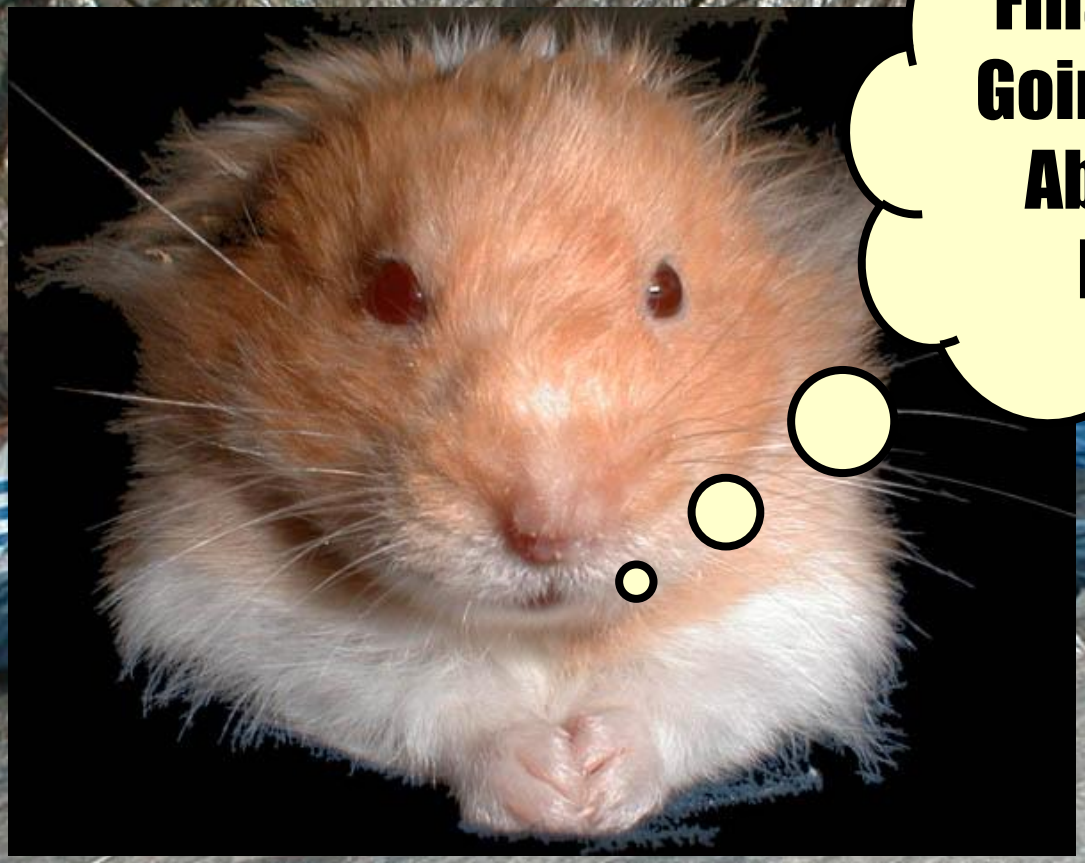
Cameron's Line in Central Park

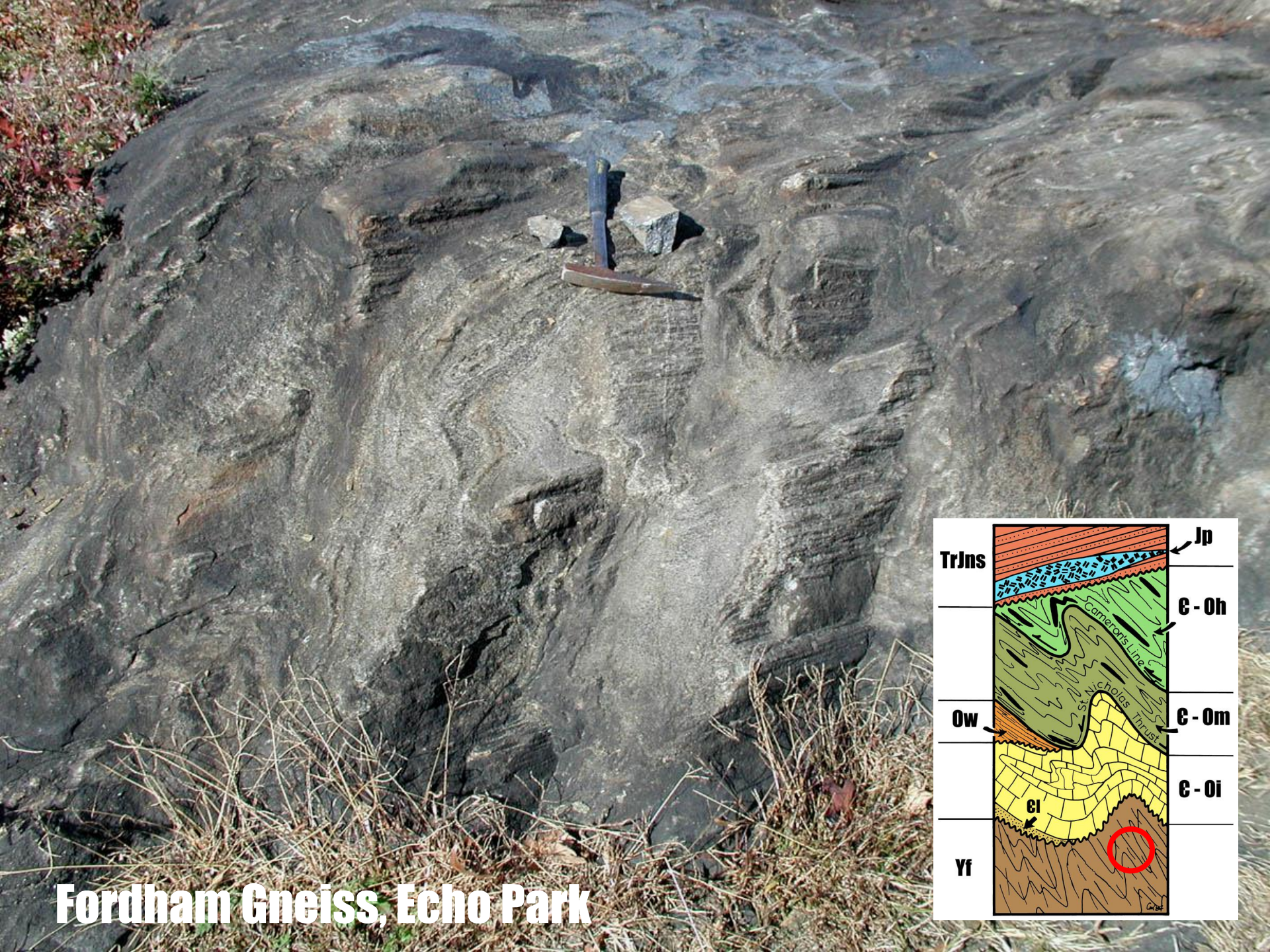


Merguerian and Merguerian, 2004

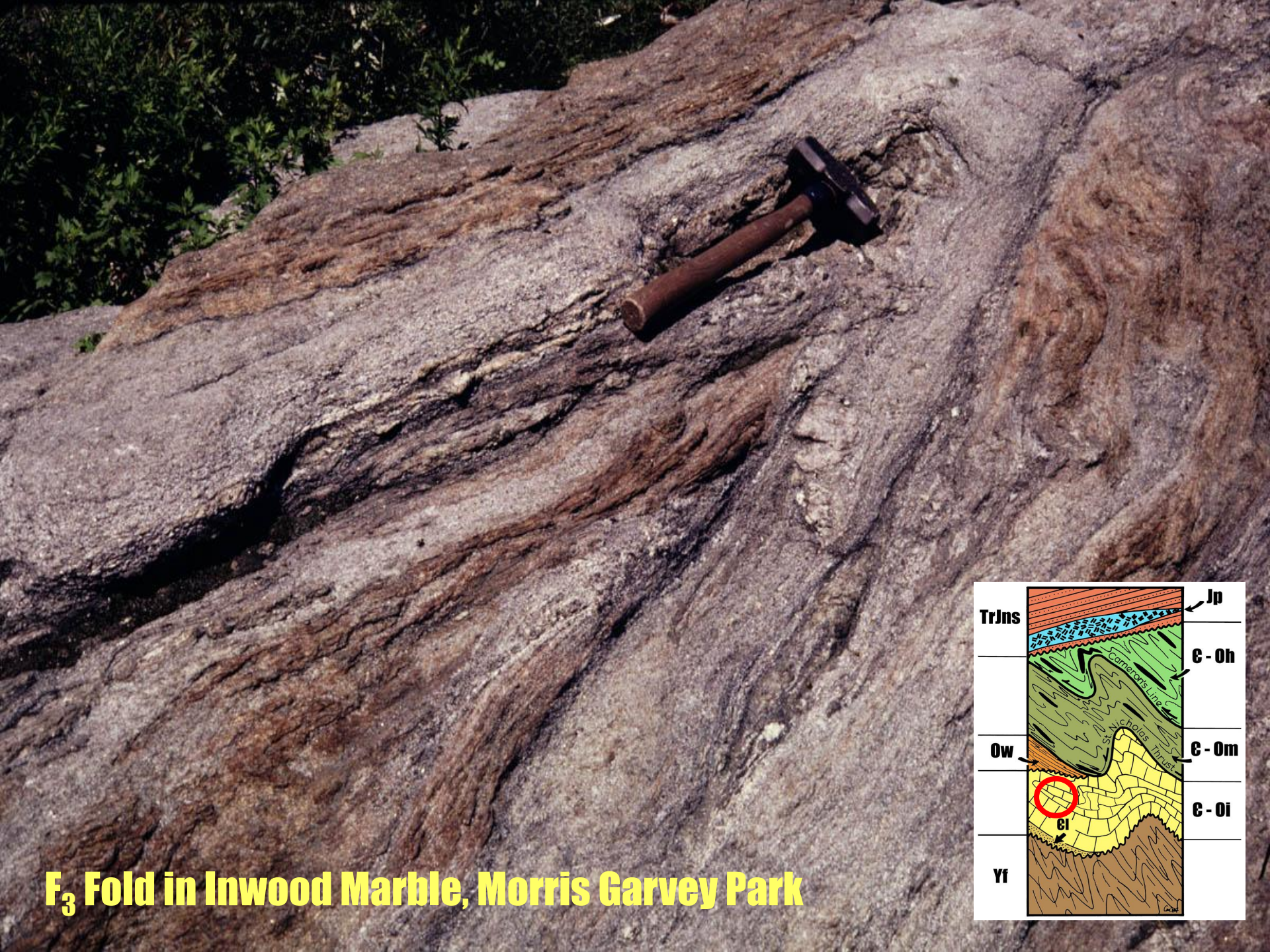

O-Ch
Hartland Formation and Manhattan Schist (upper unit)
Omm
Manhattan Schist (middle unit)
Oml
Manhattan Schist (lower unit)
O-Ci
Inwood Marble
Y
Fordham Gneiss
Zy
Yonkers Gneiss
N
WESTCHESTER COUNTY
BRONX COUNTY
Hudson River
O-Ch
Oml
O-Ci
Omm
Y
St. Nicholas thrust
Cameron's Line
0
0.5
1
2 KILOMETER
O-Ch
TERRANE
(HUTCHINSON RIVER
Long Island Sound
Hudson River
East River
HARTLAND TERRANE
0 1 2 MILES
0 1 2 KILOMETERS
after Merguerian, 1983


EARLY MEDIAL ORDOVICIAN
(Early Chazyan)
PALEOGEOGRAPHY
by Marshall Kay
Drawn by Erwin Raisz
Palinspastic base - Sinusoidal projection
0 500 1000
Miles
Paleo-equator
PENEPLANE ON CRYSTALLINE PRE-CAMBRIAN ROCKS
SANDY COASTAL PLAIN of Upper Cambrian
LIMY COASTAL PLAIN of Lower Ordovician
Sandy Delta
CORDILLERAN BELT
MILLARD BELT
CHAMPLAIN BELT
MAGOG BELT
Seas with limy and sandy bottoms on miogeosynclines
Seas with bottoms of argillaceous muds and volcanic rocks on eugeosynclines
after Kay, 1951

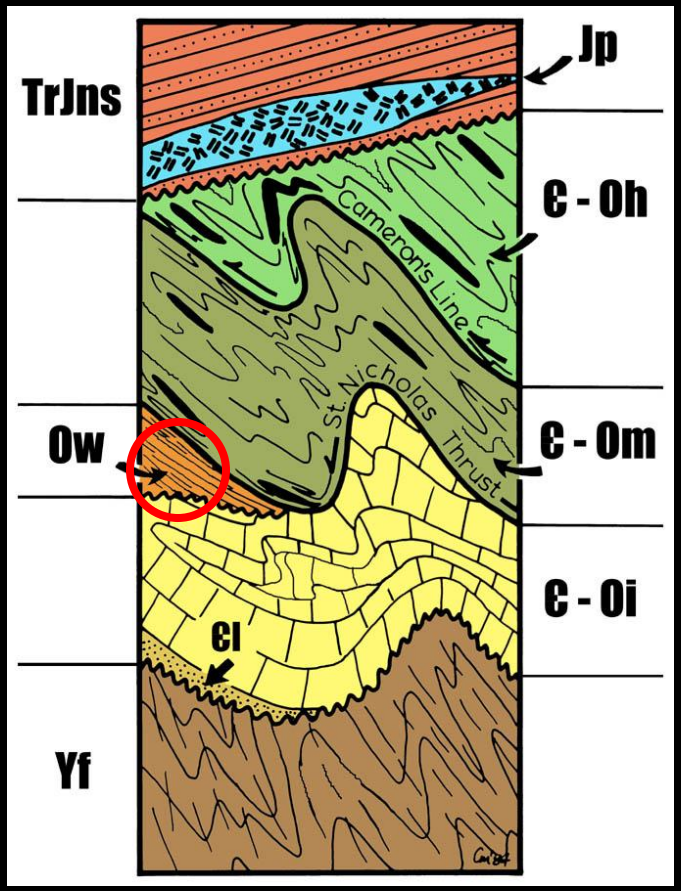

Finally, He's Going to Talk About the Rocks



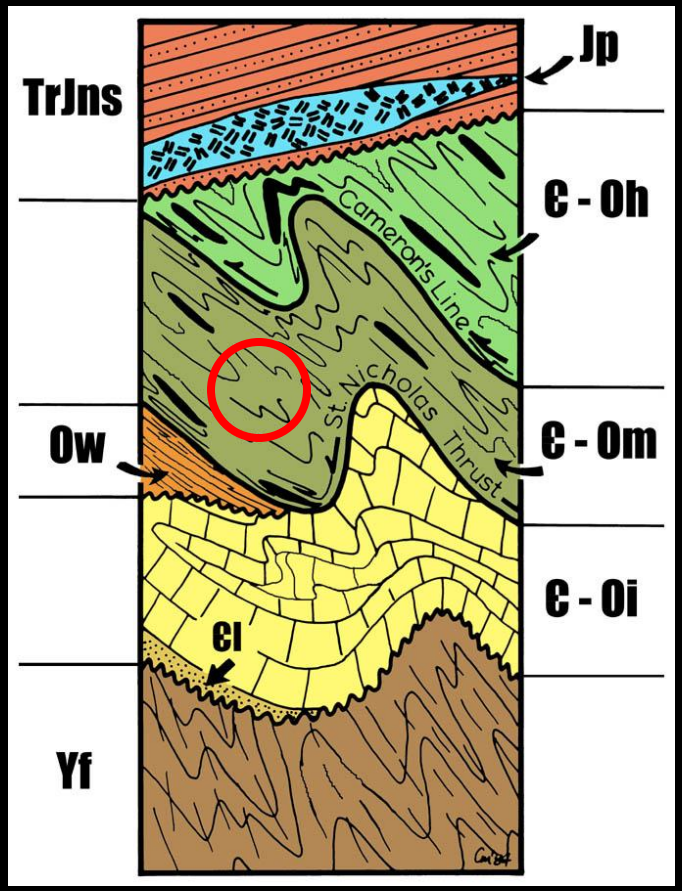
Fordham Gneiss, Echo Park



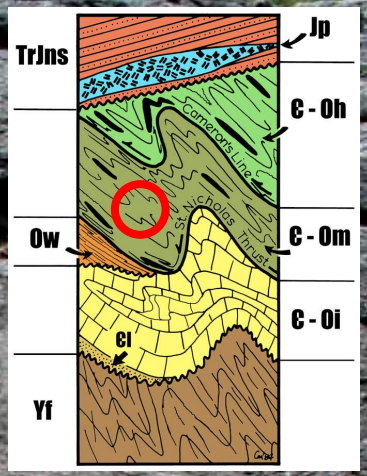
F_3 Fold in Inwood Marble, Morris Garvey Park



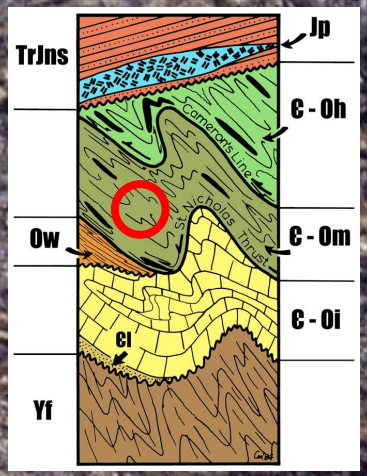
Walloomsac "Balmville" Contact, Grand Concourse, Bronx, NY



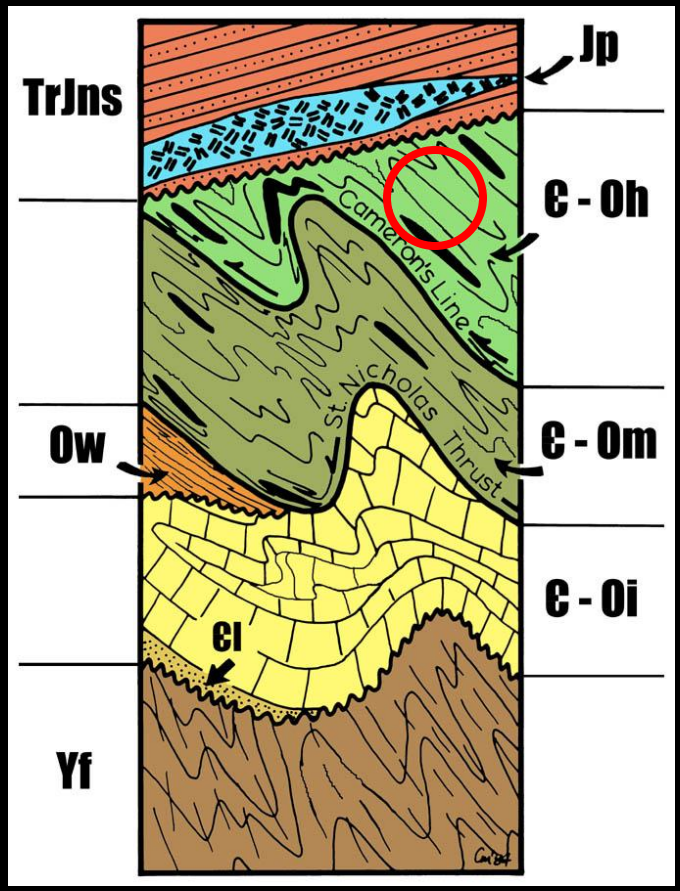
Manhattan Schist
F_3 Folds of S_2
Central Park, NYC



Manhattan Schist, Central Park

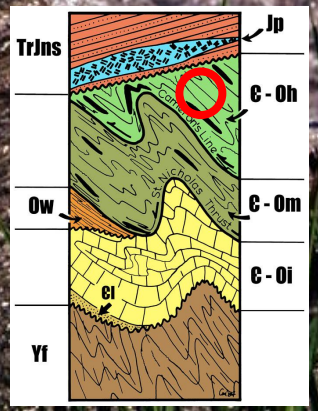


Sheared Manhattan Schist, St. Nicholas Park

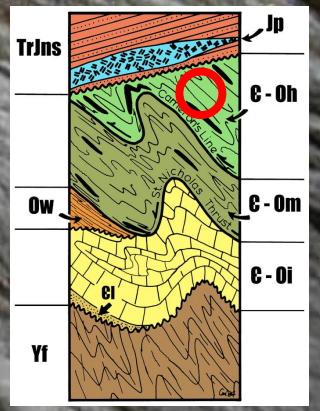


SW-Plunging F_3 Folds
Hartland Formation
Riverside Park, NYC

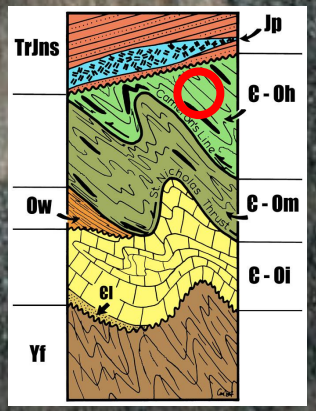
Hartland Schist, Riverside Park



F_2 Fold and Pegmatite, Central Park, NYC



N296 Hartland Granofels




N361 - Hartland Schist and Granofels


Hartland Amphibolite N567

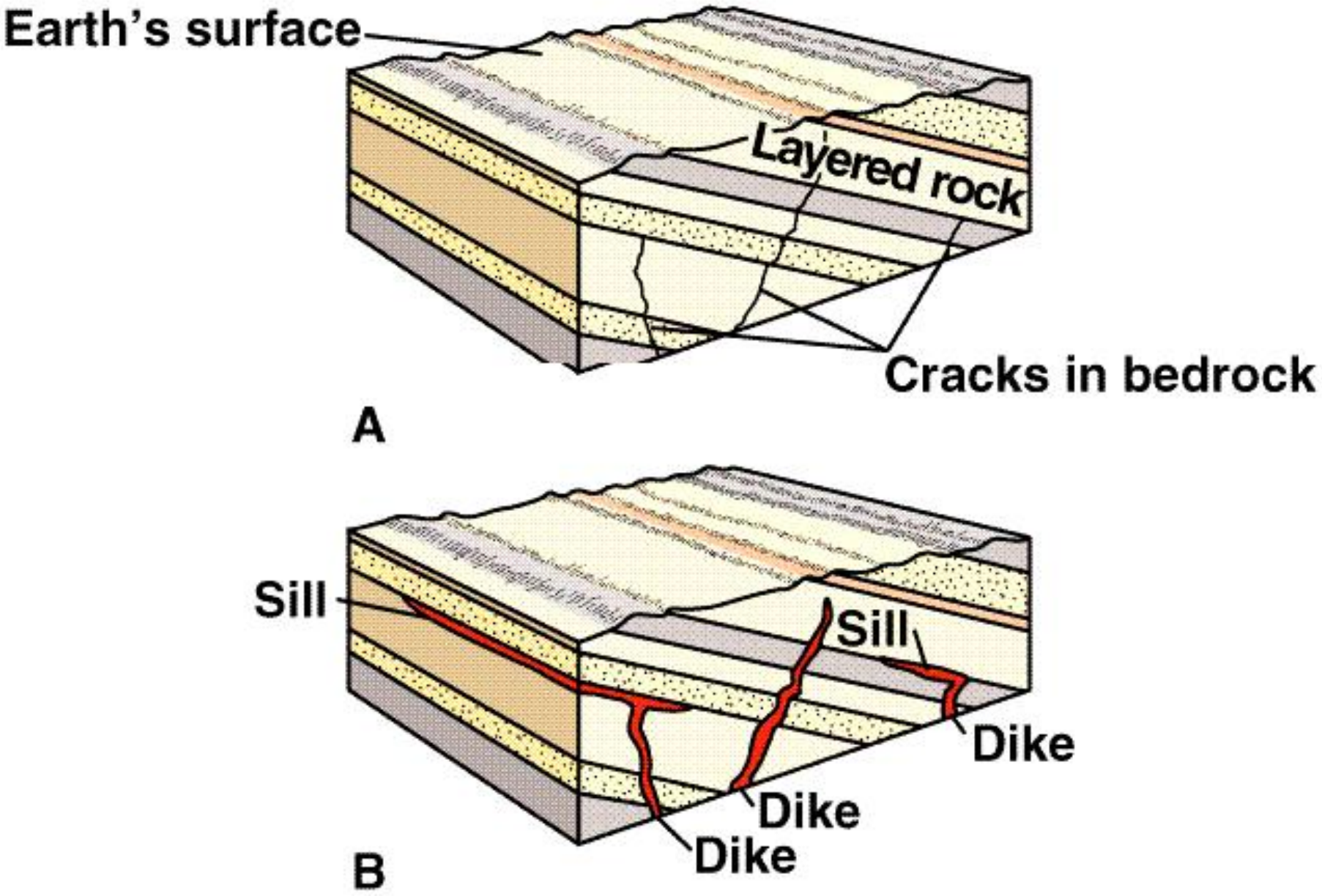

Hartland Amphibolite N567

What Does the Geologist See?


Pegmatite Sill-like Intrusive

Pegmatite Dike, So. Twin Island

Intrusive Structures: Dike and Sill




What Does the Geologist See?


Pegmatite Dike with Chilled Margin


FOLD PATTERNS
N566 C0h


FOLD PATTERNS
Manhattan Schist, Central Park

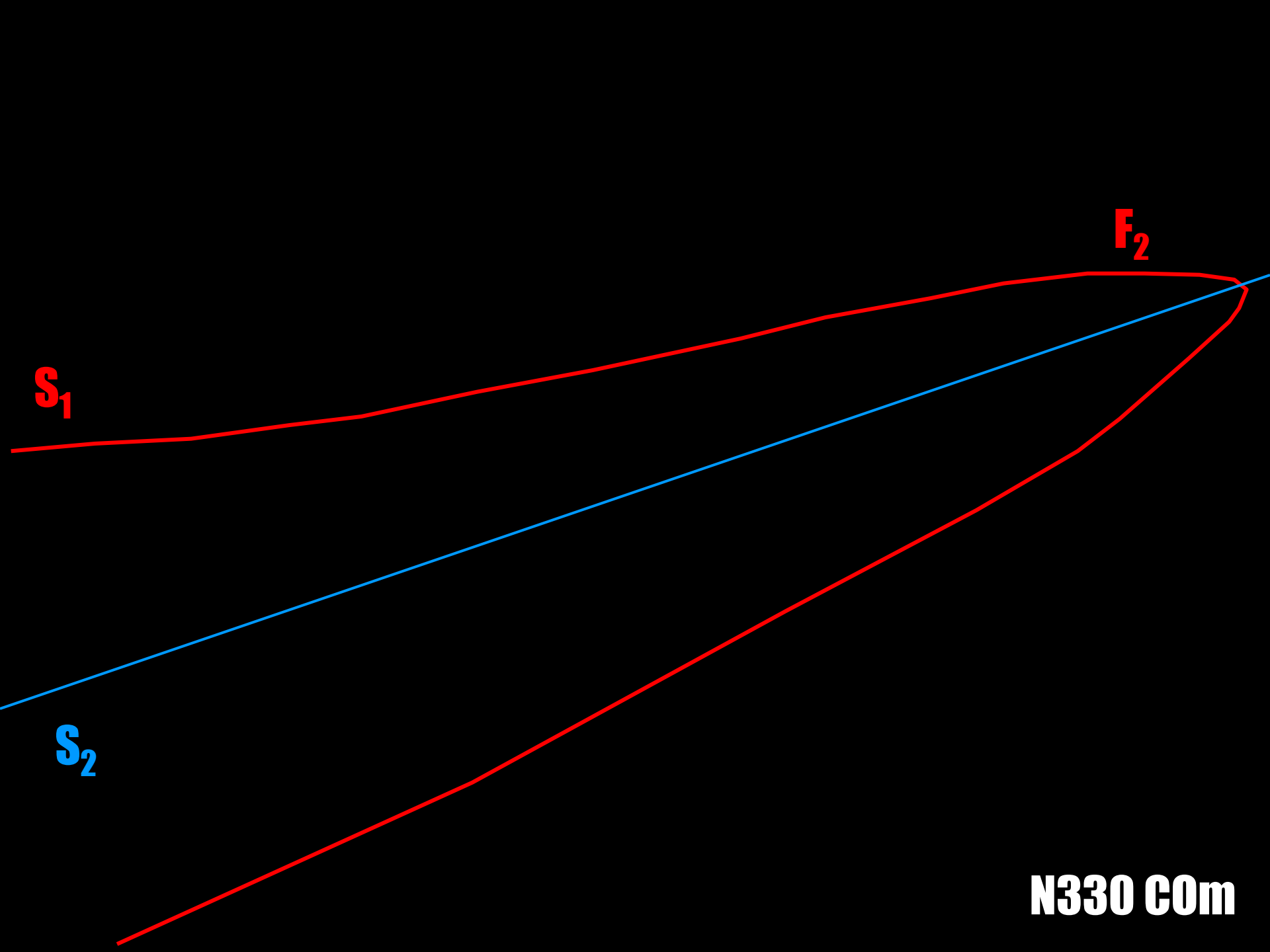
Central Park is a Canvas for Students


What Does the Geologist See?


Pegmatite Intrusive Crosscuts Fold but is also Folded

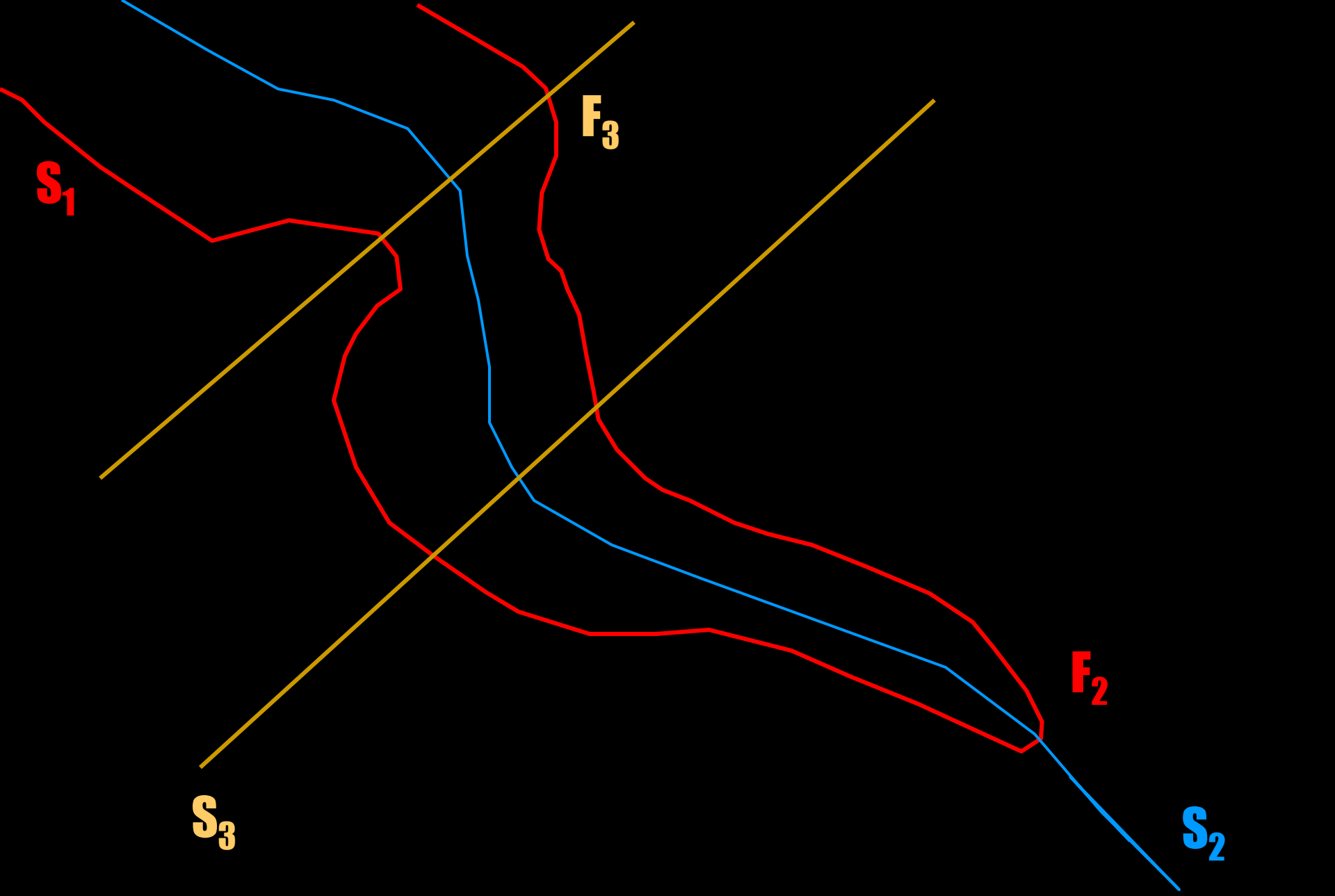

N330 C0m


F_2
S_1
S_2
N330 C0m


F2
S1
S2
N330 COm

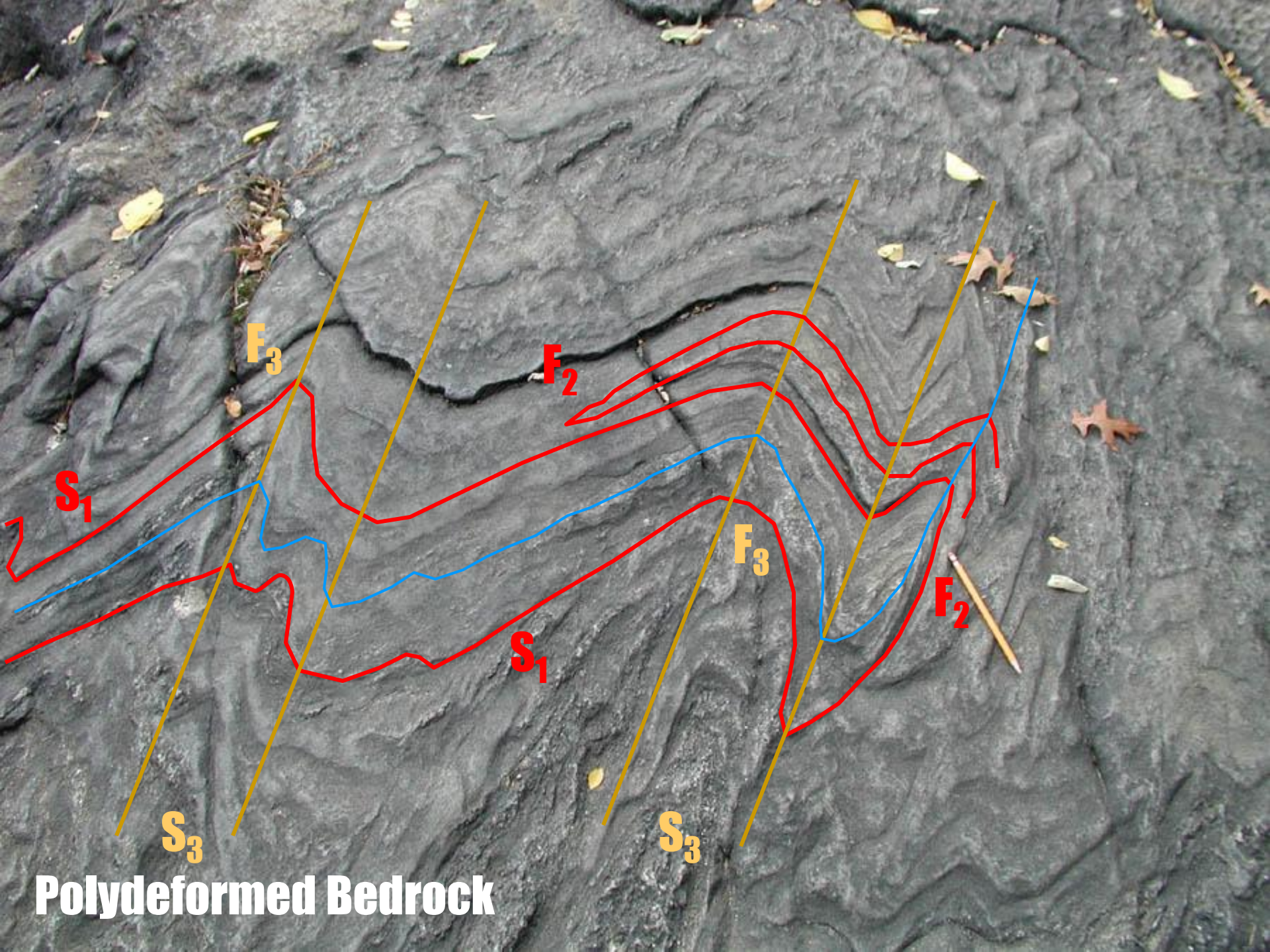
Polydeformed Bedrock

Polydeformed Bedrock

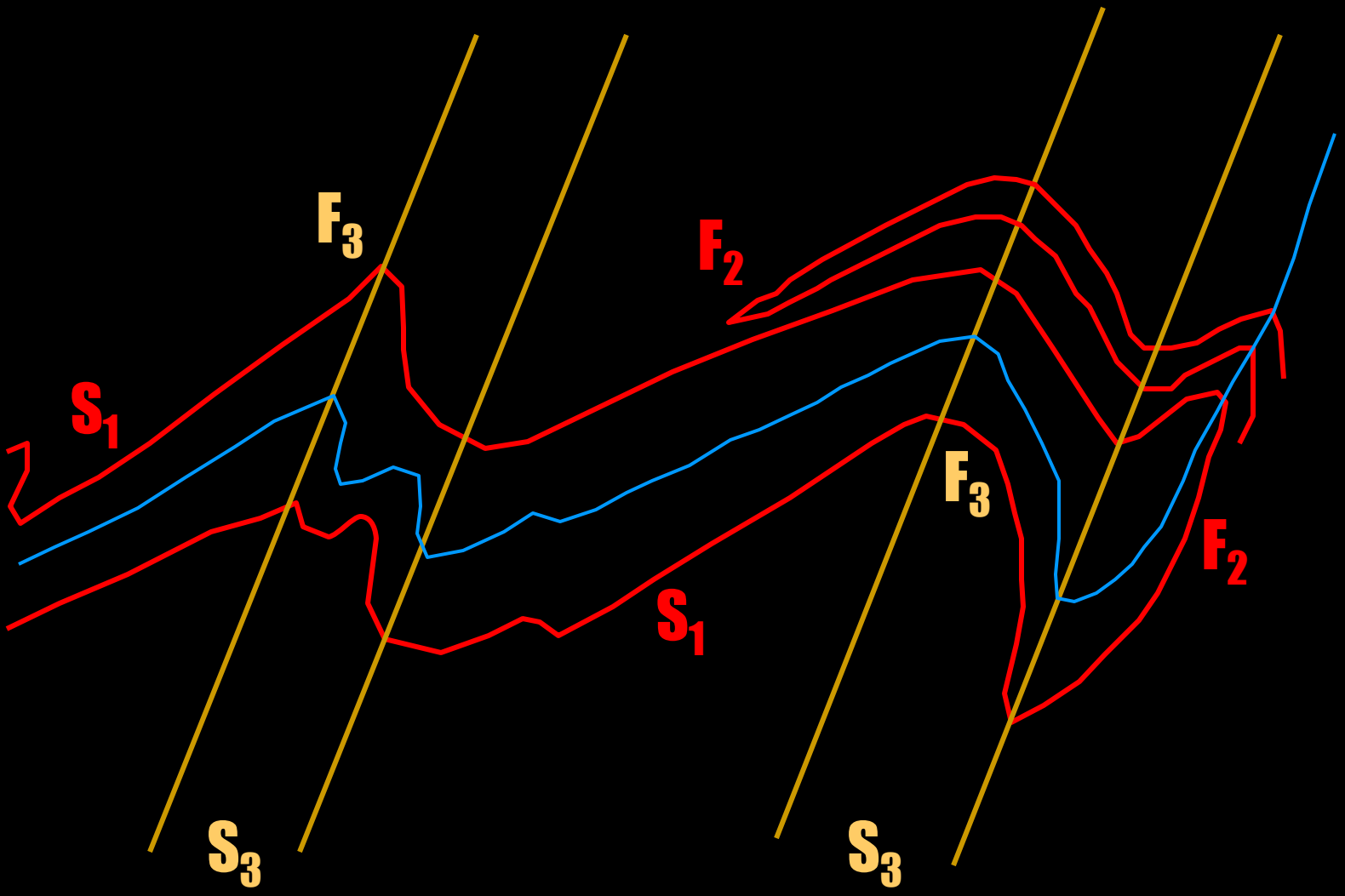


Polydeformed Bedrock

Polydeformed Bedrock

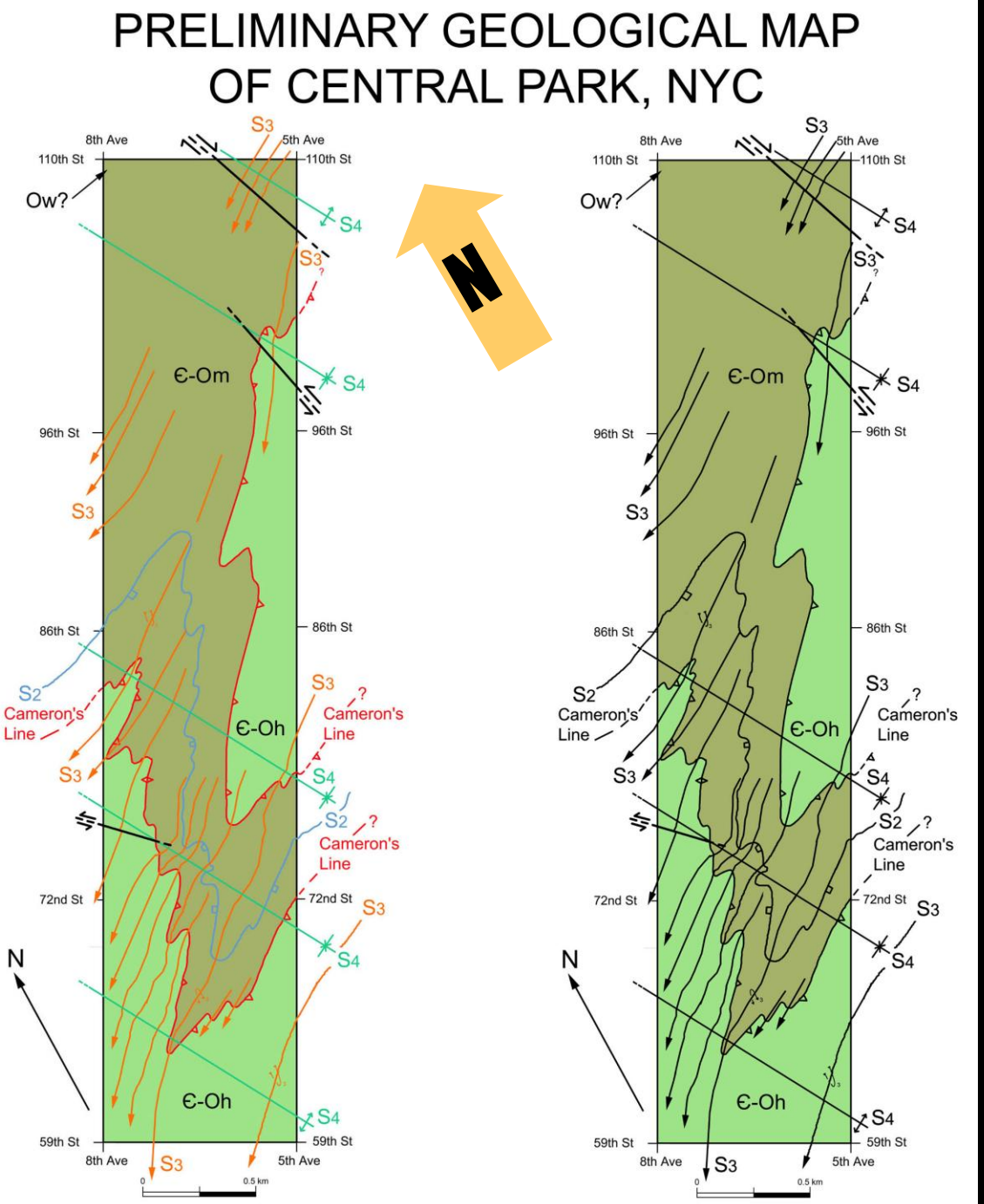


Polydeformed Bedrock

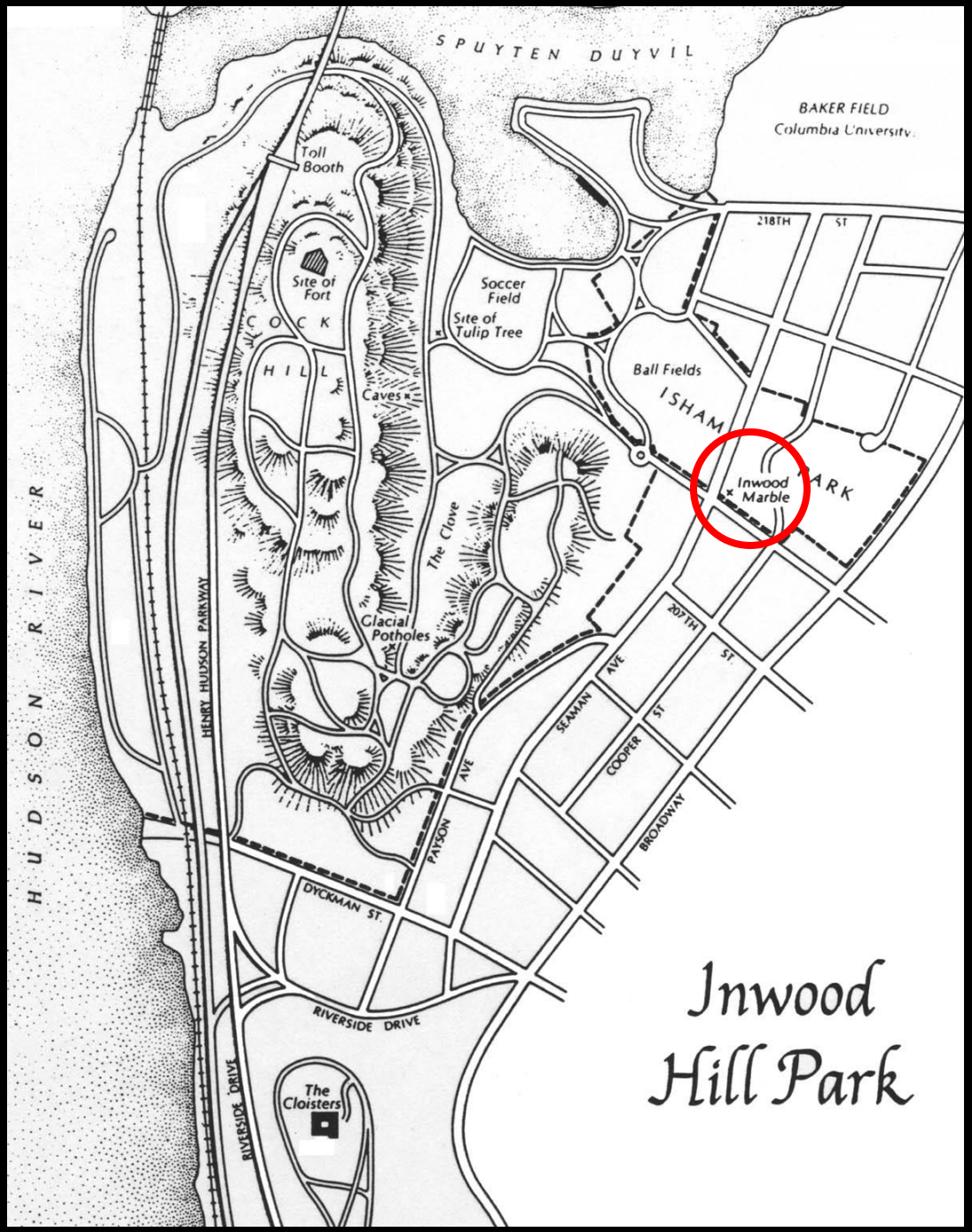


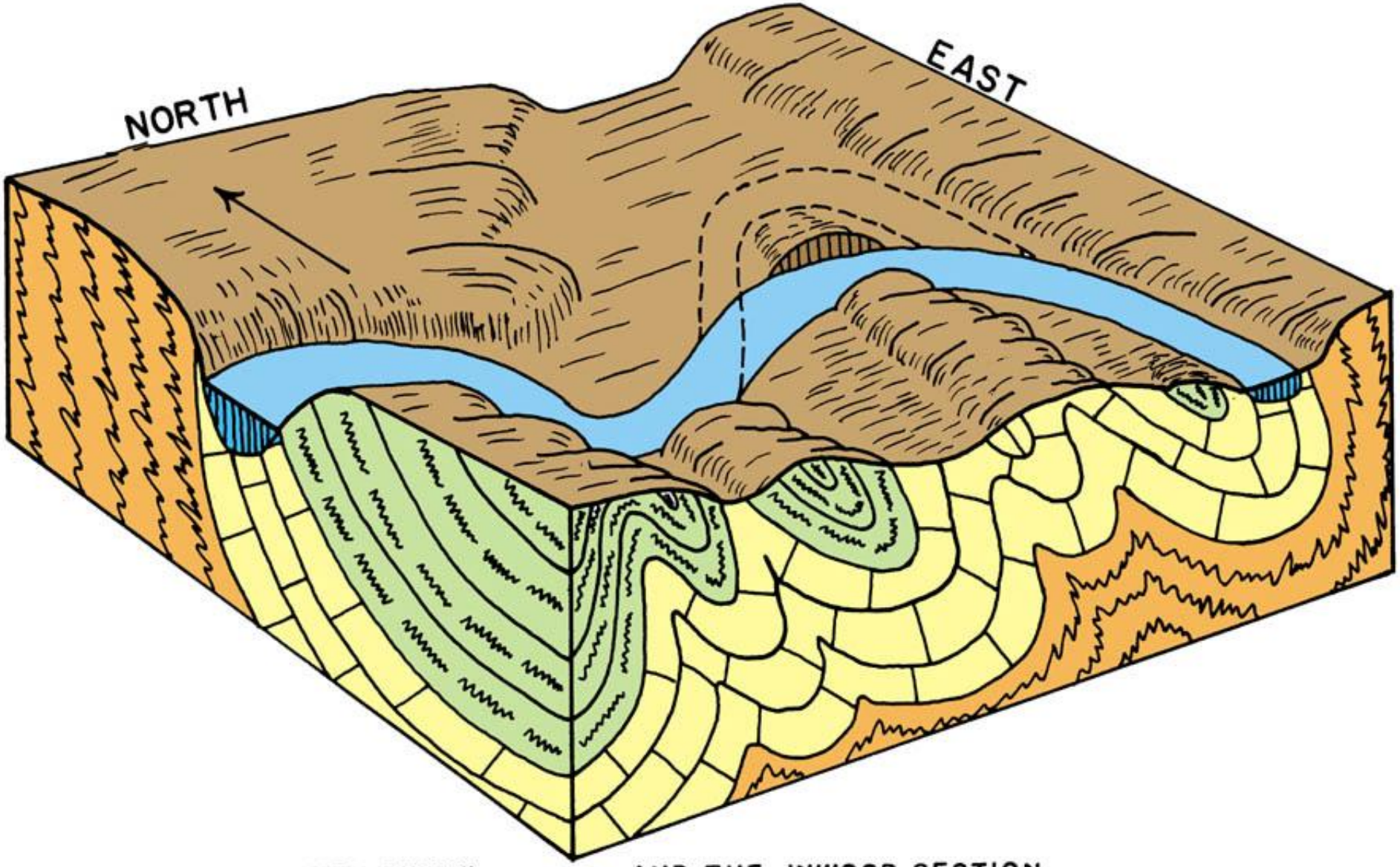
Polydeformed Bedrock

Cameron's Line in Central Park



Merguerian and Merguerian, 2004

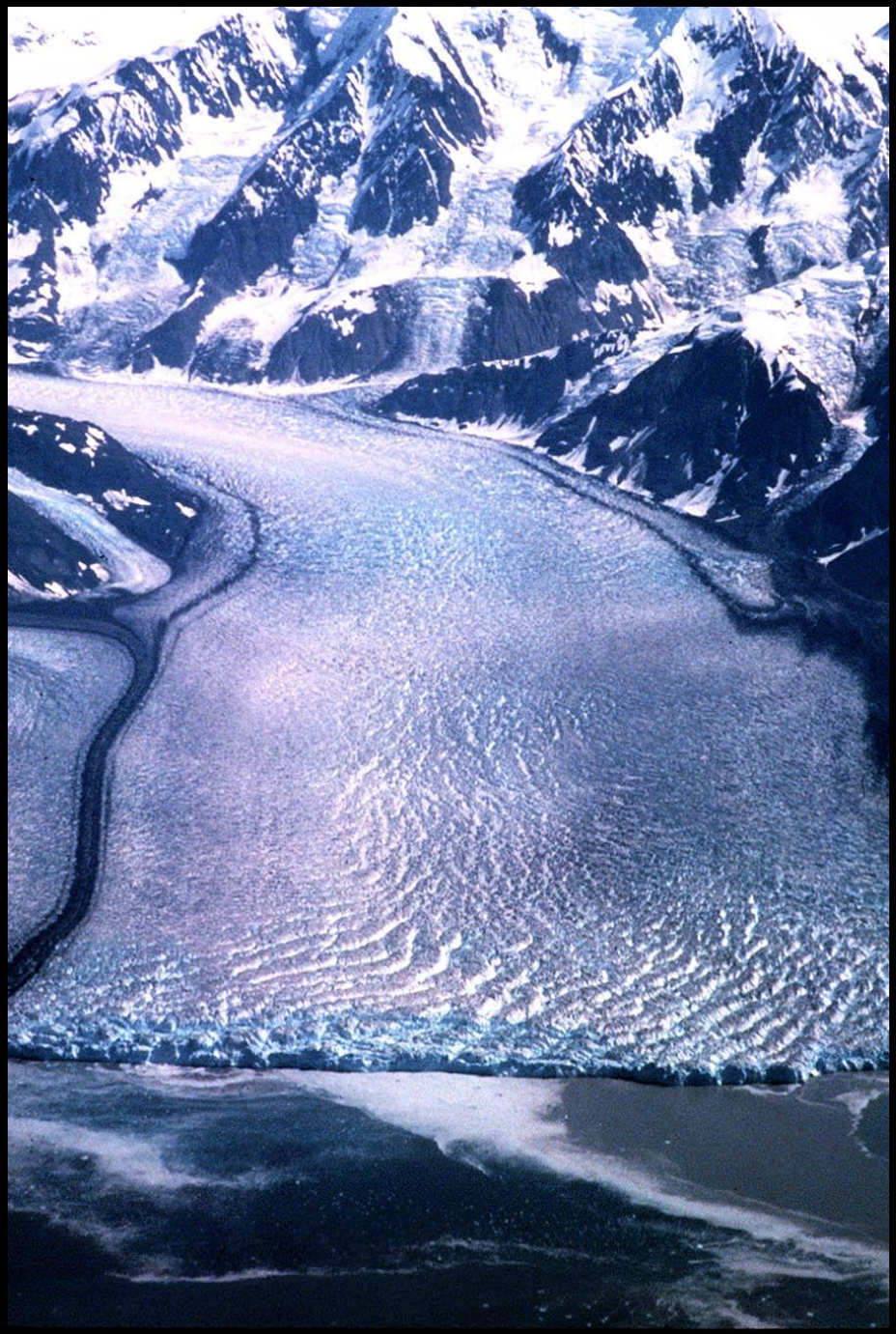

SPUYTEN DUYVIL
BAKER FIELD
Columbia University
Toll Booth
Site of Fort
COCK HILL
Soccer Field
Site of Tulip Tree
Caves
Ball Fields
ISHAM PARK
Inwood Marble
218TH ST
The Clove
Glacial Potholes
207TH ST
SEAMAN AVE
COOPER ST
BROADWAY
PAYSON AVE
DYCKMAN ST.
RIVERSIDE DRIVE
HENRY HUDSON PARKWAY
HUDSON RIVER
The Cloisters
Inwood Hill Park



SPUYTEN DUYVIL AND THE INWOOD SECTION


JUL 28 2003

Isham Park Inwood Marble



Inwood Potholes

New York City Earthquake Can it Happen Here?

1737 5.2

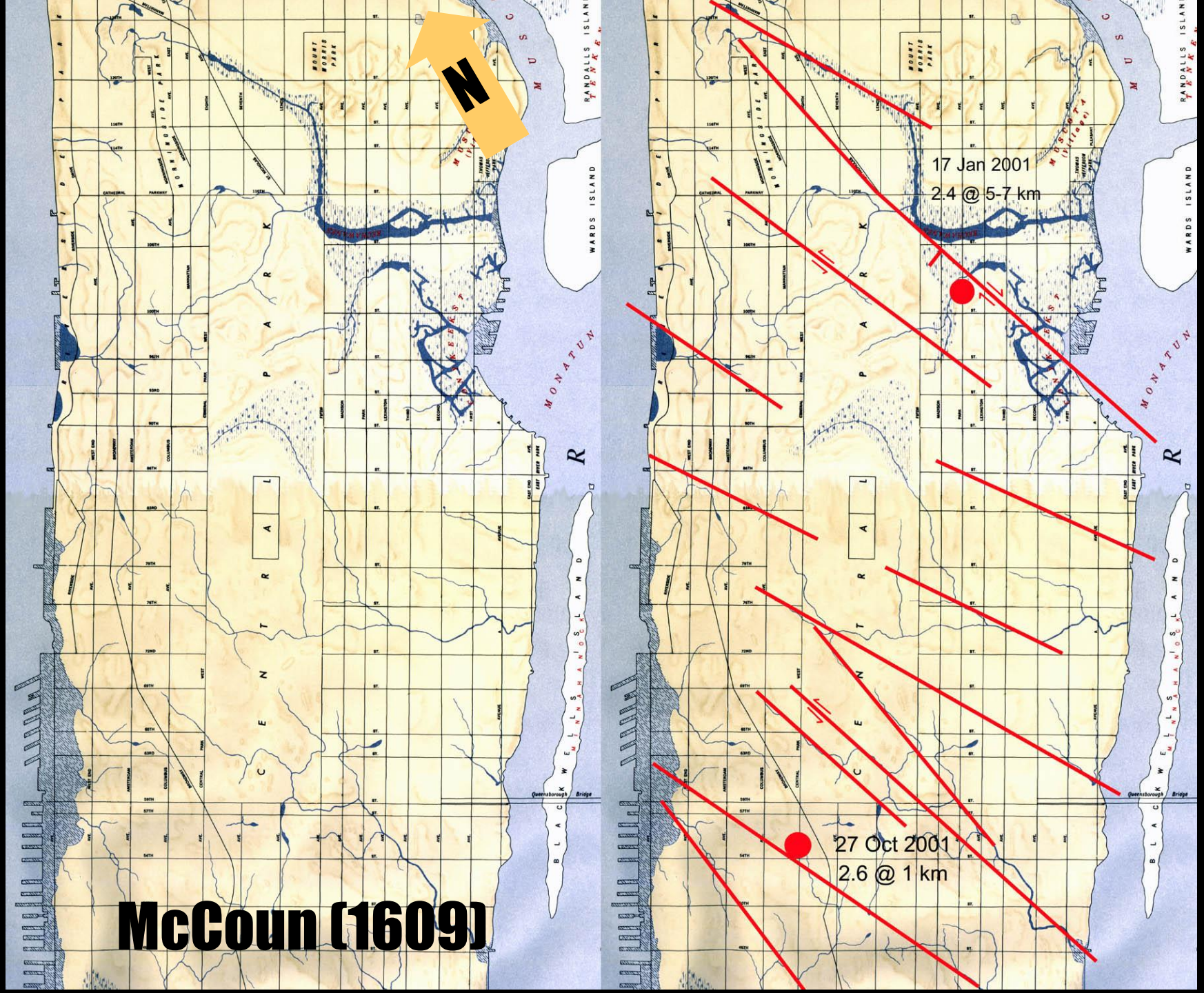
1783 4.9

1884 5.2

200? ?

How Well Will NYC Withstand A Moderate Earthquake?

How is NYC Built?


N
17 Jan 2001
2.4 @ 5-7 km
27 Oct 2001
2.6 @ 1 km
McCoun (1609)

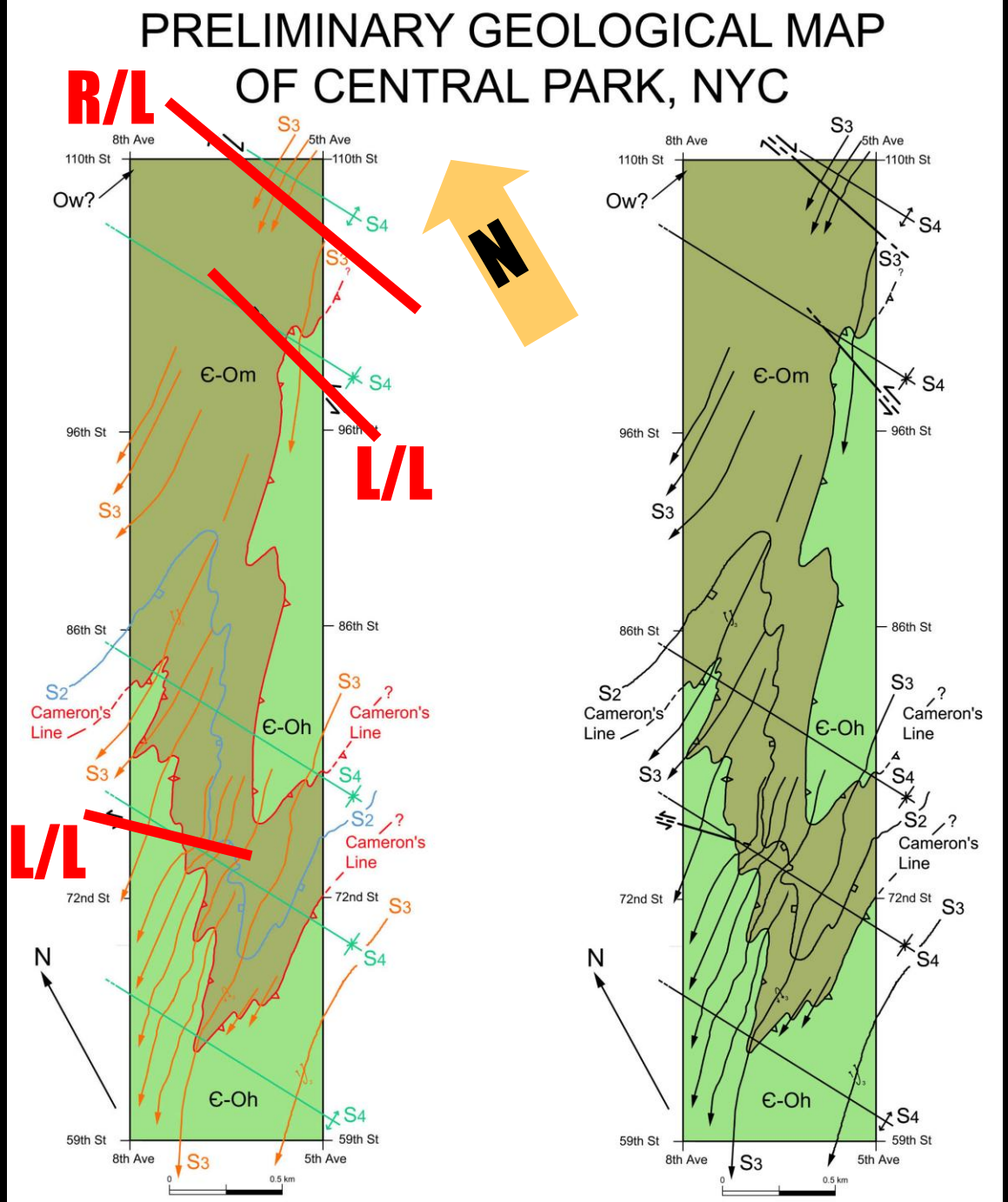

It’s Not My Fault! He put me up to this!

Manhattan Schist

Offsets F_3 Syncline

N537

Group E - N12°W, L/L Fault



Group E Faults In Central Park

Merguerian and Merguerian, 2004

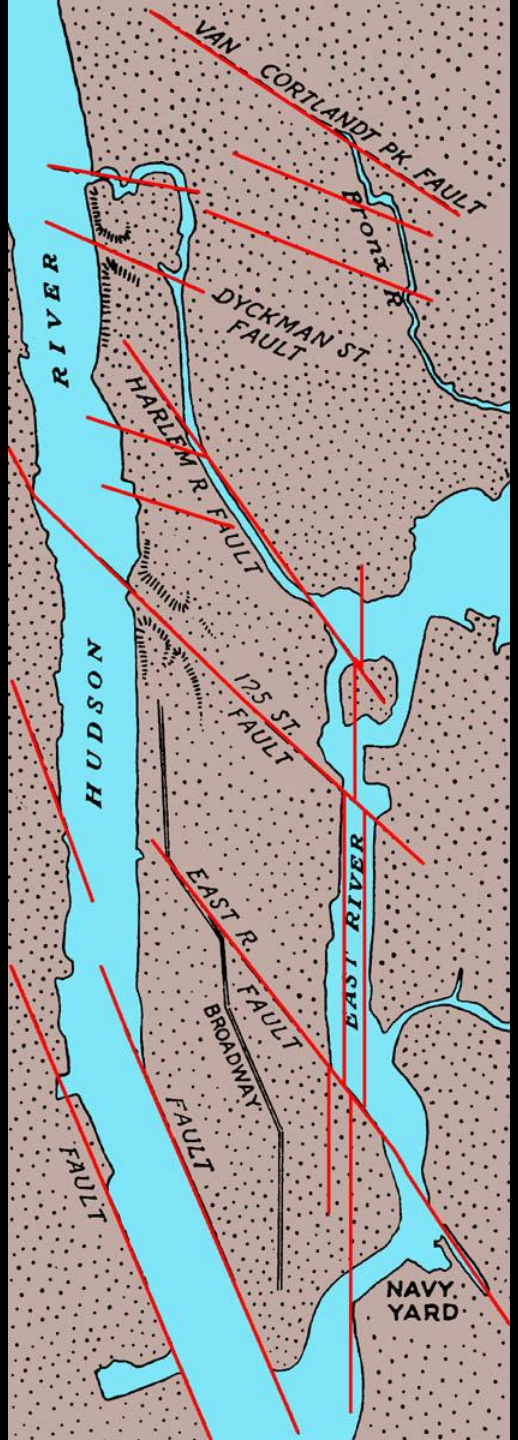
Group E - N45°W, 80°S L/L Fault

N296 Hartland Fm

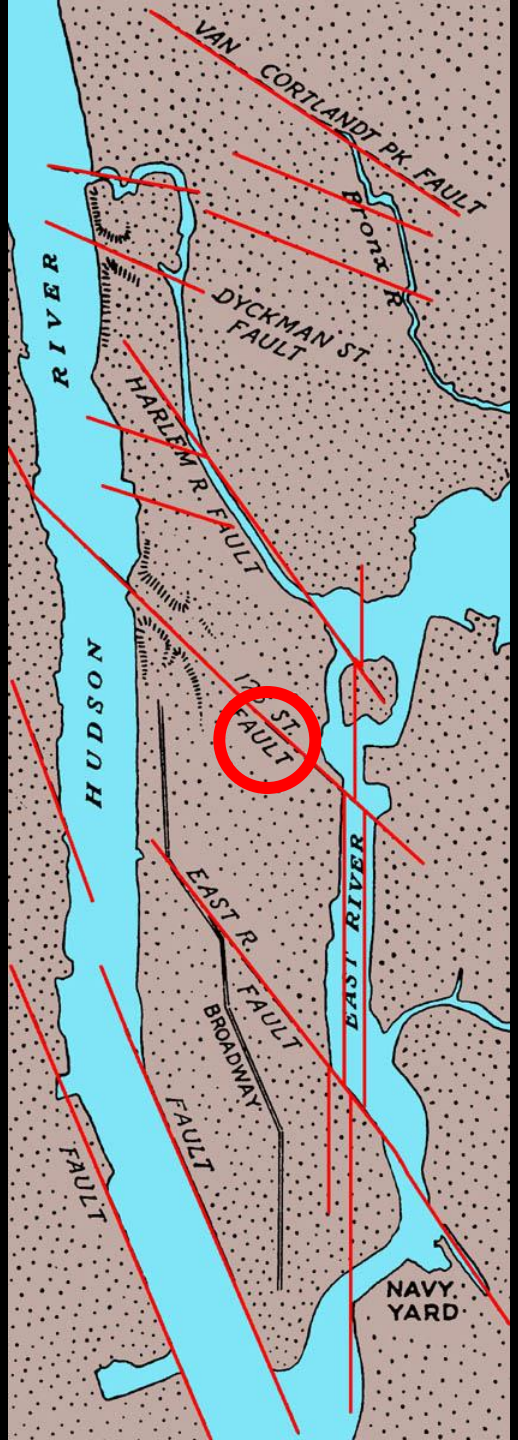

N42°E-Trending Left-Lateral Fault, South Twin Is., NY

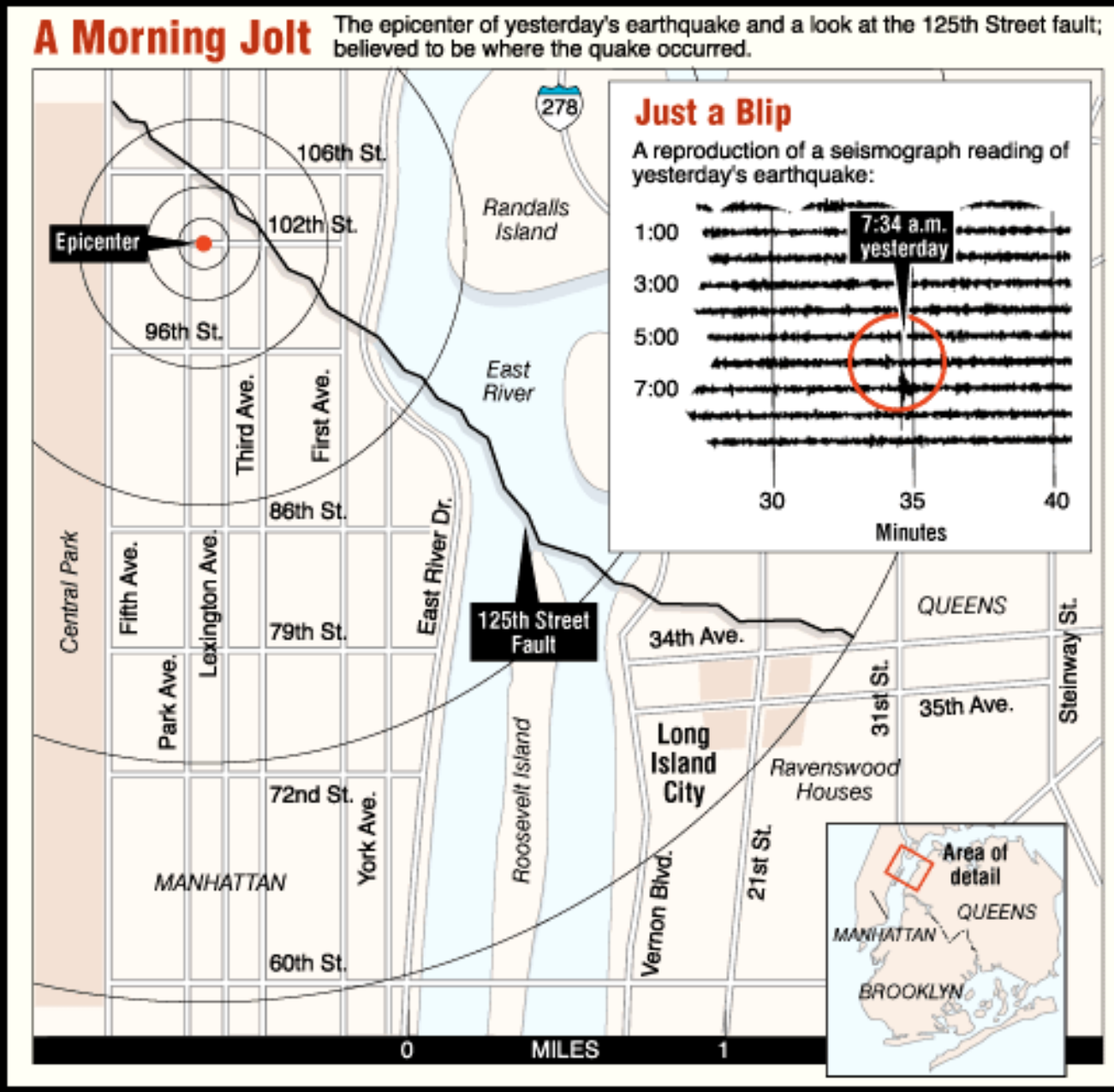

N66°W R/L Fault, So. Twin Is., NY

Group E Faults



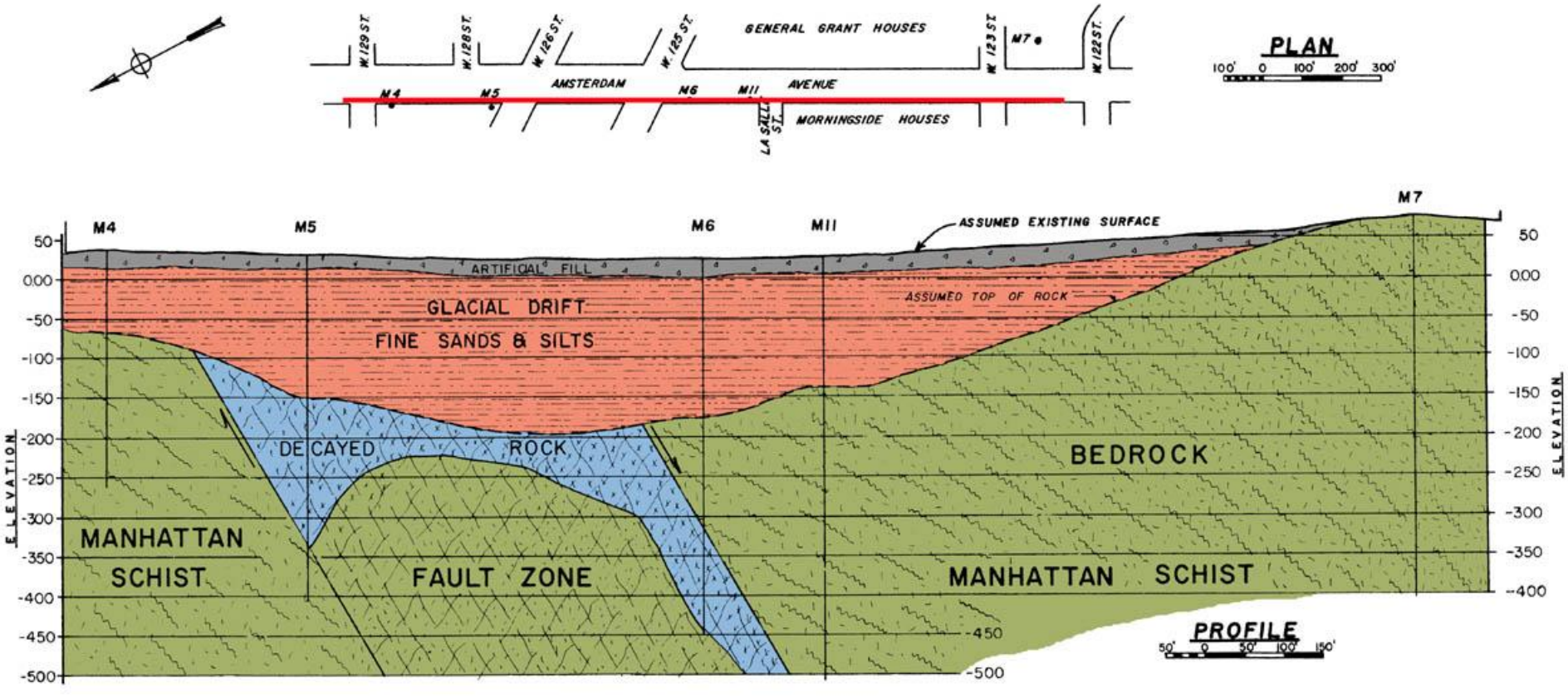
17 January 2001, M = 2.4





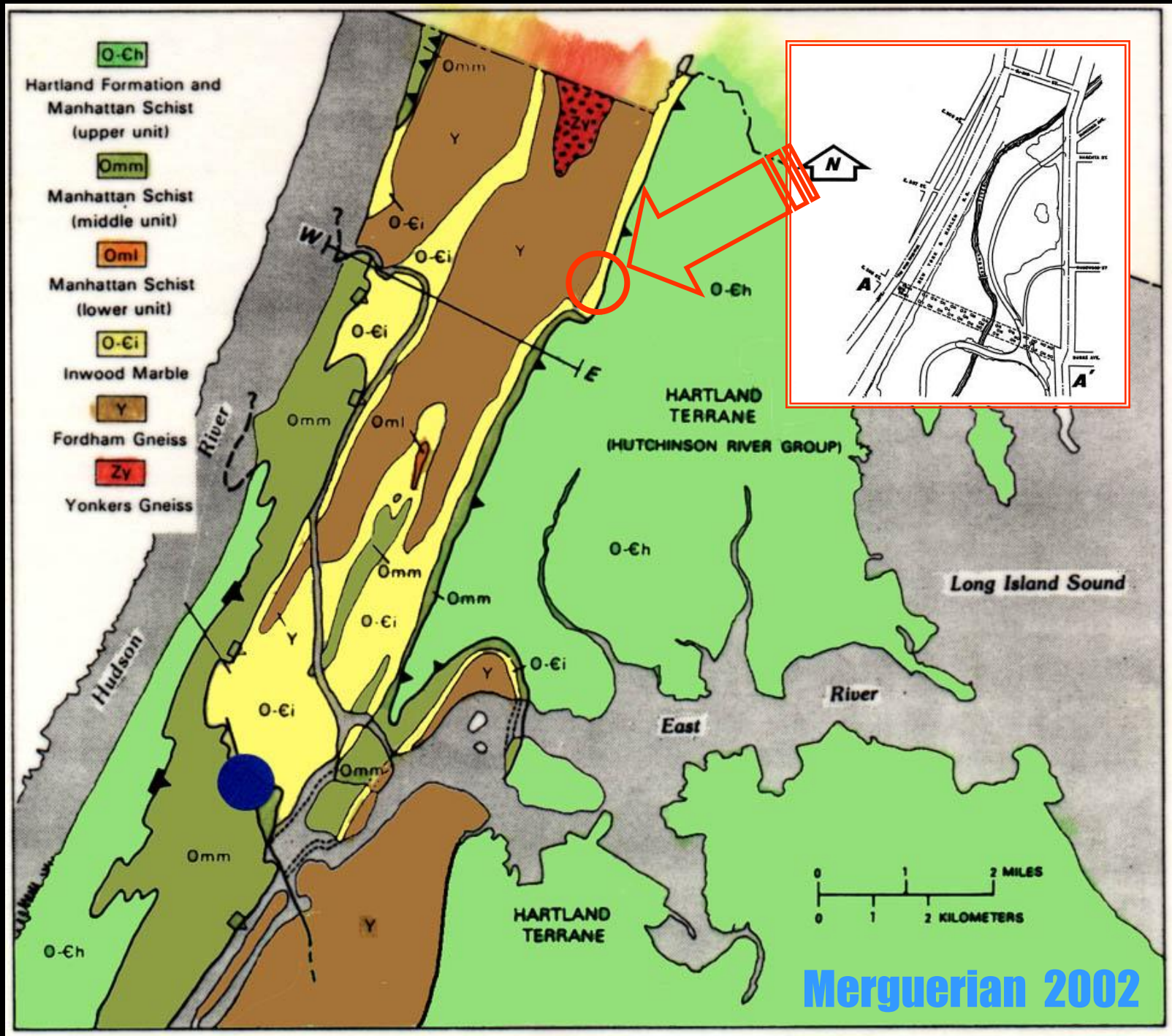

DESPATCH
MOVING & STORAGE

Manhattanville "125th Street" Fault

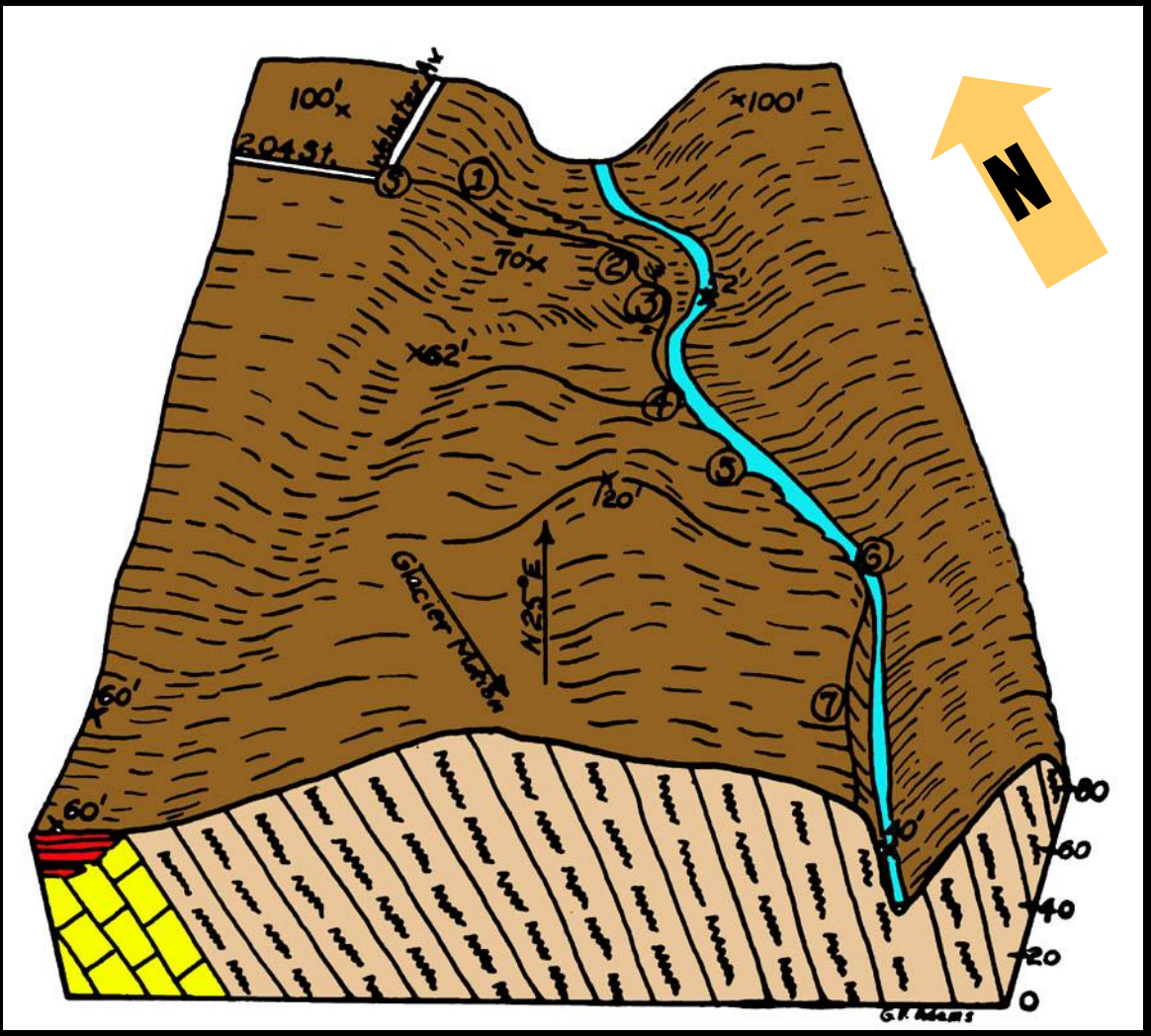


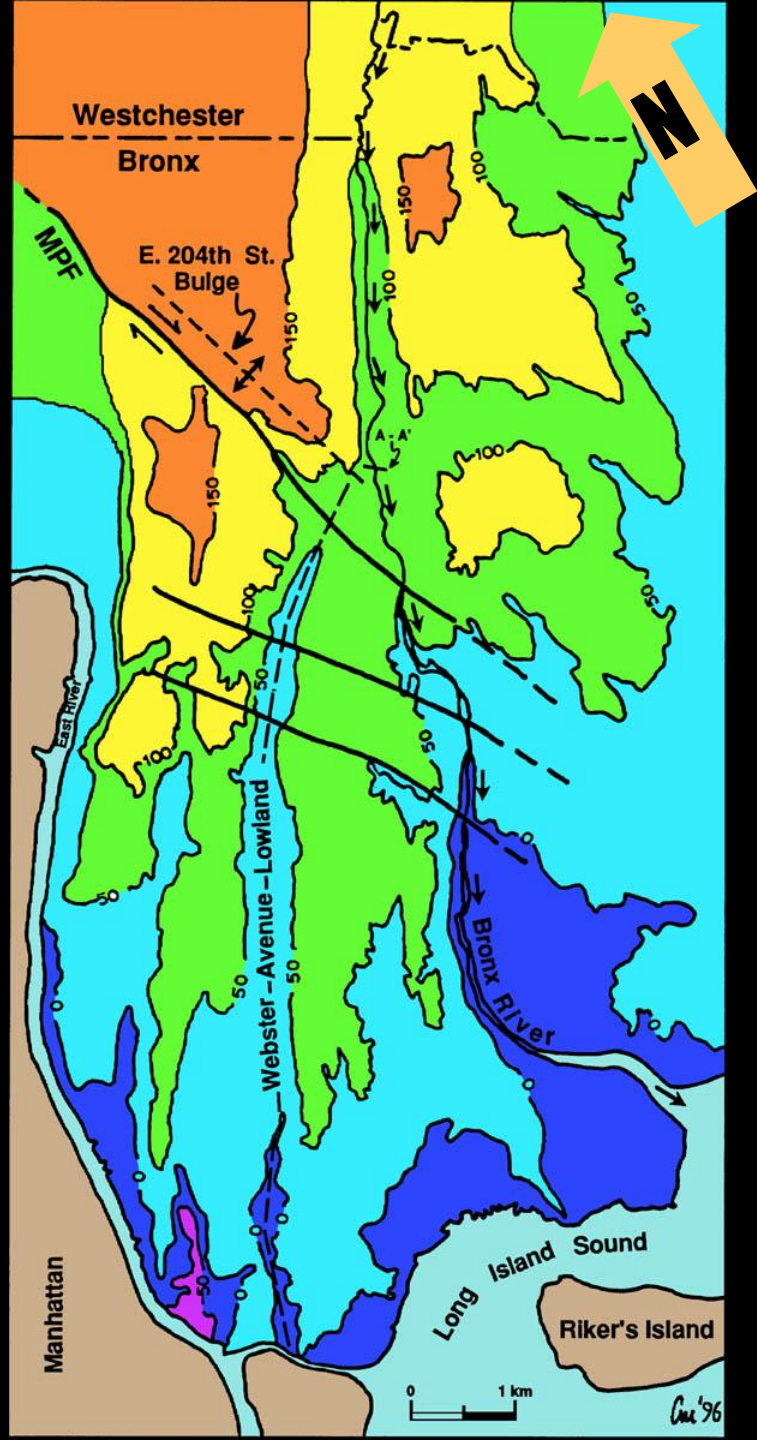
CT3, Stage 1

after Fluhr, 1969

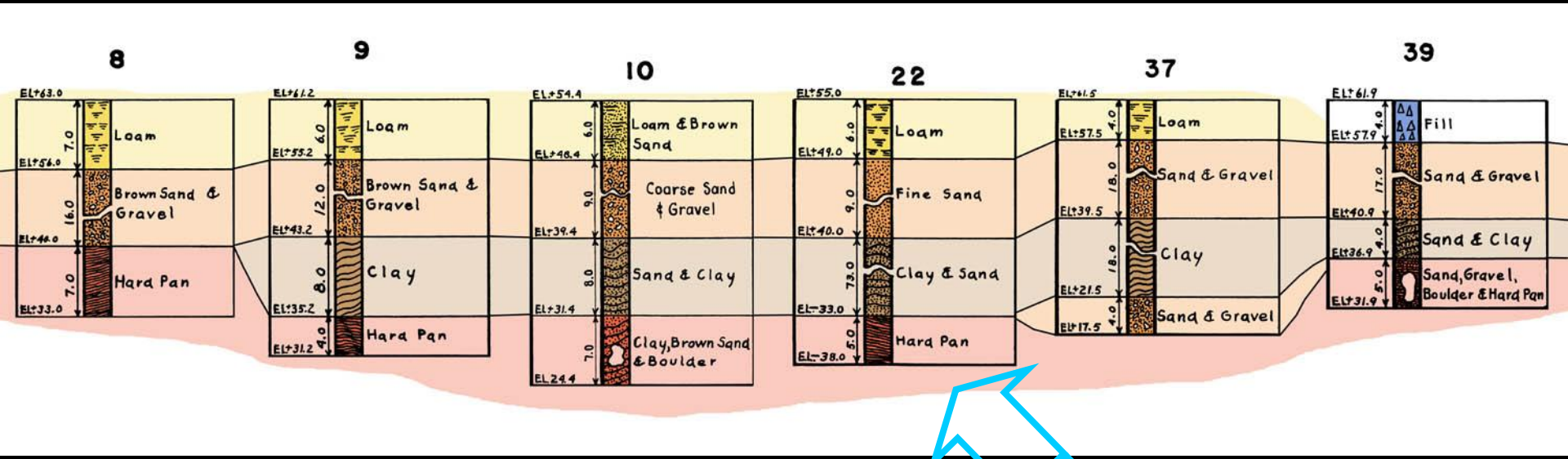

O-Ch
Hartland Formation and Manhattan Schist (upper unit)
Omm
Manhattan Schist (middle unit)
Oml
Manhattan Schist (lower unit)
O-Ci
Inwood Marble
Y
Fordham Gneiss
Zy
Yonkers Gneiss
W
E
A
A'
N
HARTLAND TERRANE
(HUTCHINSON RIVER GROUP)
HARTLAND TERRANE
Long Island Sound
Hudson River
East River
0 1 2 MILES
0 1 2 KILOMETERS
Merguerian 2002

Bronx River Drainage Anomaly





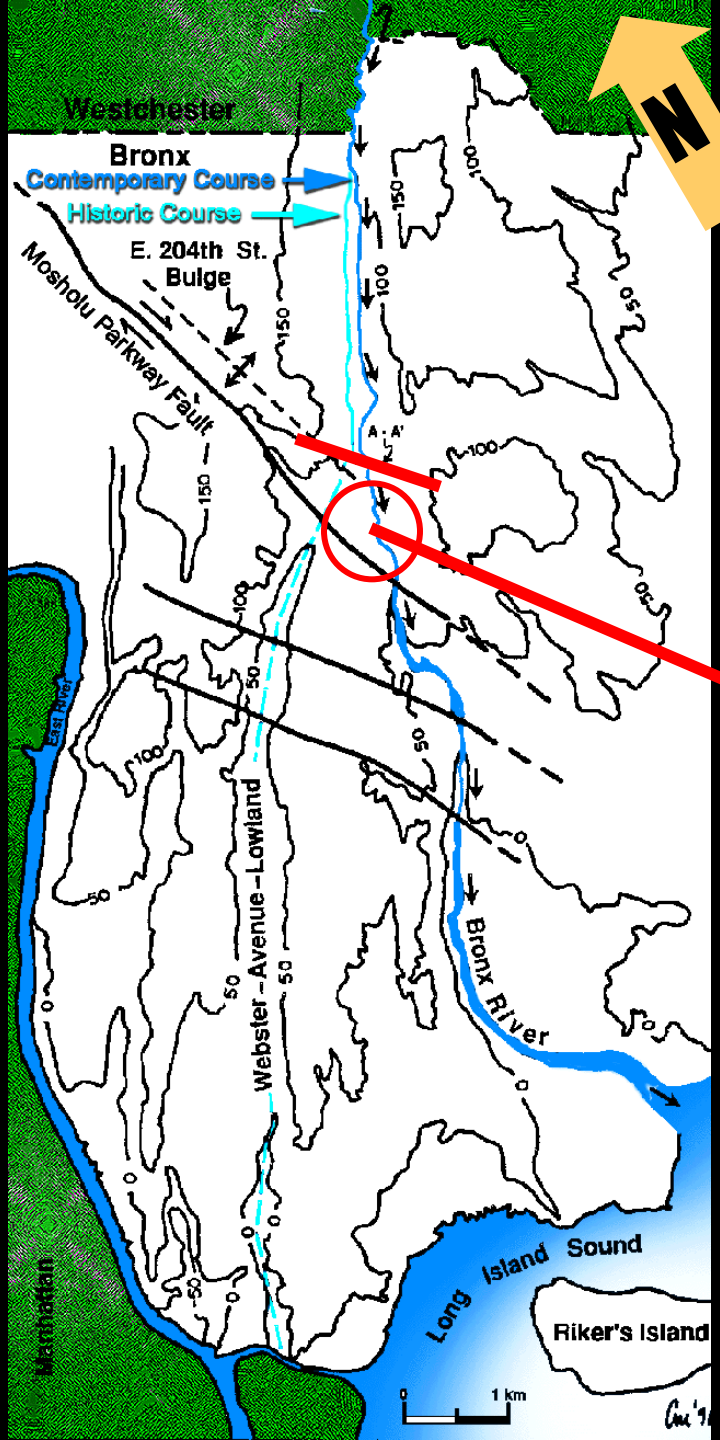
Burke Avenue Profile – Bronx WPA



Bouldery Till

Stratified Lake Sediment Overlie Glacial Drift

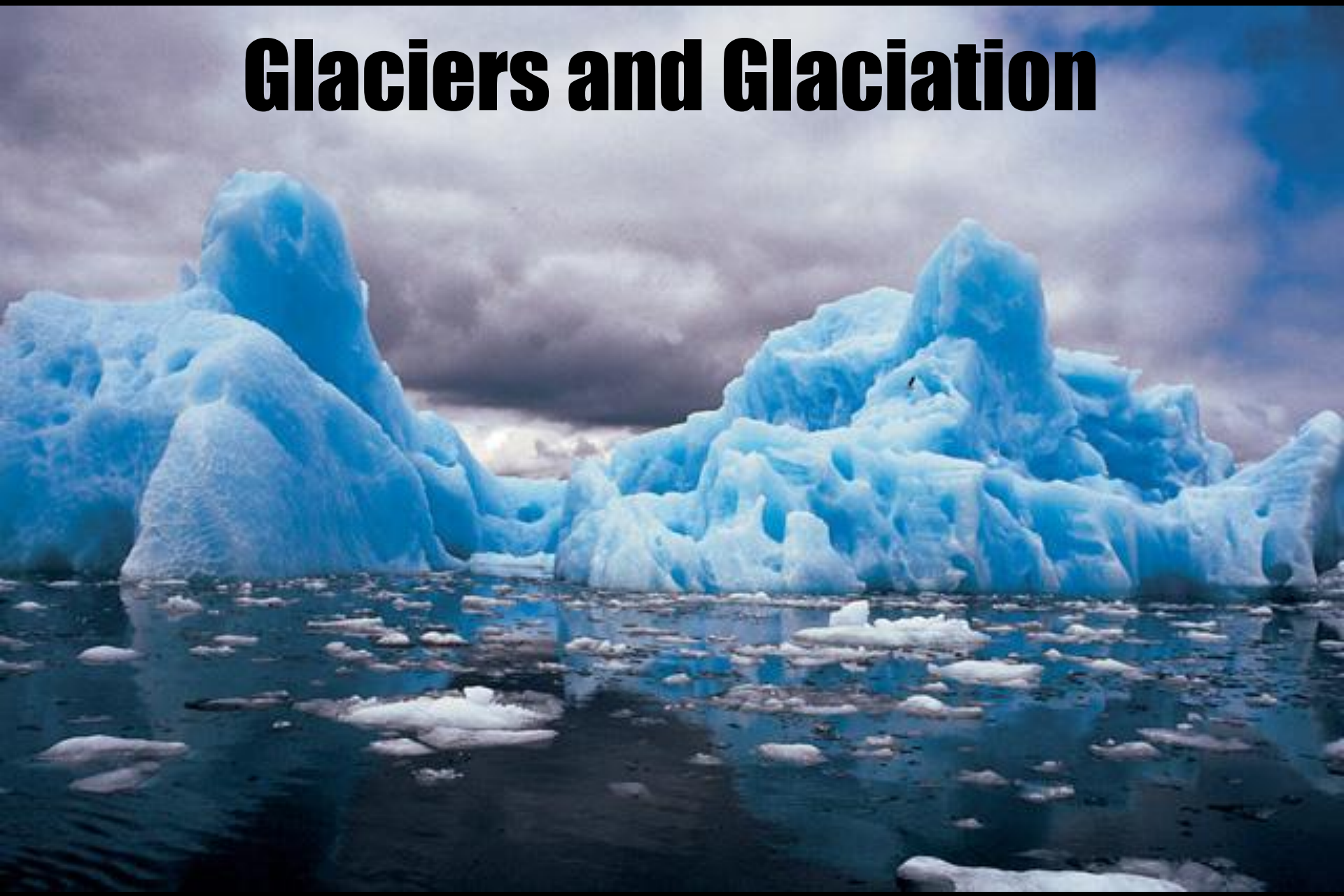
Supports Hypothesis that Damming of Bronx River was Post-Glacial



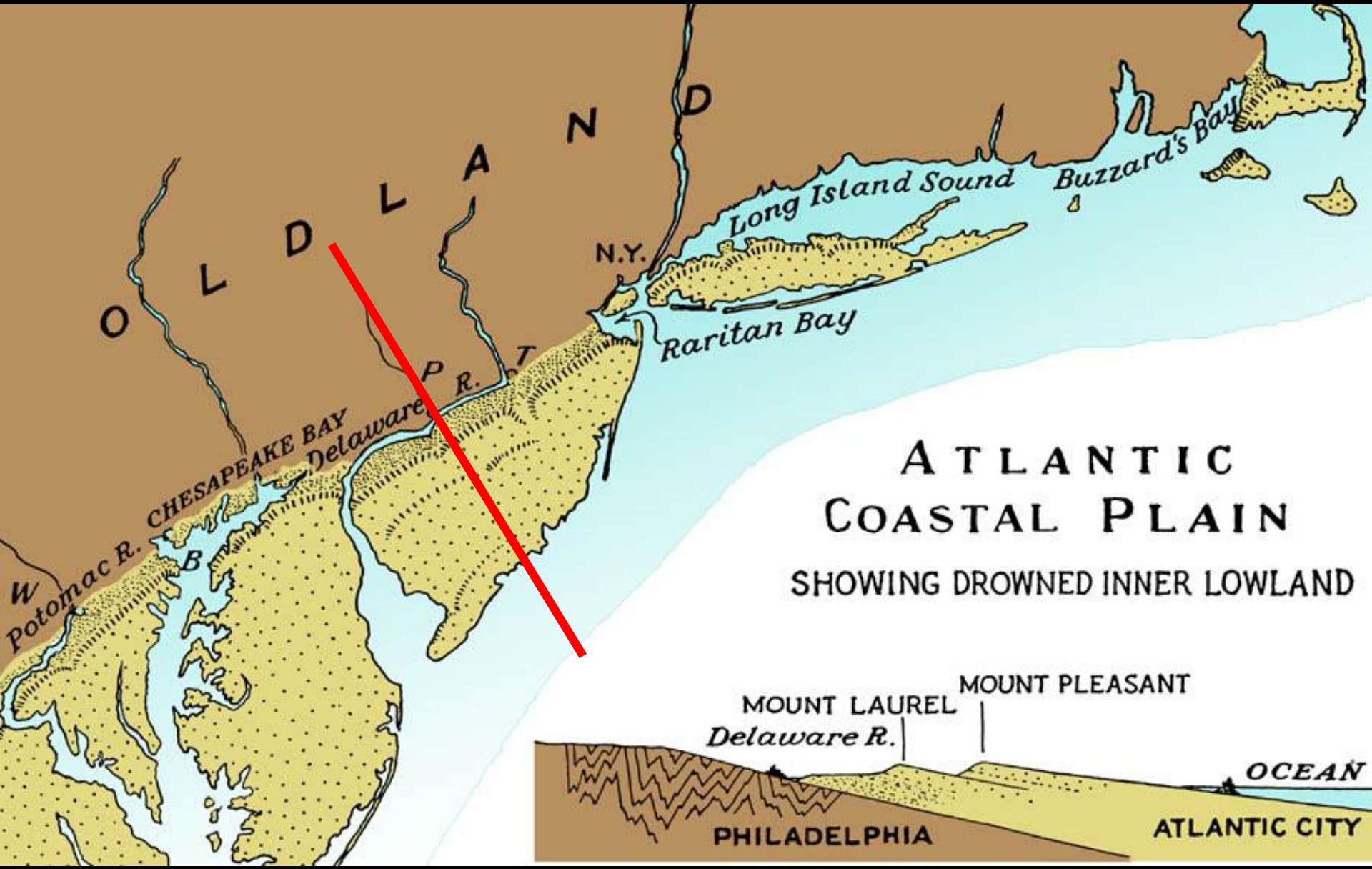
Non-glaciated V-Shaped Bronx River Valley at Snuff Mill, NY Botanical Garden

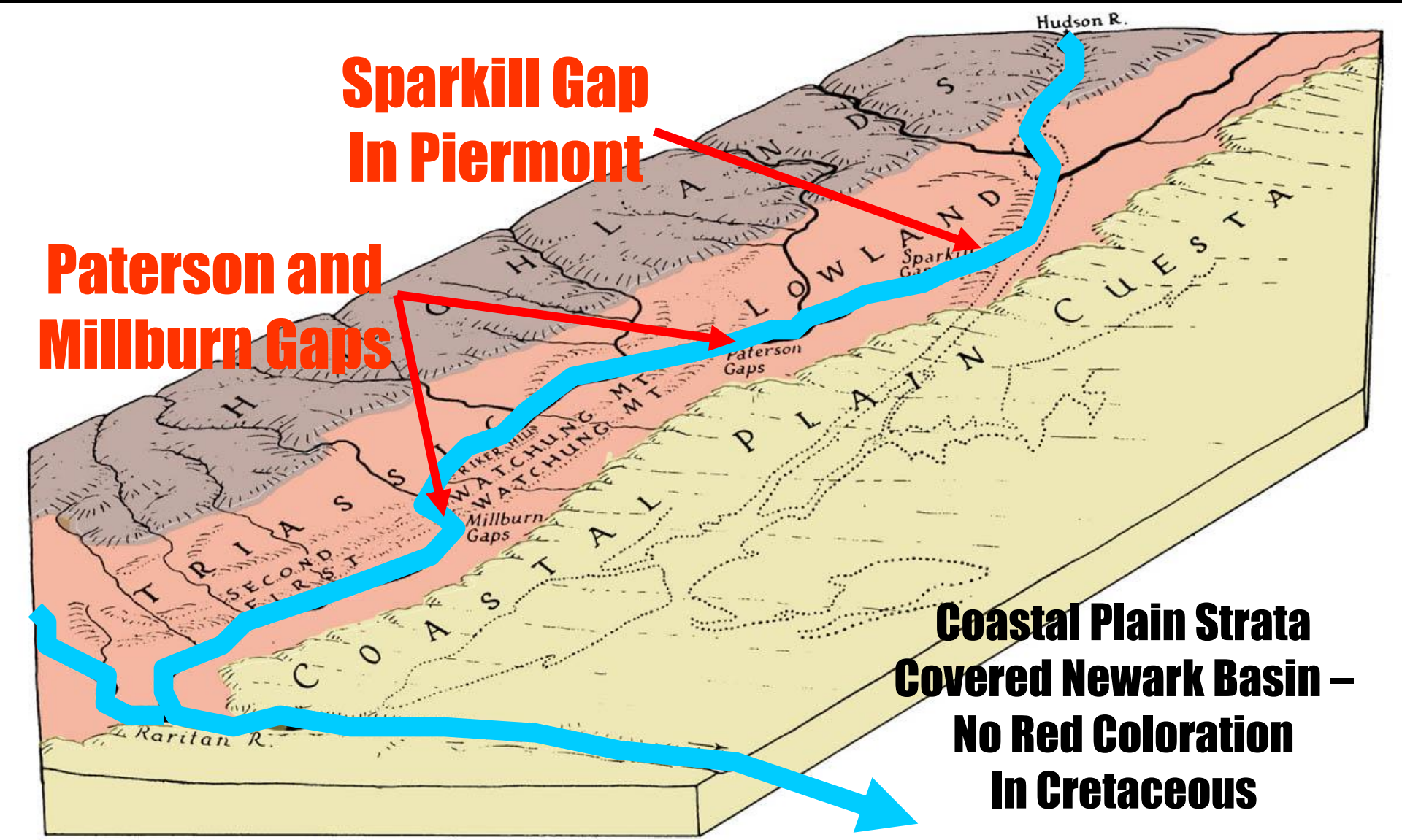

Download Geology Publications:
www.hofstra.edu
www.dukelabs.com
What's That Noise?

Glaciers and Glaciation



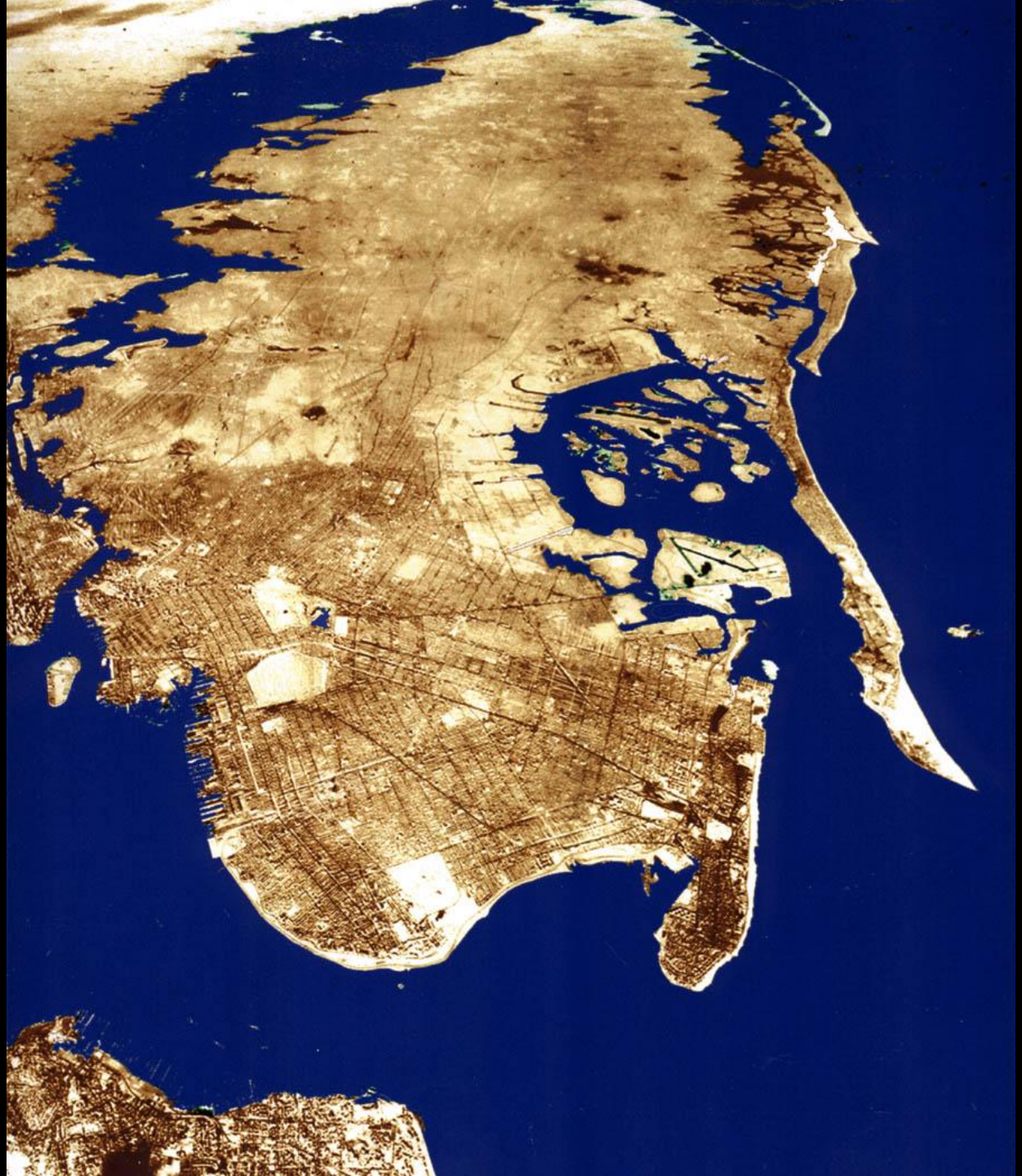
Pleistocene Glaciation


O L D L A N D
N.Y.
Long Island Sound
Buzzard's Bay
Raritan Bay
P R.
Delaware
CHESAPEAKE BAY
Potomac R.
ATLANTIC
COASTAL PLAIN
SHOWING DROWNED INNER LOWLAND
MOUNT LAUREL
MOUNT PLEASANT
Delaware R.
OCEAN
PHILADELPHIA
ATLANTIC CITY

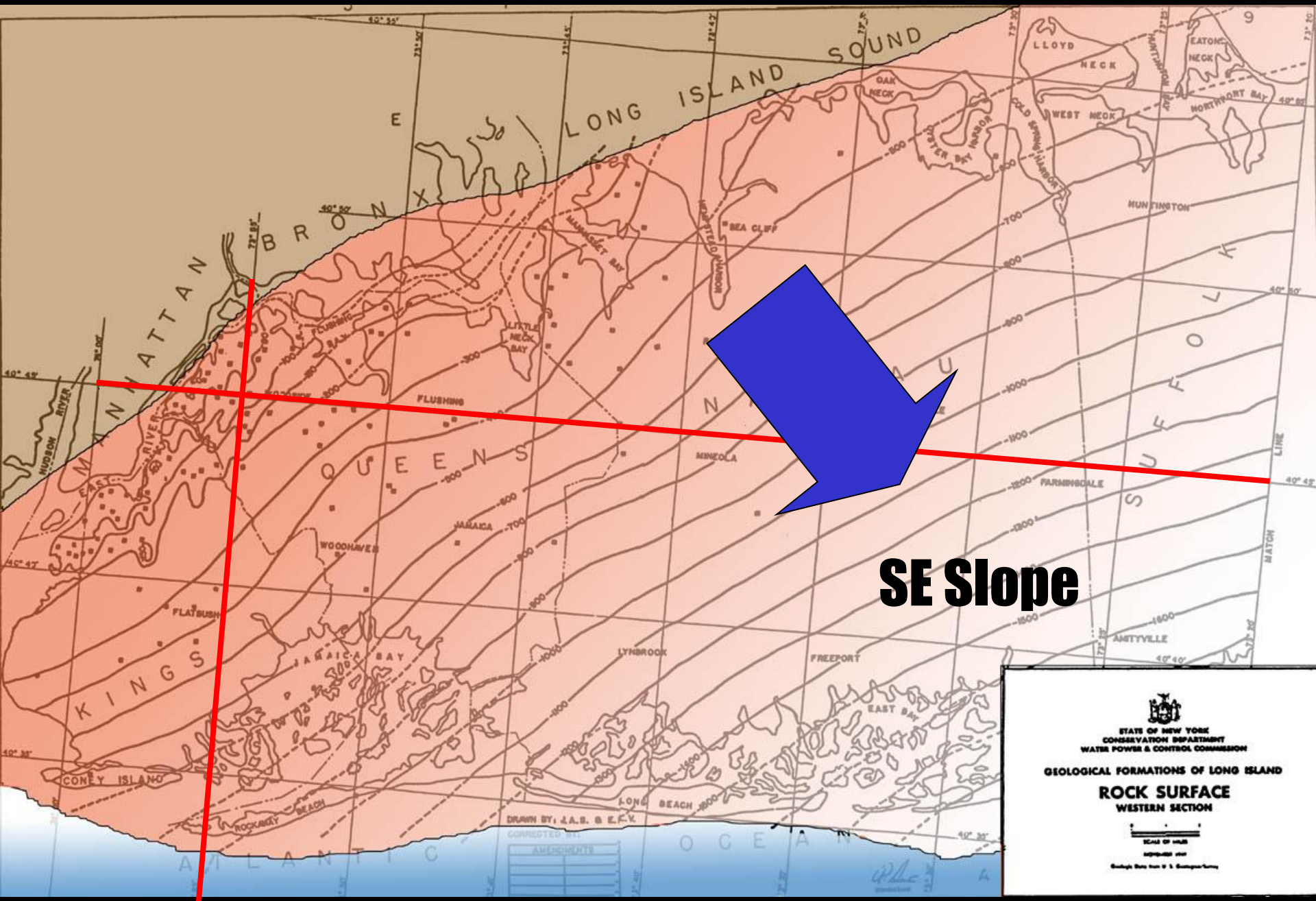


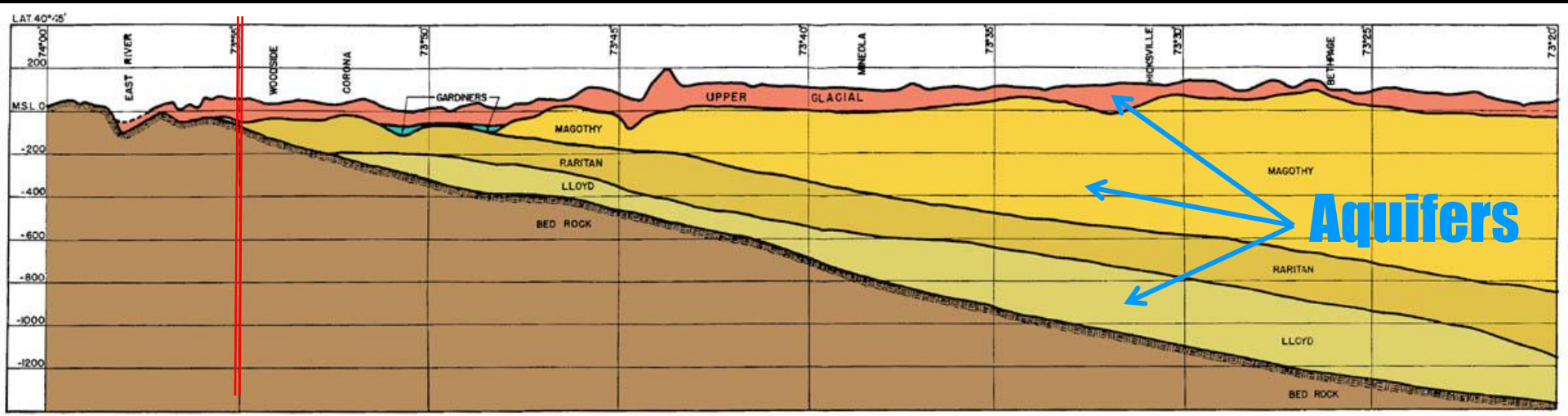
Mio/Pliocene

Johnson (1931)

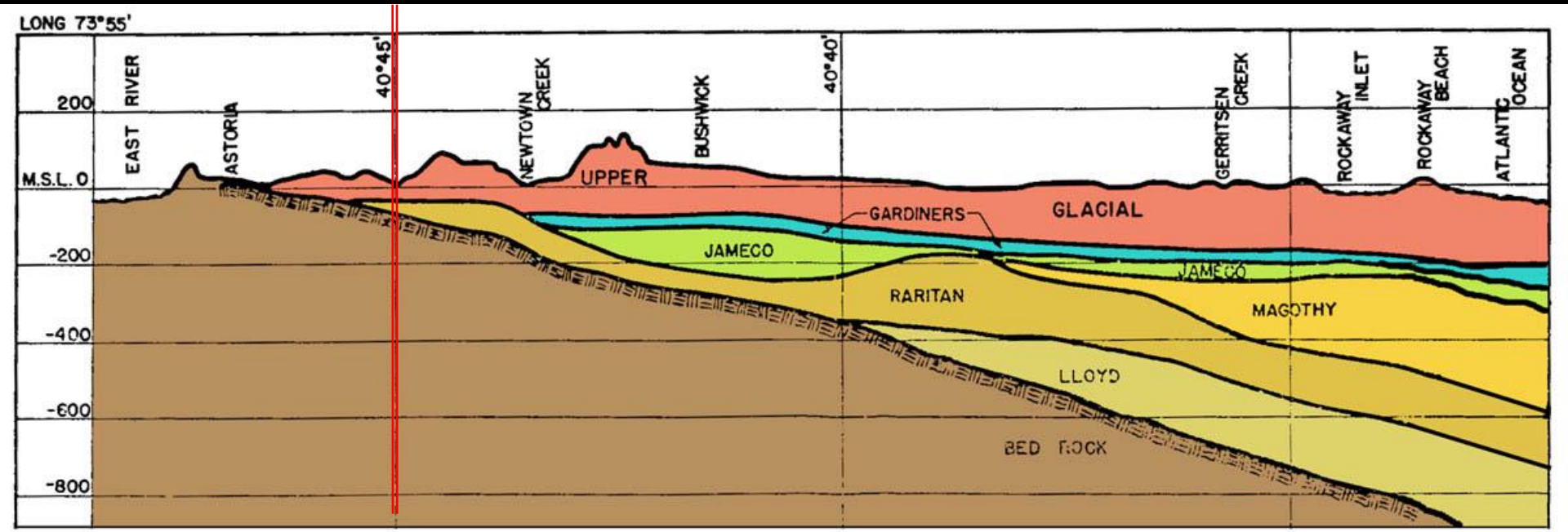


Lon Gisland


LONG ISLAND SOUND
MANHATTAN
BRONX
QUEENS
KINGS
NASSAU
SUFFOLK
LLOYD NECK
EATONS NECK
OAK NECK
WEST NECK
HUNTINGTON
BEA CLIFF
FLUSHING
MINEOLA
FARMINGDALE
JAMAICA
WOODHAVEN
FLATBUSH
JAMAICA BAY
LYNBROOK
FREEPORT
EAST BAY
AMITYVILLE
LONG BEACH
CONEY ISLAND
ROCKAWAY BEACH
ATLANTIC OCEAN
SE Slope
STATE OF NEW YORK
CONSERVATION DEPARTMENT
WATER POWER & CONTROL COMMISSION
GEOLOGICAL FORMATIONS OF LONG ISLAND
ROCK SURFACE
WESTERN SECTION



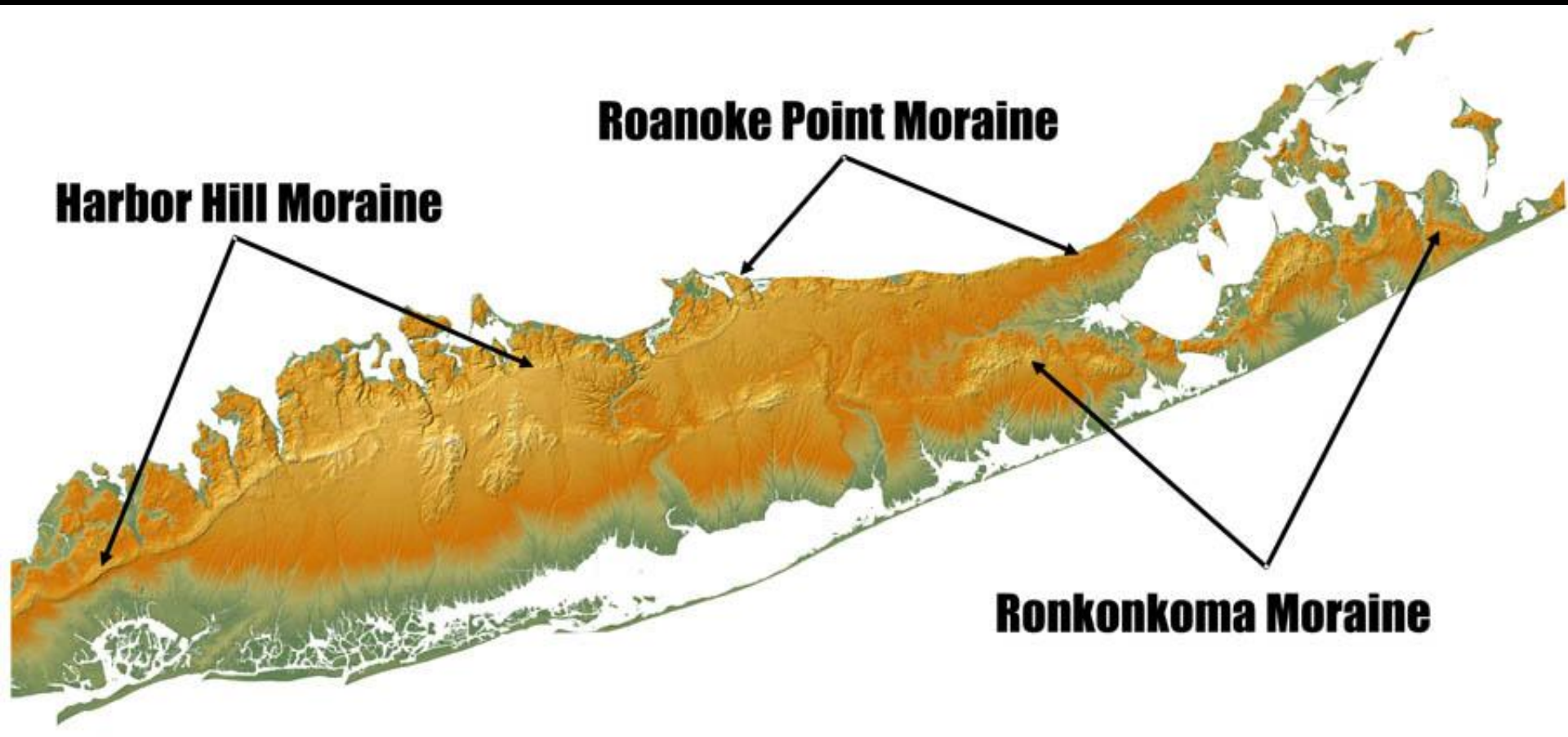
LAT. 40°=45' N



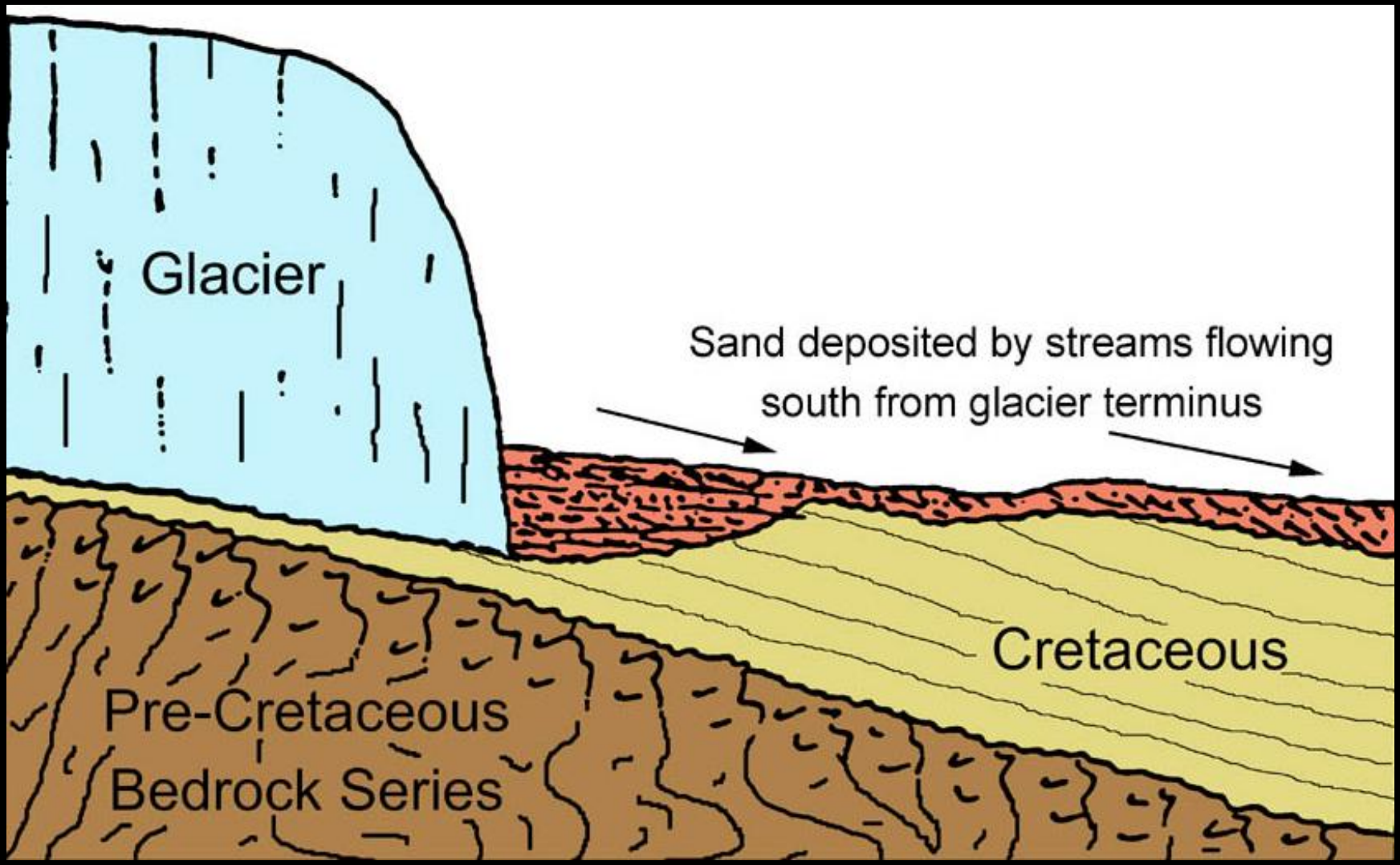
LONG. 73°=55' W

Suter et al, 1949

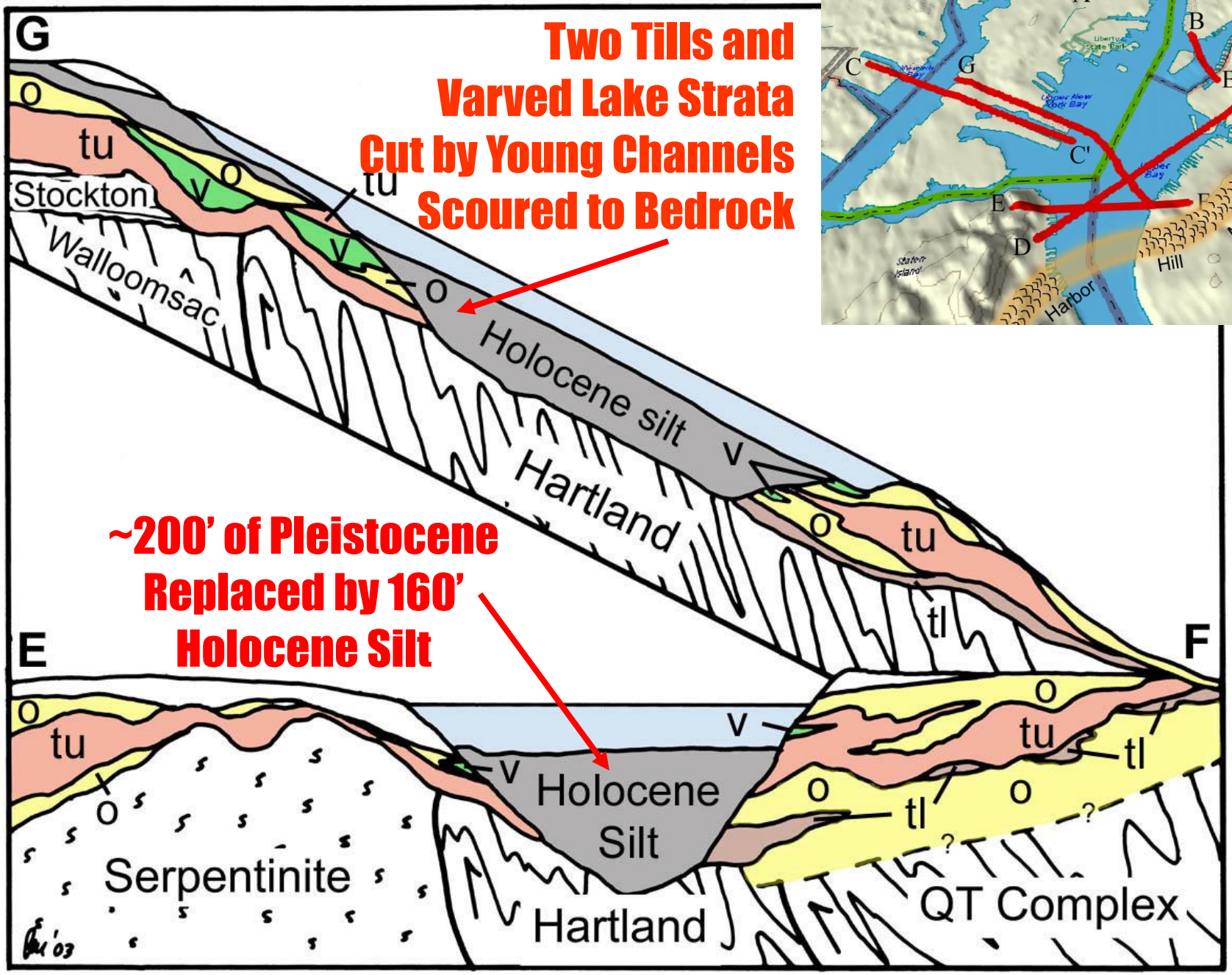
Long Island's Moraines



Long Island Outwash Fans

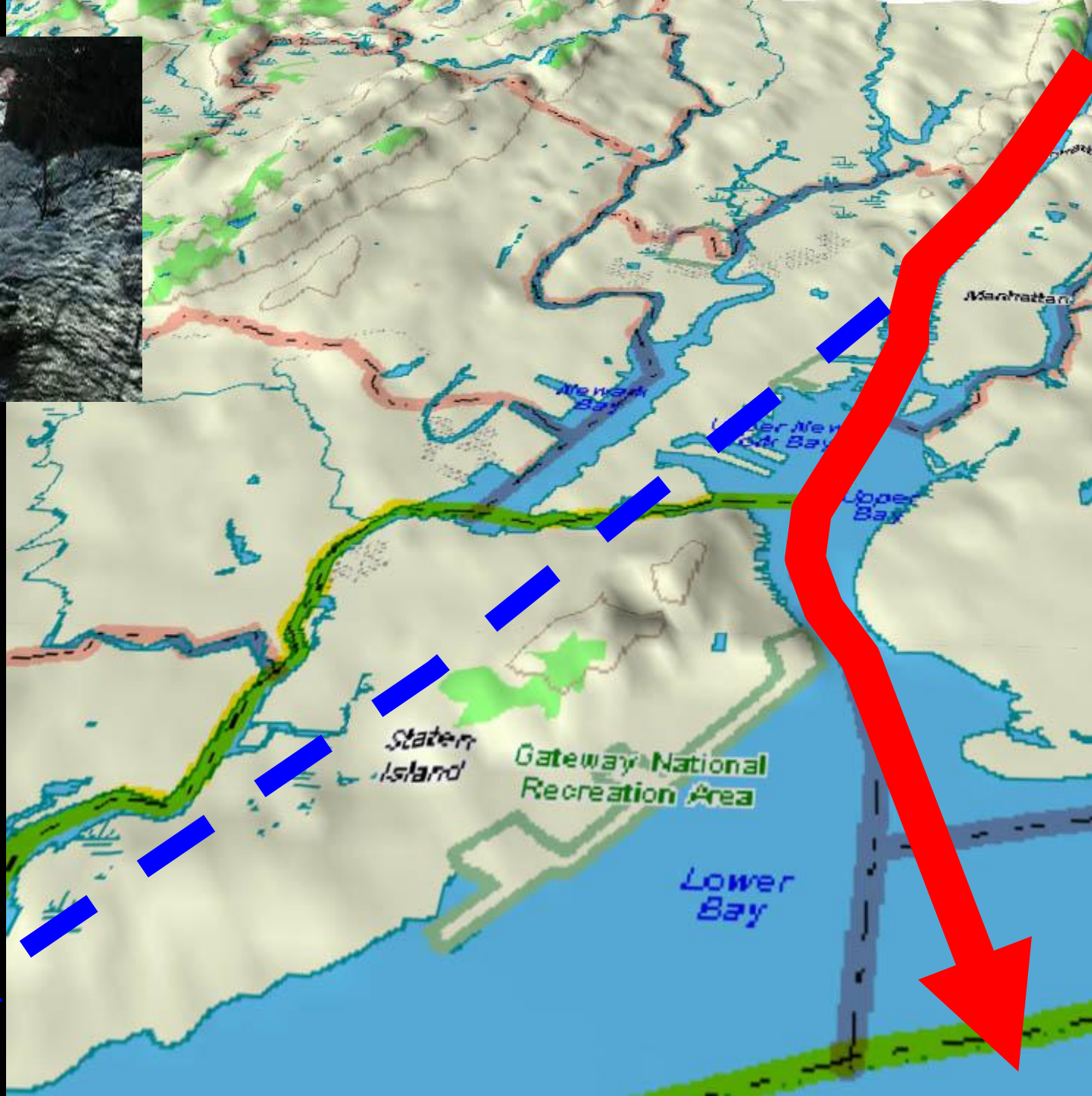


after Merguerian and Sanders 1993

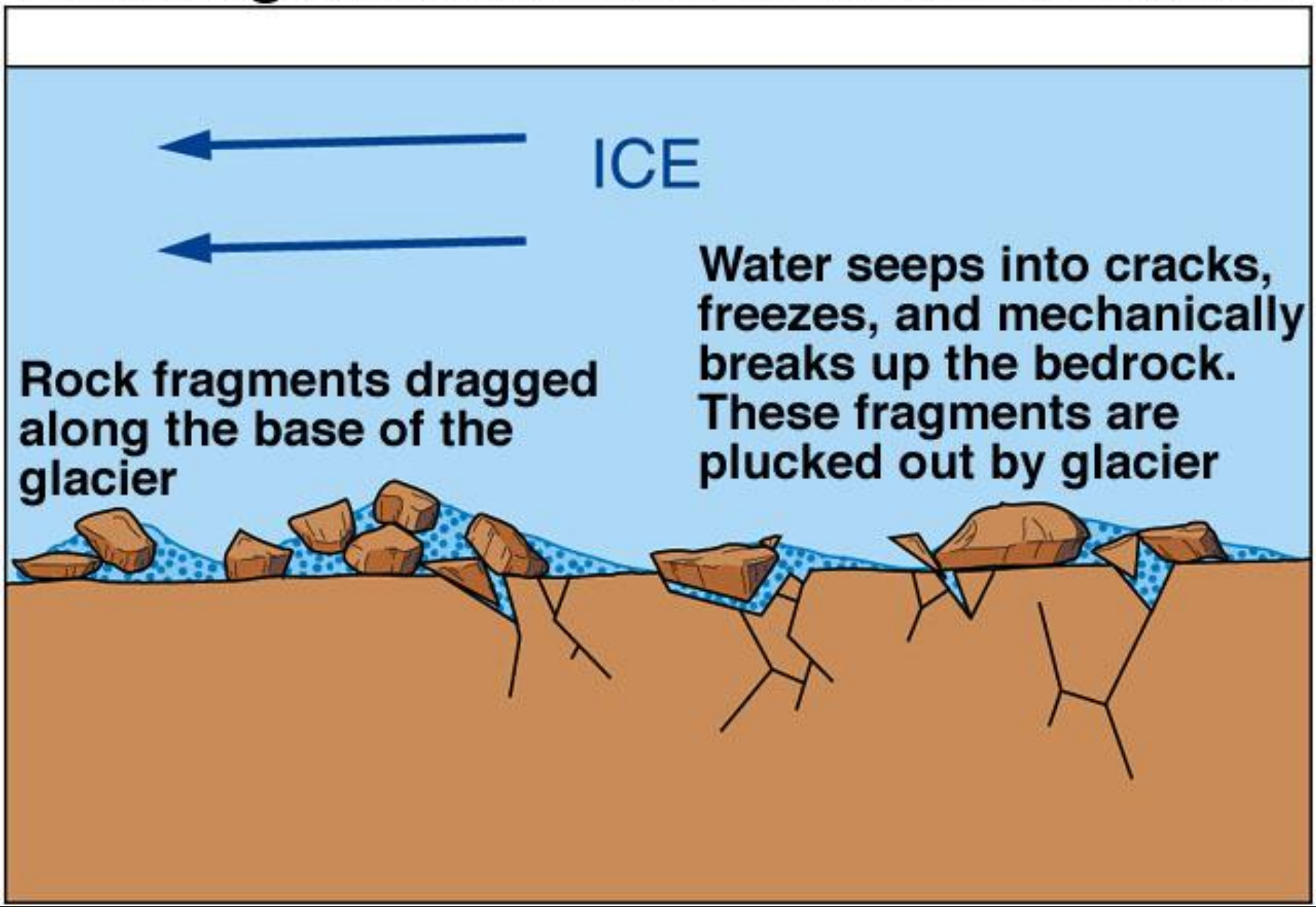


(after Merguerian 2003)

Hudson Abandons Former Channels – Floods Through Narrows



Plucking and Abrasion Beneath a Glacier



SE-Directed Glacial Striae, Central Park

S35°E-Directed Striae, So. Twin Island, Bronx

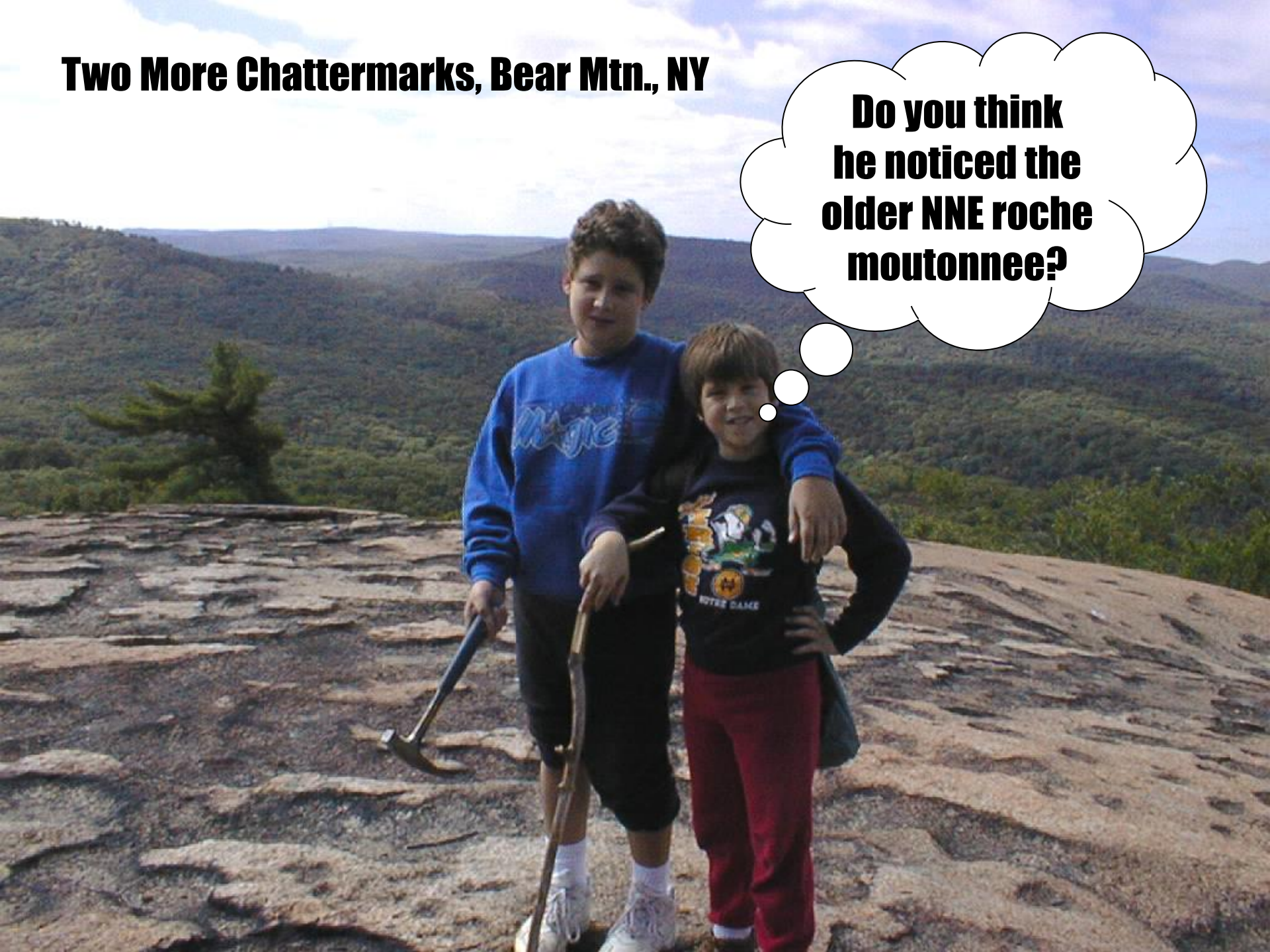

S35°E Striae, So. Twin Island

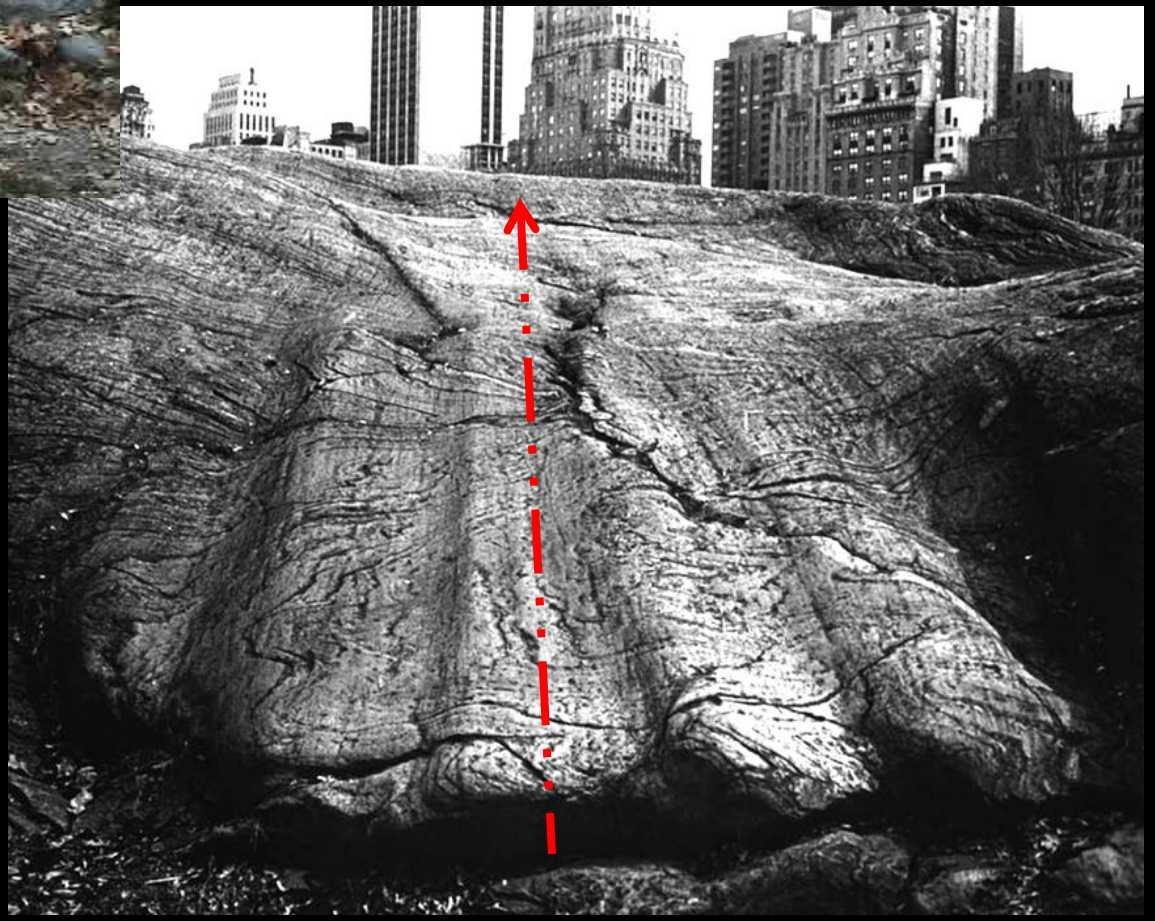
NW to SE Glacial Grooves and Striae, Bear Mtn., NY

SE-directed Chattermarks, Bear Mtn., NY

Glacial Polish and S55°E Chattermarks, Bear Mountain, NY

Two More Chattermarks, Bear Mtn., NY



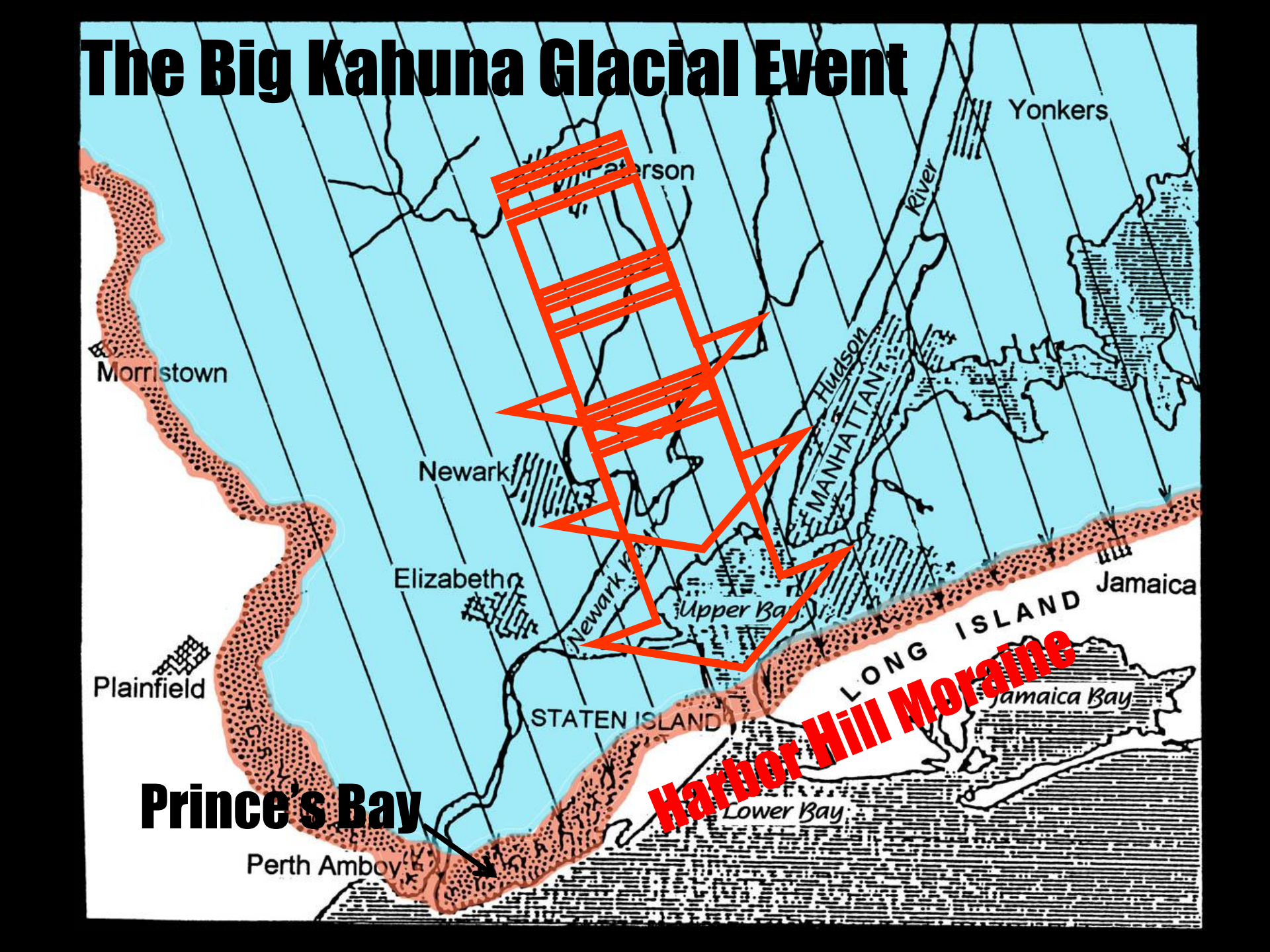


SE Glacial Grooves, Central Park, NYC

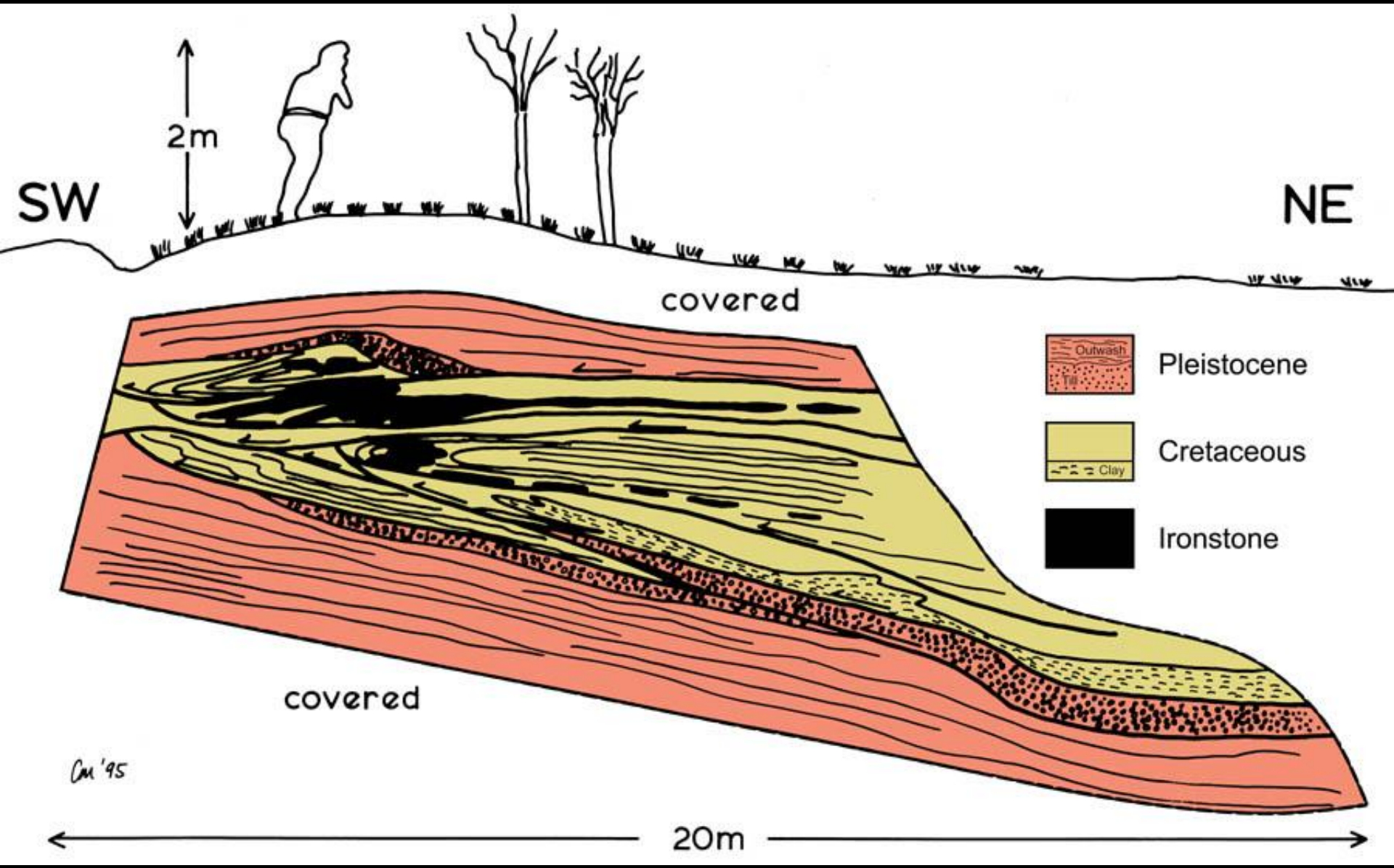

Glacial Meltwater Channel, Central Park, NY

NE Sculpting, NW Striae, and Erratic - Central Park, NYC

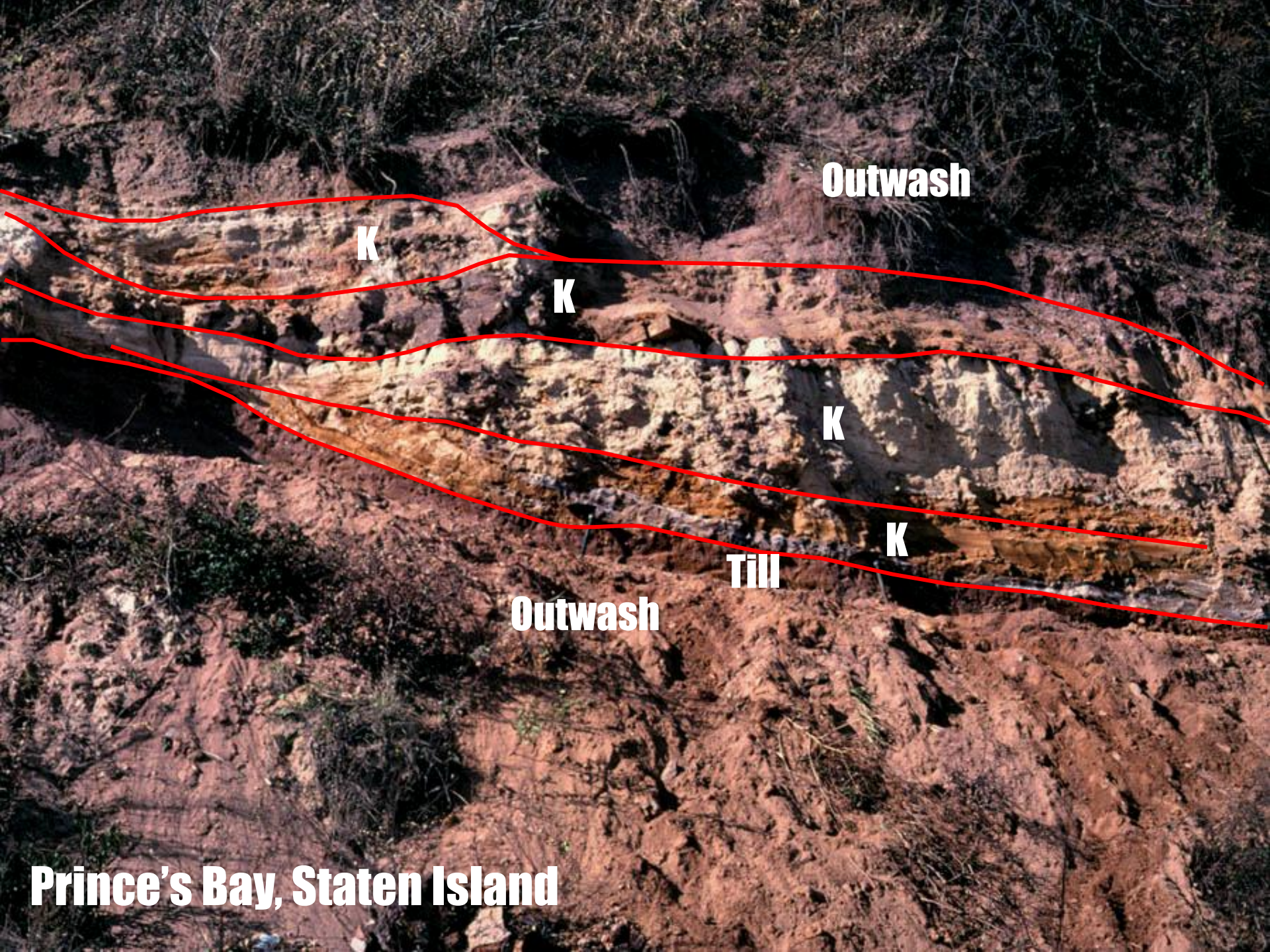

Erratic - Central Park, NYC


The Big Kahuna Glacial Event
Yonkers
Hudson River
MANHATTAN
Morristown
Newark
Elizabeth
Newark Bay
Upper Bay
Jamaica
LONG ISLAND
Plainfield
STATEN ISLAND
Jamaica Bay
Harbor Hill Moraine
Prince's Bay
Lower Bay
Perth Amboy


Prince's Bay, Staten Island


2m
SW
NE
covered
Outwash
Till
Pleistocene
Cretaceous
Clay
Ironstone
covered
Cm '95
20m


Plunge 17° into S60°W
AP = N4°E, 20°NW


Outwash
K
K
K
K
Till
Outwash
Prince's Bay, Staten Island

EXTRA SLIDES

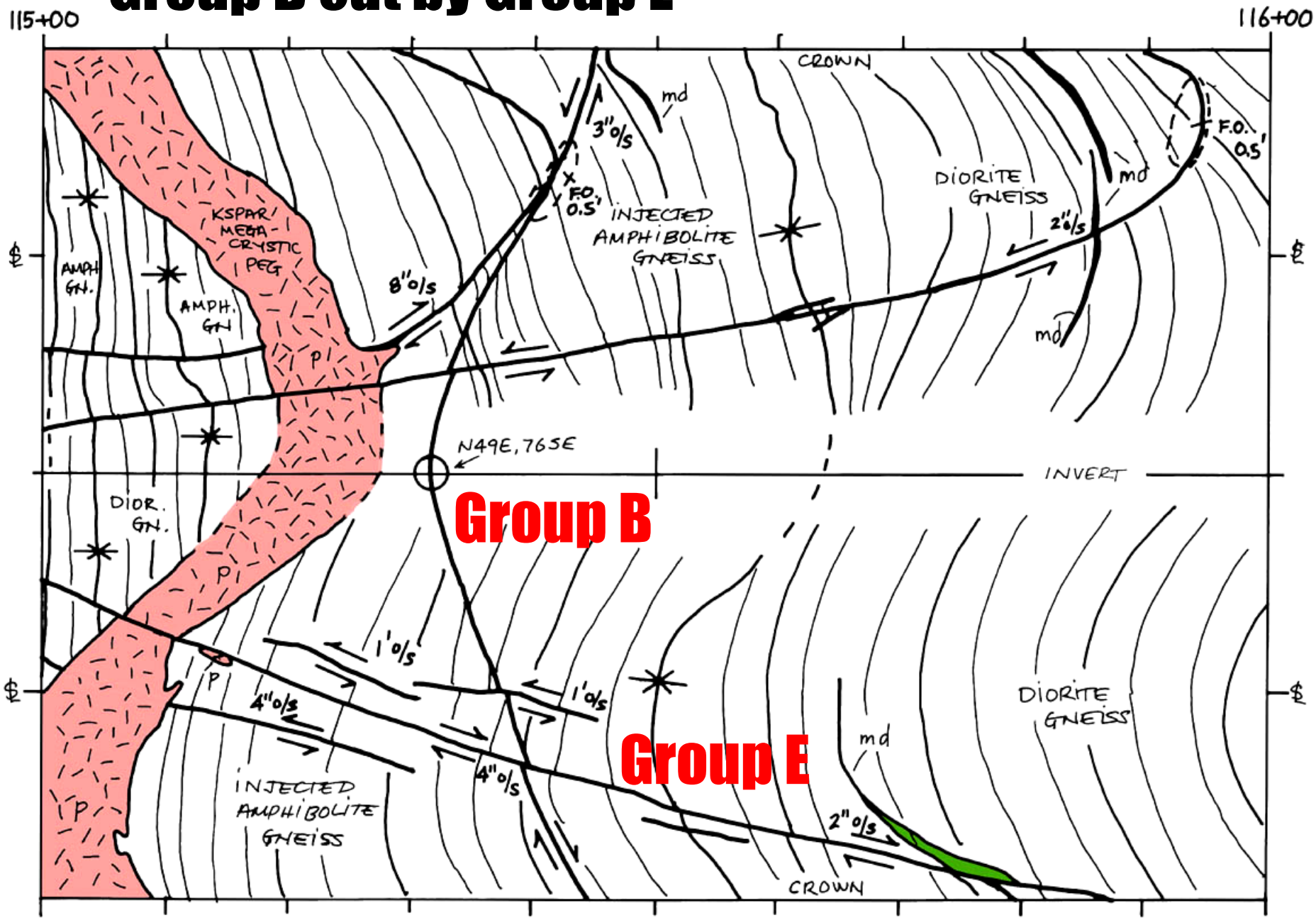

Late Paleozoic Bedrock Features


Retrograde Muscovite after Kyanite

NW Joints, Mosholu Fault, Bronx, NY


NNW-Trending "Manhattanville" Strike-Slip Faults
Splays and Conjugate Joints
Queens Tunnel Sta. 75+85
156+40
156+35
156+30
156+20

Group B cut by Group E

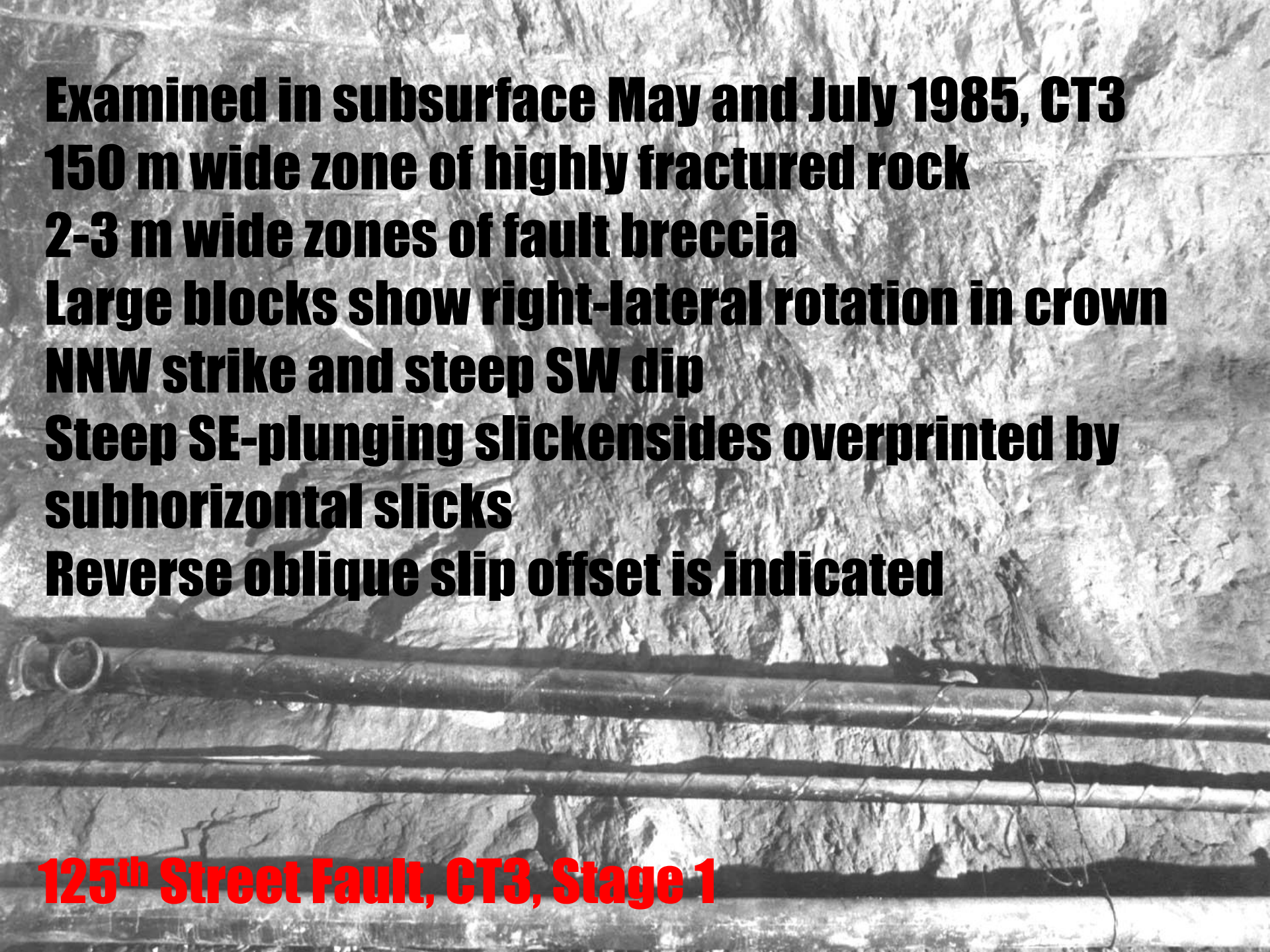


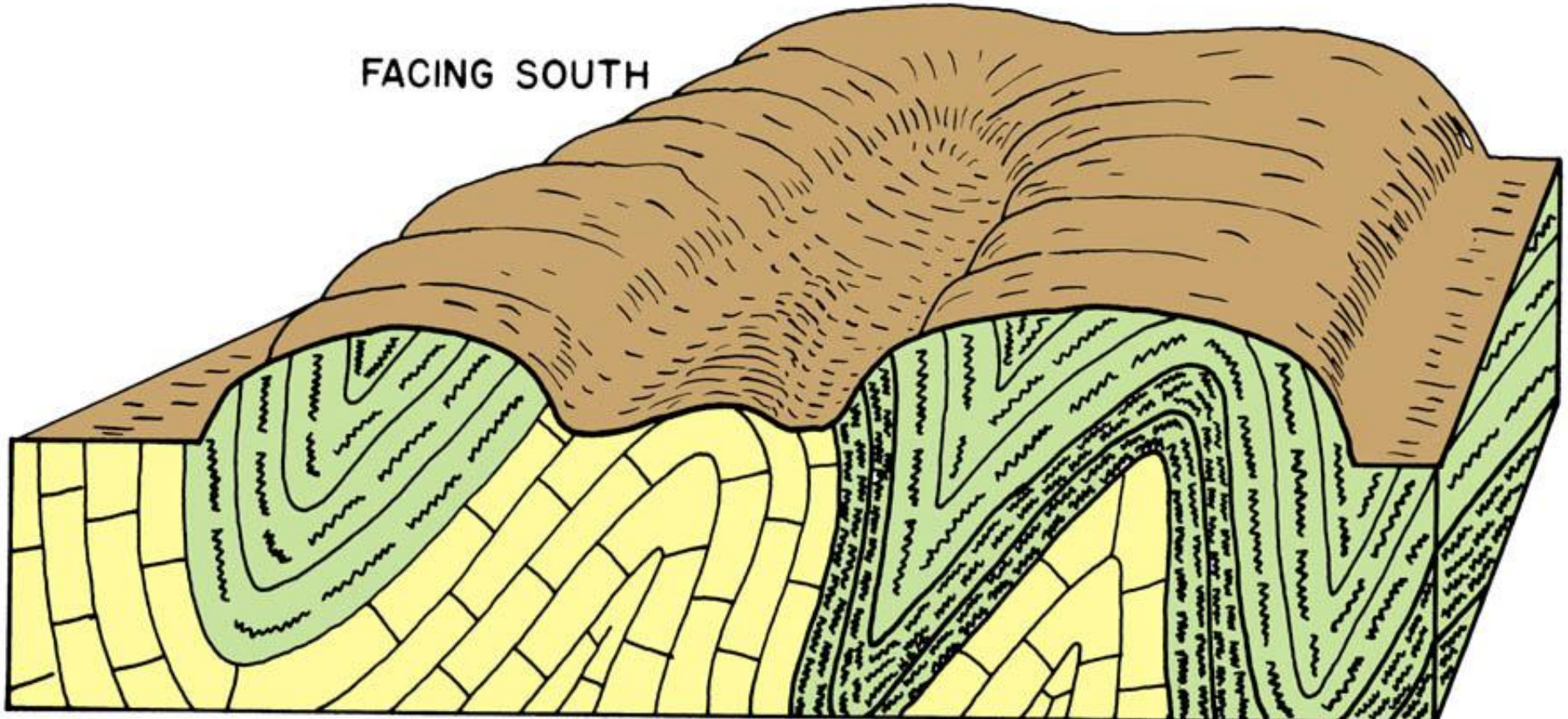

Crown Failure in Overstressed Rock
Queens Tunnel Sta. 253+40


N569 Mylonitic C0m


Retrograde Muscovite after Kyanite


125th Street Fault, CT3, Stage 1


Examined in subsurface May and July 1985, CT3
150 m wide zone of highly fractured rock
2-3 m wide zones of fault breccia
Large blocks show right-lateral rotation in crown
NNW strike and steep SW dip
Steep SE-plunging slickensides overprinted by subhorizontal slicks
Reverse oblique slip offset is indicated
125th Street Fault, CT3, Stage 1



CROSS-SECTION AT INWOOD PARK SHOWING CANOE VALLEY