

# Megaconstruction Projects in New York City

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Charles Merguerian



Hofstra Geology



# Merguerian's Early Field Work on Manhattan Island







**Merguerian Has  
Devoted?  
Spent?  
(Wasted?)**

**Most of his Career  
Mapping the Surface  
and Subsurface  
Geology of NYC**

**Proper Field Attire  
For NYC**

EARLY MEDIAL ORDOVICIAN  
(Early Chazyan)  
PALEOGEOGRAPHY

by Marshall Kay

Drawn by Erwin Raisz

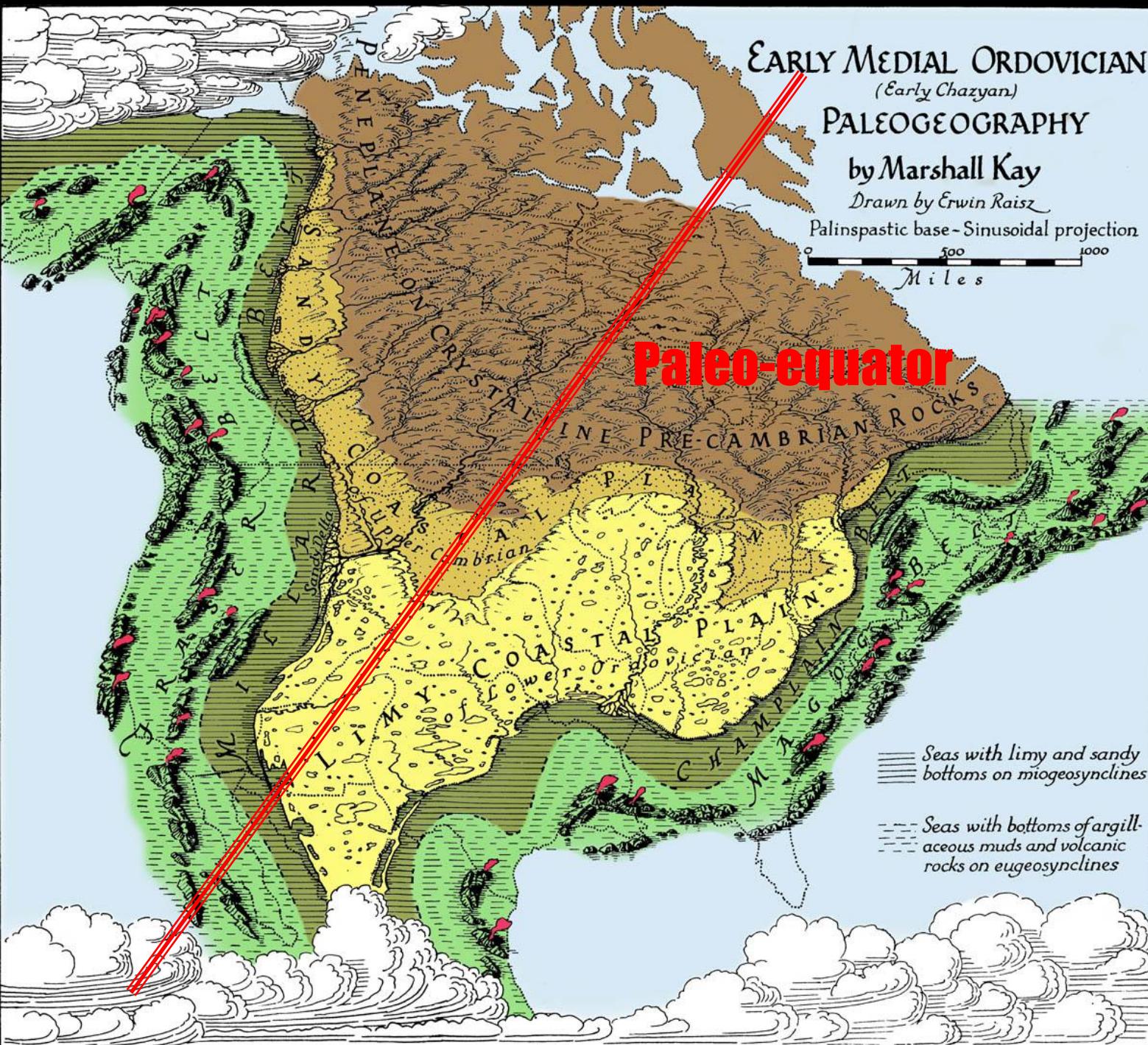
Palinspastic base - Sinusoidal projection

Miles

Paleo-equator

Seas with limy and sandy bottoms on miogeosynclines

Seas with bottoms of argillaceous muds and volcanic rocks on eugeosynclines



EARLY MEDIAL ORDOVICIAN  
(Early Chazyan)  
PALEOGEOGRAPHY

by Marshall Kay

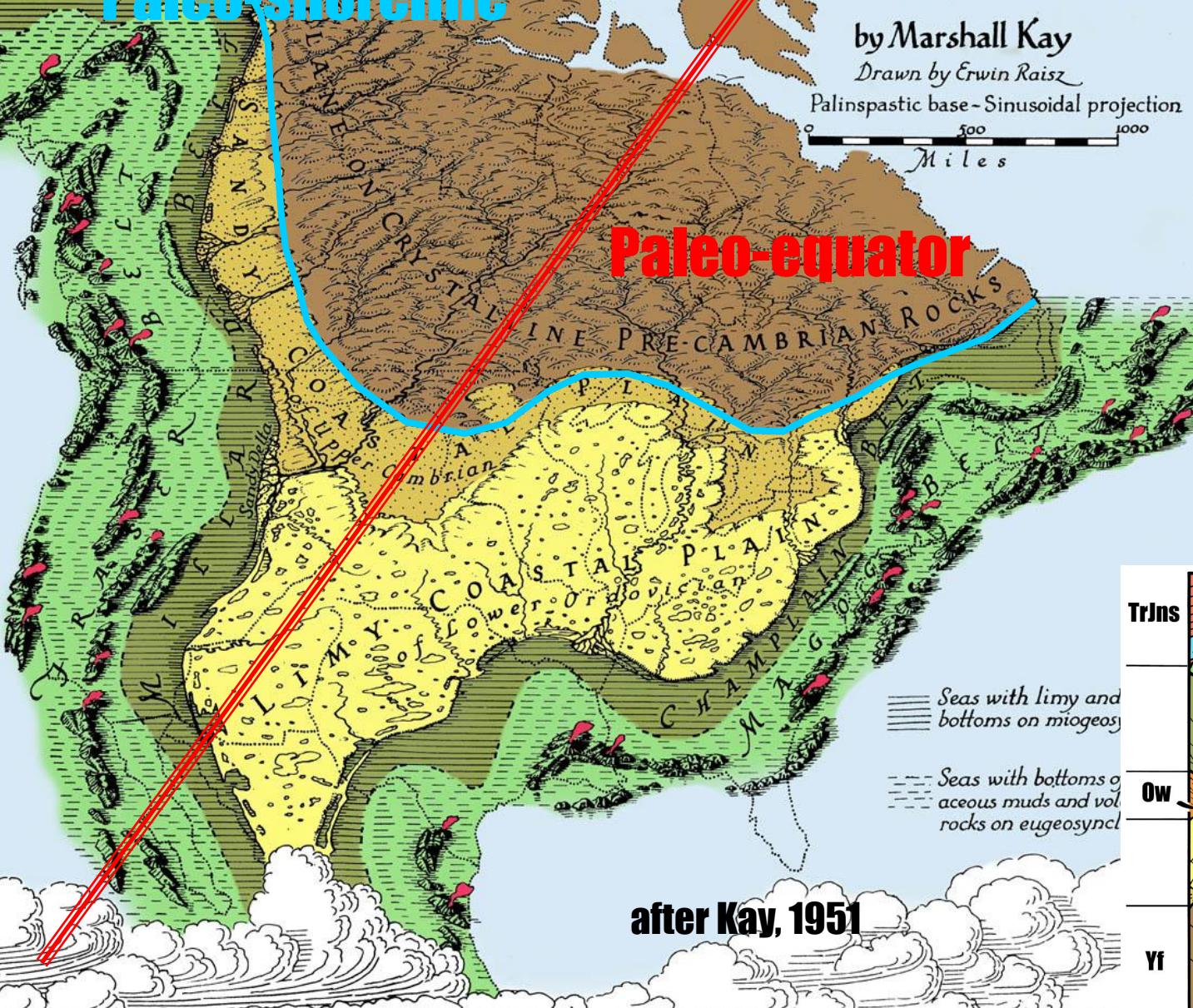
Drawn by Erwin Raisz

Palinspastic base - Sinusoidal projection

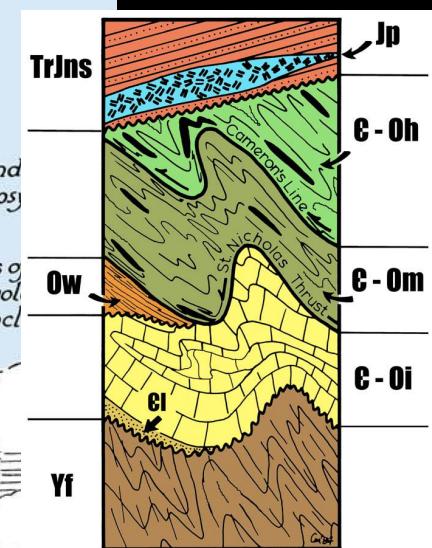
0 300 1000 Miles

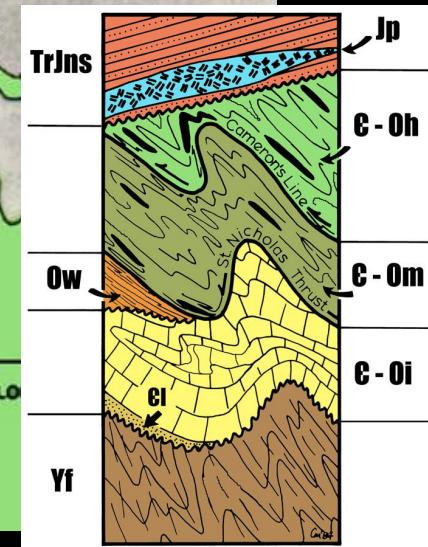
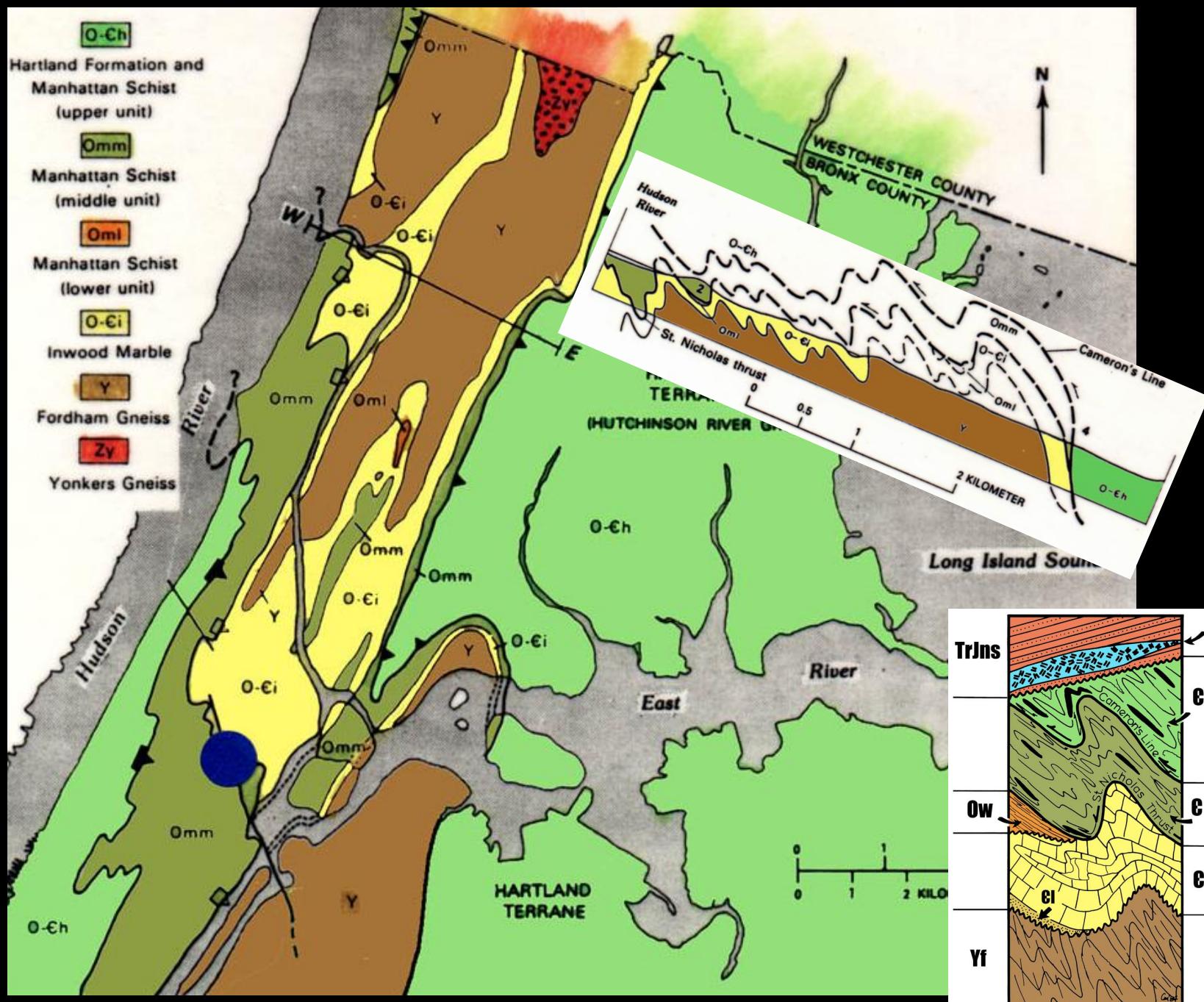
Paleo-shoreline

Paleo-equator



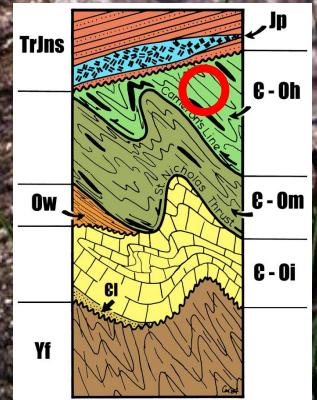
after Kay, 1951





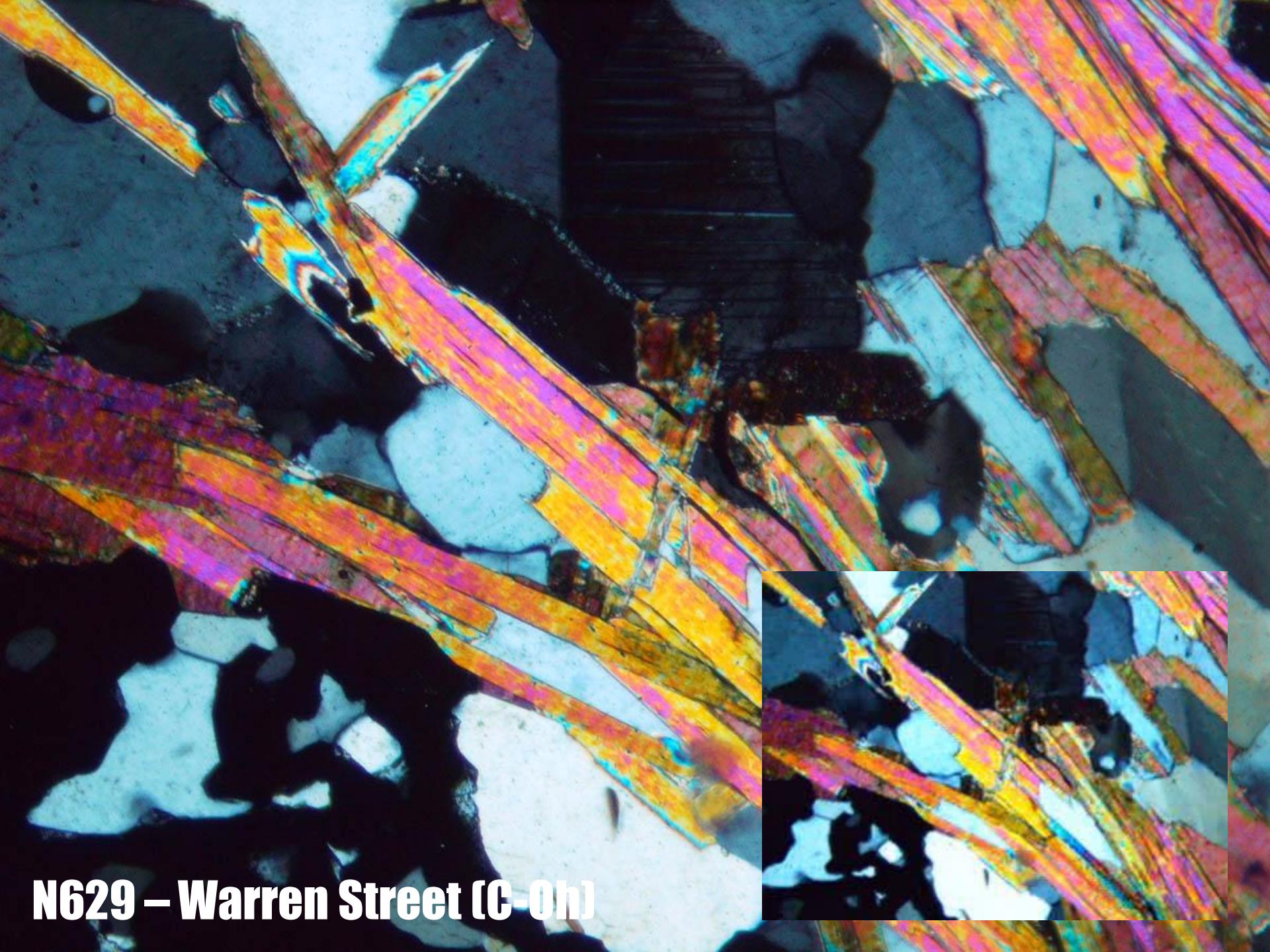


Hartland Schist, Riverside Park

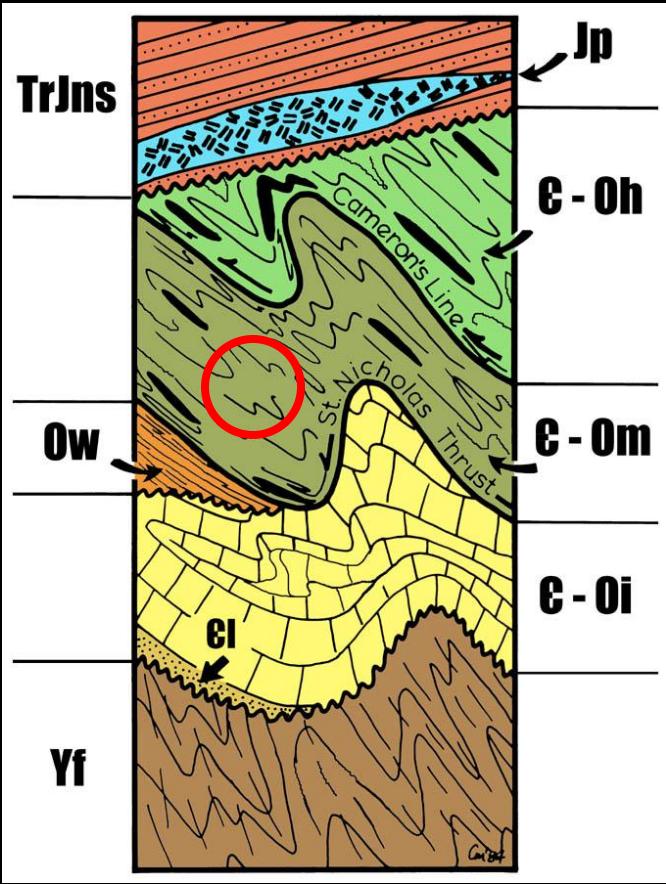




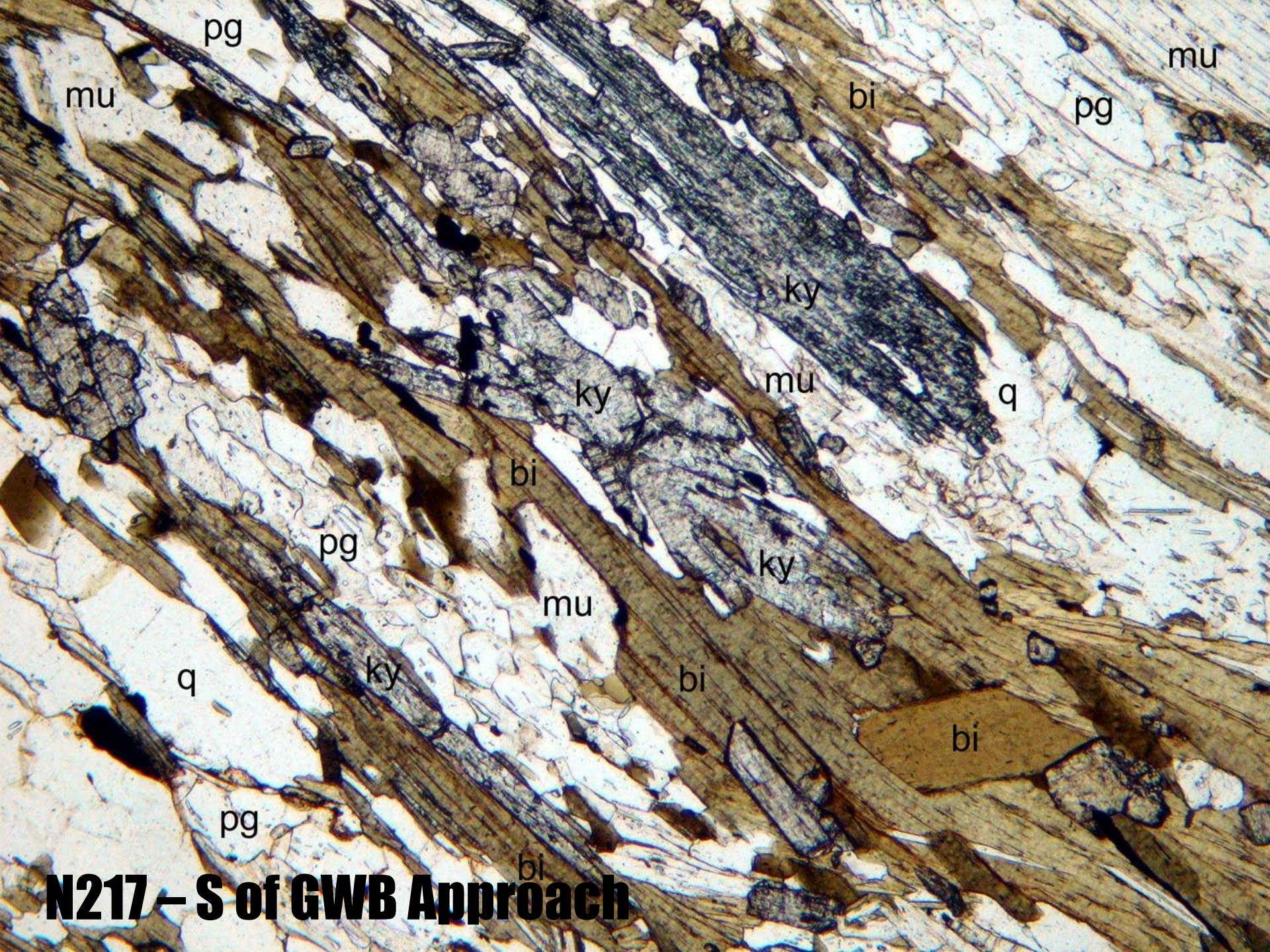
N125 – 112<sup>th</sup> Street, Riverside Park



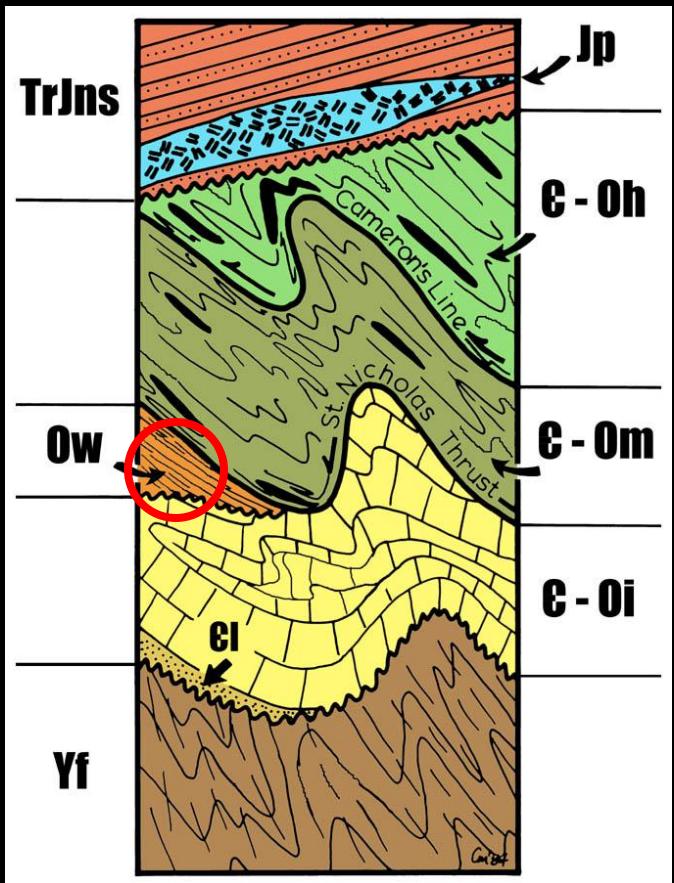
N629 – Warren Street (C-O<sub>h</sub>)



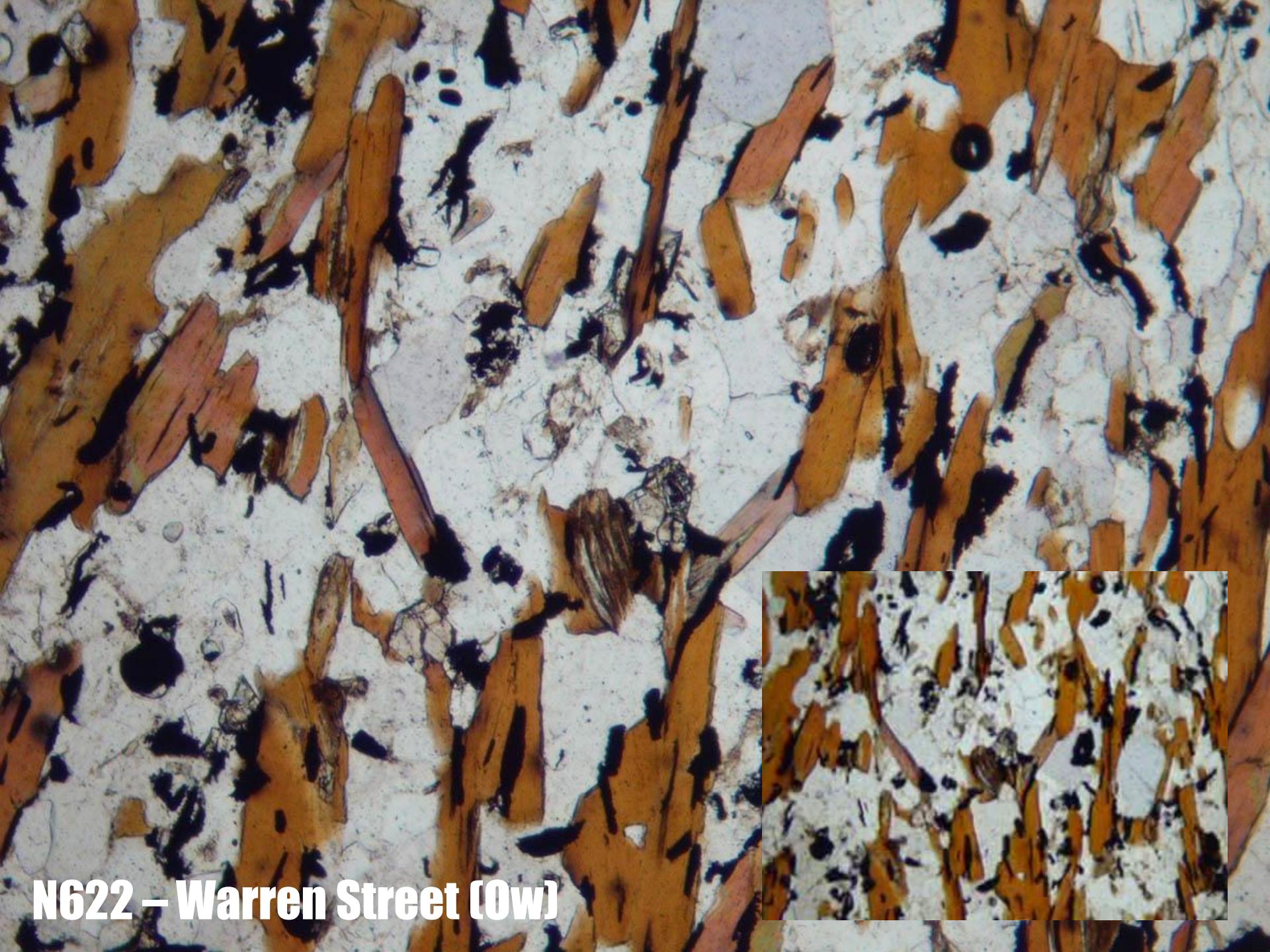
**Manhattan Schist**  
 **$F_3$  Folds of  $S_2$**   
**Central Park, NYC**



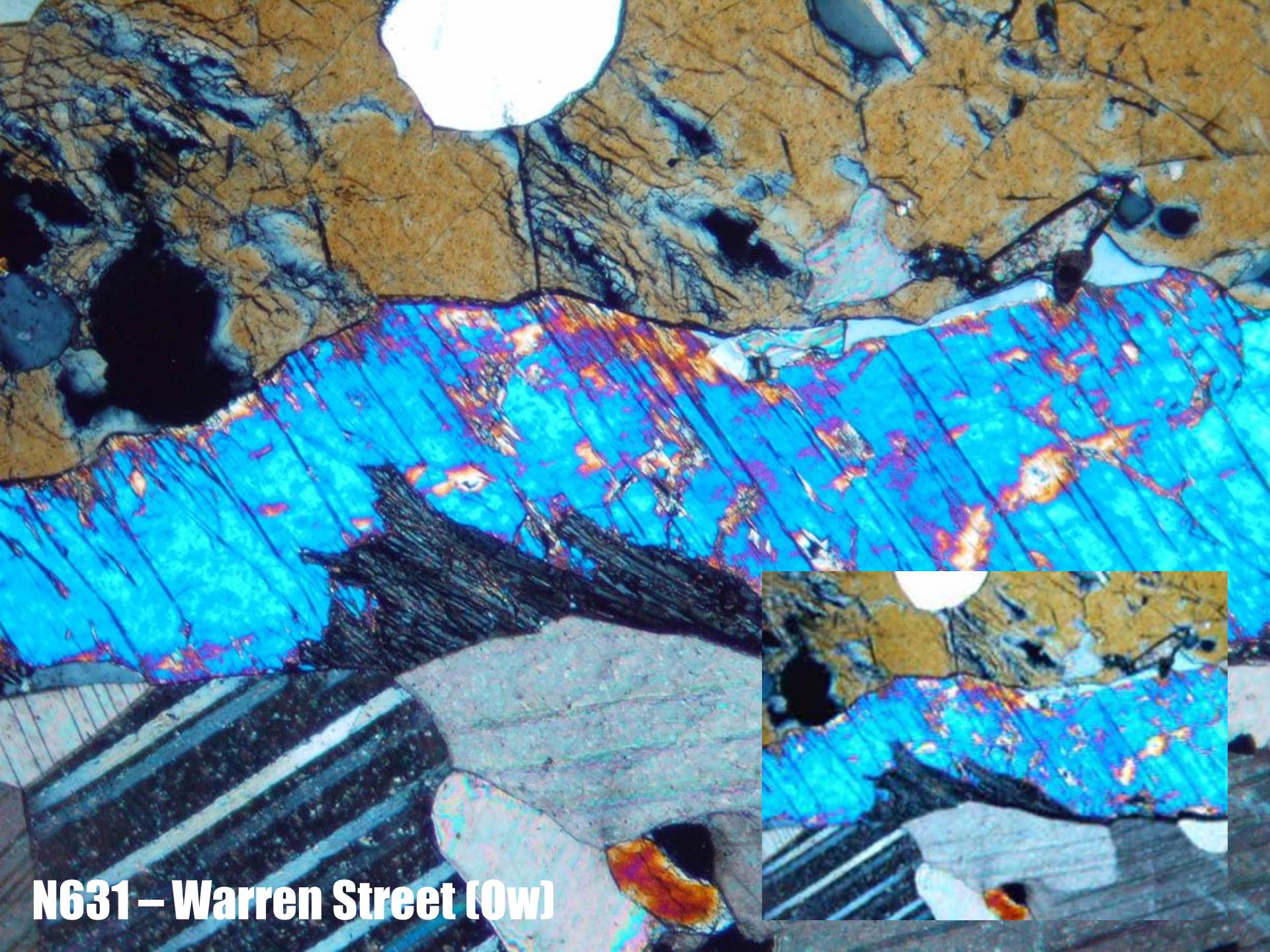
**N217 – S of GWB Approach**



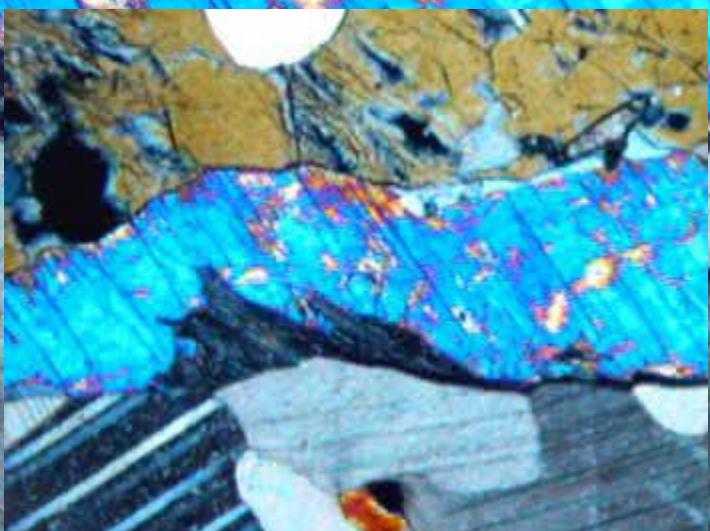
Walloomsac “Balmville” Contact, Grand Concourse, Bronx, NY



N622 – Warren Street (0w)

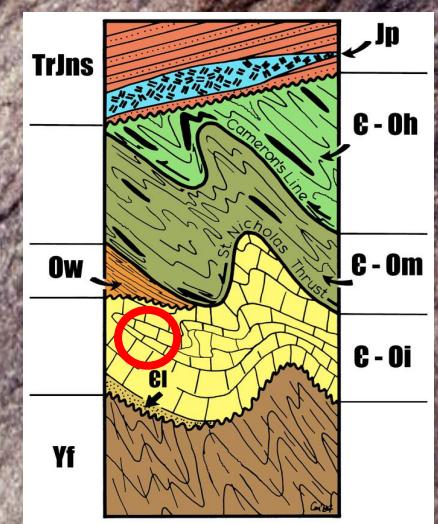


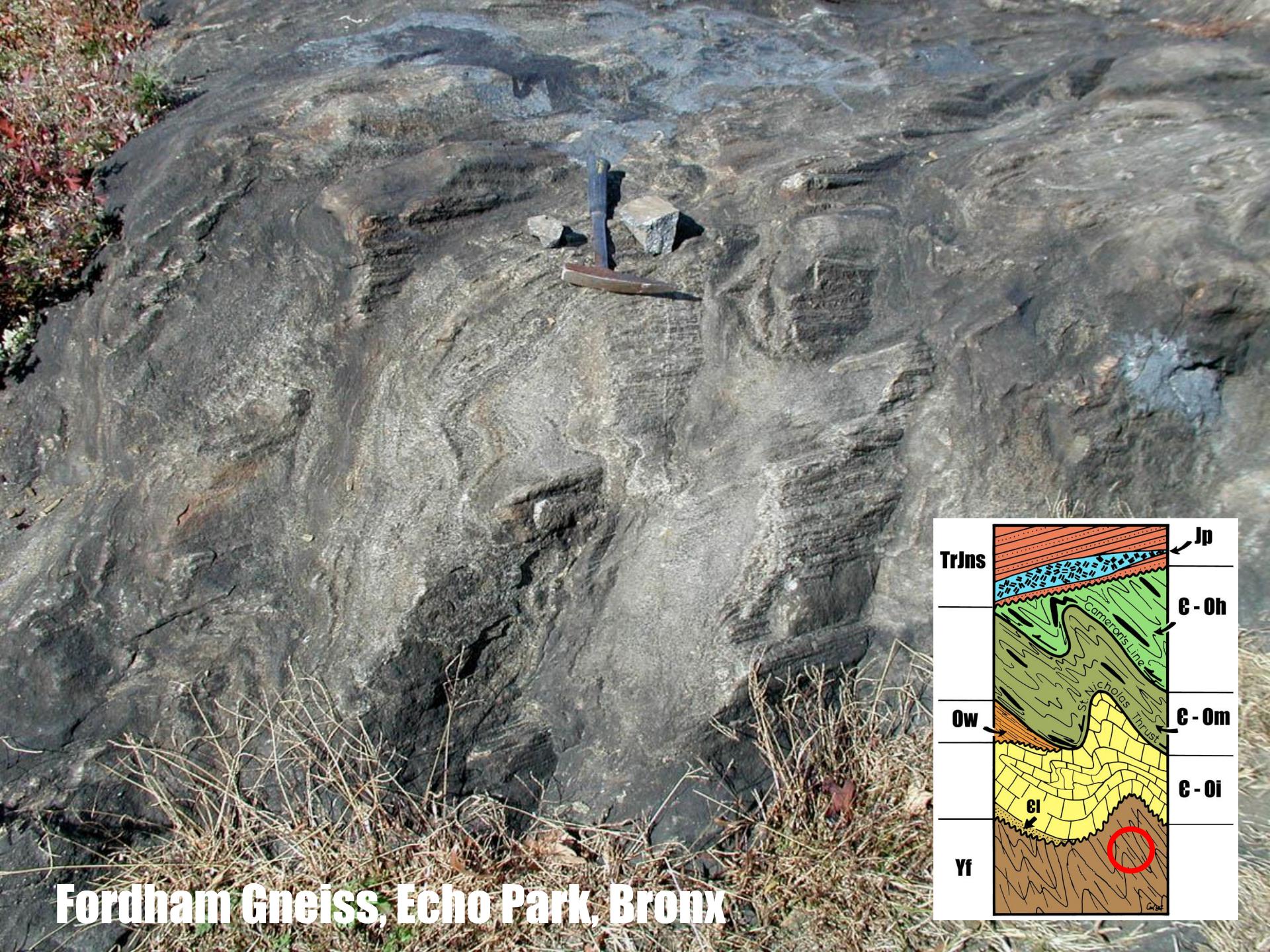
N631 – Warren Street [0w]



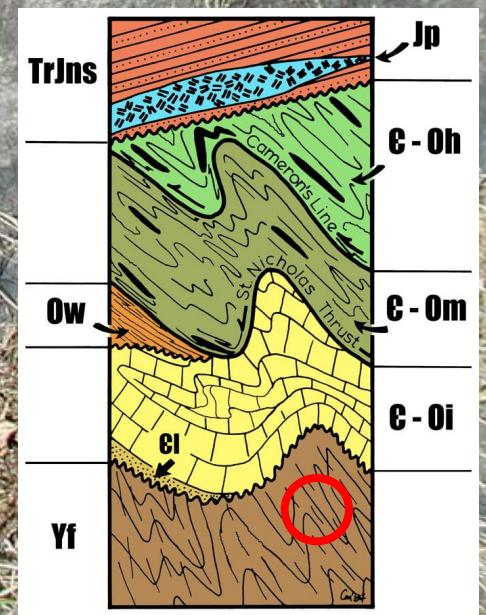


**F<sub>3</sub> Fold in Inwood Marble, Morris Garvey Park**

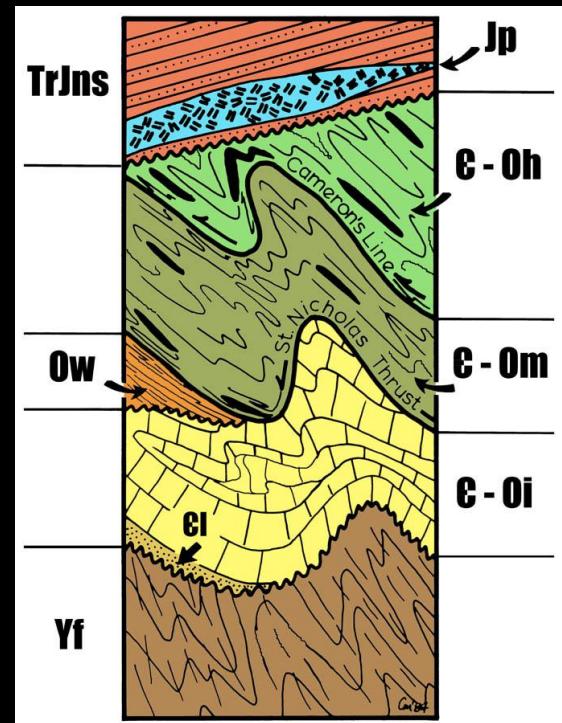
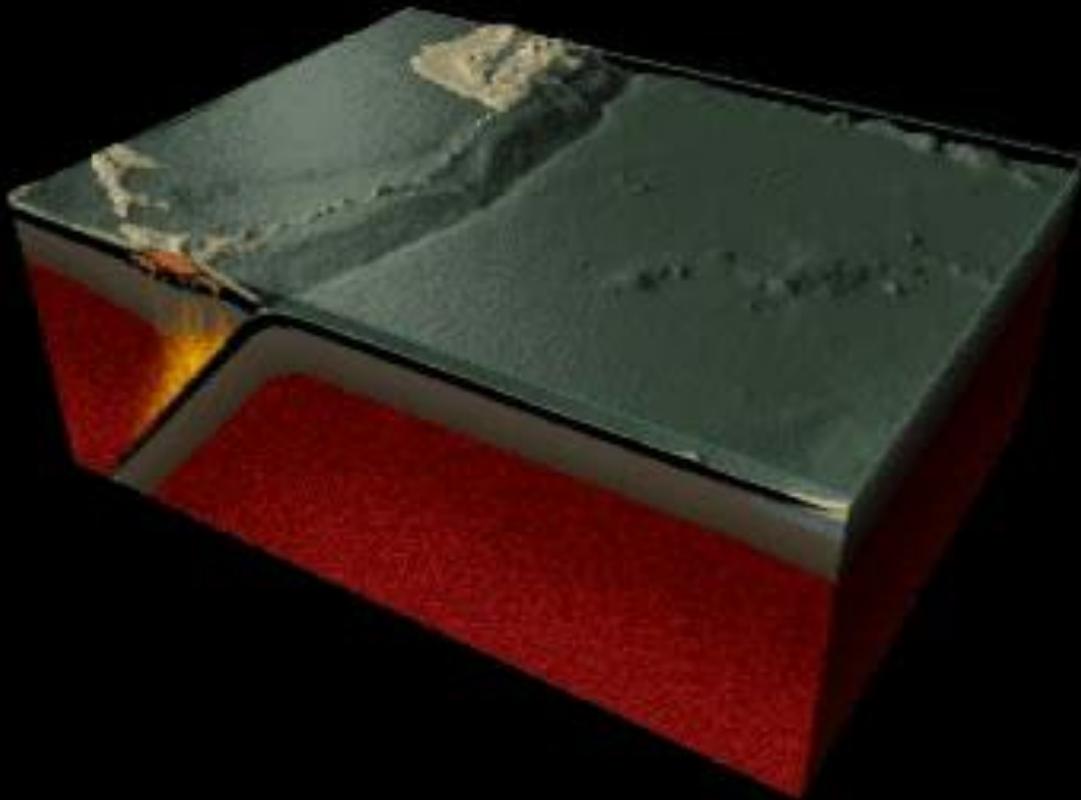




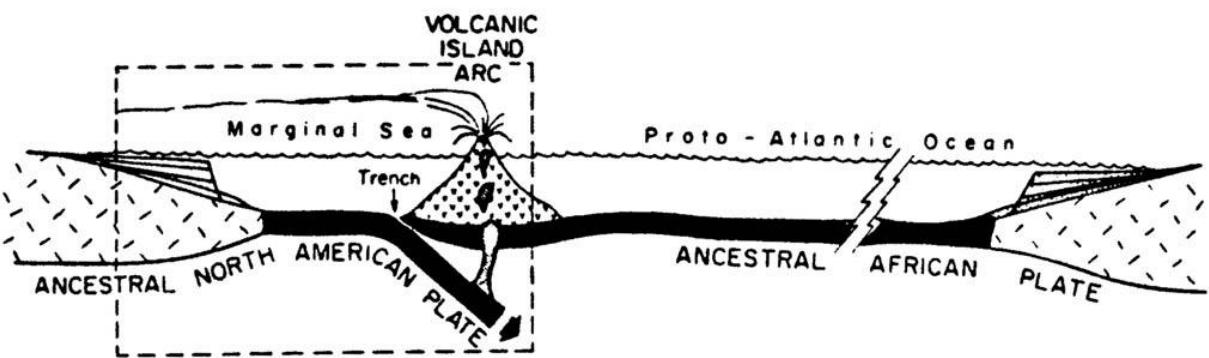
Fordham Gneiss, Echo Park, Bronx



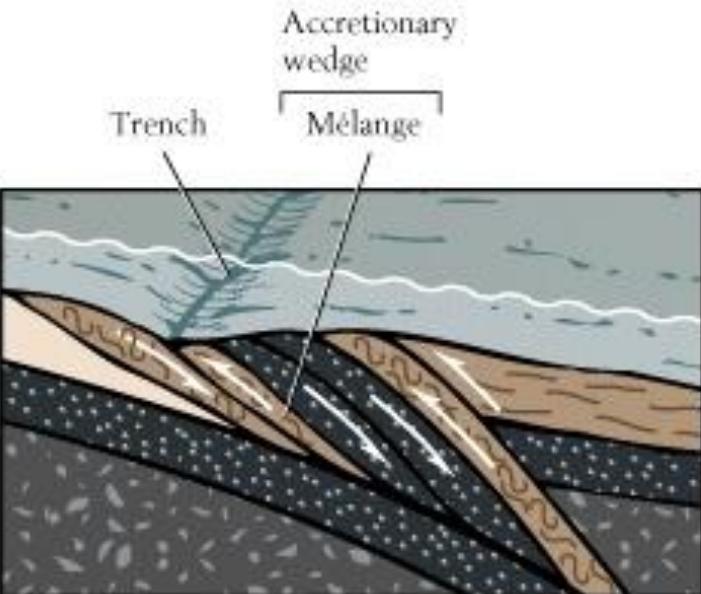
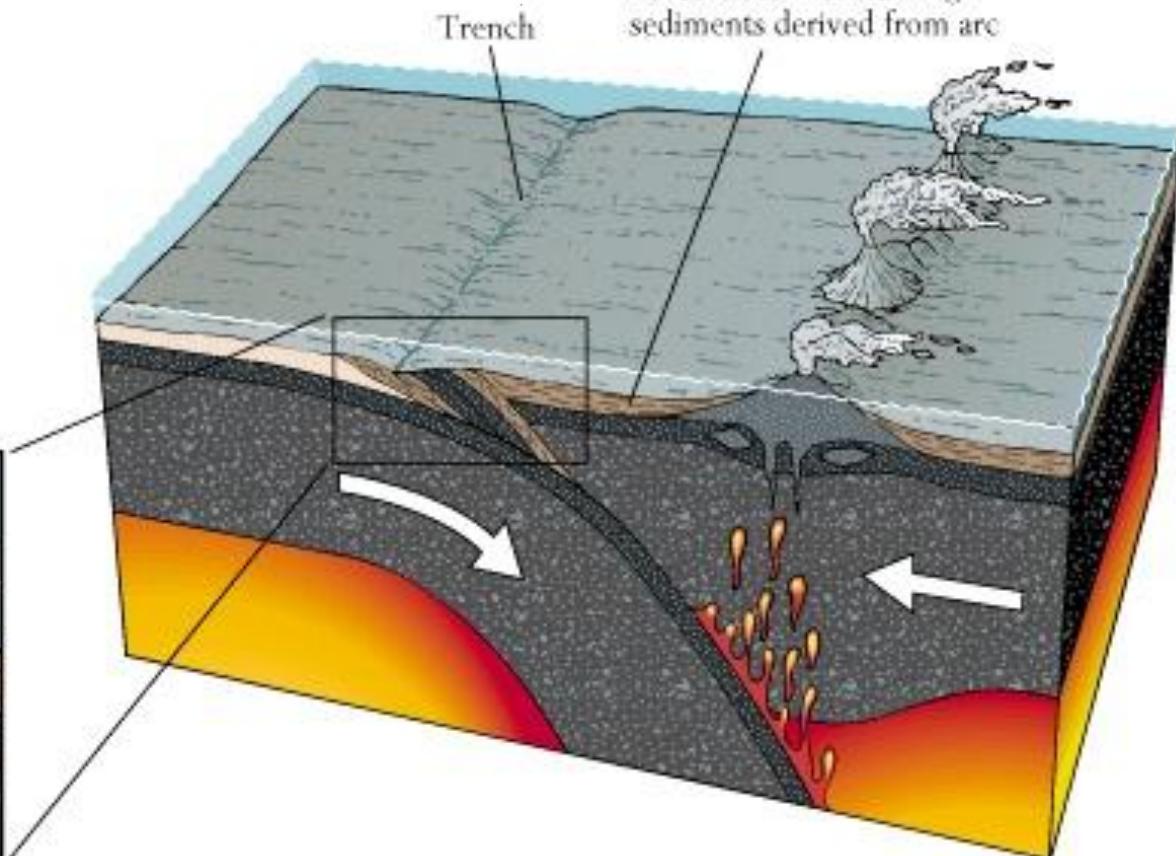
# Taconic Arc – Passive Margin Collision



# Plate Boundary Accretionary Tectonics



Forearc basin containing sediments derived from arc





# Urban Construction Projects

December 2004



**First Look**

# Excavation Continues - Zoned Ellipsoidal Mass



# Serpentinite Core





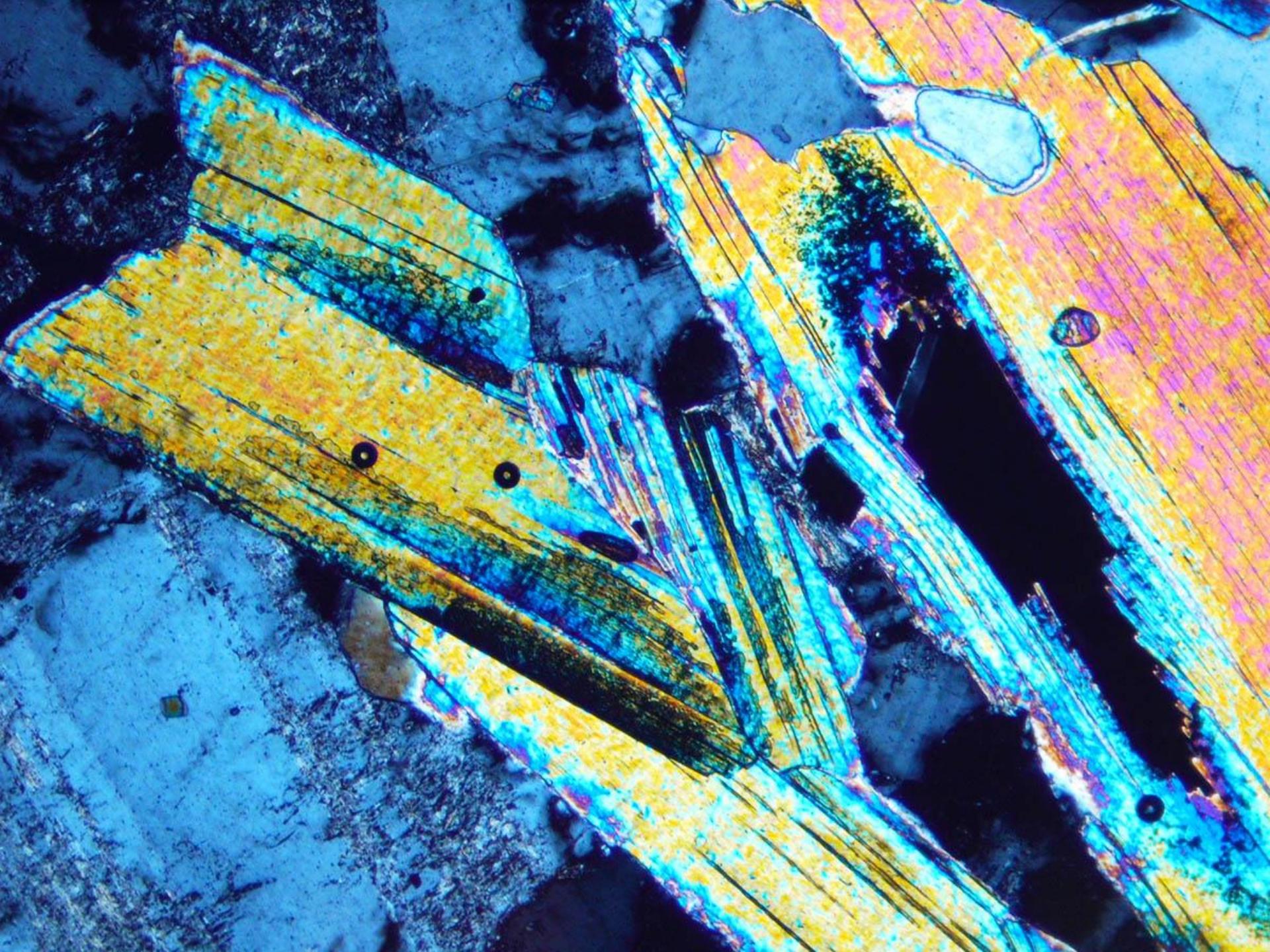
**Talc-Chlorite-Biotite Shear Envelope**

# Sheared Western Margin Gently Plunging Slicks





**Grades Outward to Pelitic Schist**





Last Look

**Cigar-Shaped  
Mass with  
Steep Plunge  
Southward**

**Base Not  
Exposed**

**>10 m Long  
Dimension**

**70°**

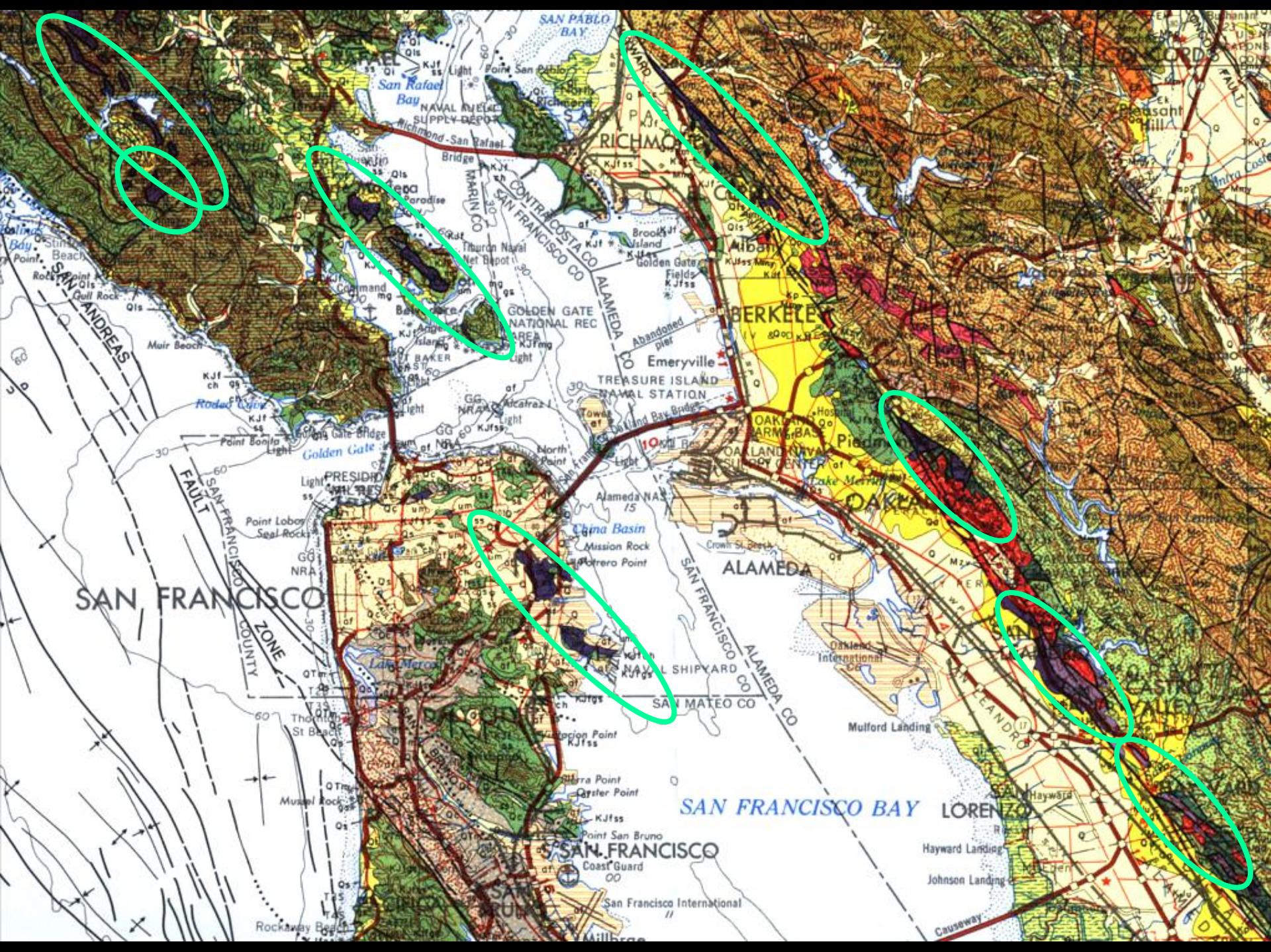


# California Coast Ranges



**Knockers**





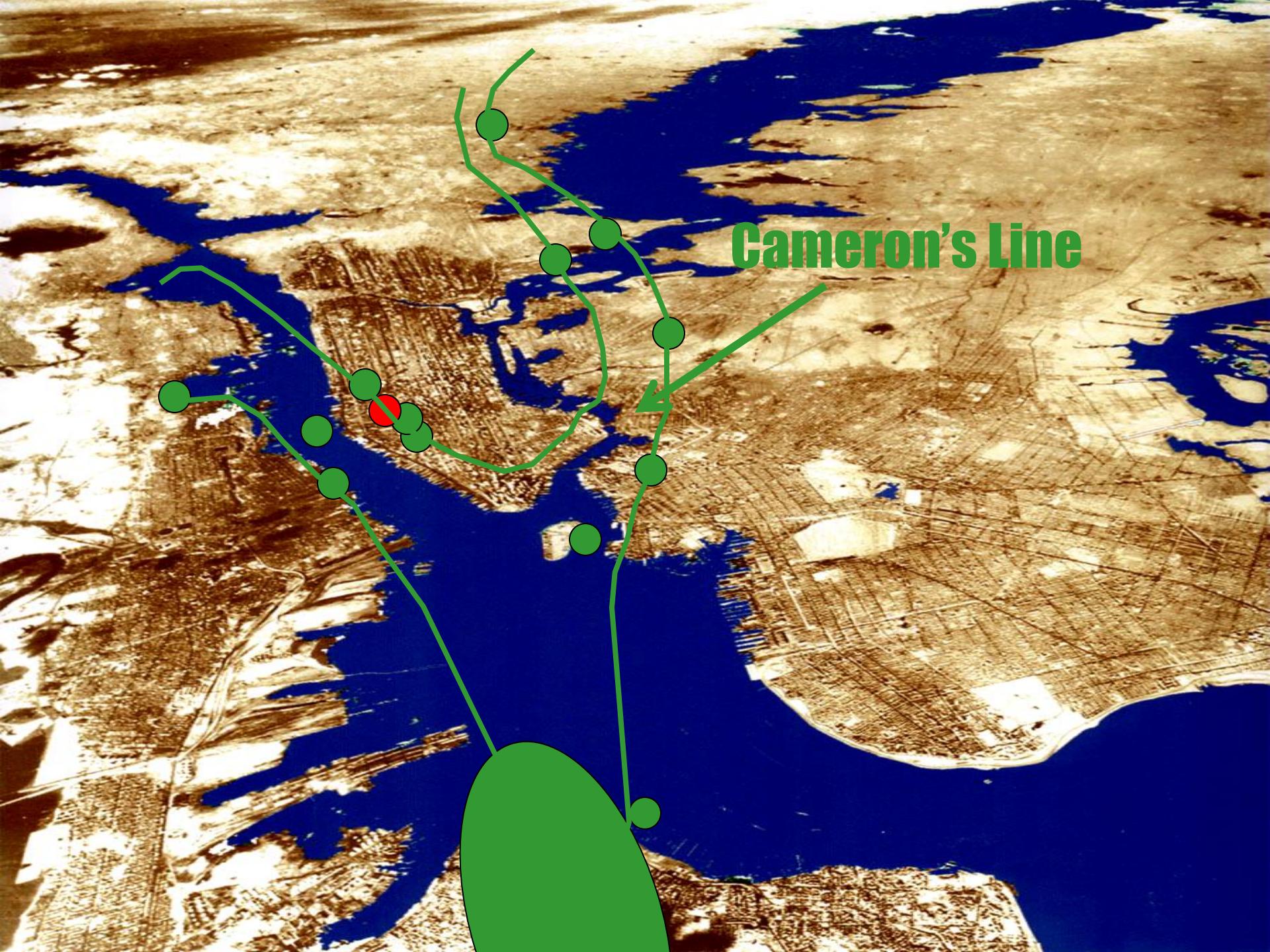
# Franciscan Complex



# Serpentinite



24 May 2004



**Cameron's Line**

# Mega-Construction Projects

- Con Edison Steam Tunnel
- IRT #7 Line Extension
- Second Avenue Subway
- East Side Access
- NYC Water Tunnel #3



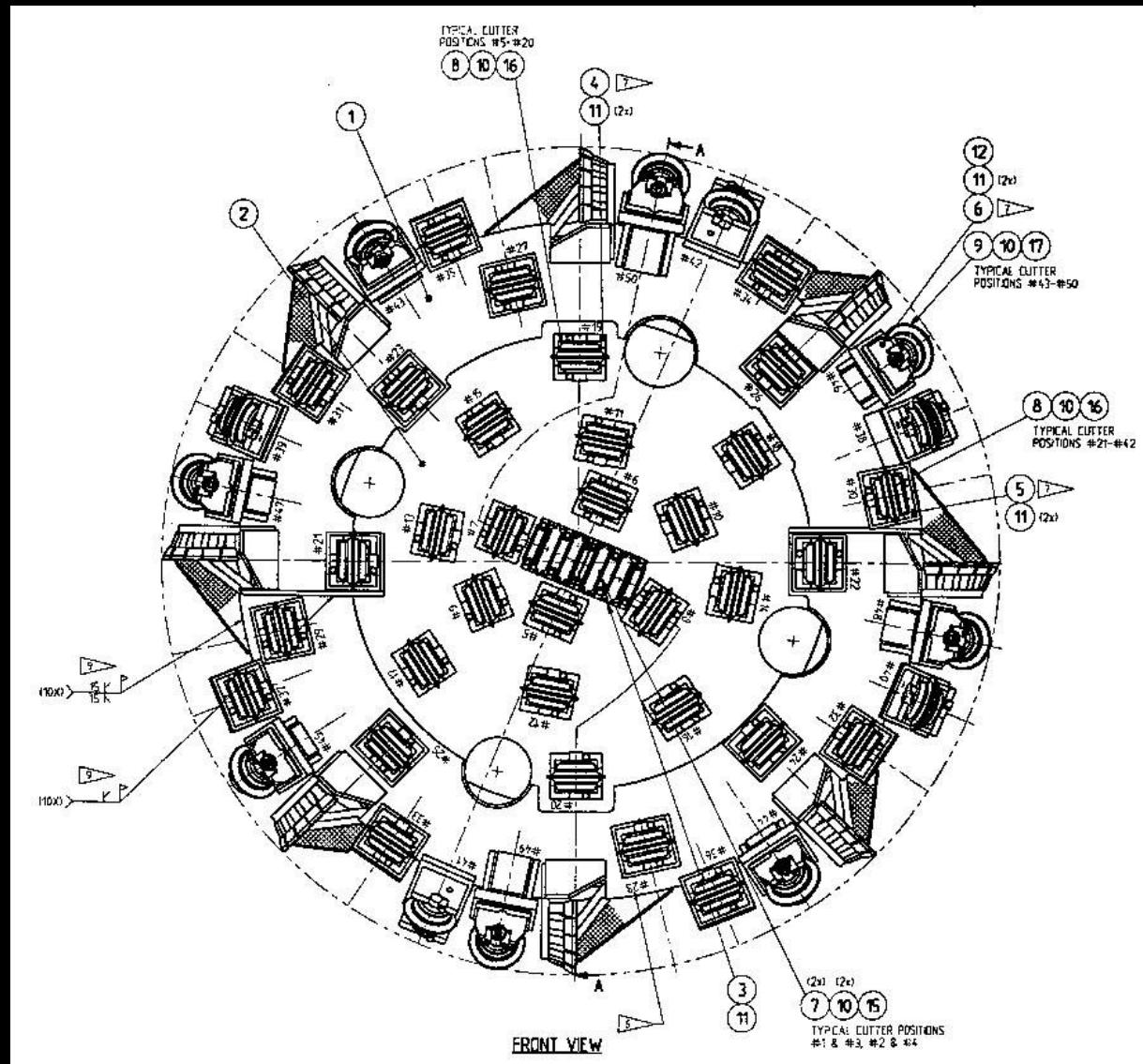


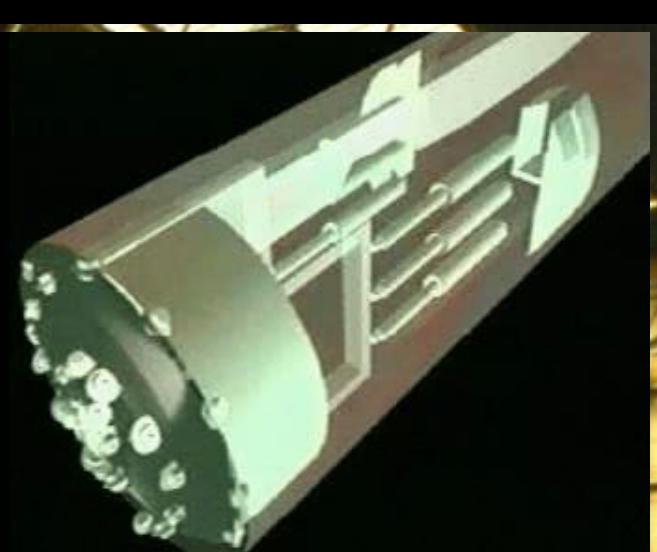
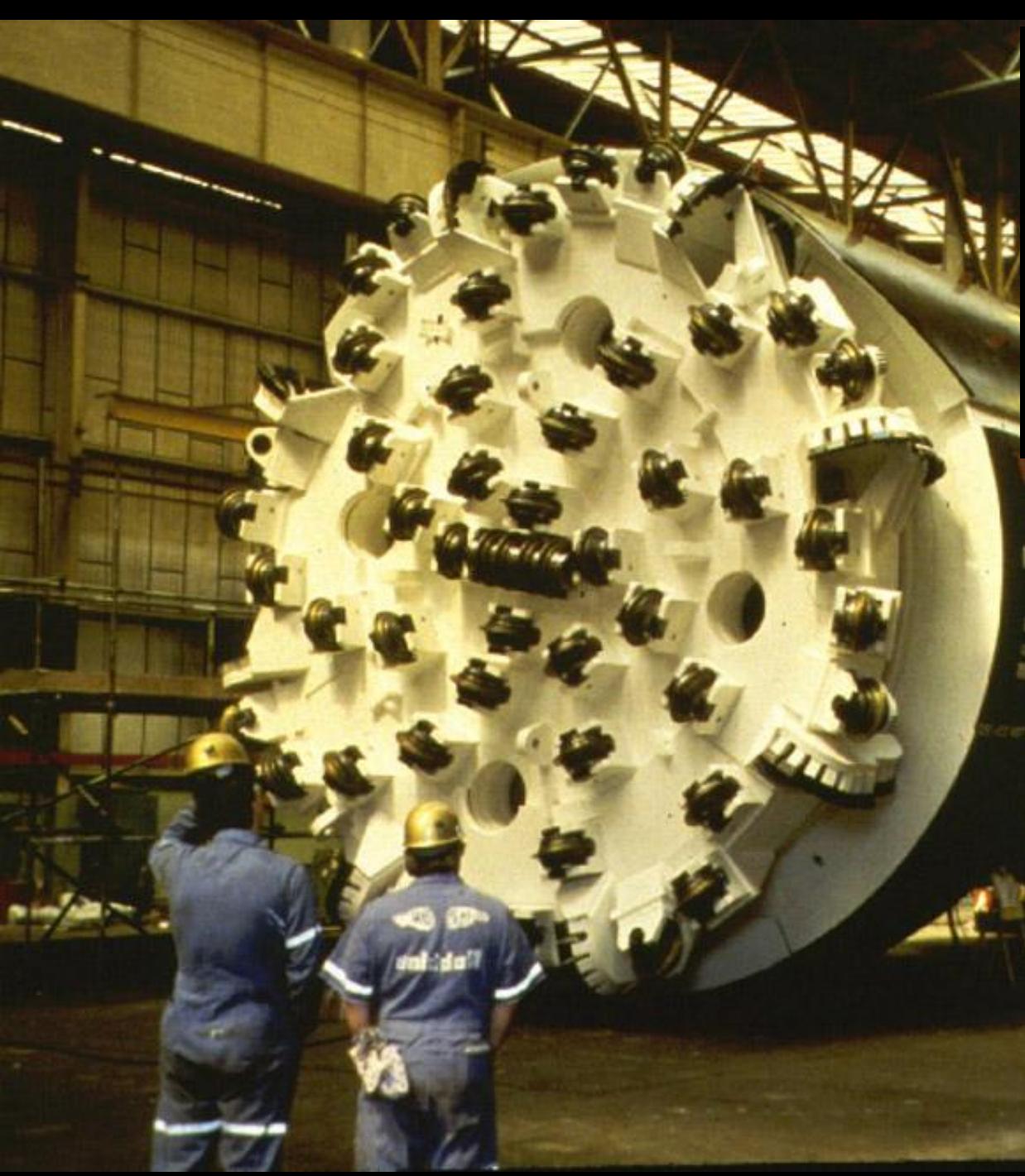
**Jarva MK 15-52b**

# Robbins 235-282 HP TBM



# TBM Chip Production





**Robbins 235-282 HP**

# Con Edison Utility Tunnel



# TBM at Con Ed Tunnel

30 Street  
and 1st Avenue





# TBM Starter Tunnel



# Southern Heading

Shallow NW Dip



# IRT #7 Line Extension



# Second Avenue El

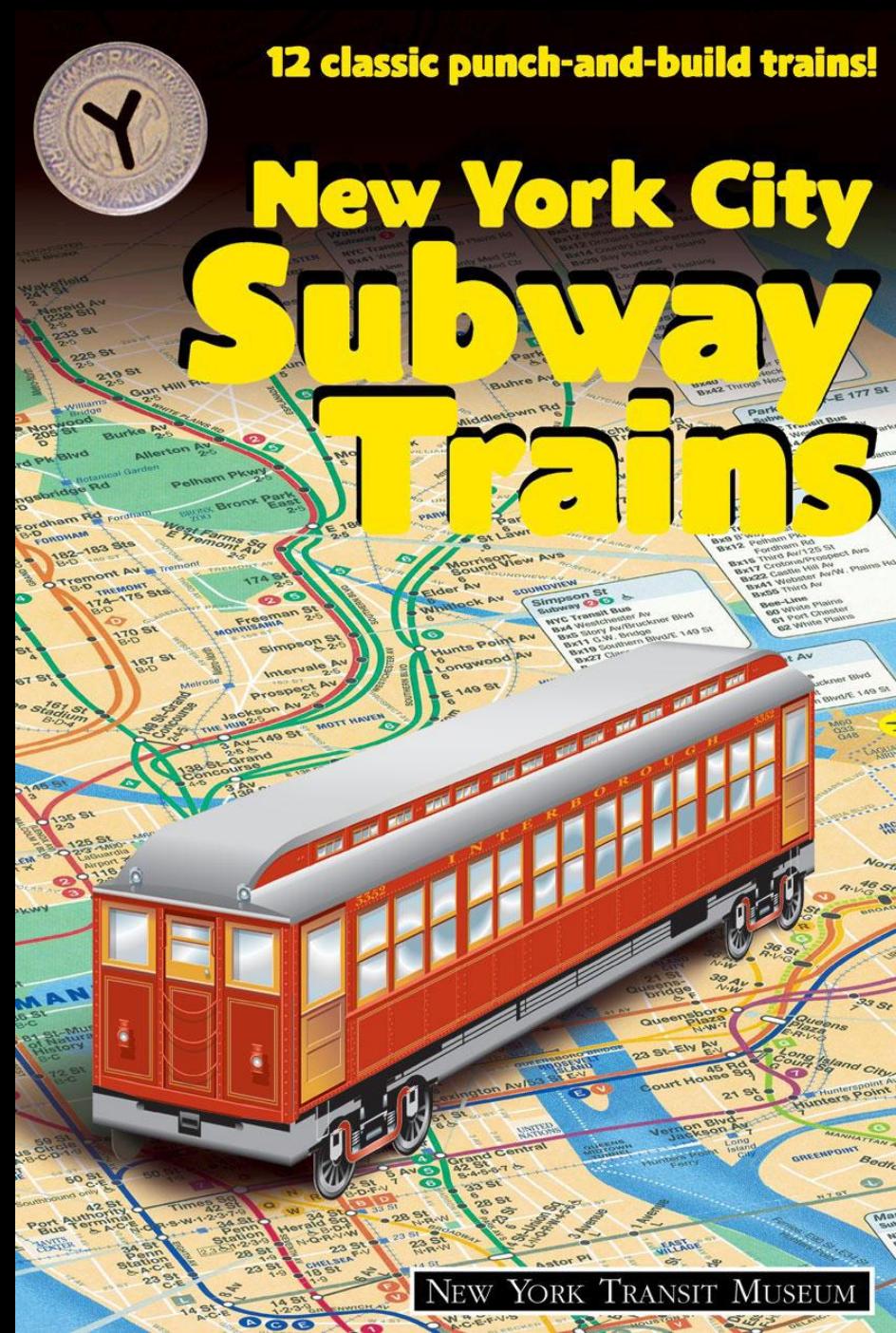


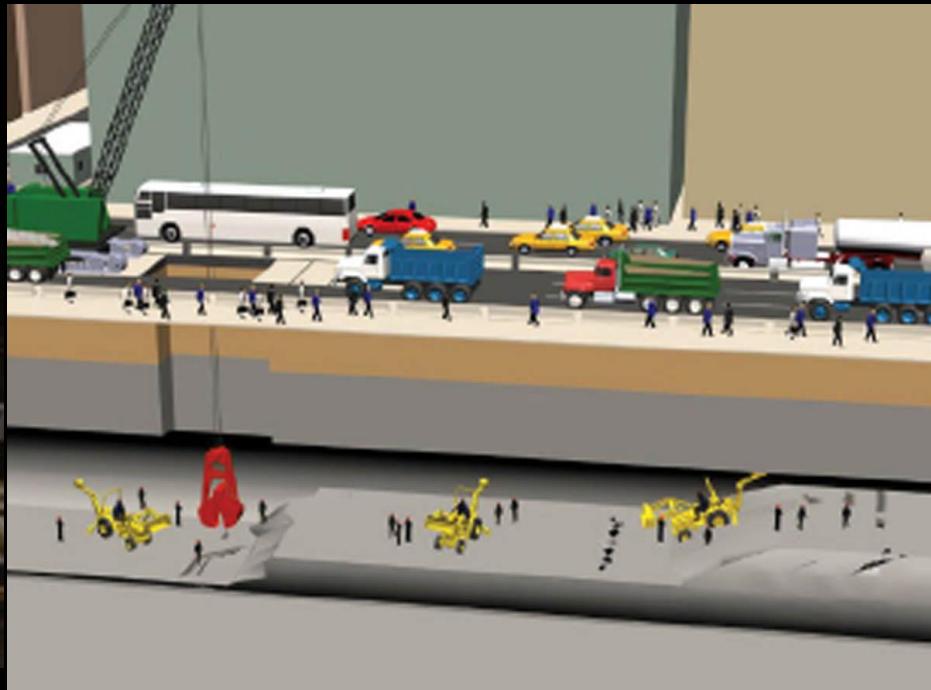
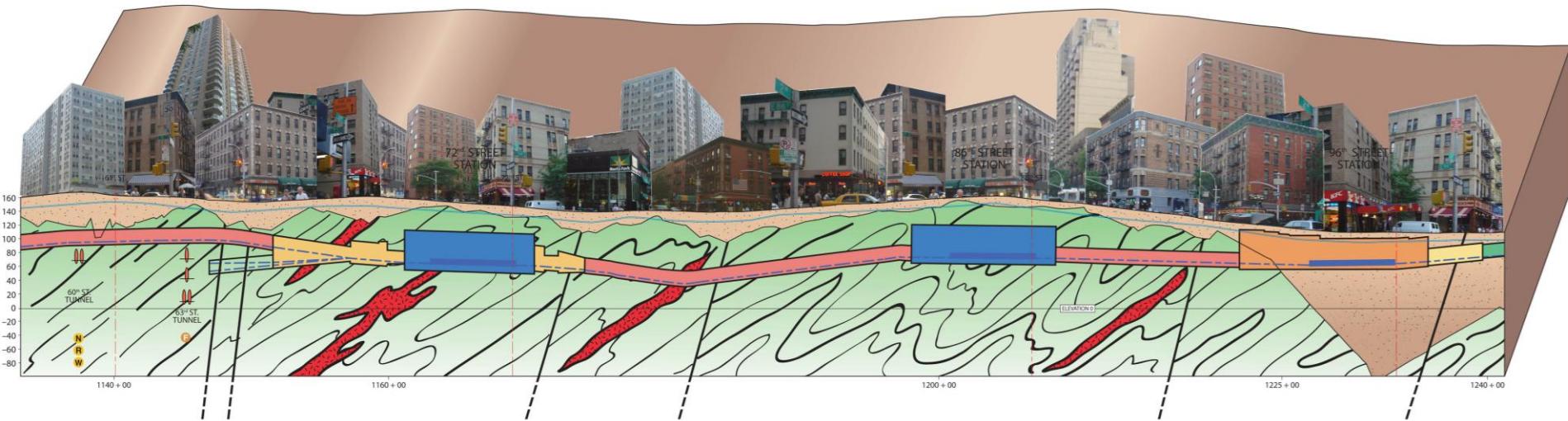
**1929 – NYC BOT Proposes  
Second Avenue Subway**  
**1931 – Plans Postponed  
Depression Era**  
**\$86M → \$249M → \$500M**  
**By 1948 – (Abandonment)**

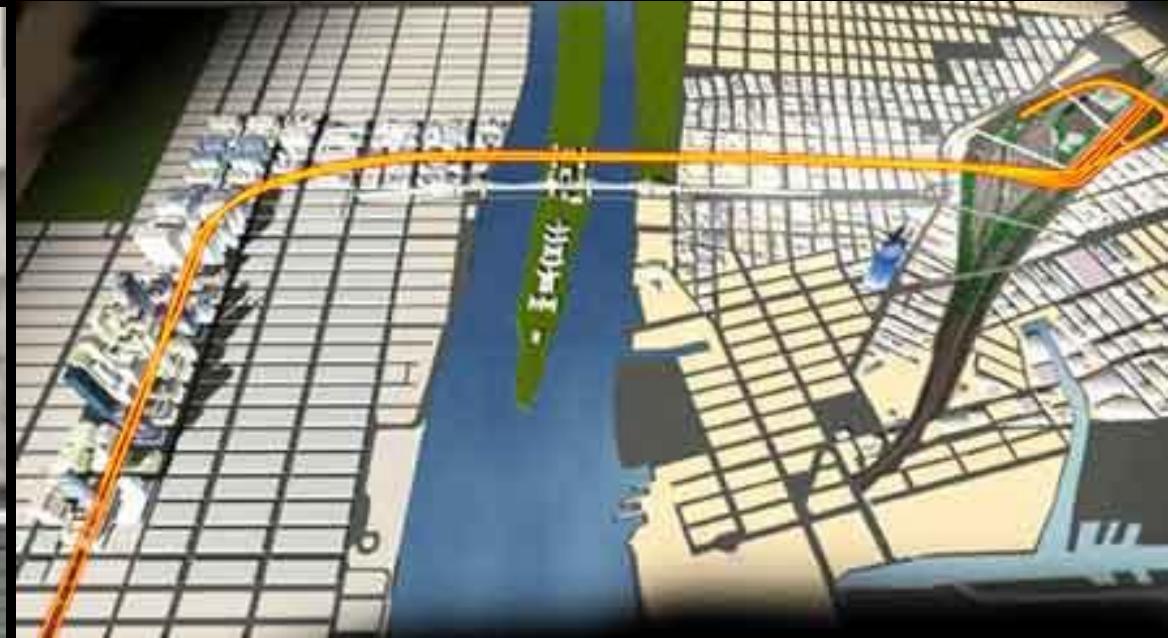
# Second Avenue Subway



12 classic punch-and-build trains!

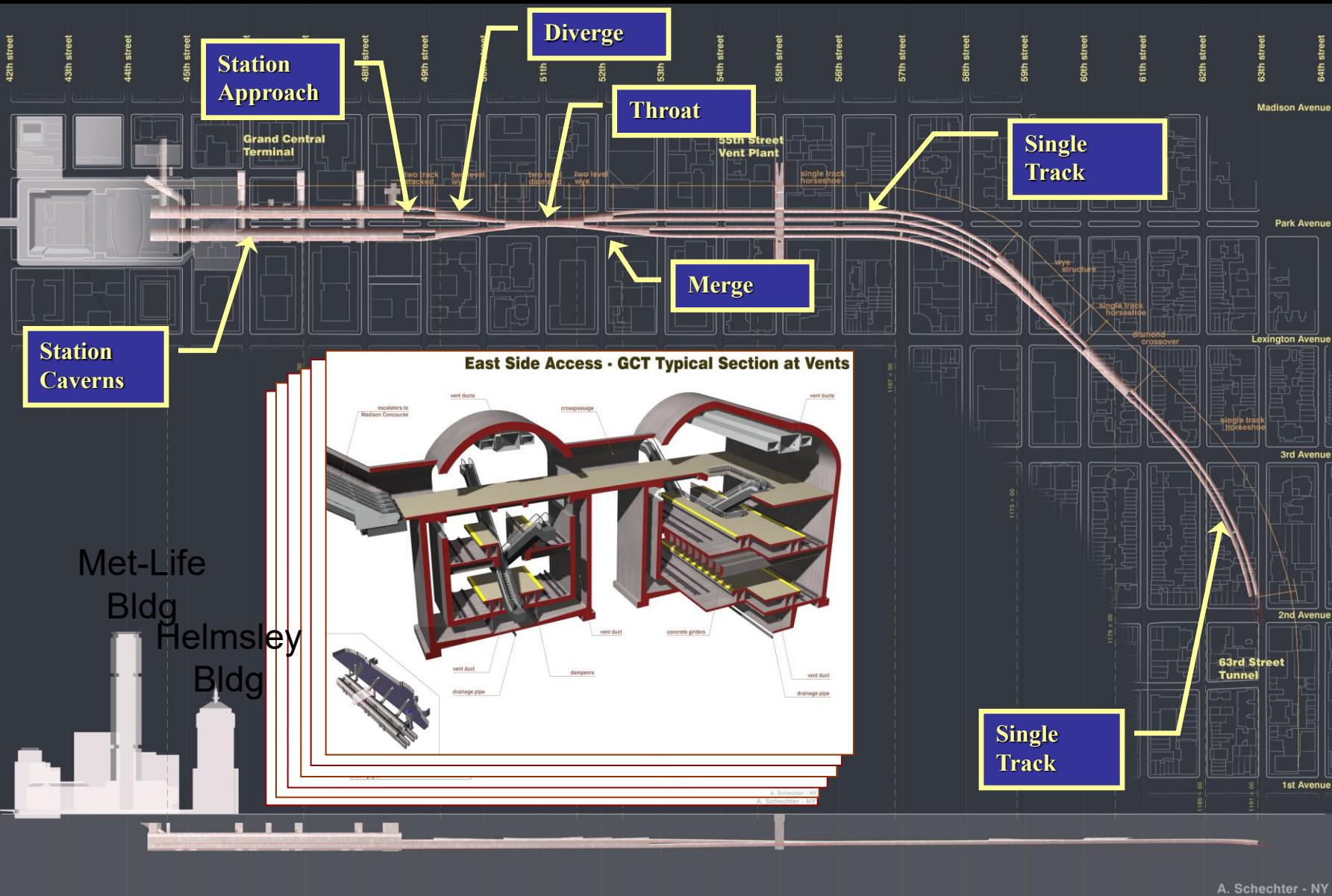






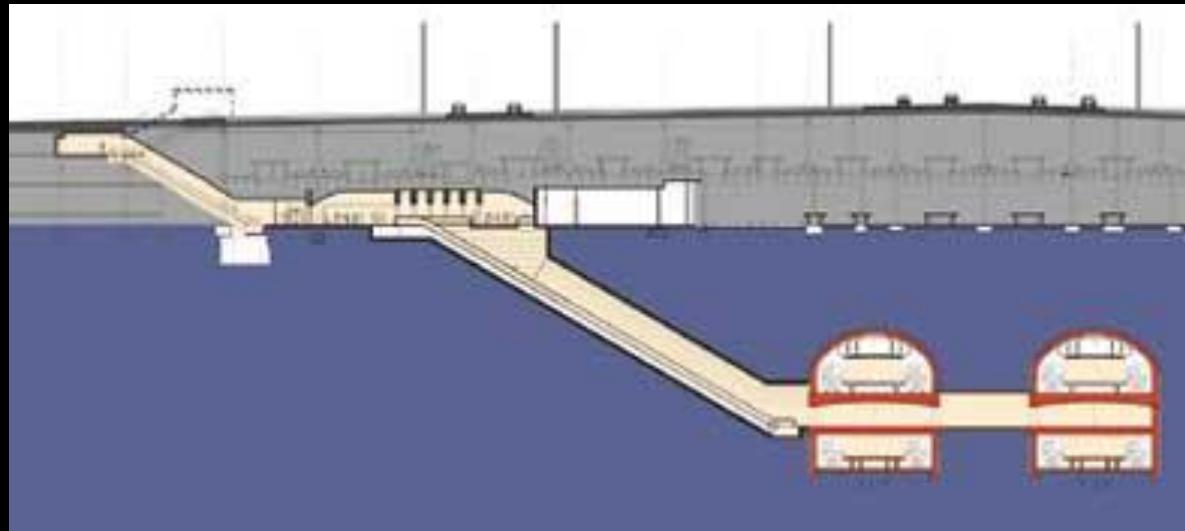
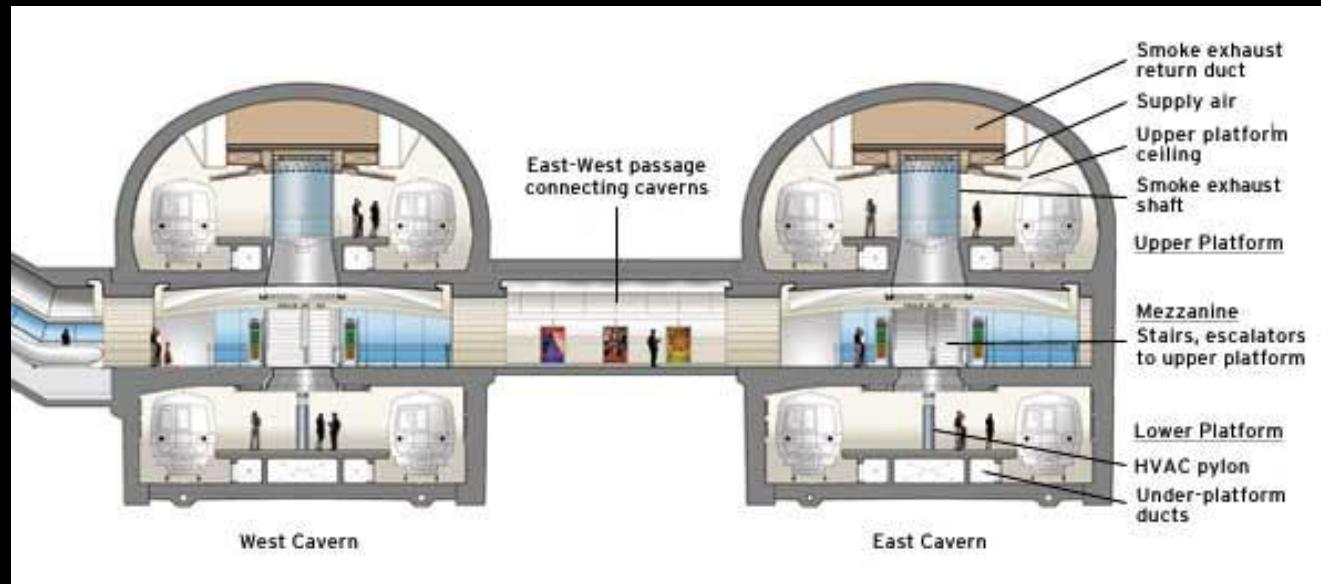
# East Side Access

# East Side Access Project Plans



A. Schechter - NY

# Construction Will Take Place Under Existing GCT



# **CT3, Stage2 Manhattan Water Tunnel**



## **Shaft 26B**



**10 Oct 2002**



**Shaft 26B**

Greenwich Village



**South Heading**

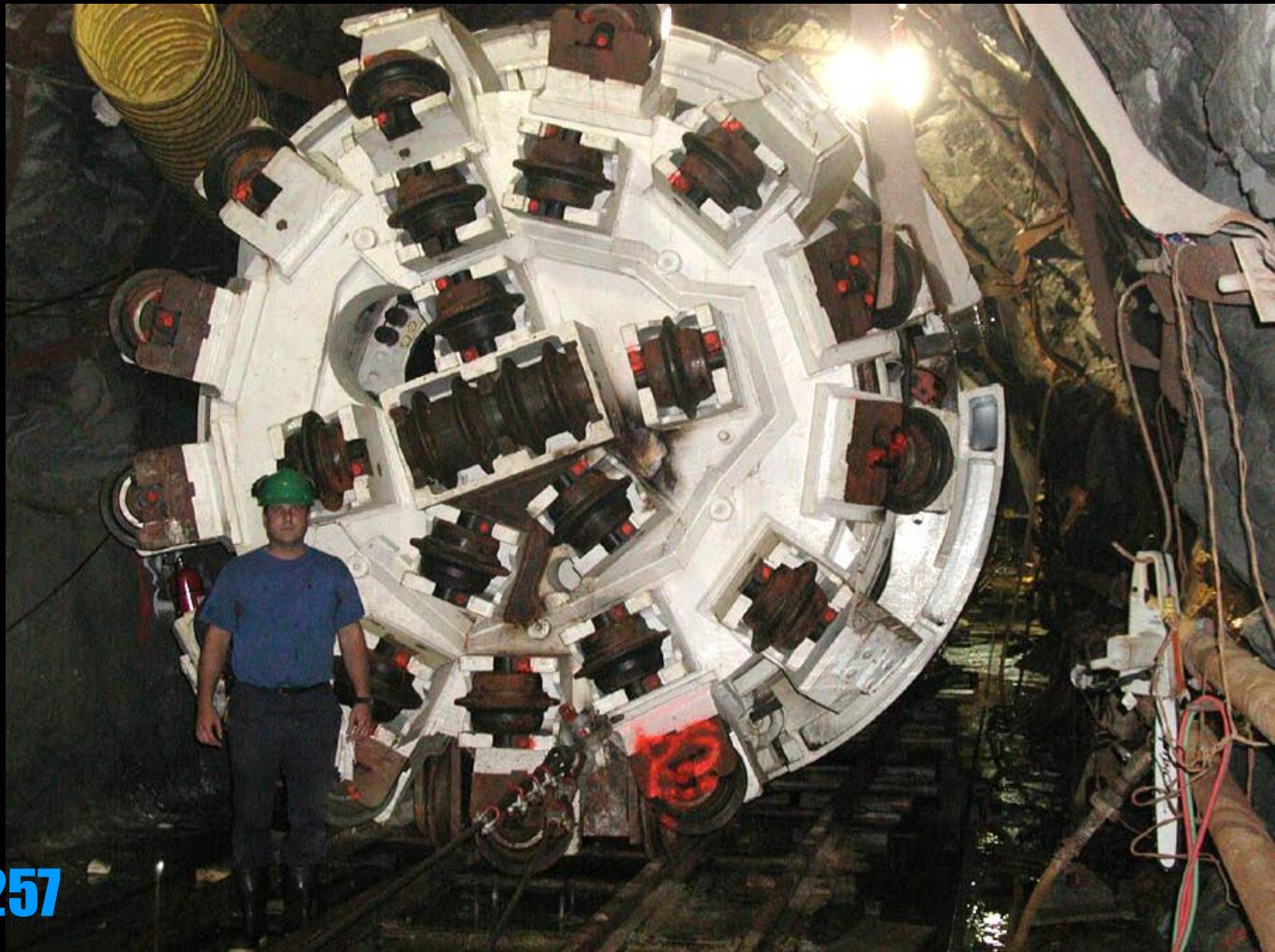
# Bottom of Shaft 26B 580' Deep





# **Manhattan Tunnel TBM**

**Rebuilt Robbins HP 215-257 hard rock machine  
(used first on Con Ed Utility Tunnel on 1st Avenue)**



**Robbins HP 215-257**

A large-scale photograph of a tunnel boring machine (TBM) in operation. The machine's cutterhead is visible at the top, with several circular cutting discs and red protective panels. Below the cutterhead, the tunnel wall is being excavated, showing large, angular rock blocks and some fine material. The machine's body is white and grey, with various mechanical components and cables. The background shows more of the tunnel's length and surrounding rock mass.

# **What Are the Geological Controls on Effective Hard Rock TBM Tunneling in Crystalline Terrains?**

**Low Penetration Rates**  
**Excessive Fines**  
**Blocky Ground**  
**Unstable Headings and Sidewalls**

A large, grey, granular pile of aggregate or sand is shown in the foreground, with a conveyor belt structure visible on the left. In the background, several dark storage bins are stacked, each labeled "TOP".

# Excessive Fines

# Desirable Kerf Pattern in Hard Rocks



# Blocky Ground



# Collapsed Crown and Sidewalls

A photograph of a collapsed tunnel or excavation site. The image shows a dark, cramped space with wooden timbering and metal support beams. A large amount of dark, crumbly material, likely rock or soil, has collapsed onto the floor and between the supports. The lighting is dim, coming from a flashlight or headlamp, casting long shadows and highlighting the texture of the collapsed material.

Short Stand-up Times

Station 153+30

# Unforeseen Tunneling Problems

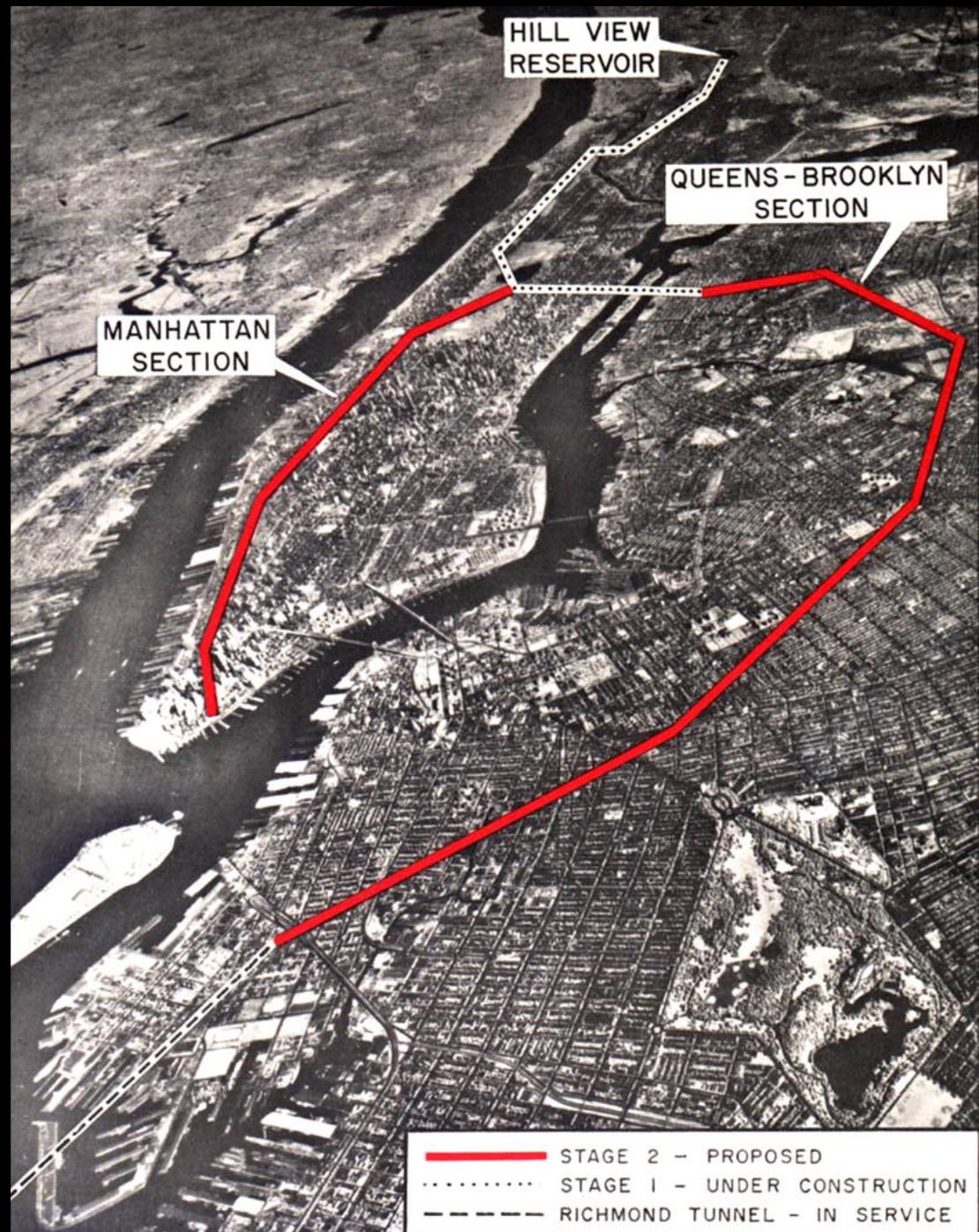


# Queens Tunnel Problems – A Case History

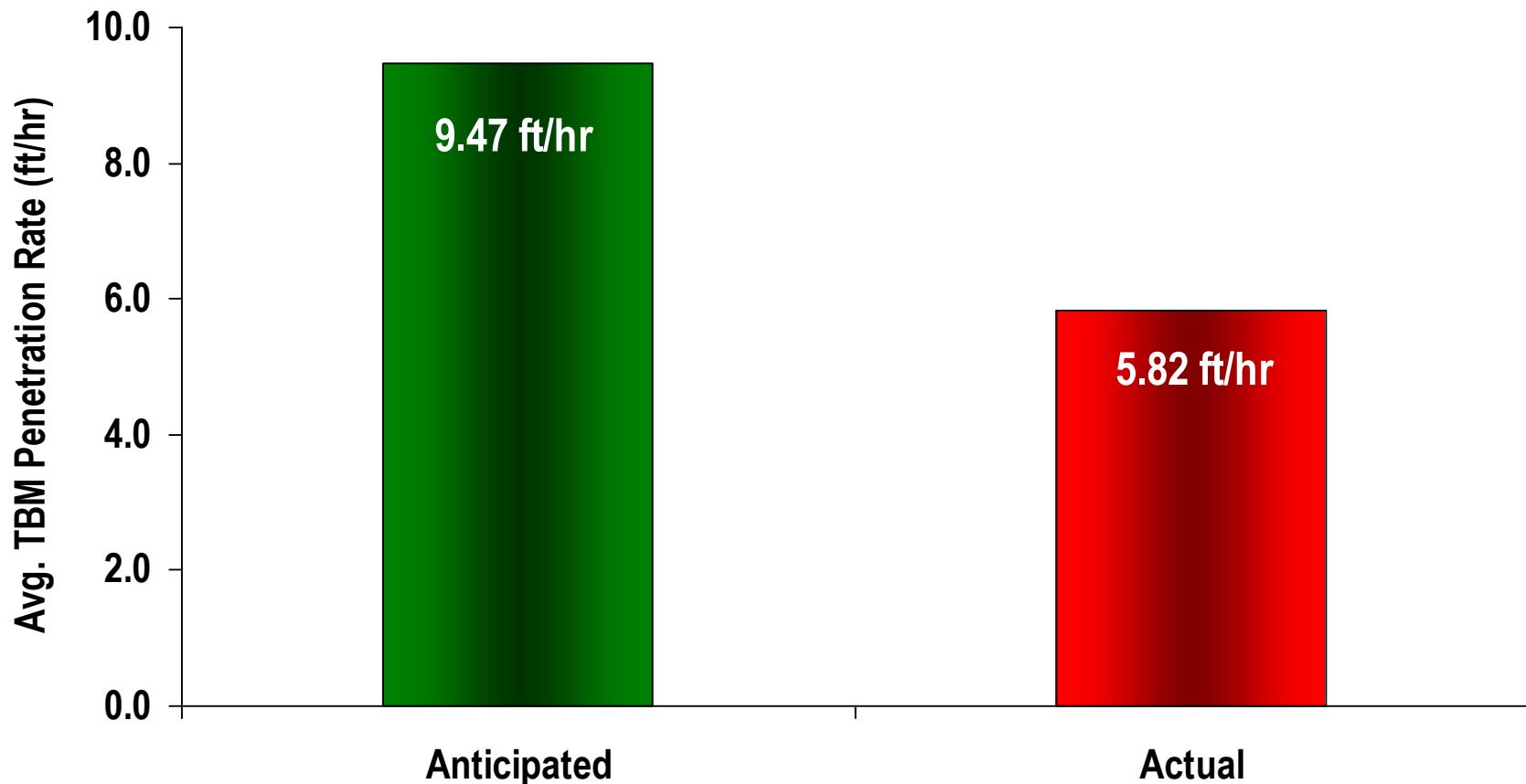


Robbins 235-282 HP TBM

# City Tunnel #3 Stages 1 and 2



# QT Anticipated vs. Actual Penetration Rates



# Pre-Bid Analysis Should Include:



- Published Maps and Reports
- Boring Analysis

Fractures

Rock Types

Rock Fabrics

Density Studies

Petrographic Studies

- Rock Fabric Studies

Mineralogy

Texture

Orientation

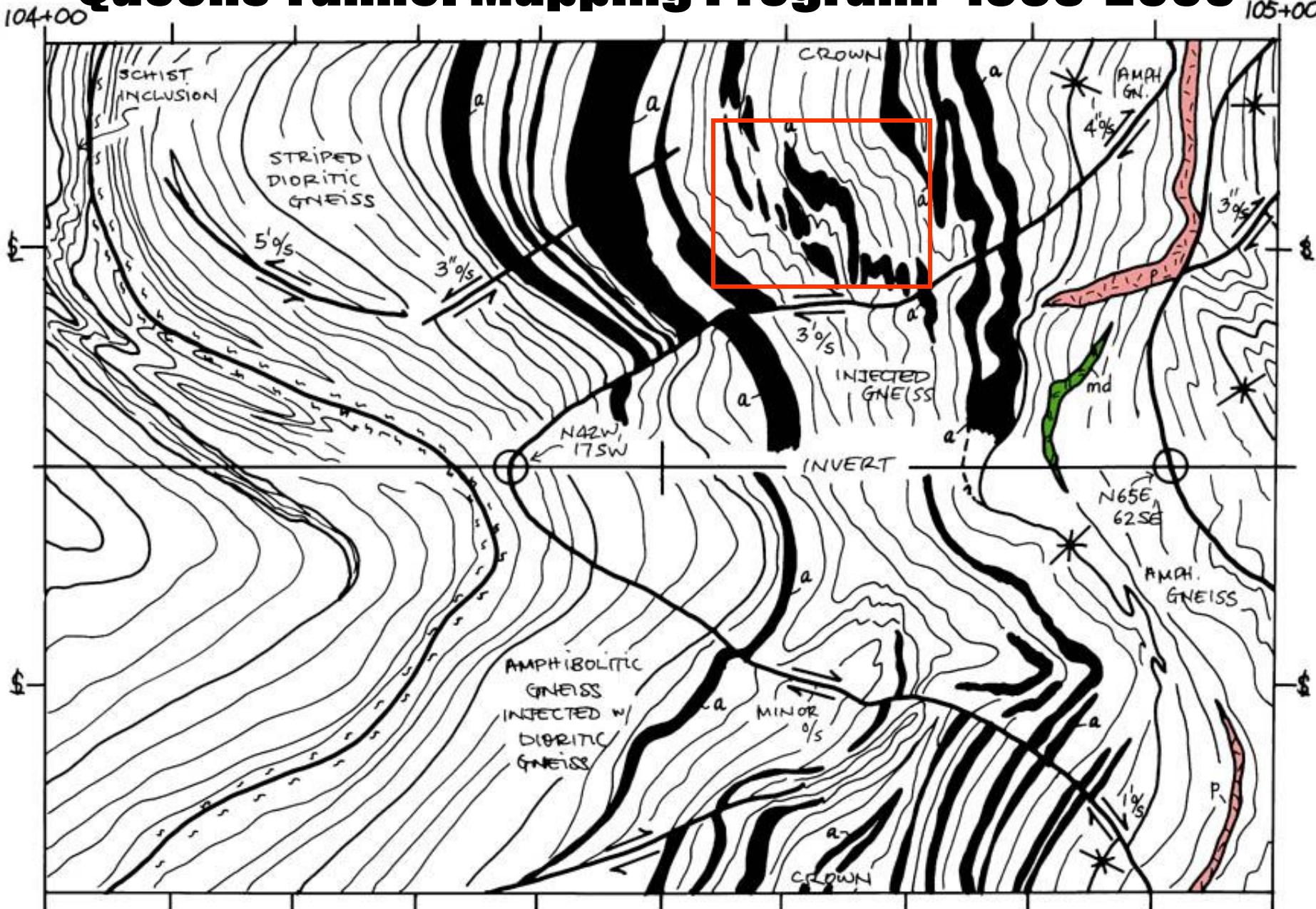
# Can Geologic Studies Help Predict TBM Penetration Destiny?





**Merguerian's Field Office**

# Queens Tunnel Mapping Program: 1998-2000



- Scale 1 in. = 10 ft

1306

1215

104-155

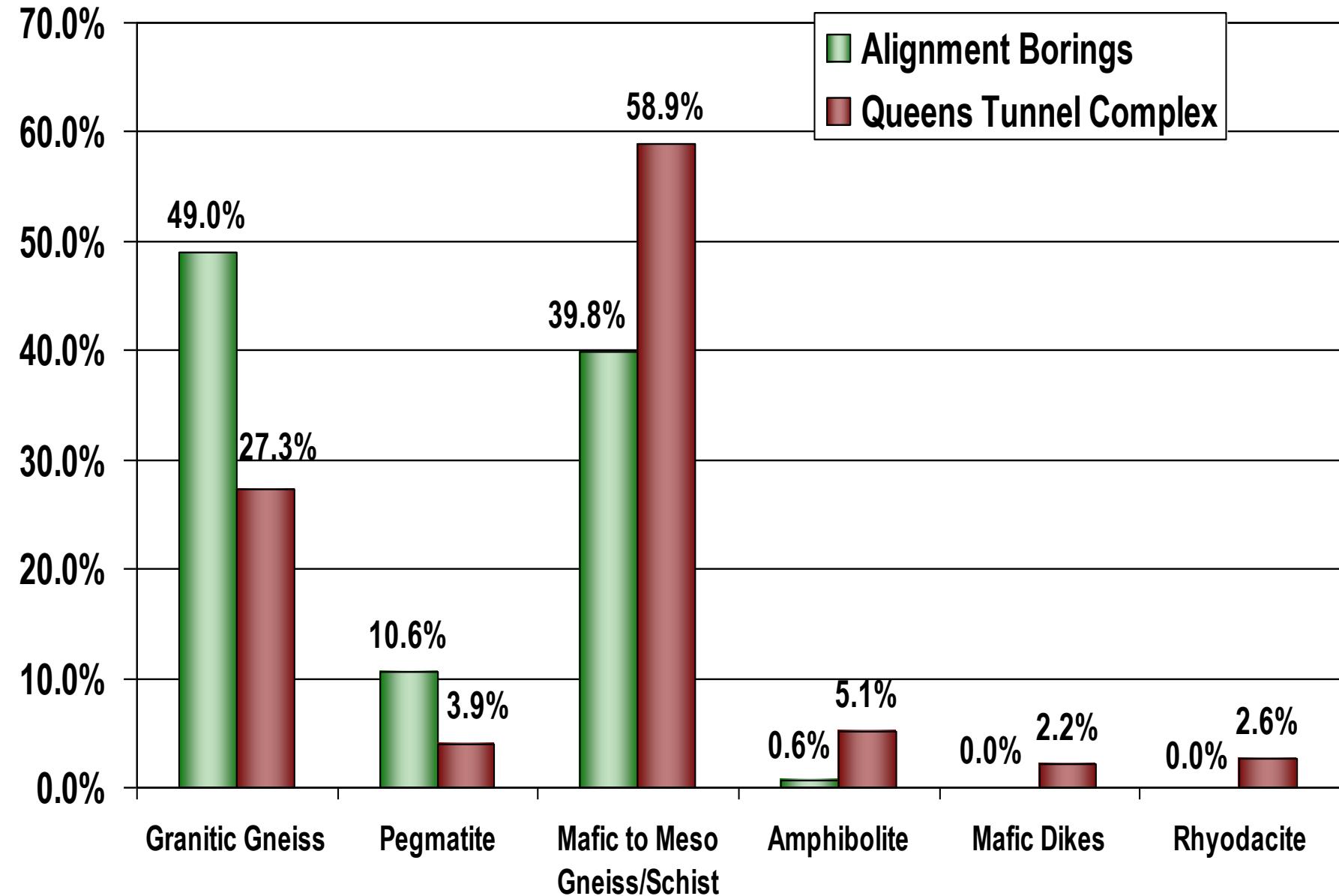
104-155

104-160

104-155

104-155

# Comparative Lithologic Analysis



# **The Queens Tunnel Complex**

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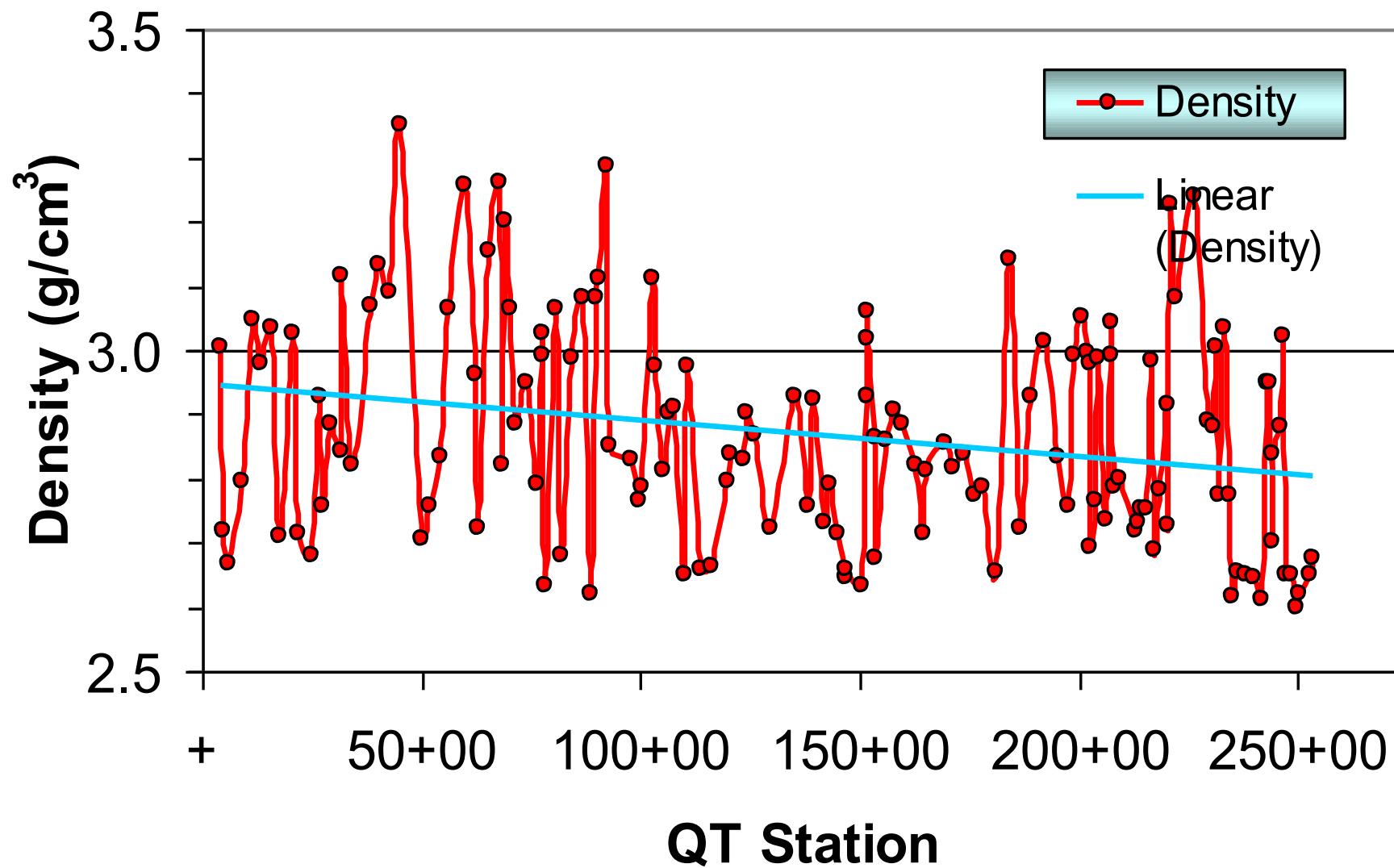
**I. Garnet-Clinopyroxene-Plagioclase Rocks  
+/- Hornblende, Quartz, K-feldspar**

**II. Leuco- to Mesocratic Gneiss**

**III. Mafic to Mesocratic Rocks**

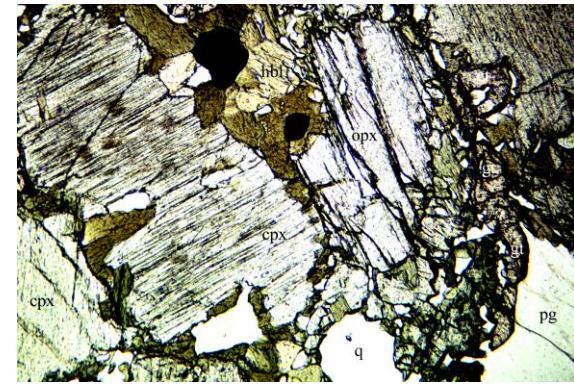
**Leucocratic (0%-35% mafic mineral content),  
Mesocratic (35%-65% mafic mineral content), and  
Melanocratic (65%-90% mafic mineral content)  
gneiss form the bulk of the Queens Tunnel Complex**

# Density Queens Tunnel (Mean = 2.87 g/cm<sup>3</sup>)



# • Petrographic Analysis (92 Samples)

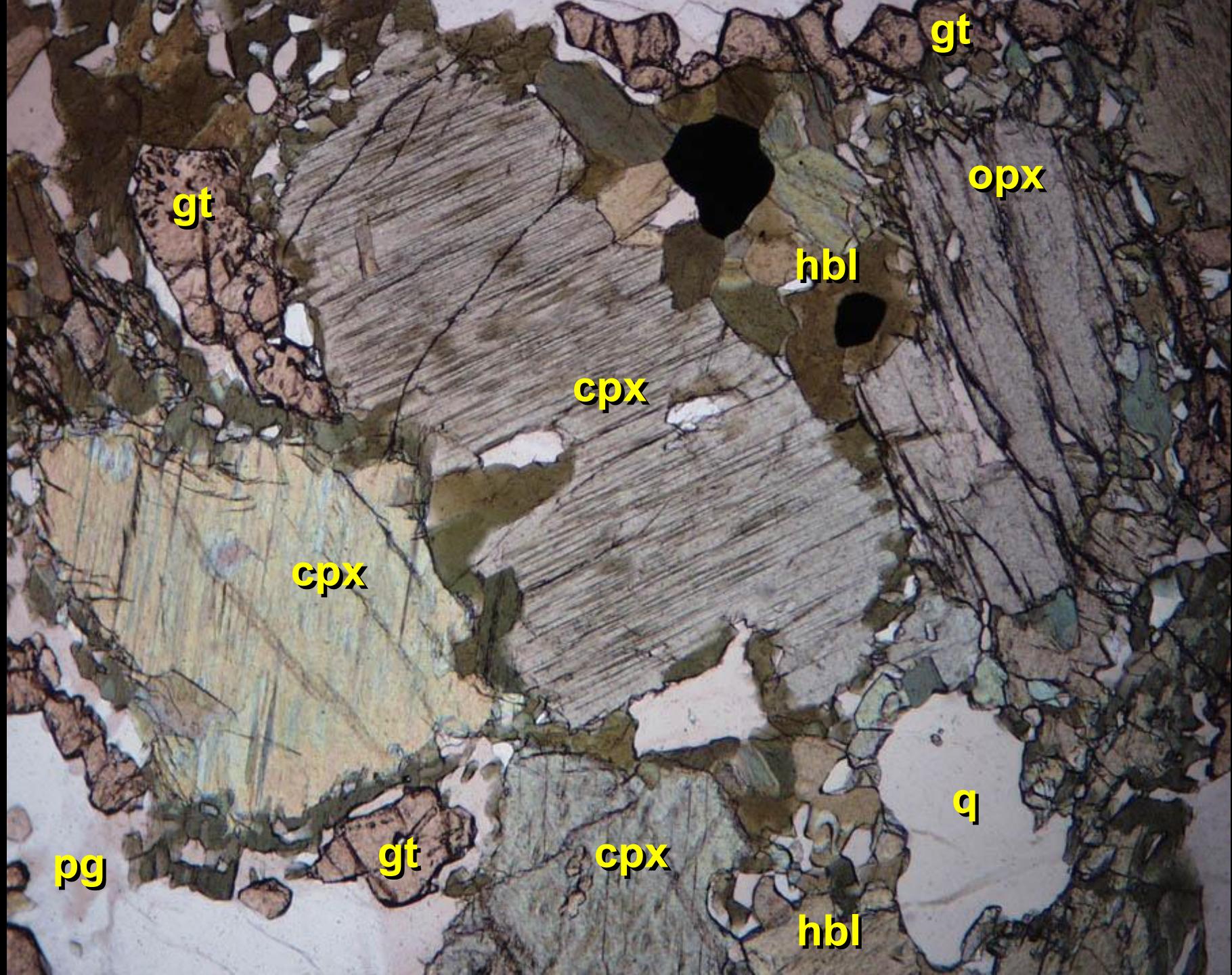
- Texture
- Mineralogy
- Internal Structure
- Metamorphism



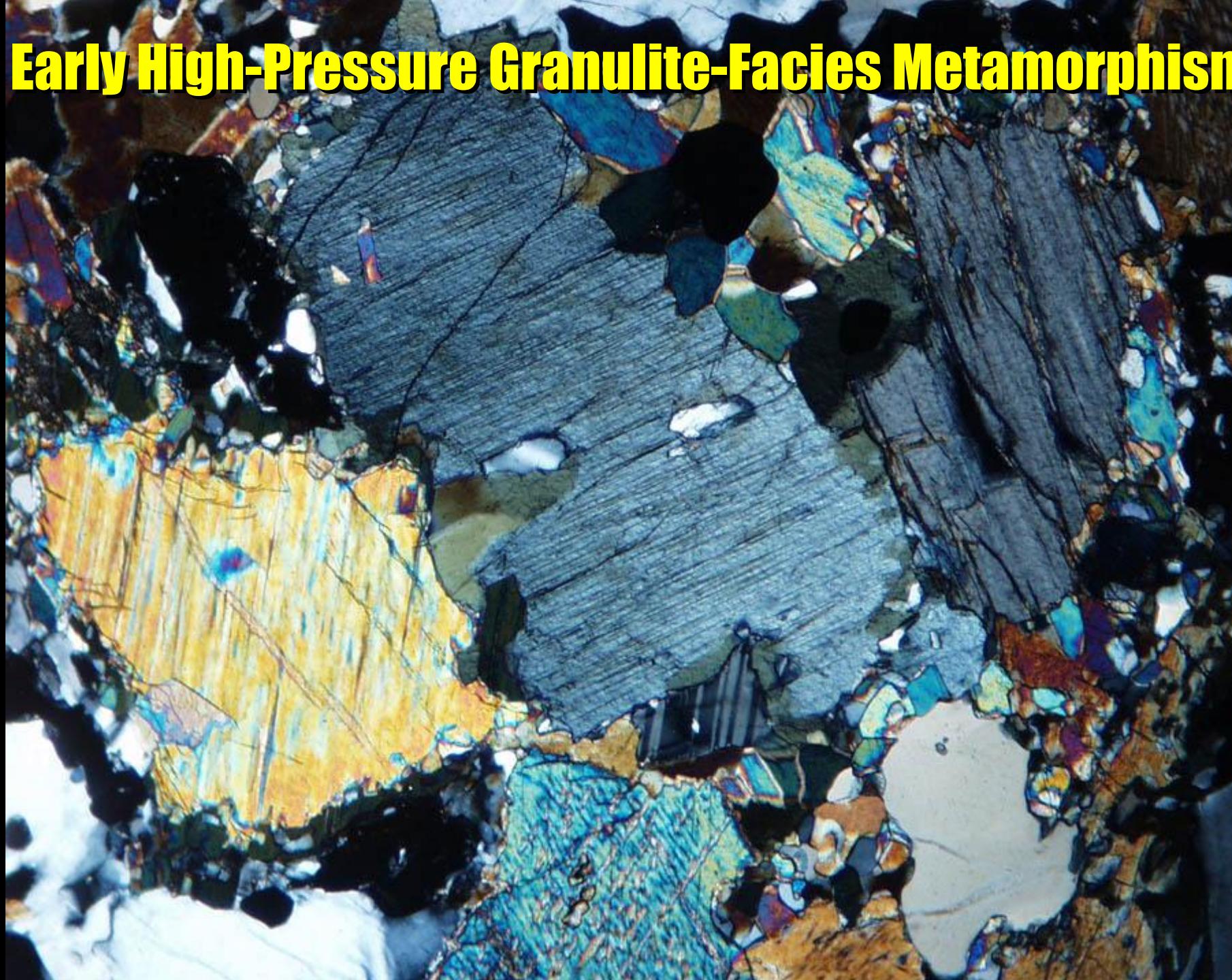
Thin section photomicrograph

Number	Location	Color	Density	Qtz	Kspar	Plagio/ An	Opx	Cpx	Hbld	Bio	Garnet	Opaque
Q109	004+80					M	35	M	M			
Q109	004+80	25	2.72	M		M	35		m	m	m	
Q110	006+42	10	2.66	M	tr+AP	M				m gnbk	tr	tr
Q111	009+25	25	2.79	M		M	m		tr	m	M py encl Q	tr
Q112	011+60	35	3.05	m		M	51	M exsol	m gnkh		M py	
Q114	015+90	45	3.03	m		M	53-39n	M someExsol	mgnkh		m necklace	tr
Q115	017+70	10	2.71	M	tr AP	M			m bgn sieve	m rbn	m porange	tr
Q117a	022+25	15	2.72	M	tr	m	27		m dgyn	m rbn	m porange sieve	tr
Q119	026+65	45	2.93	m 10n15		M	27		M khgn	tr rdbn	m	m
Q123	032+15	60	3.11	m		m	44	m	m gnHB	m rbn	M sieve	tr
Q127	042+67	60	3.09	m		M		tr	M gnkh	m red	M	m
Q129	049+95	25	2.71	M	M	M	low			M kh	M	
Q130	051+83	15	2.76	40	tr	M				m obn	M.vermic/sieve	tims
Q133	059+95	55	3.26	m		M	38-29		M khtan	m	M	m
Q134	062+45	60	3.17	m		M	28-40Rev Zoning	M	M bgn some vermic wi Qtz	M fine sieve/vermi	10c vermi	
068+10	068+10	5:50		M		M	55	m	M gn		m vermic with plaq	
070+60	070+60	45		M		M	45+	?	core?	m. Gn	M	m
Q141	071+80	30	2.9	5		M sieve	M sieve		tr gn	M okh	M sieve	2

Petrographic Data Sheet

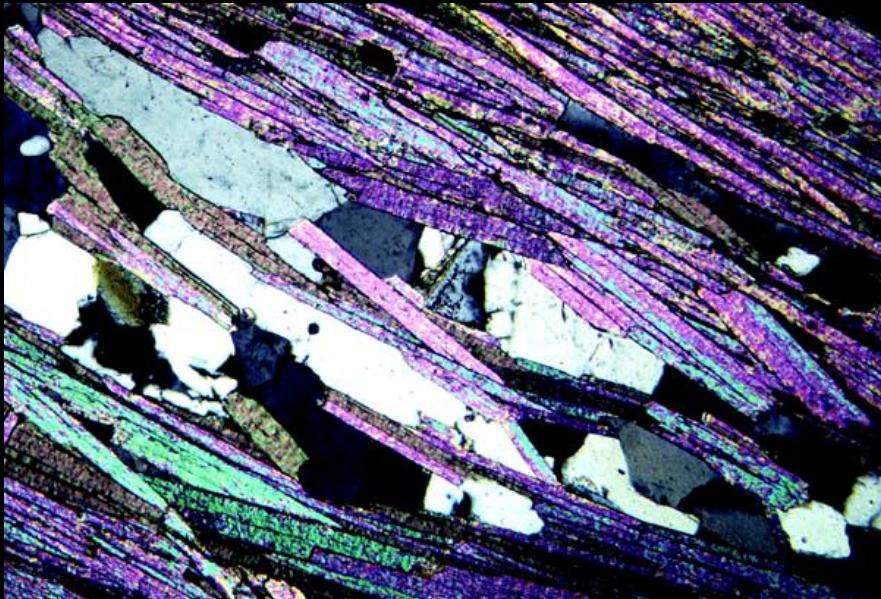


# Early High-Pressure Granulite-Facies Metamorphism

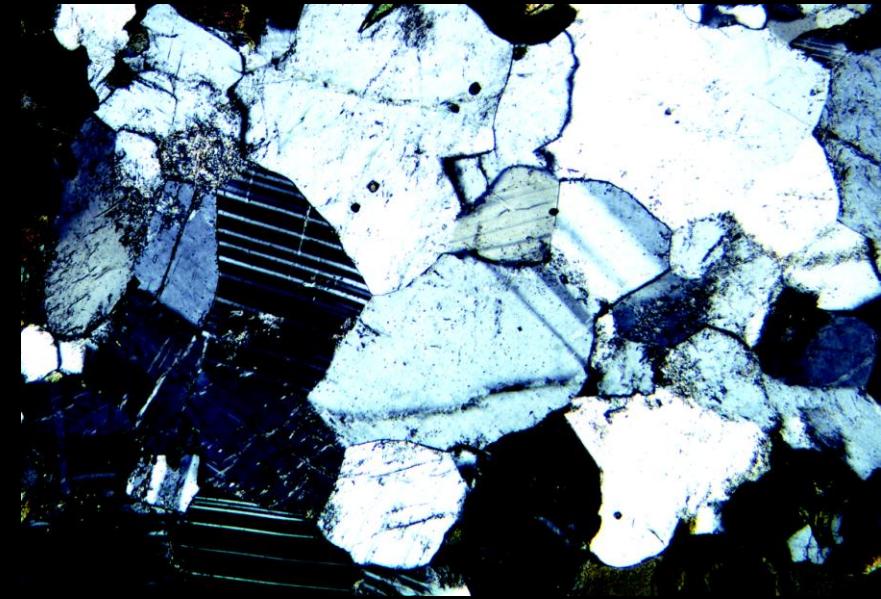


# Mica Content of Rock Fabric

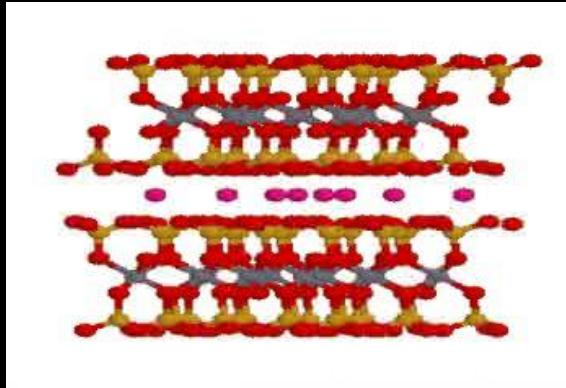
Micaceous (+/- hornblende) penetrative foliation  
vs. non-foliated “granoblastic” rock mass



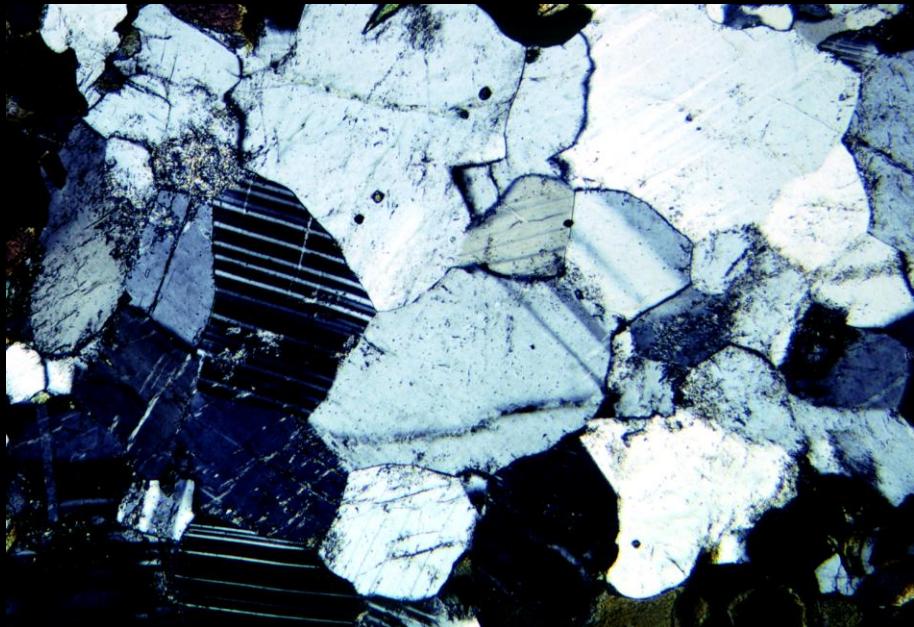
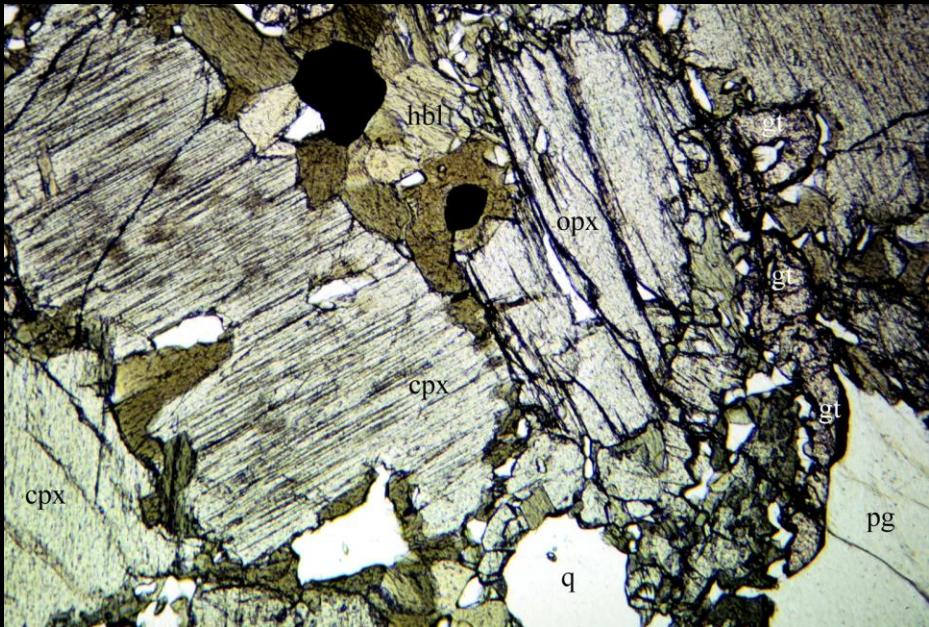
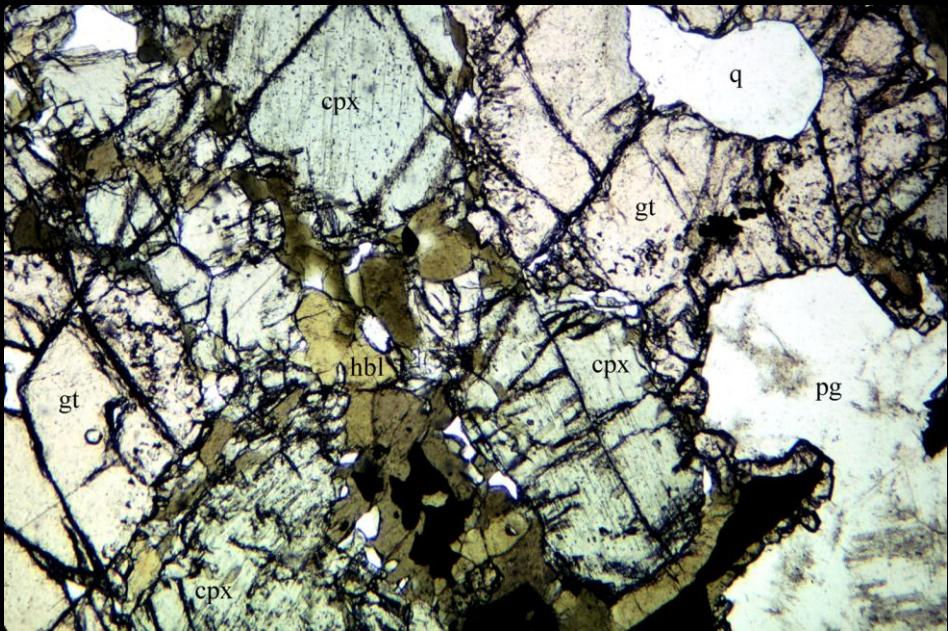
Foliated

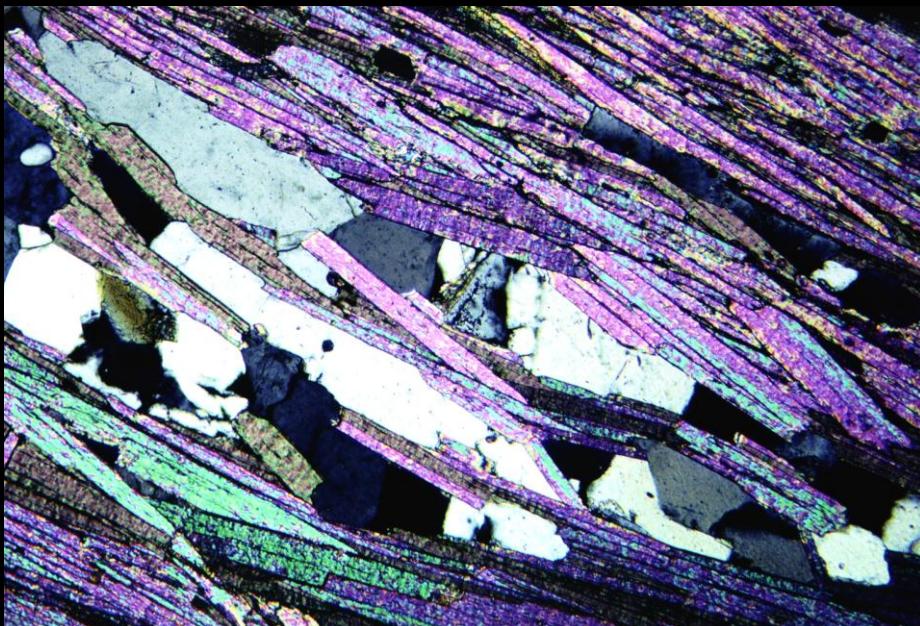
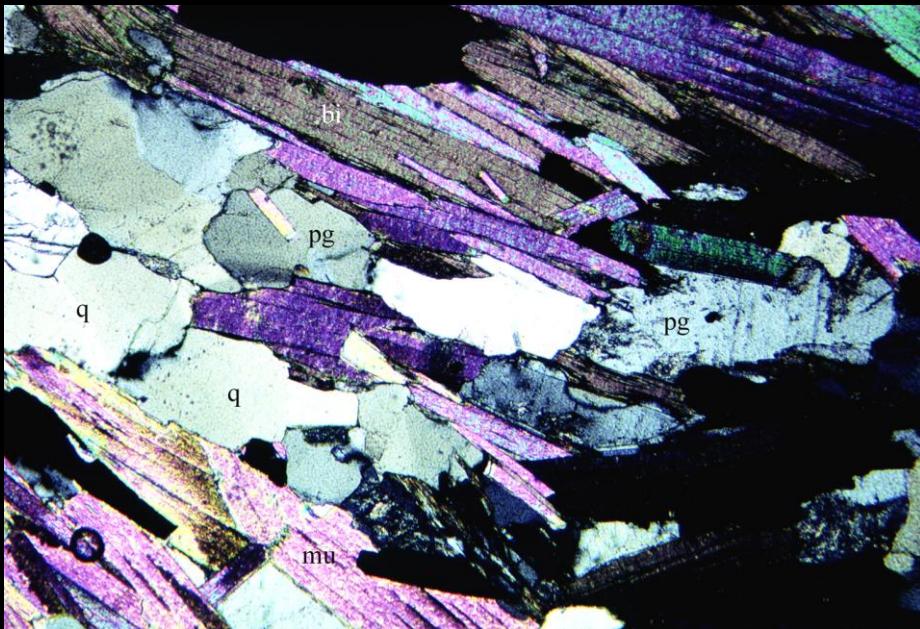


Non-Foliated



# Granulite Facies Gneisses Found in the Queens Tunnel Granoblastic Textures Tough Rocks for Tunneling





**In Western Manhattan:  
Amphibolite Facies Schists  
Well-layered Hartland Fm.  
Foliated Textures  
Great Rocks for Tunneling  
and Excavation!**



# Orientation of Rock Layering

**NE strike and moderate 57° dip anticipated**

- [Based on borings, Chesman, Tarkoy]

**Highly variable trends found**

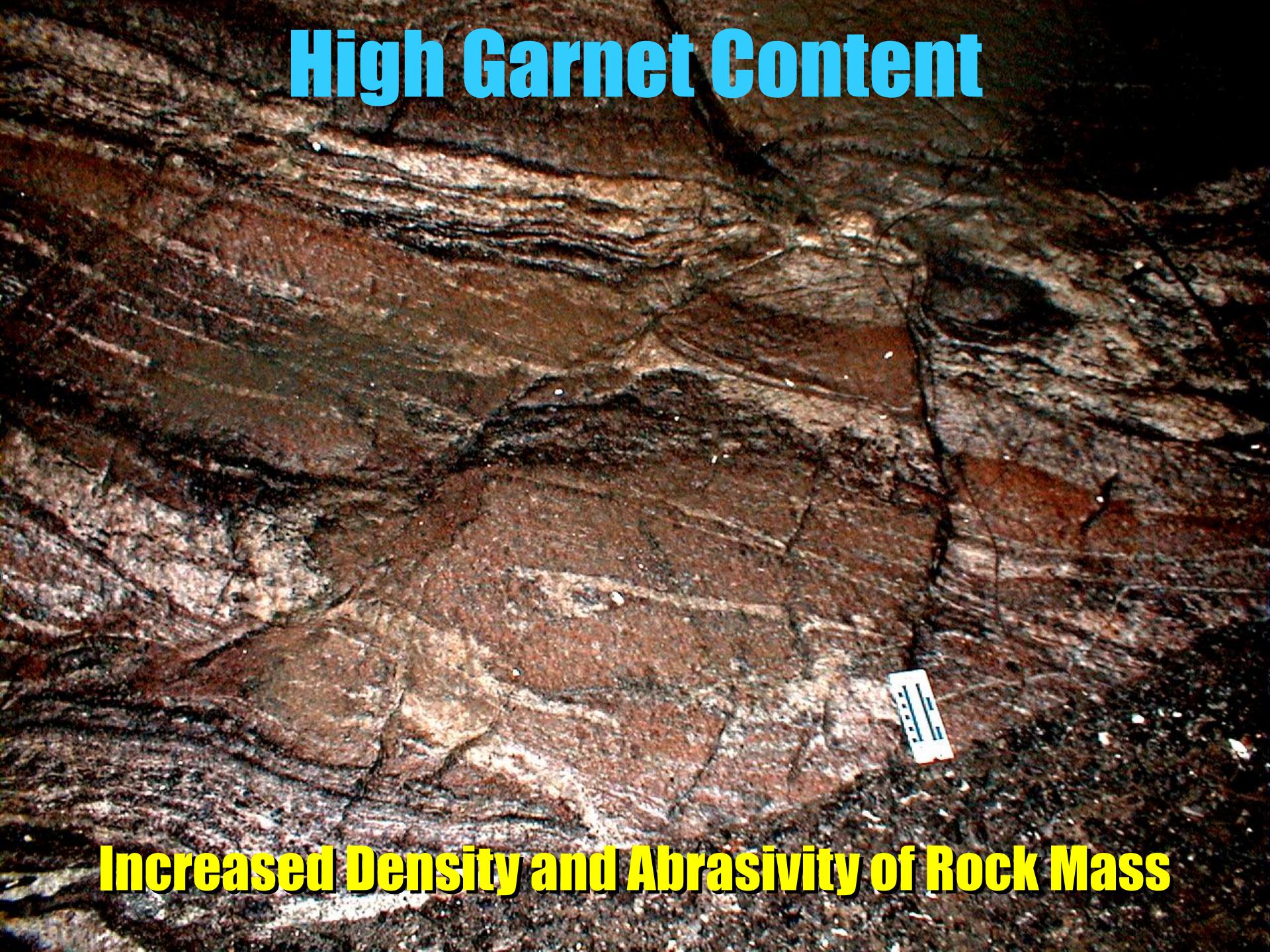
- Extended reaches of tunnel exhibited gentle dips



**Only one boring (QTL-12) exhibited gentle dips at tunnel horizon**

	NE Leg	NW Leg
Gentle Dips	17/93	18%
Moderate Dips	34/93	37%
Steep Dips	42/93	45%

# **High Garnet Content**



**Increased Density and Abrasivity of Rock Mass**

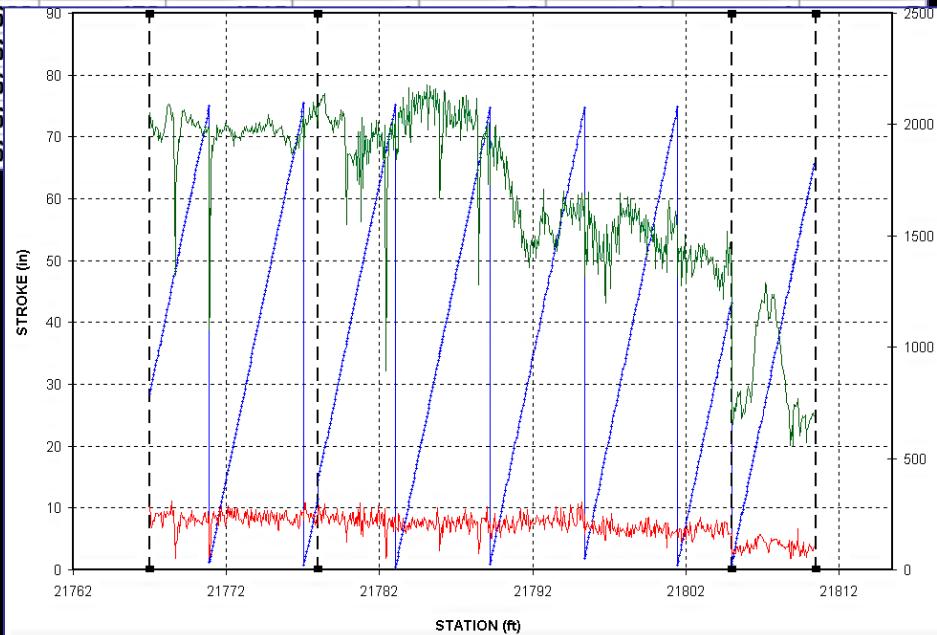
# Reduced TBM Penetration Rate Investigation

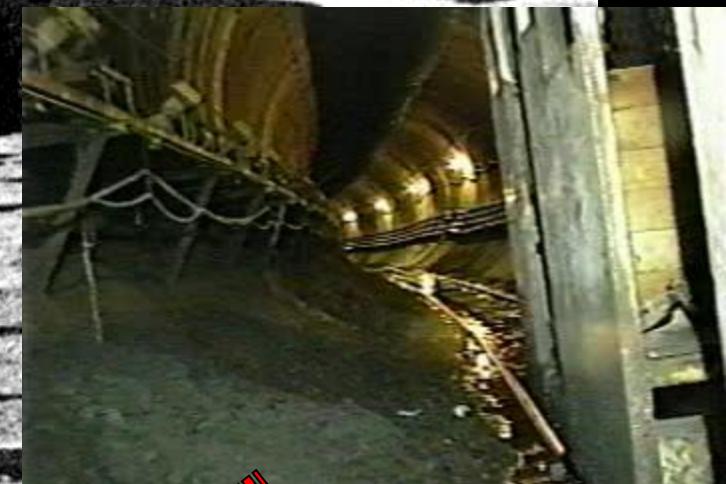
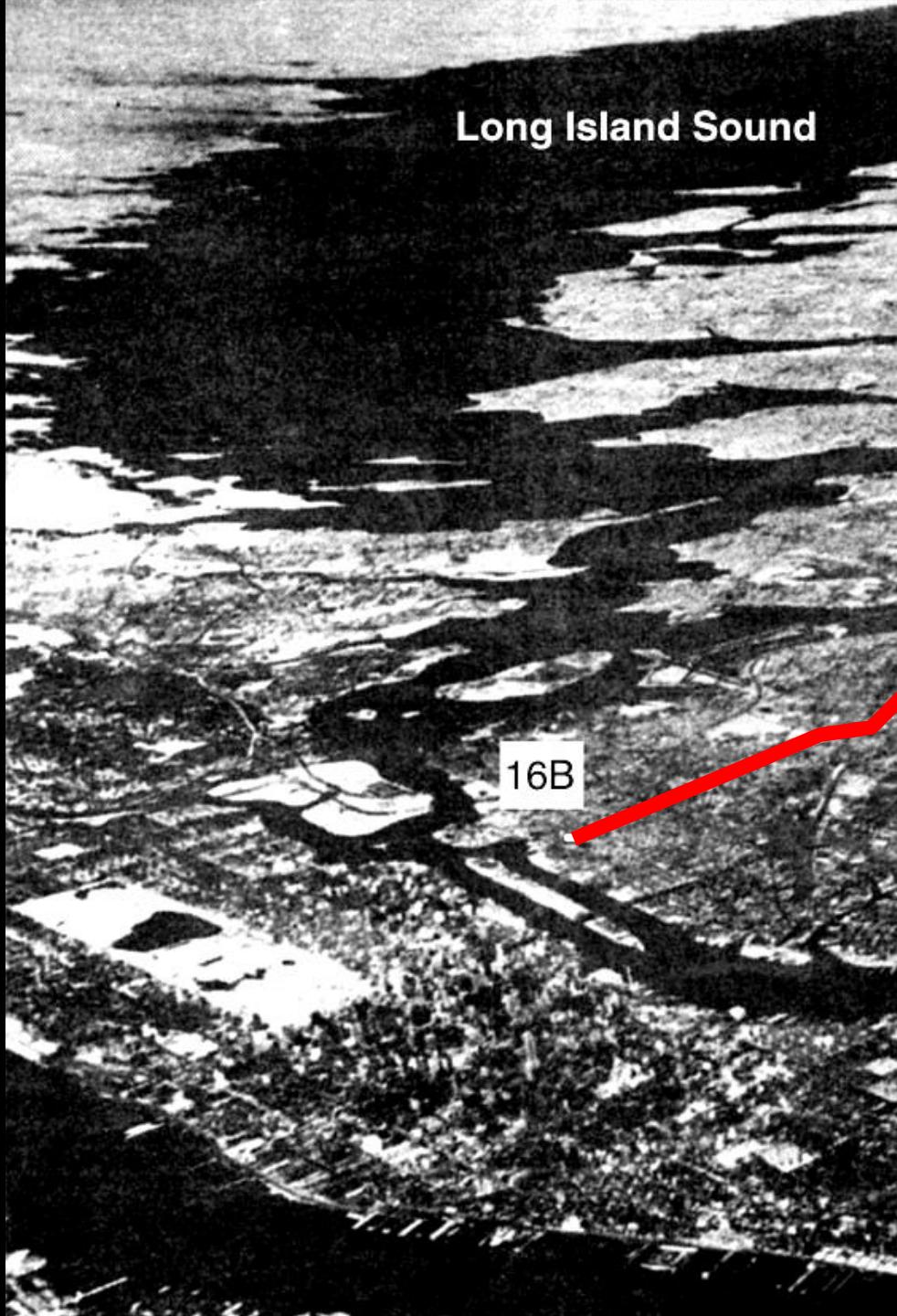
*(TBM Data Logger)*

The Queens Tunnel TBM utilized a CIC-200 Data Recorder capable of continuous data gathering.

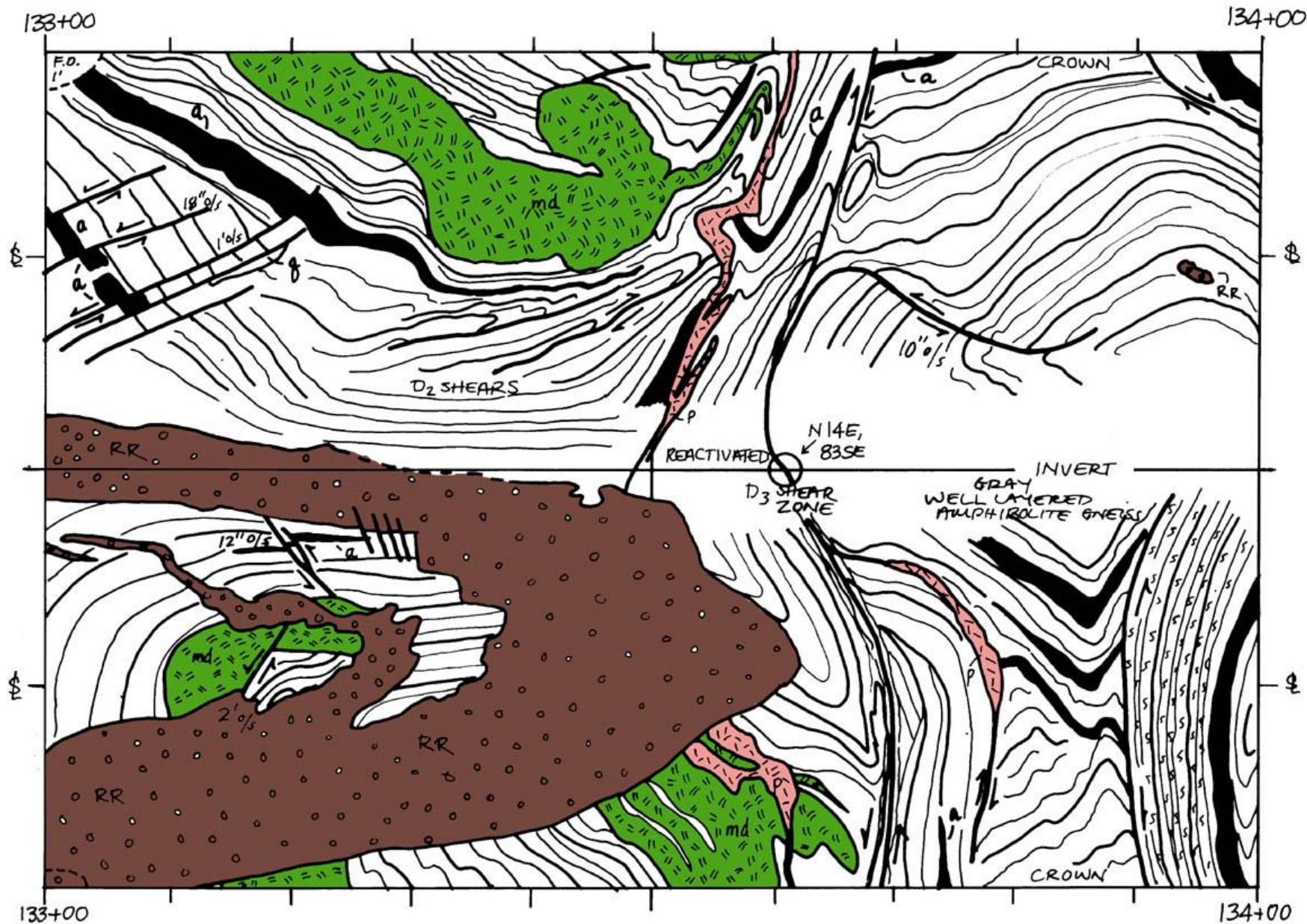
Robbins	TBM	235-282	Queens													
File	opened	on	Thu	4/1/1999	0:00:04											
DATE	TIME	SPARE	STROK	FT/HR	VOLTS	SPARE	AMPS	TONS	BORNG	L.SID	R.SID	PGRIP	M1_M10S1			
4/1/1999	2:09:10	0	36.2	0	488	701	36	643	1	-3.8	-1.4	1	7			
4/1/1999	2:09:40	0	36.4	1.3	490	701	54	1026	1	-3.8	-1.4	1	7			
4/1/1999	2:10:10	0	36.5	1.3	488	698	85	1419	1	-3.8	-1.4	1	7			
4/1/1999	2:10:40	0	37	3.6	485	695	151	1511	1	-3.8	-1.4	1	7			
4/1/1999	2:11:10	0	37.4	5.2	483	695	151	1511	1	-3.8	-1.4	1	7			
4/1/1999	2:11:40	0	38.1	5.9	480	695	151	1511	1	-3.8	-1.4	1	7			
4/1/1999	2:12:10	0	38.8	8.2	481	695	151	1511	1	-3.8	-1.4	1	7			
4/1/1999	2:12:40	0	39.7	7.5	478	695	151	1511	1	-3.8	-1.4	1	7			
4/1/1999	2:13:10	0	40.5	8.2	480	695	151	1511	1	-3.8	-1.4	1	7			

Data logger recorded the TBM data every 30 seconds





# Dike 4





# Short Stand-up Times



# Major Lithologic Contrast



# Lava Flows in Woodside?



**Download NYC Geology Publications @**  
**[www.hofstra.edu](http://www.hofstra.edu)**  
**[www.dukelabs.com](http://www.dukelabs.com)**

**What's That  
Noise?**

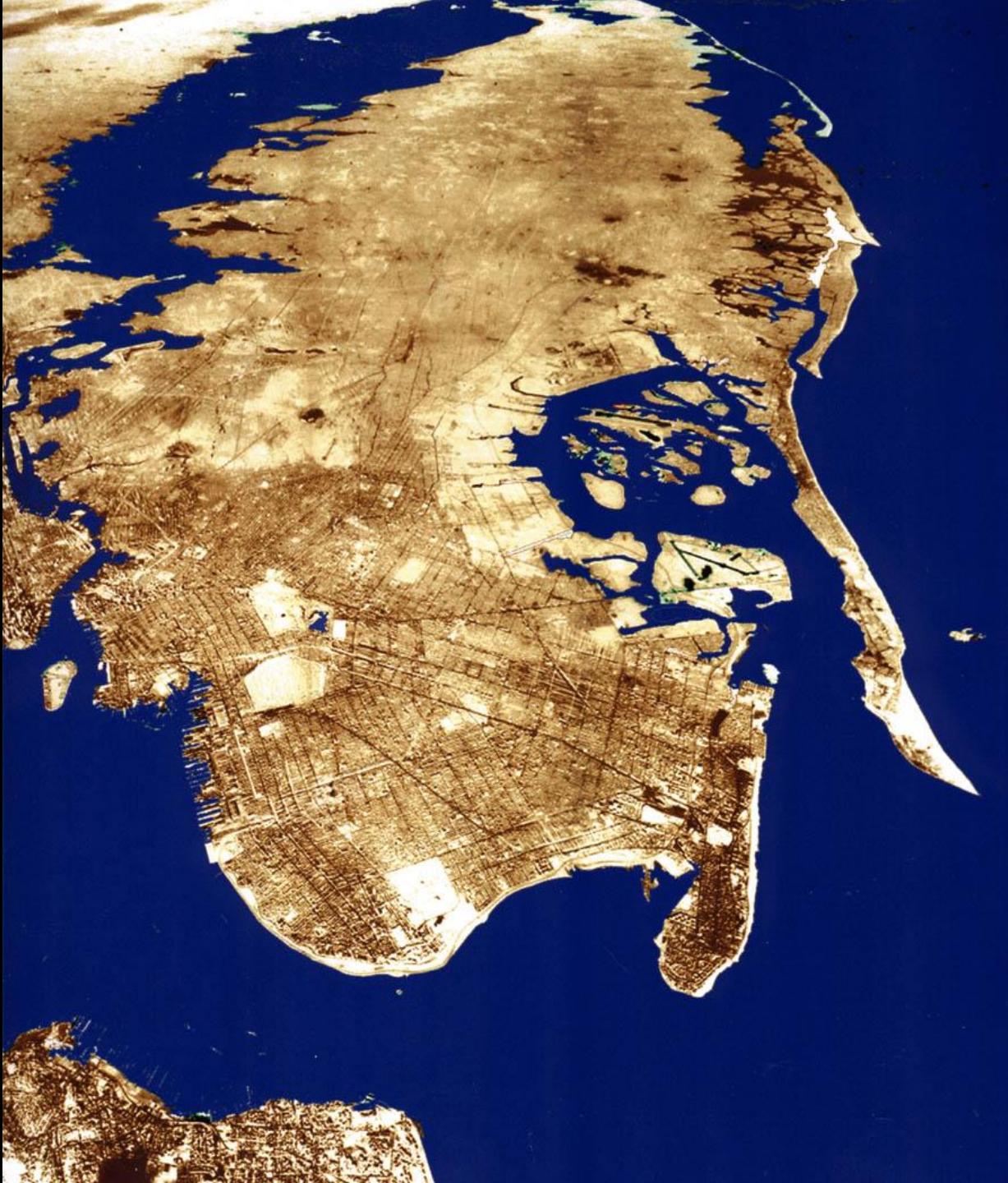




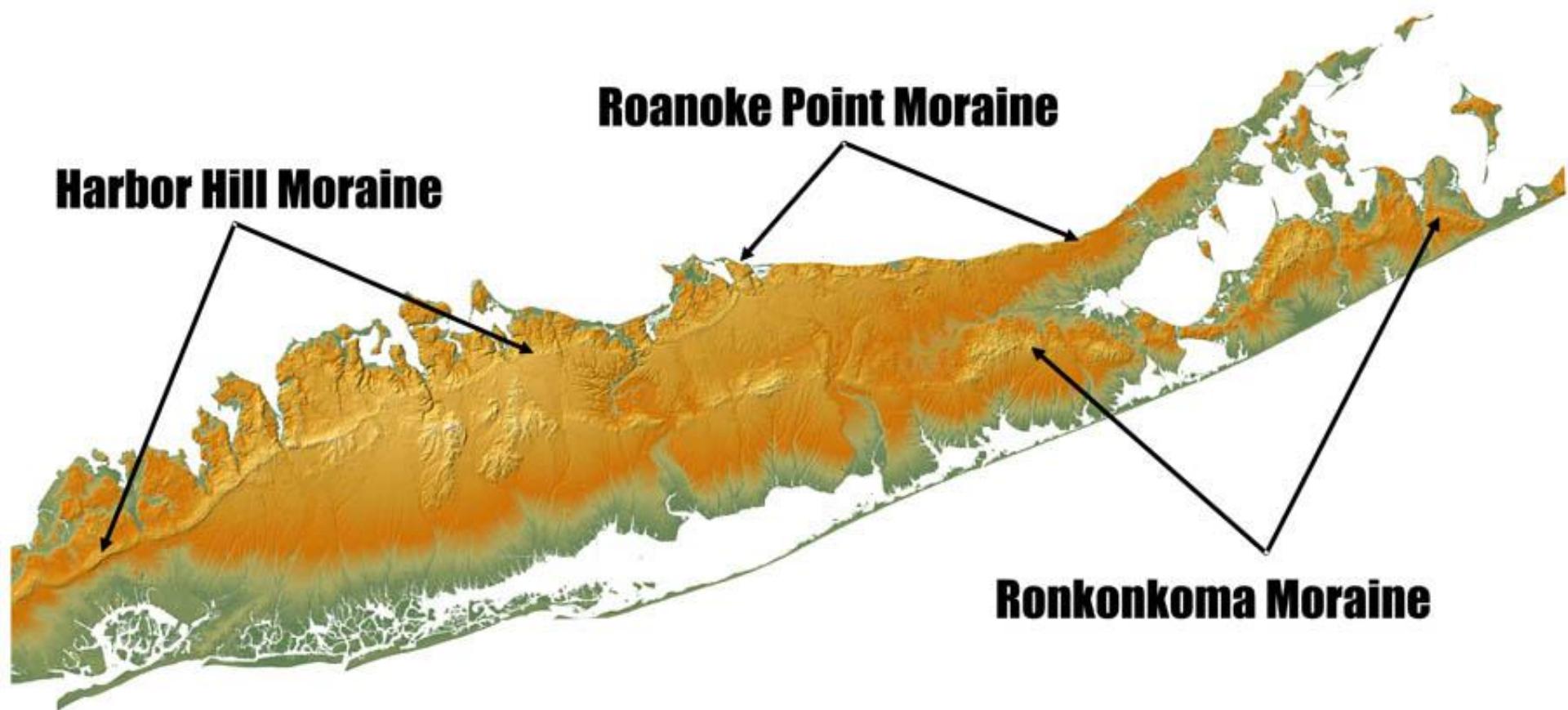


# **Lon Gisland**

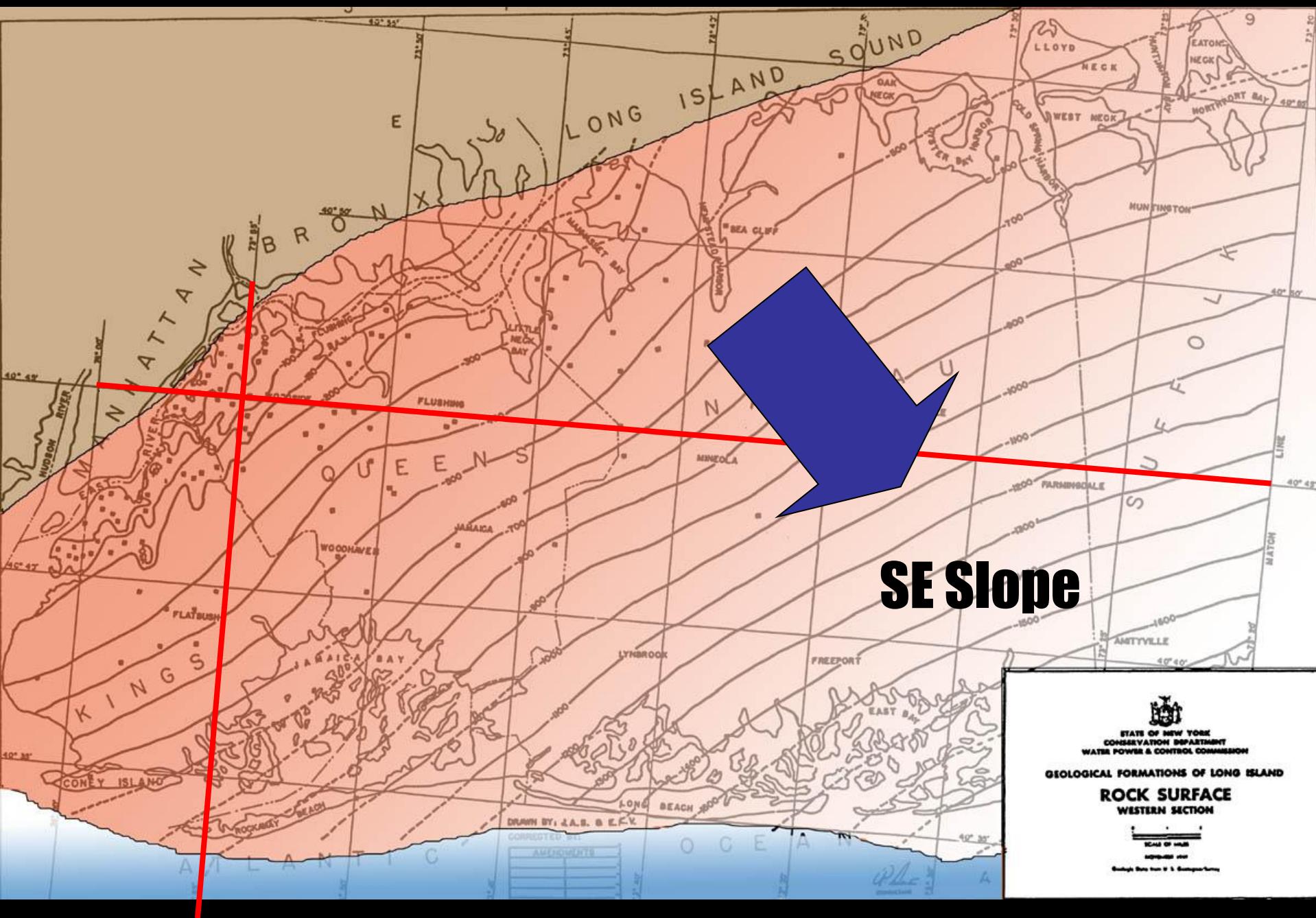
**Proper Spelling  
and  
Pronunciation**

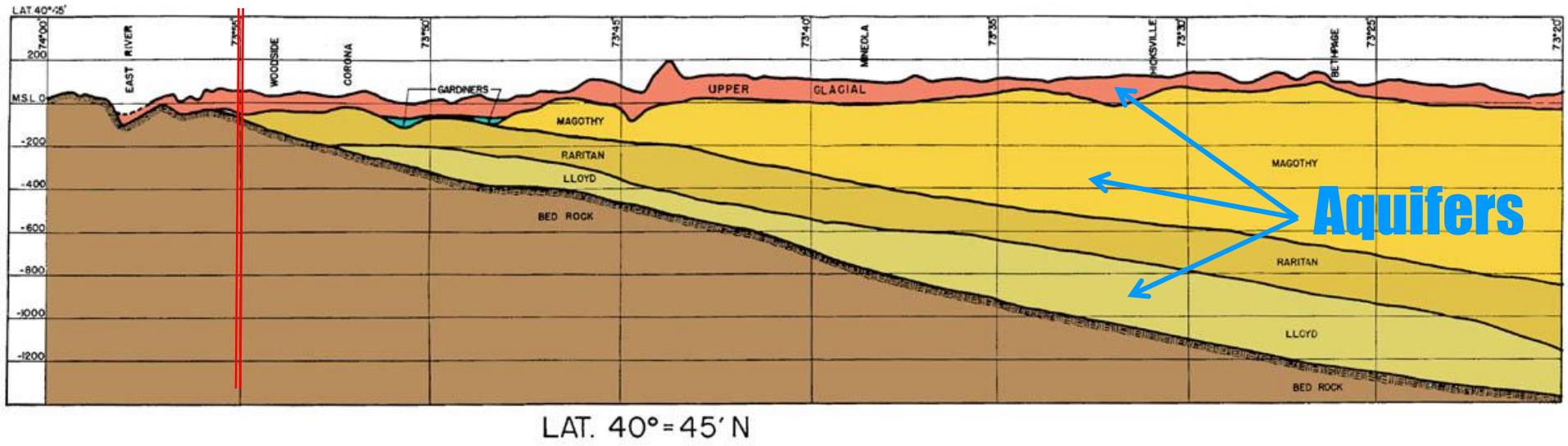


# Long Island's Glacial Moraines

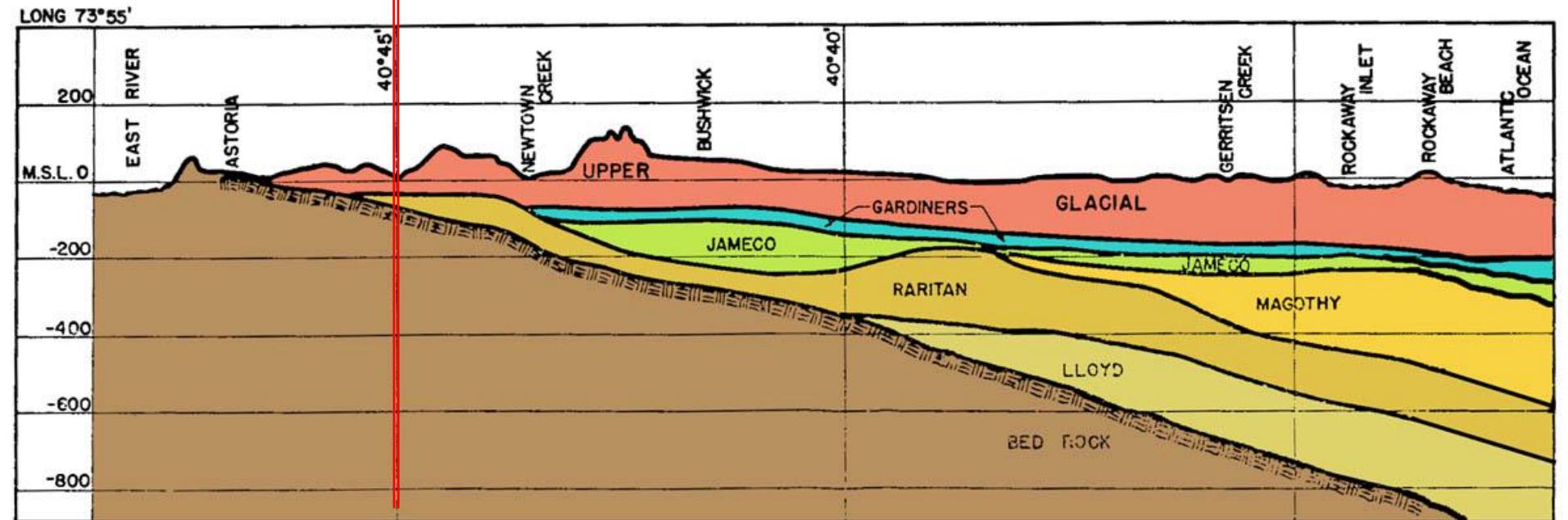


after Bennington, 2003





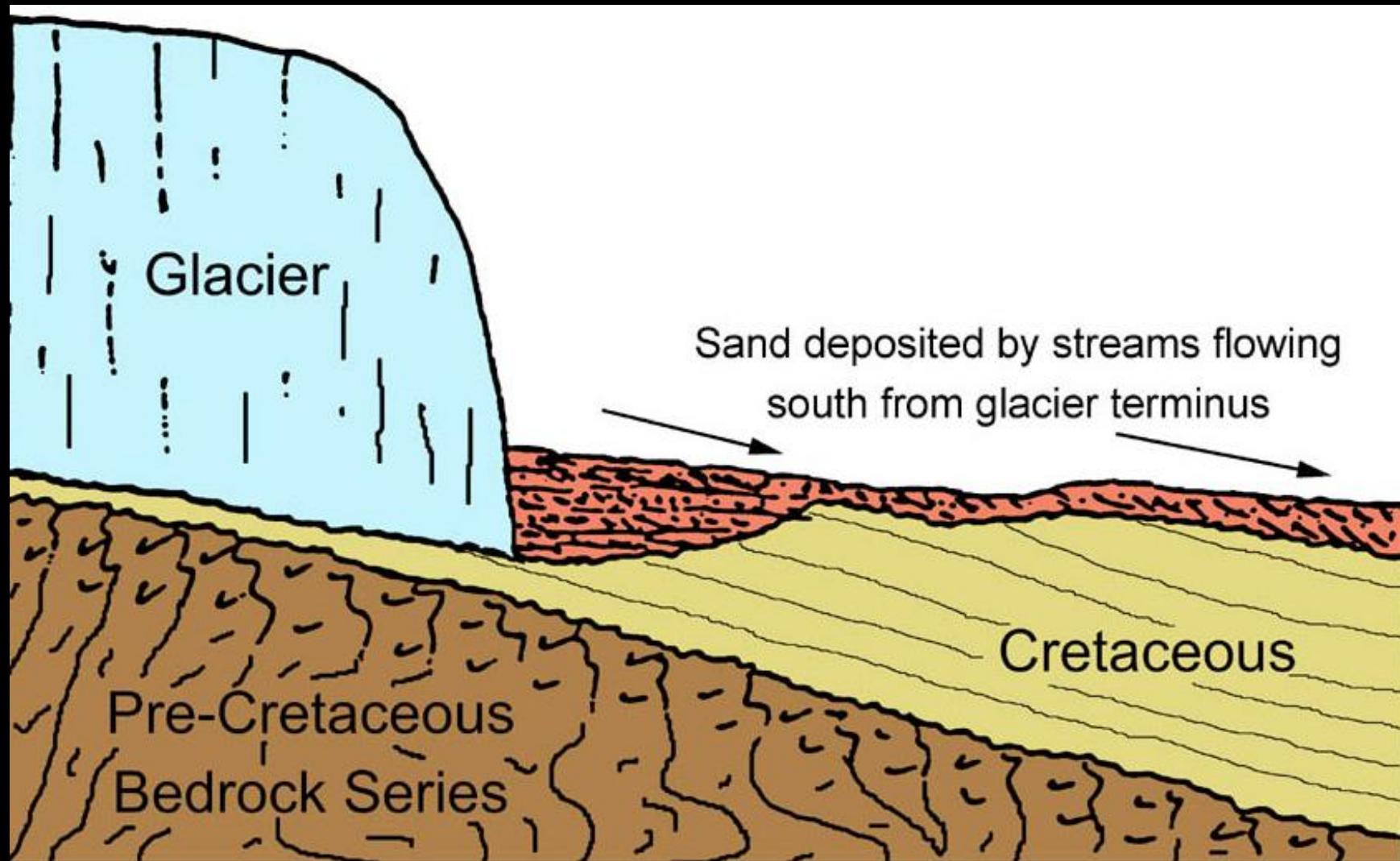
LAT. 40° = 45' N



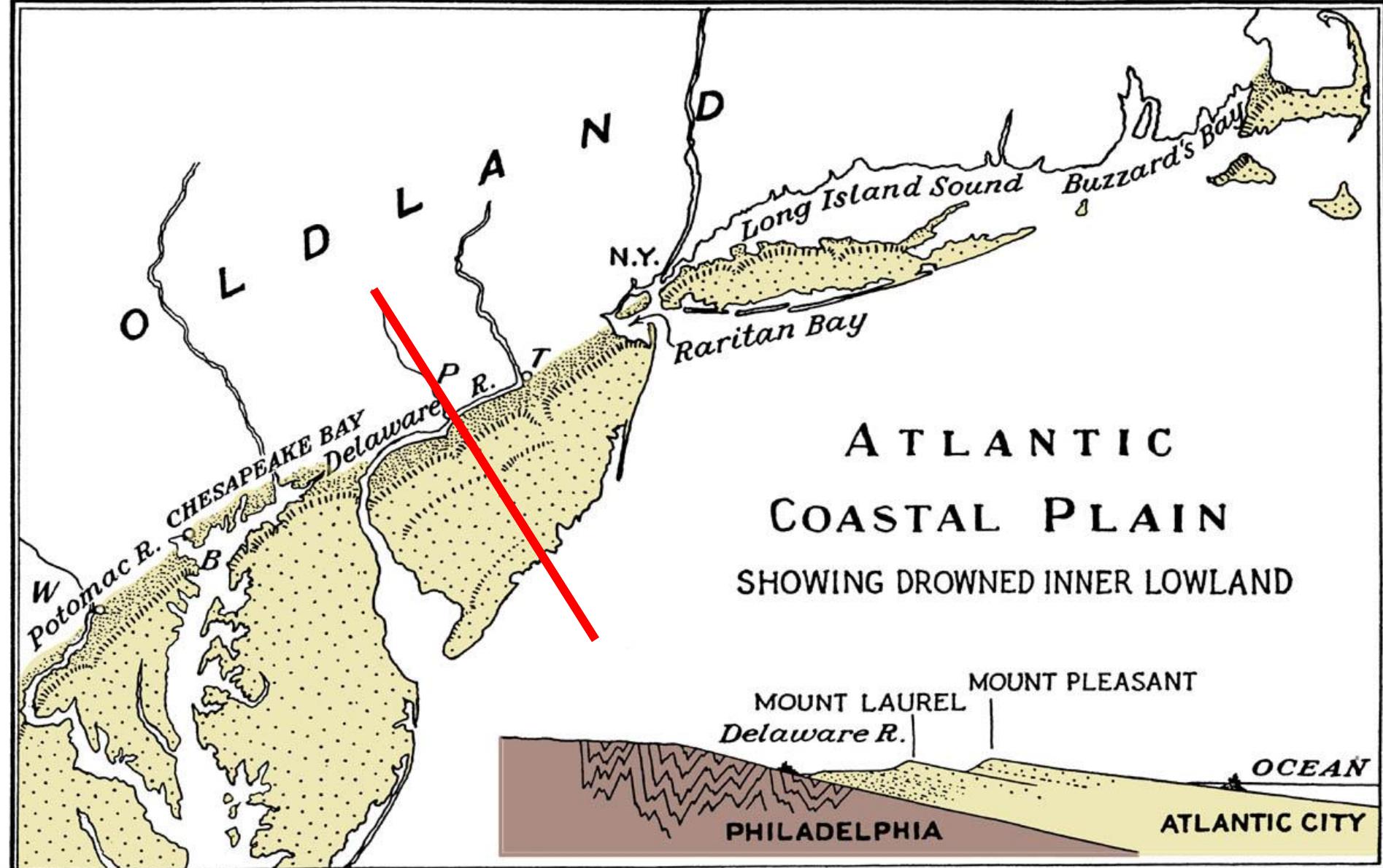
LONG. 73° = 55' W

Suter et al, 1949

# Long Island Outwash Fans



after Merguerian and Sanders 1993



# Cretaceous Coastal Plain



# Pleistocene Glaciation

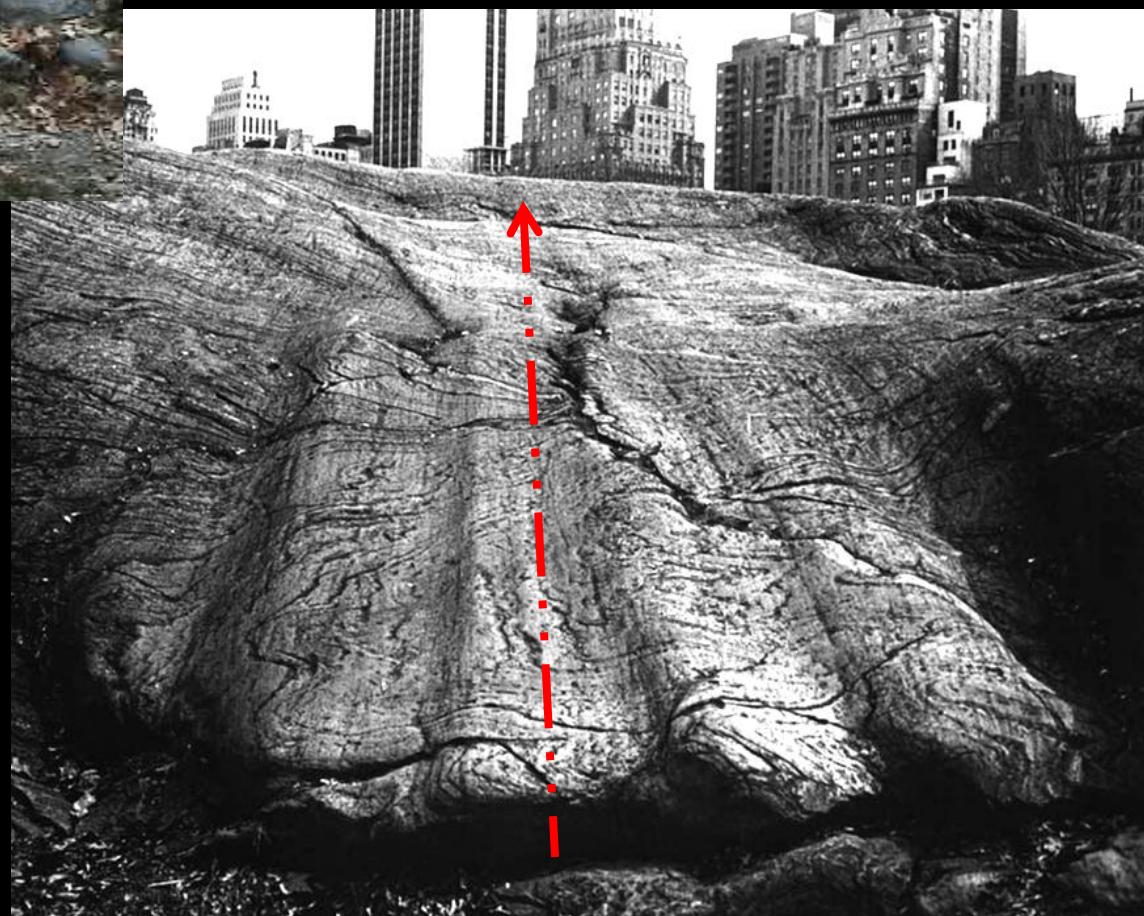




**SE-Directed Glacial Striae, Central Park, NYC**

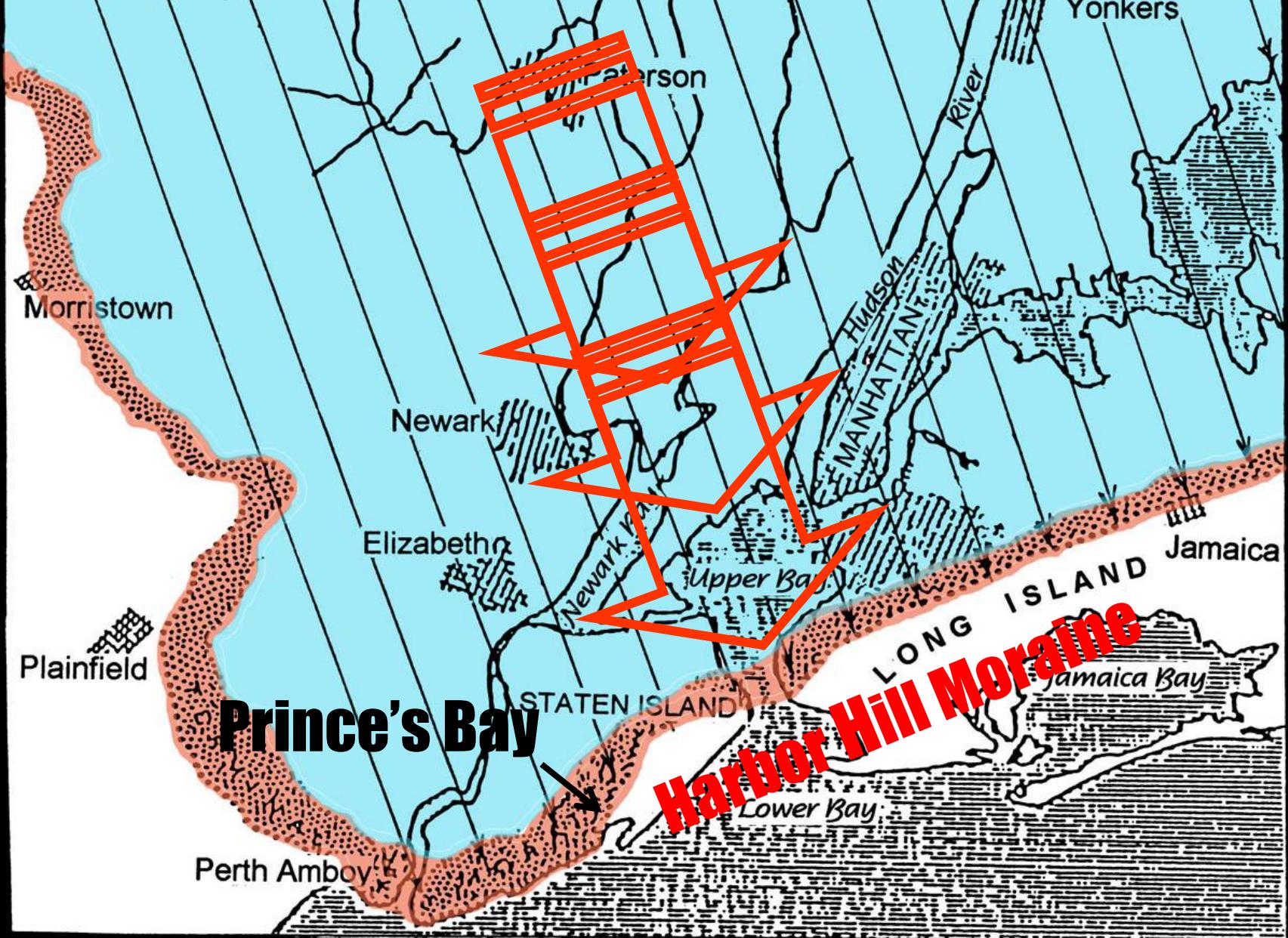


# SE Glacial Grooves Central Park, NYC



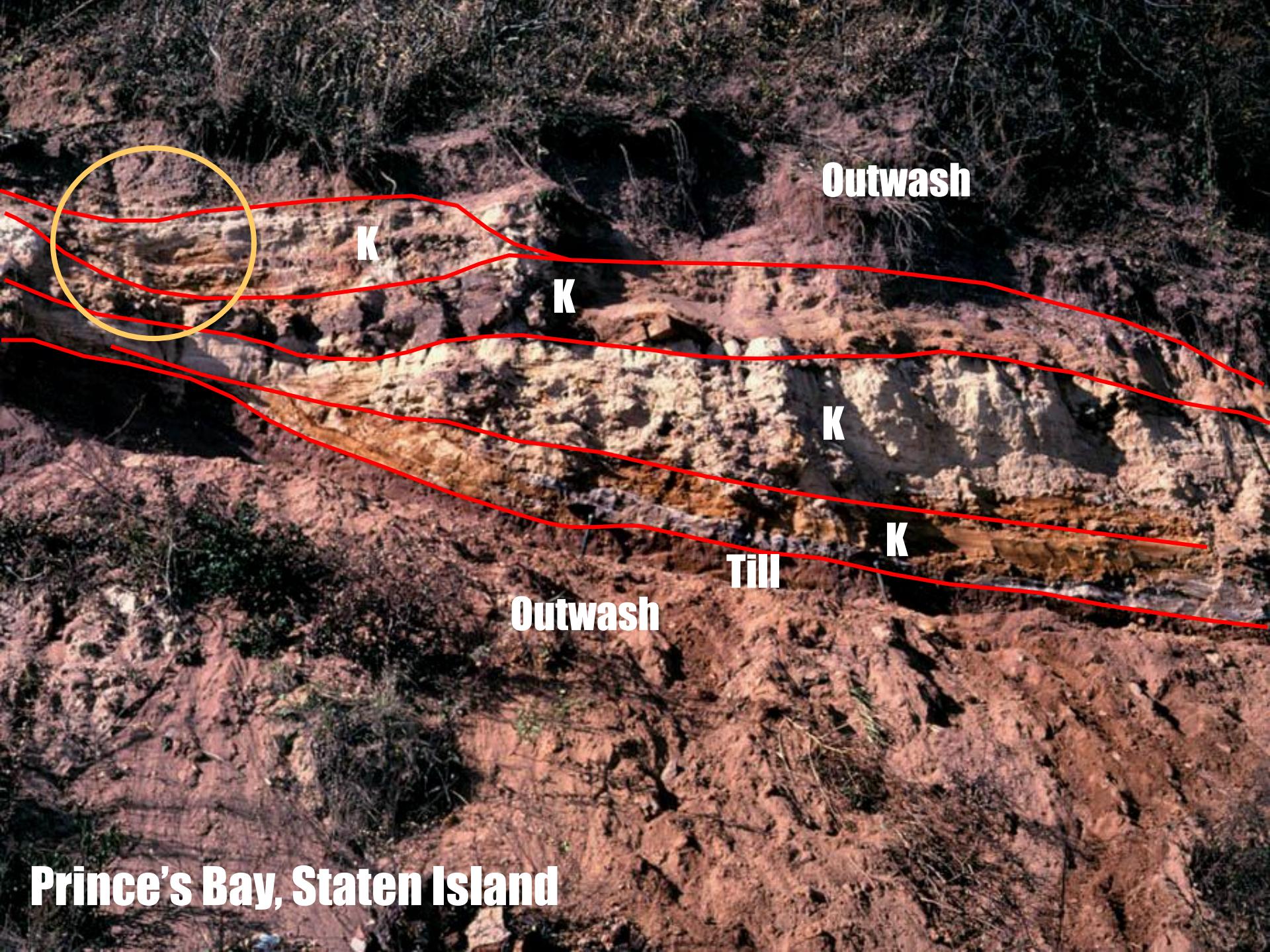
N343

# The Big Kahuna Glacial Event





**Prince's Bay, Staten Island**



Prince's Bay, Staten Island

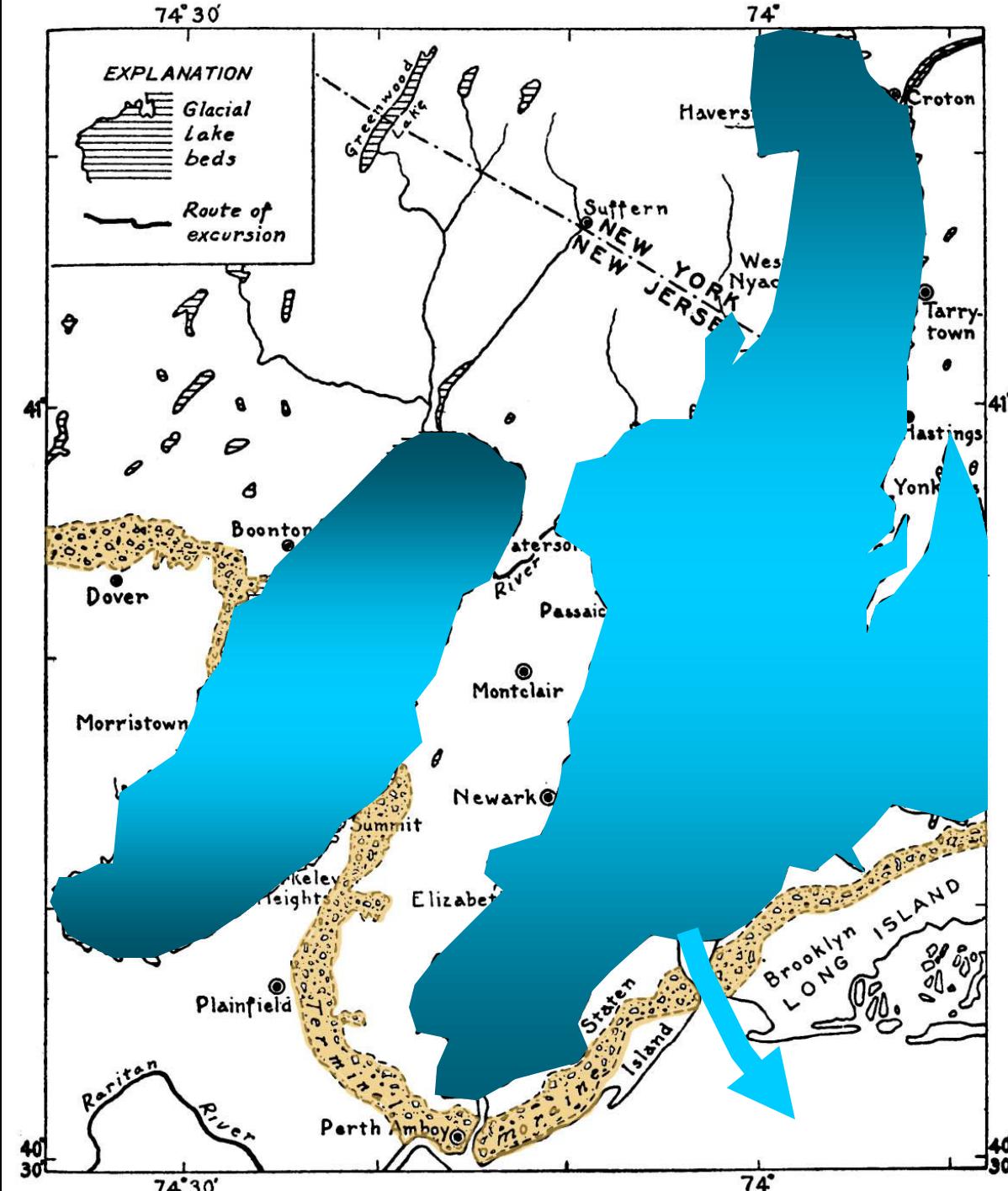


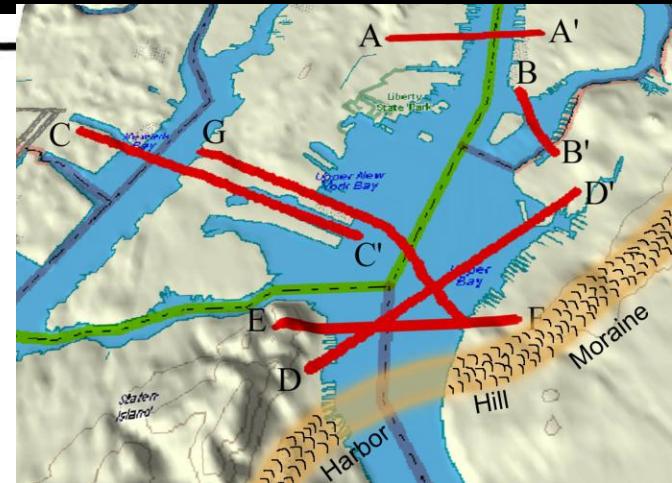
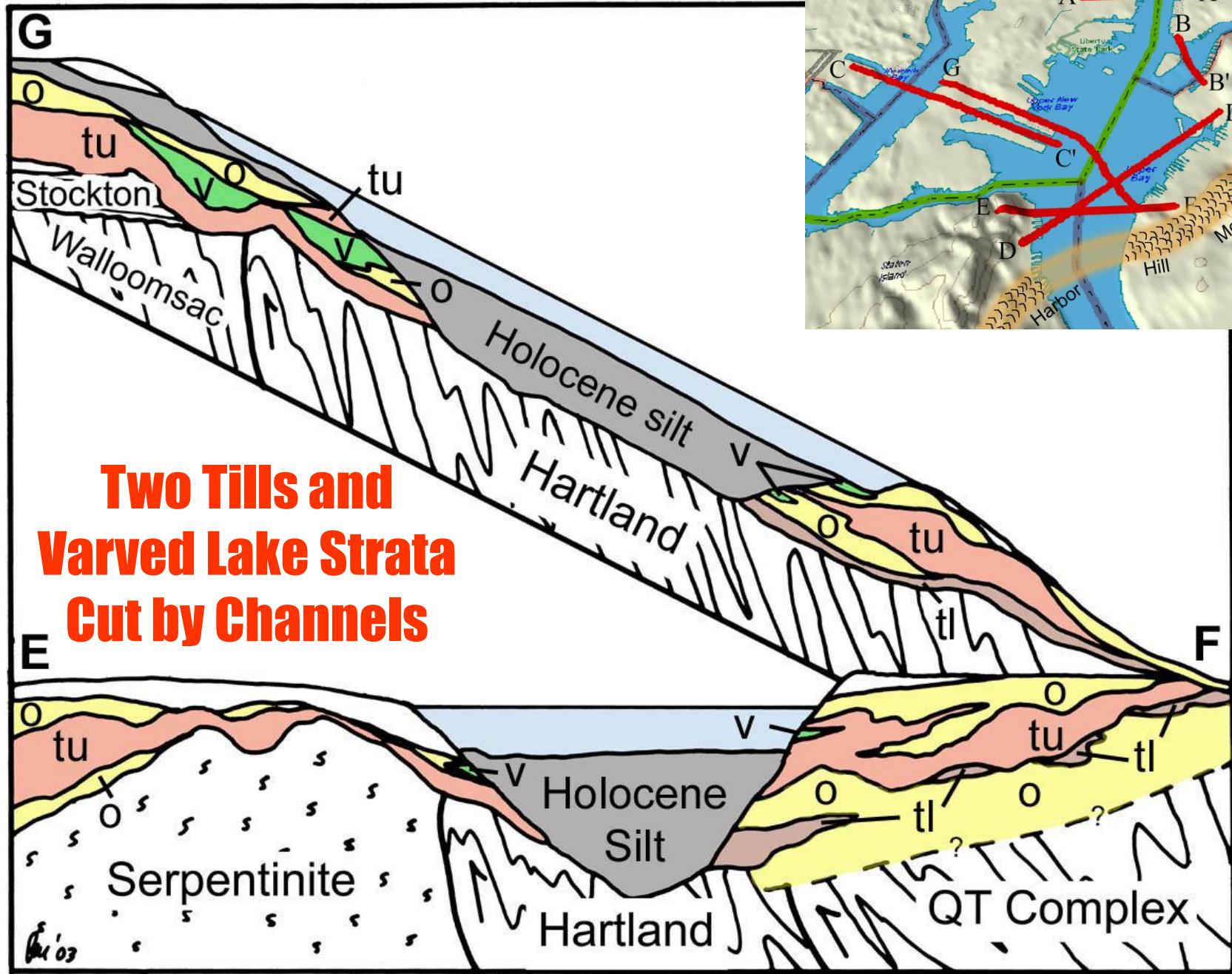
**Plunge 17° into S60°W  
AP = N4°E, 20°NW**

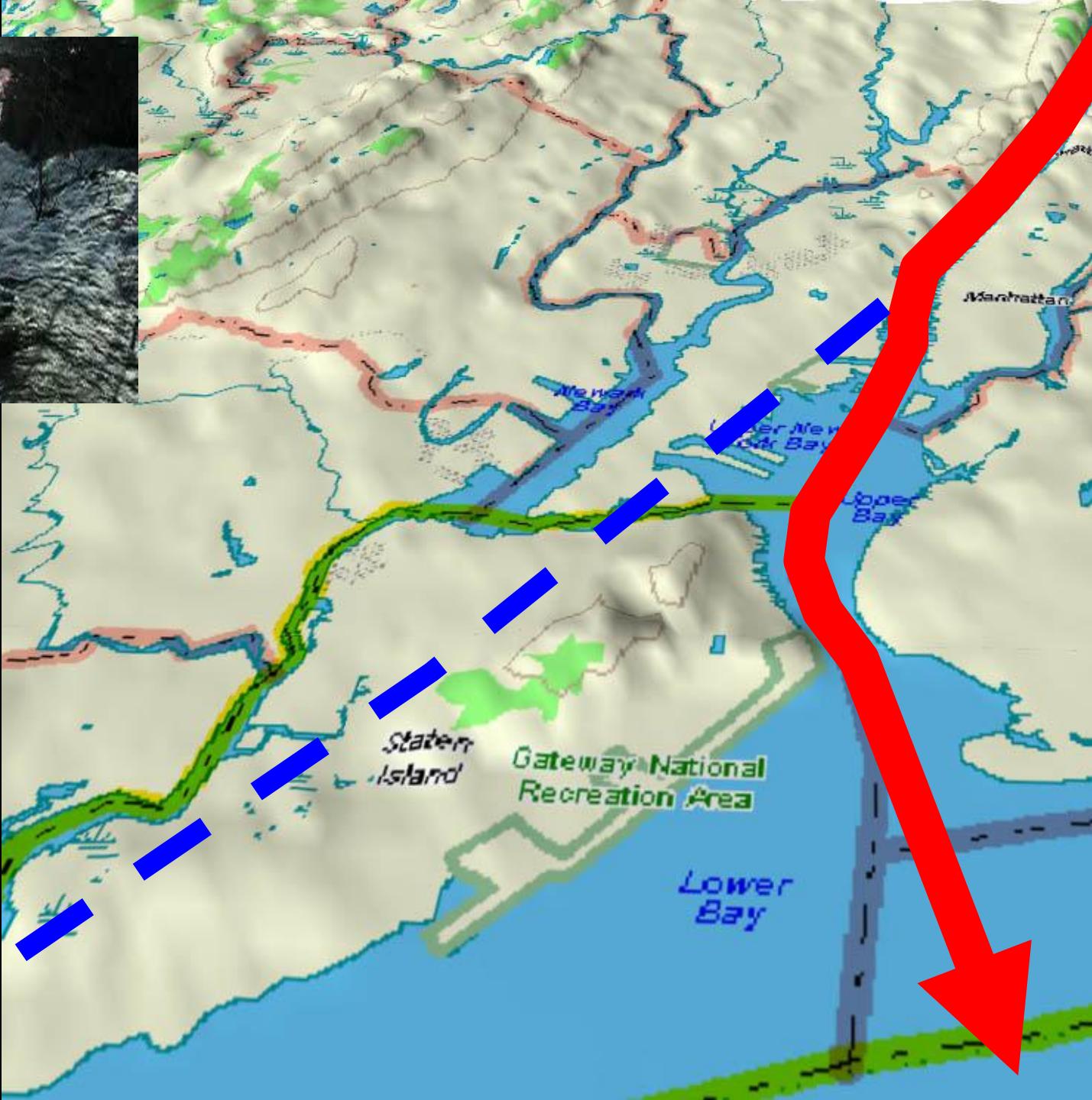
# Glacial Lake Strata and the Harbor Hill Moraine

Post-  
Woodfordian  
Drainage  
Through  
The Narrows

Berkey (1933)







Hudson  
Abandons  
Former  
Channels –  
Floods  
Through  
Narrows