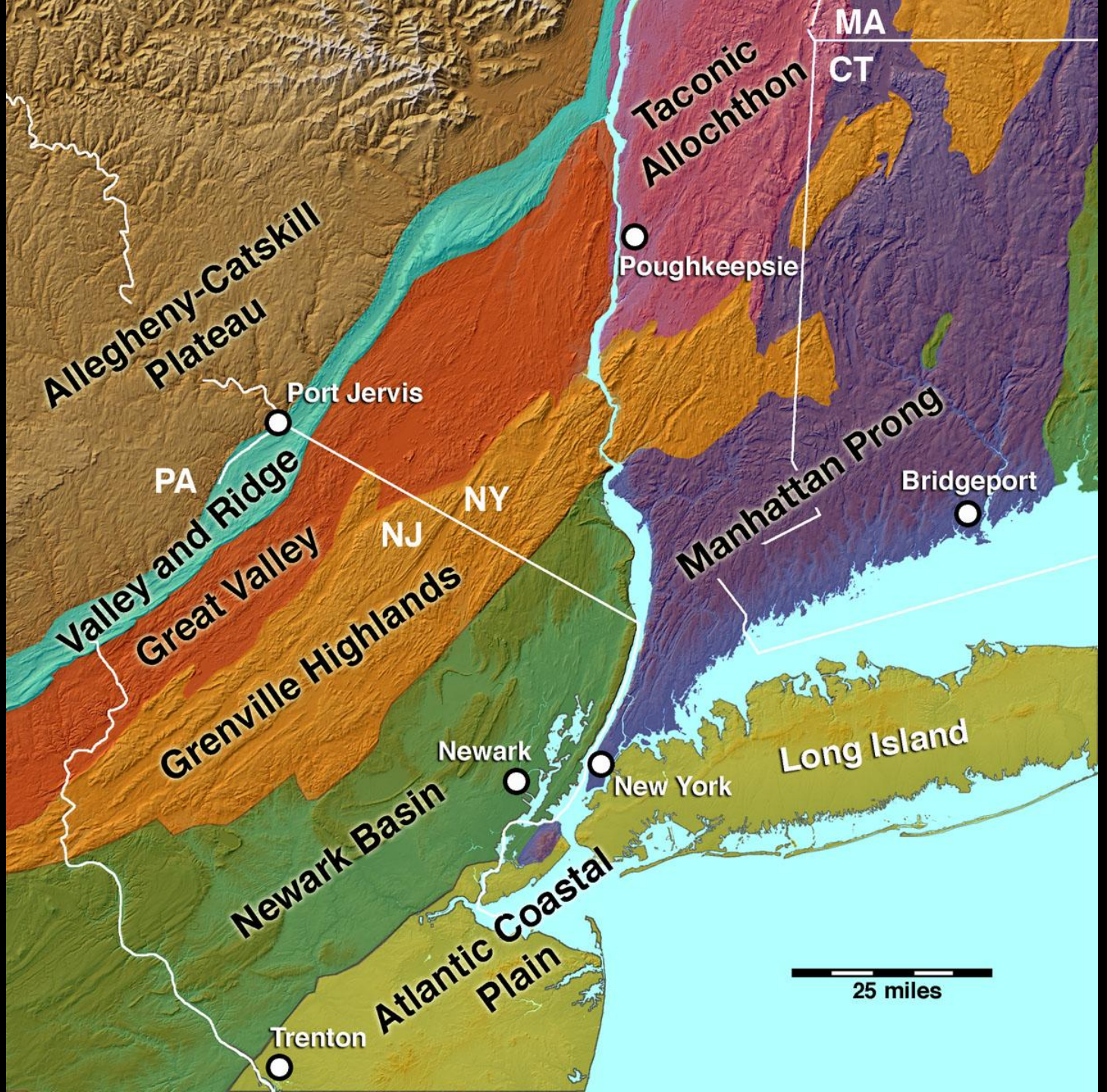
New York Mineralogical Club

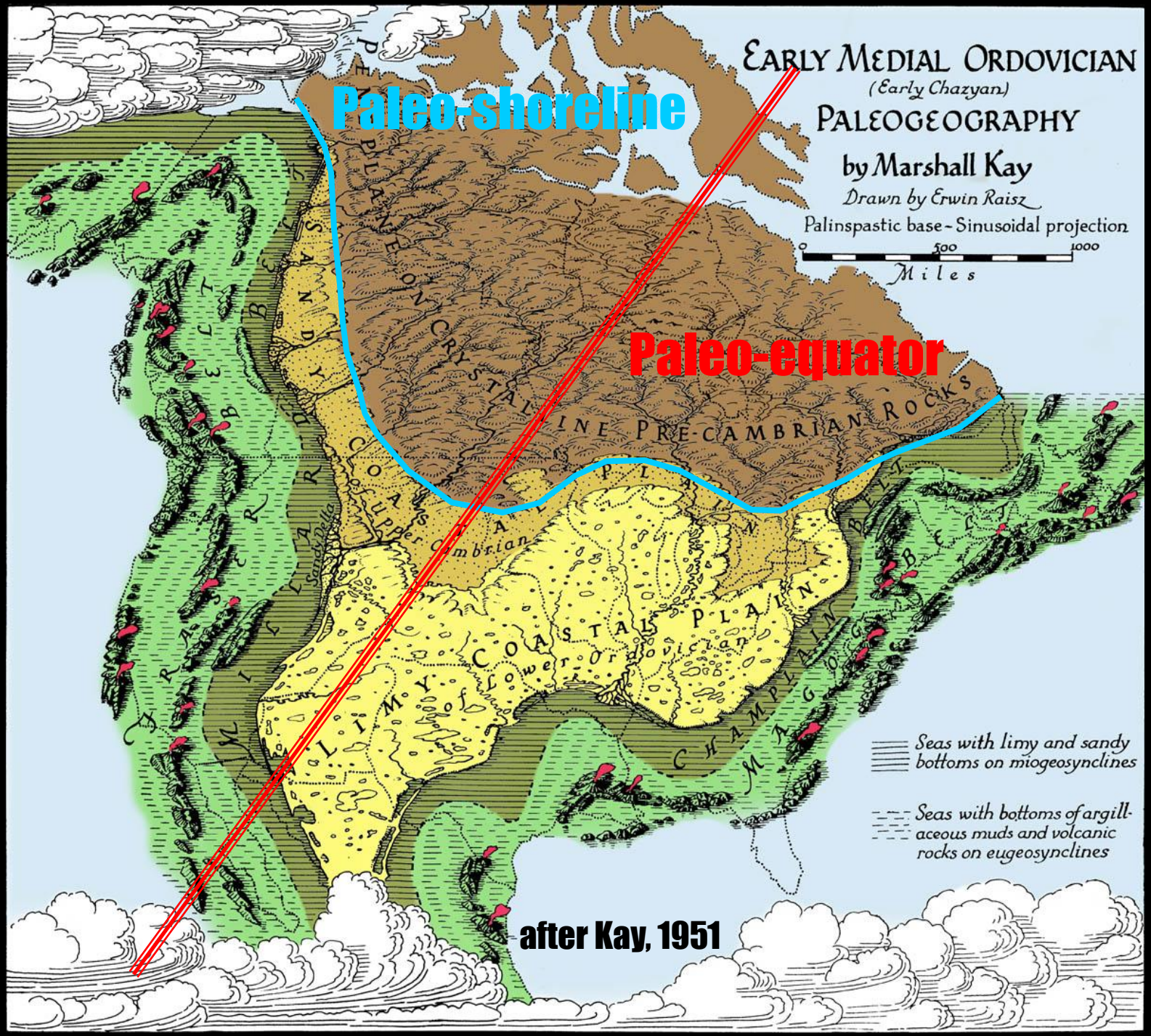
Geology and Megaconstruction Projects, New York City, NY

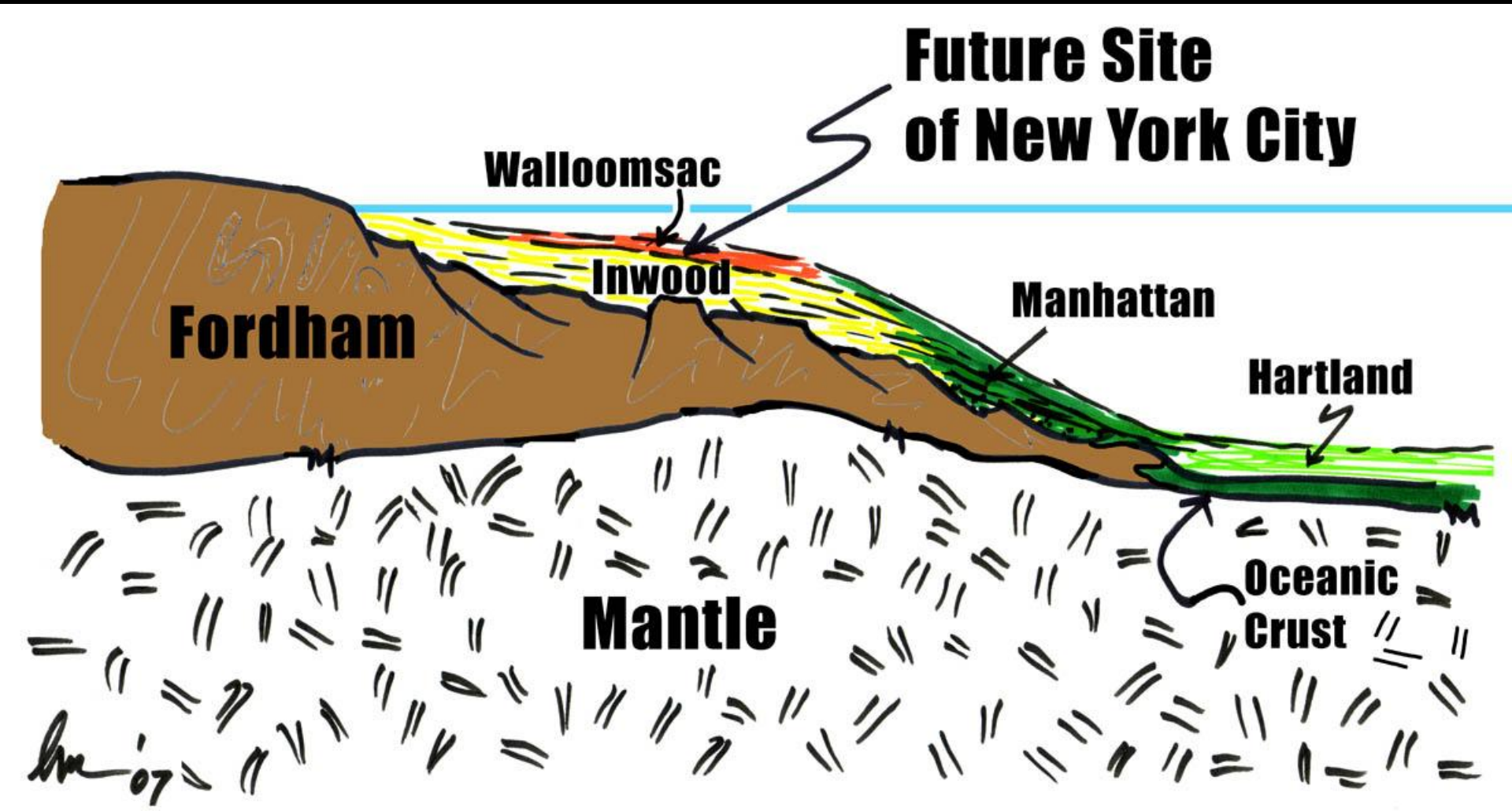
Charles Merguerian

07 Mar 2009

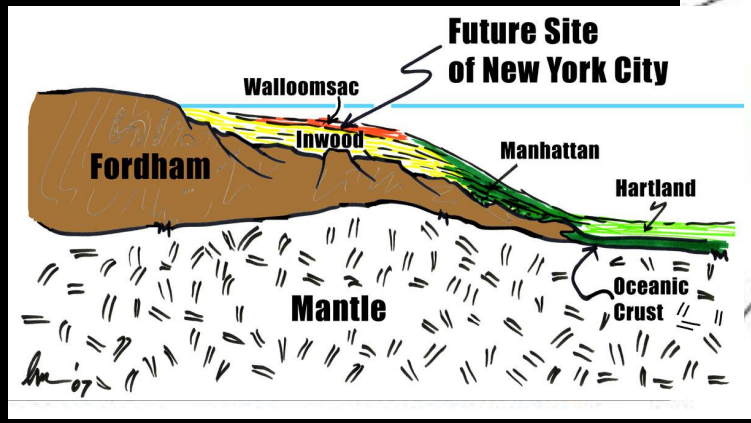

MA
CT
Taconic Allochthon
Poughkeepsie
Allegheny-Catskill Plateau
Port Jervis
PA
NY
NJ
Valley and Ridge
Great Valley
Grenville Highlands
Manhattan Prong
Bridgeport
Newark
New York
Long Island
Newark Basin
Atlantic Coastal Plain
Trenton
25 miles

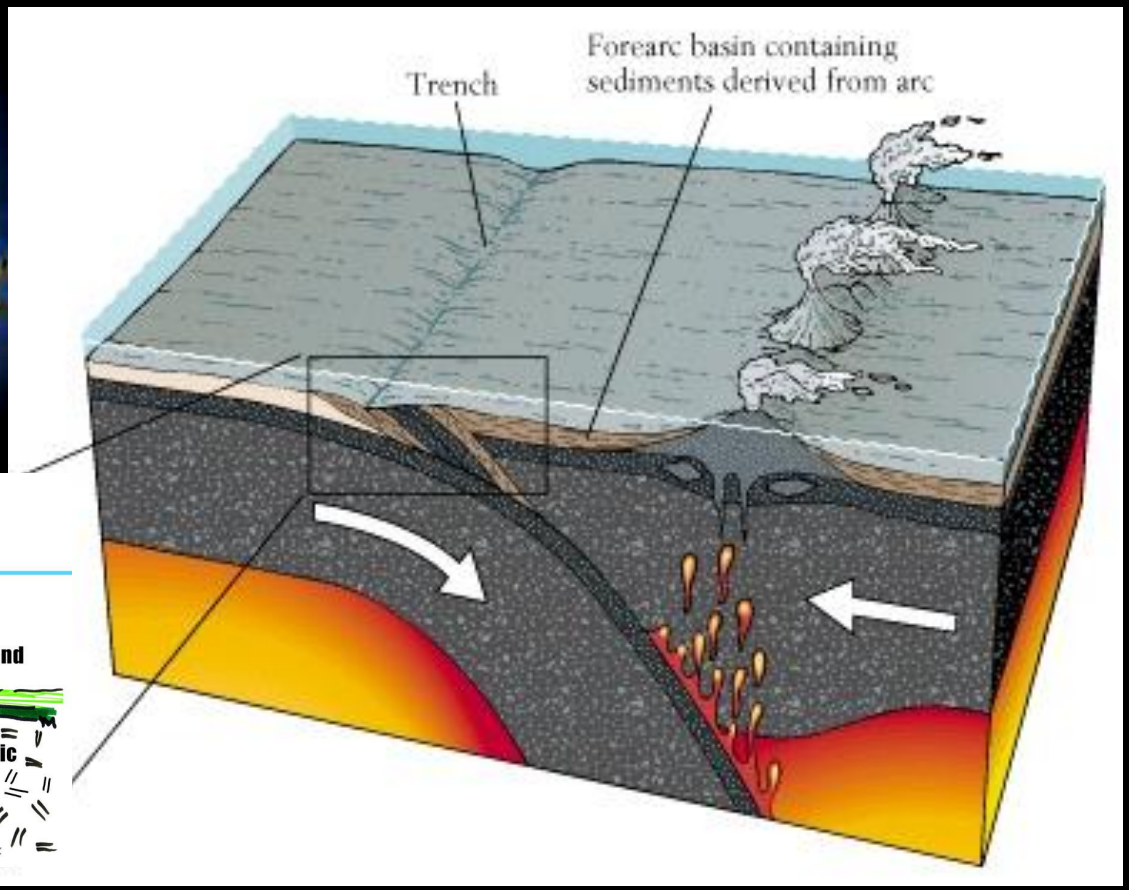
Let's Go Back In Time From Today to the Cambrian!

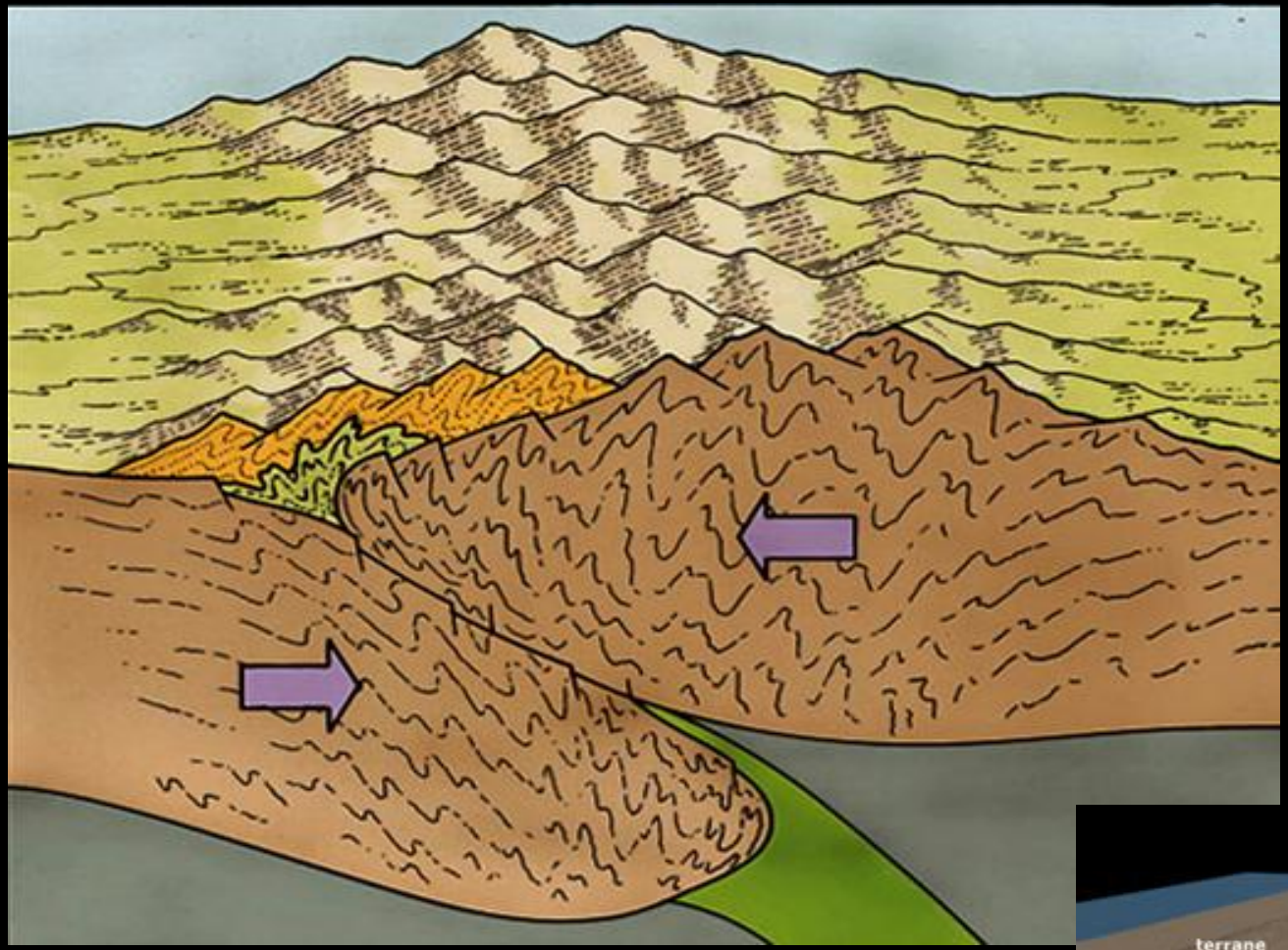

Paleo-shoreline
Paleo-equator
EARLY MEDIAL ORDOVICIAN
(Early Chazyan)
PALEOGEOGRAPHY
by Marshall Kay
Drawn by Erwin Raisz
Palinspastic base - Sinusoidal projection
500
1000
Miles
PENEPLANED CRYSTALLINE PRE-CAMBRIAN ROCKS
SANDY COASTAL PLAIN of Upper Cambrian
LIMY COASTAL PLAIN of Lower Ordovician
CHAMPLAIN MAGEOGEOSYNCLINE
APPALACHIAN GEOSYNCLINE
Seas with limy and sandy bottoms on miogeosynclines
Seas with bottoms of argillaceous muds and volcanic rocks on eugeosynclines
after Kay, 1951

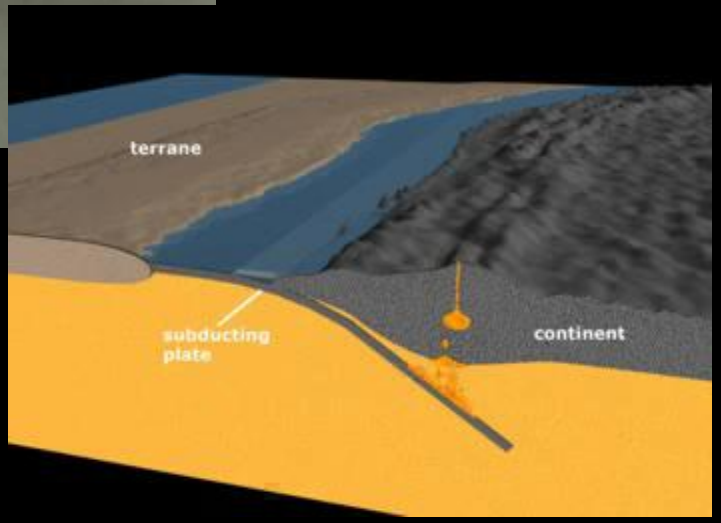

Future Site
of New York City
Walloomsac
Inwood
Fordham
Manhattan
Hartland
Oceanic
Crust
Mantle
'07

~ 450 Ma Taconic Arc – Passive Margin Collision







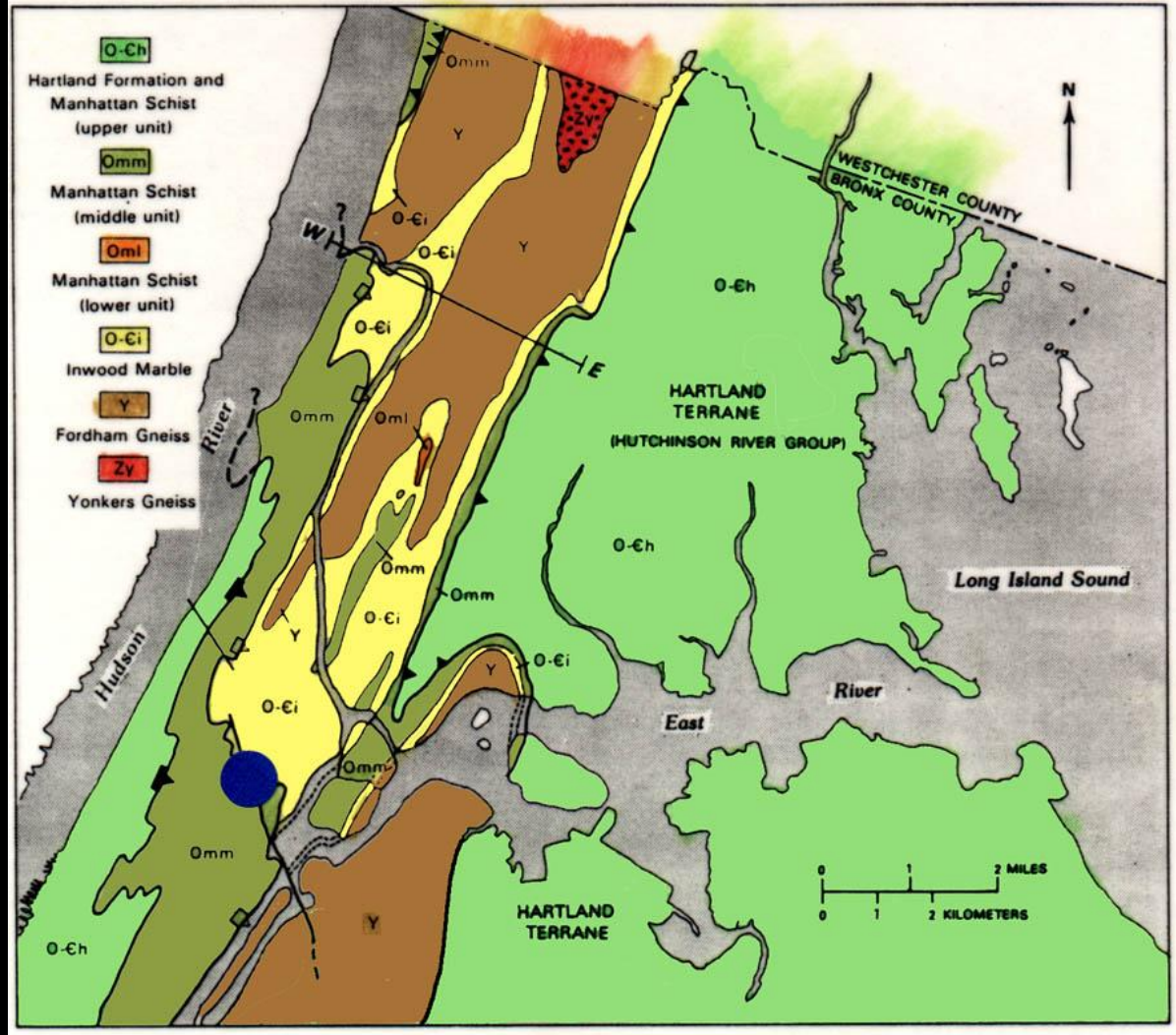


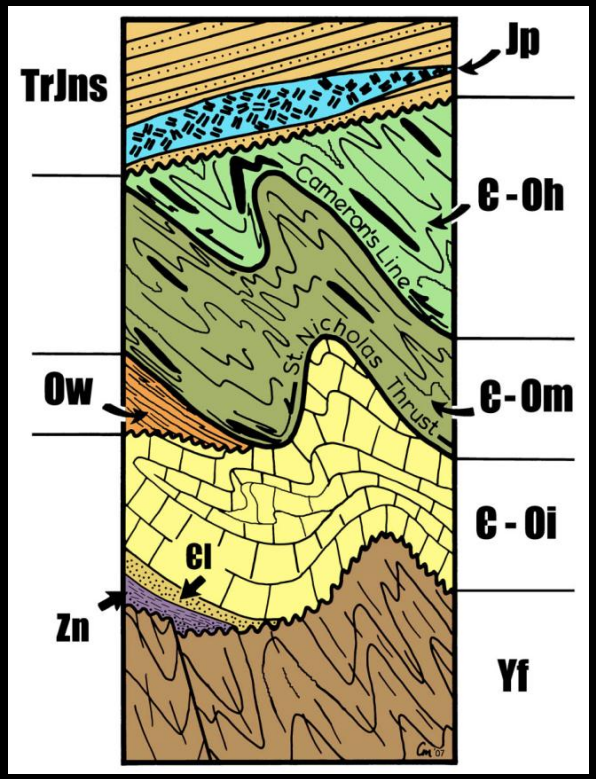
450 Ma to 250 Ma Protracted Plate Collisions Form the Appalachians

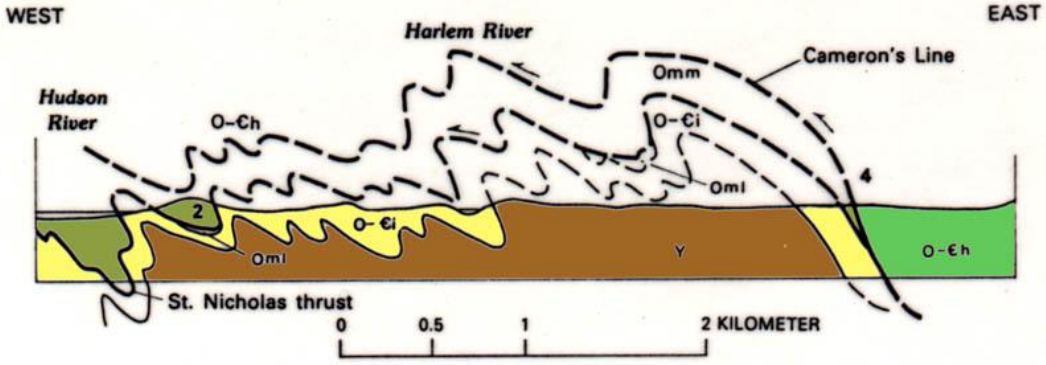
Merguerian's Early Field Work on Manhattan Island

In The Days When He Was Limber

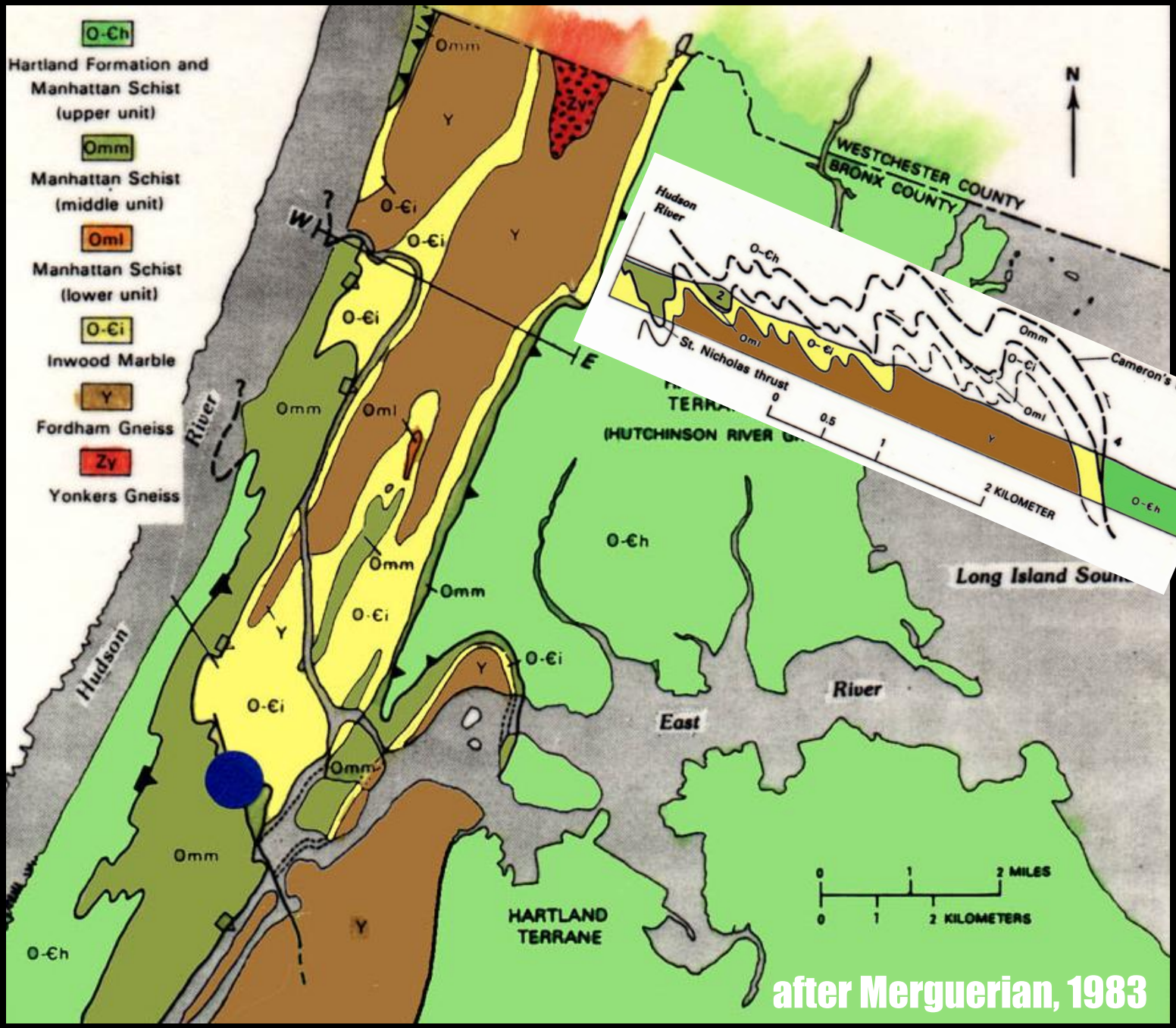
New York City





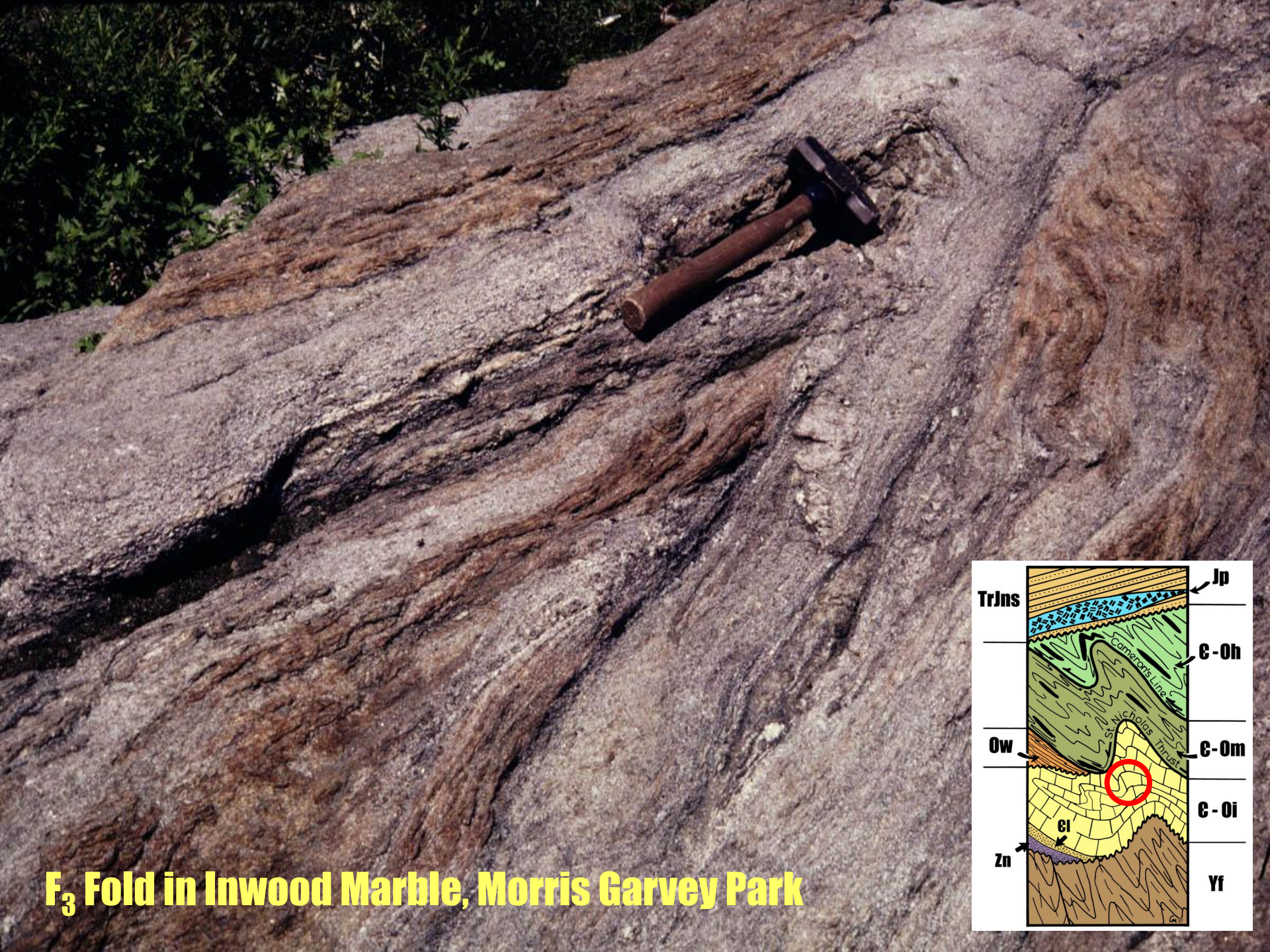


Merguerian, 2001


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
TERRANE
(HUTCHINSON RIVER
Long Island Sound
River
East
HARTLAND TERRANE
0 1 2 MILES
0 1 2 KILOMETERS
after Merguerian, 1983

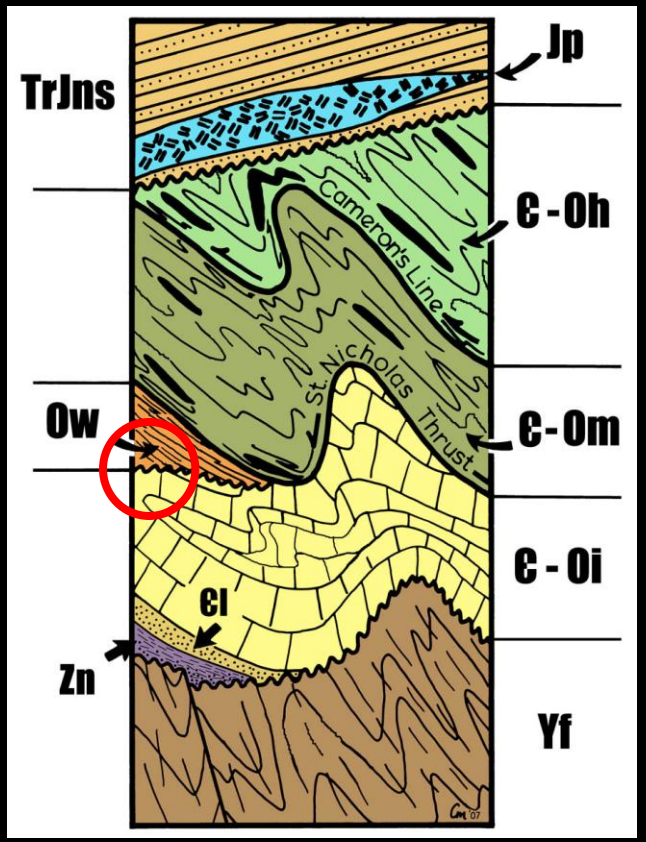

Fordham Gneiss, Echo Park

TrJns
Jp
Cameron's Line
St. Nicholas Thrust
Ow
Zn
Yf

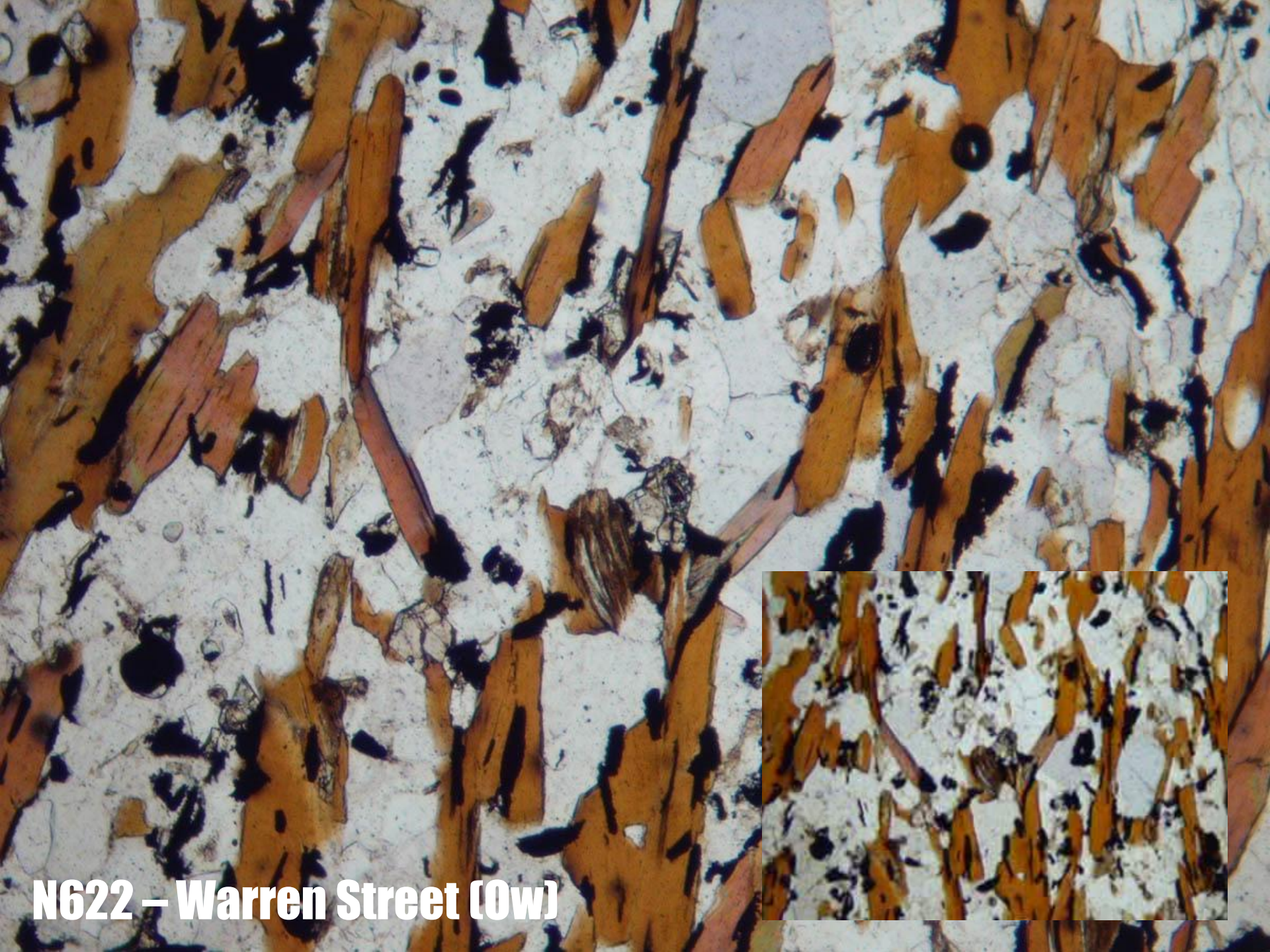


F_3 Fold in Inwood Marble, Morris Garvey Park

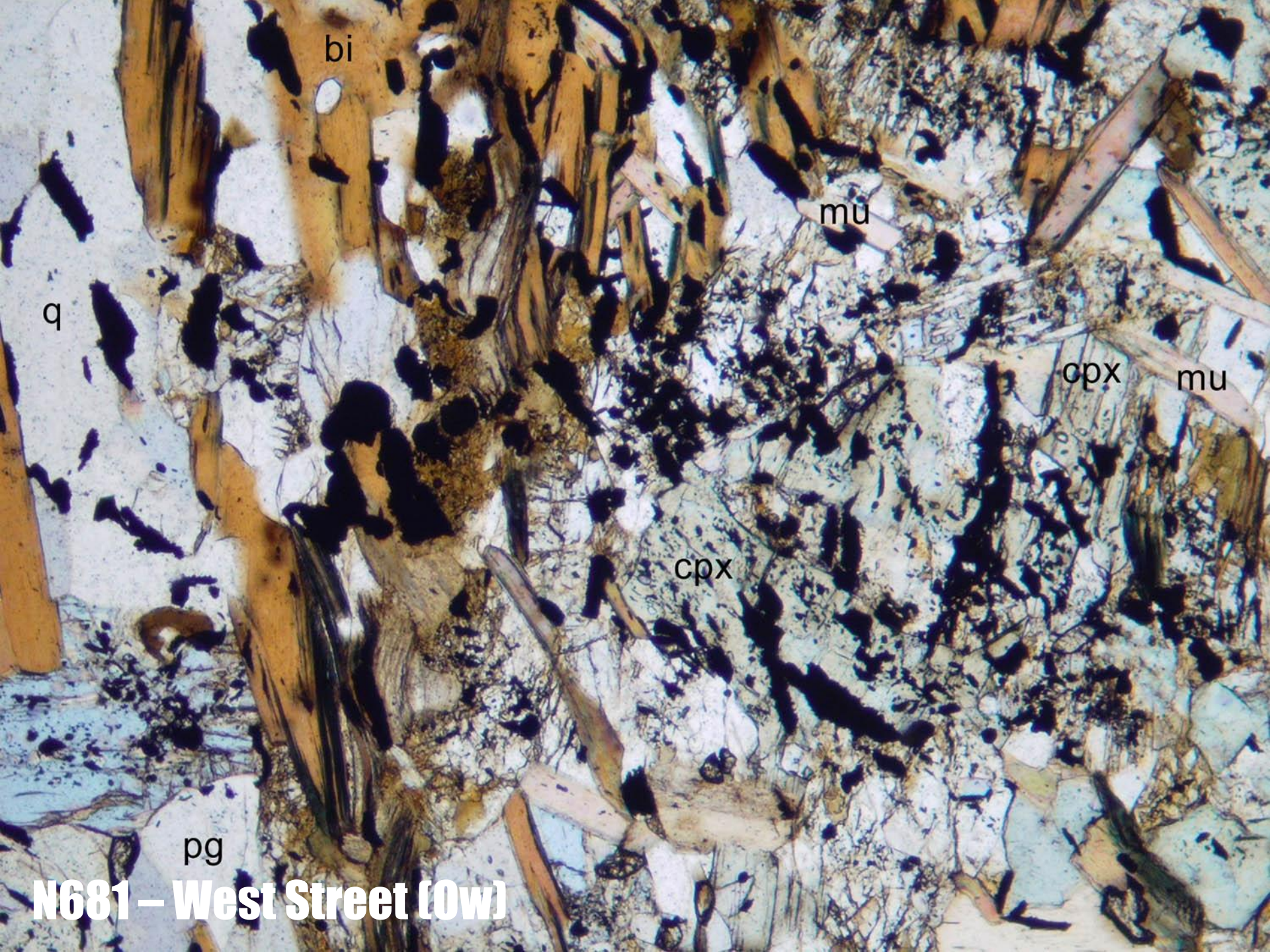
N631 – Warren Street (Ow)



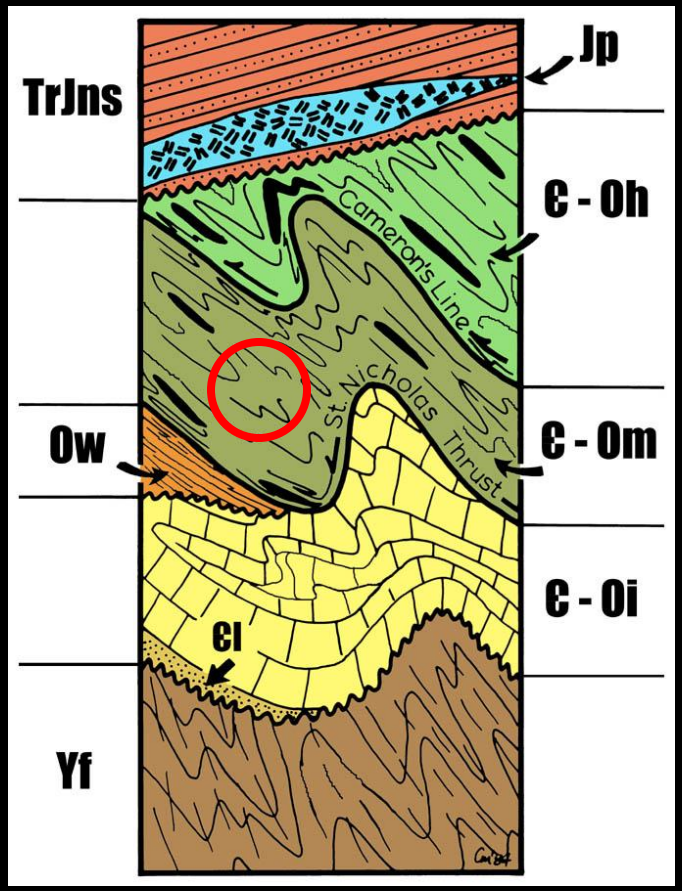
Walloomsac "Balmville" Contact, Grand Concourse, Bronx, NY



N622 – Warren Street (Ow)

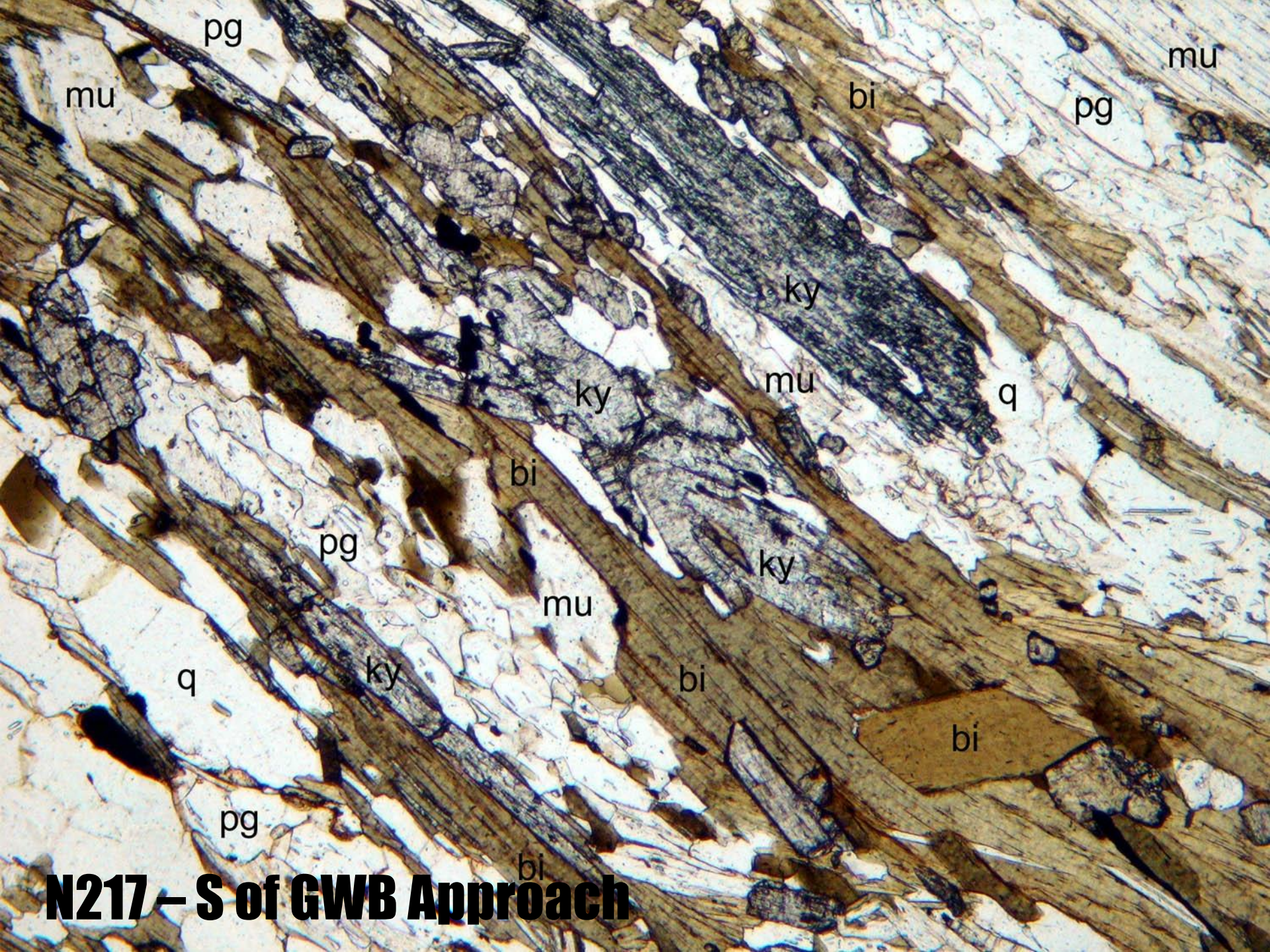


N681 – West Street (Ow)



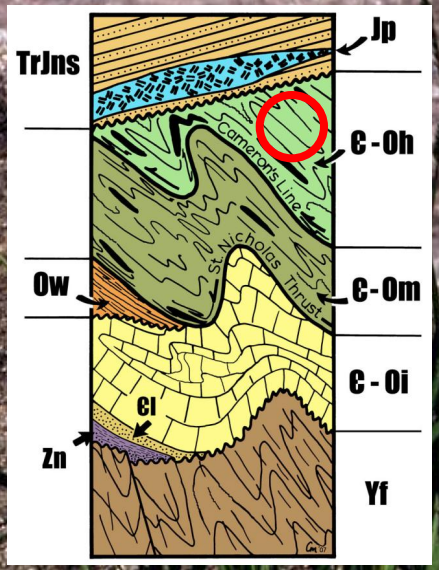
Manhattan Schist
F_3 Folds of S_2
Central Park, NYC

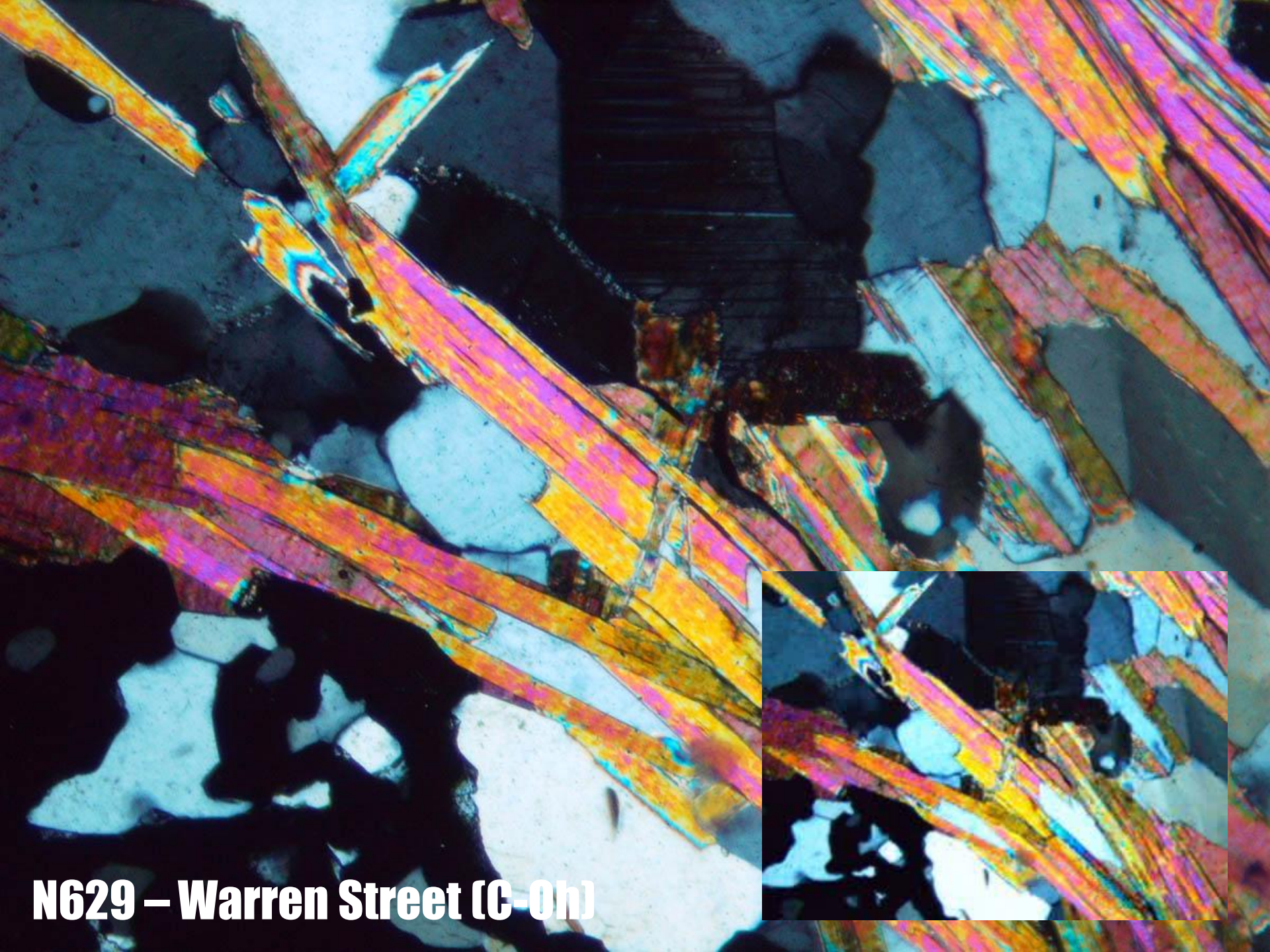

Manhattan Schist, Central Park
TrJns
Jp
Cameron's Line
St. Nicholas Thrust
Ow
Zn
Yf

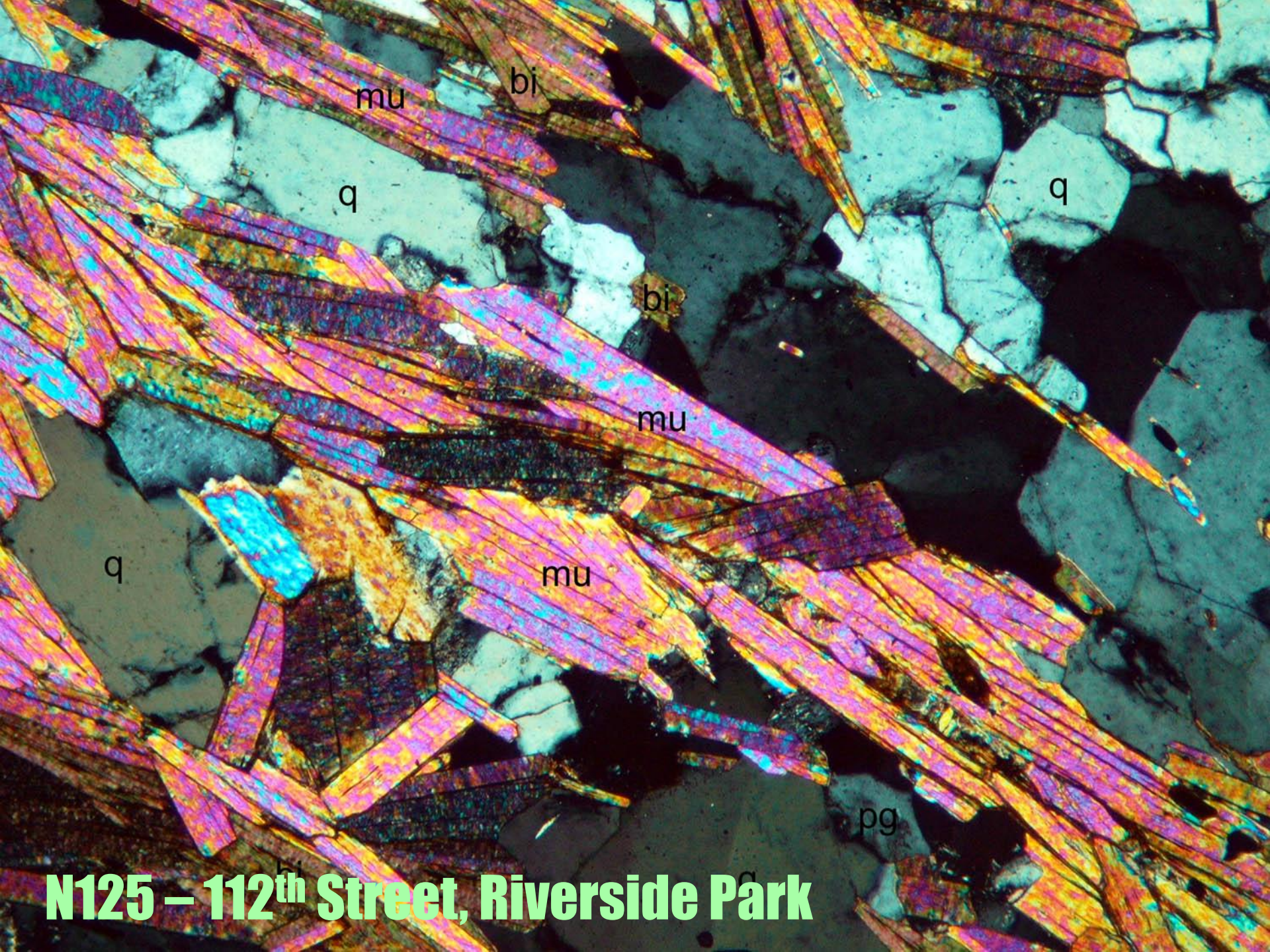


N217 – S of GWB Approach

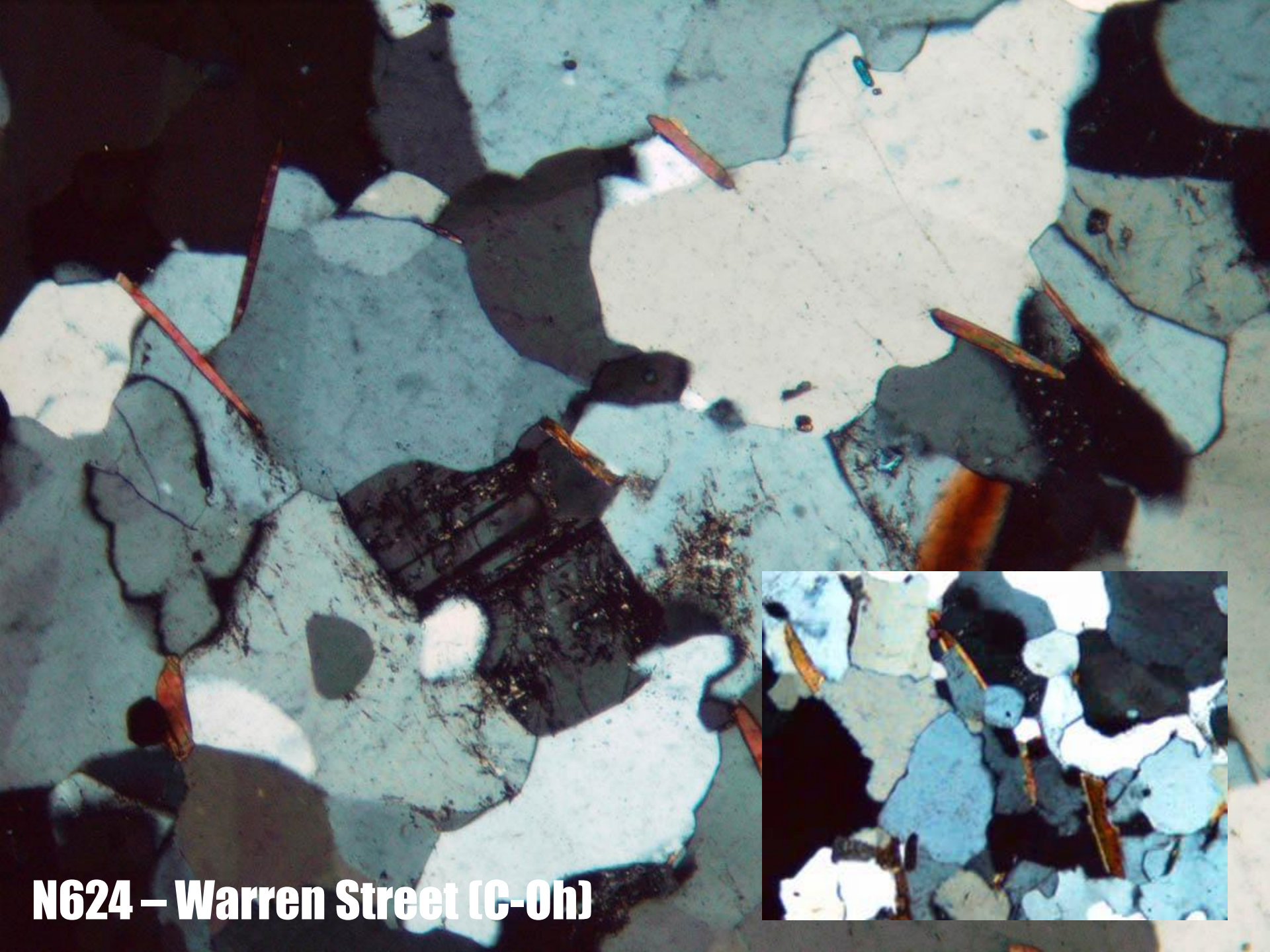
Hartland Schist, Riverside Park




N629 – Warren Street (C-Oh)

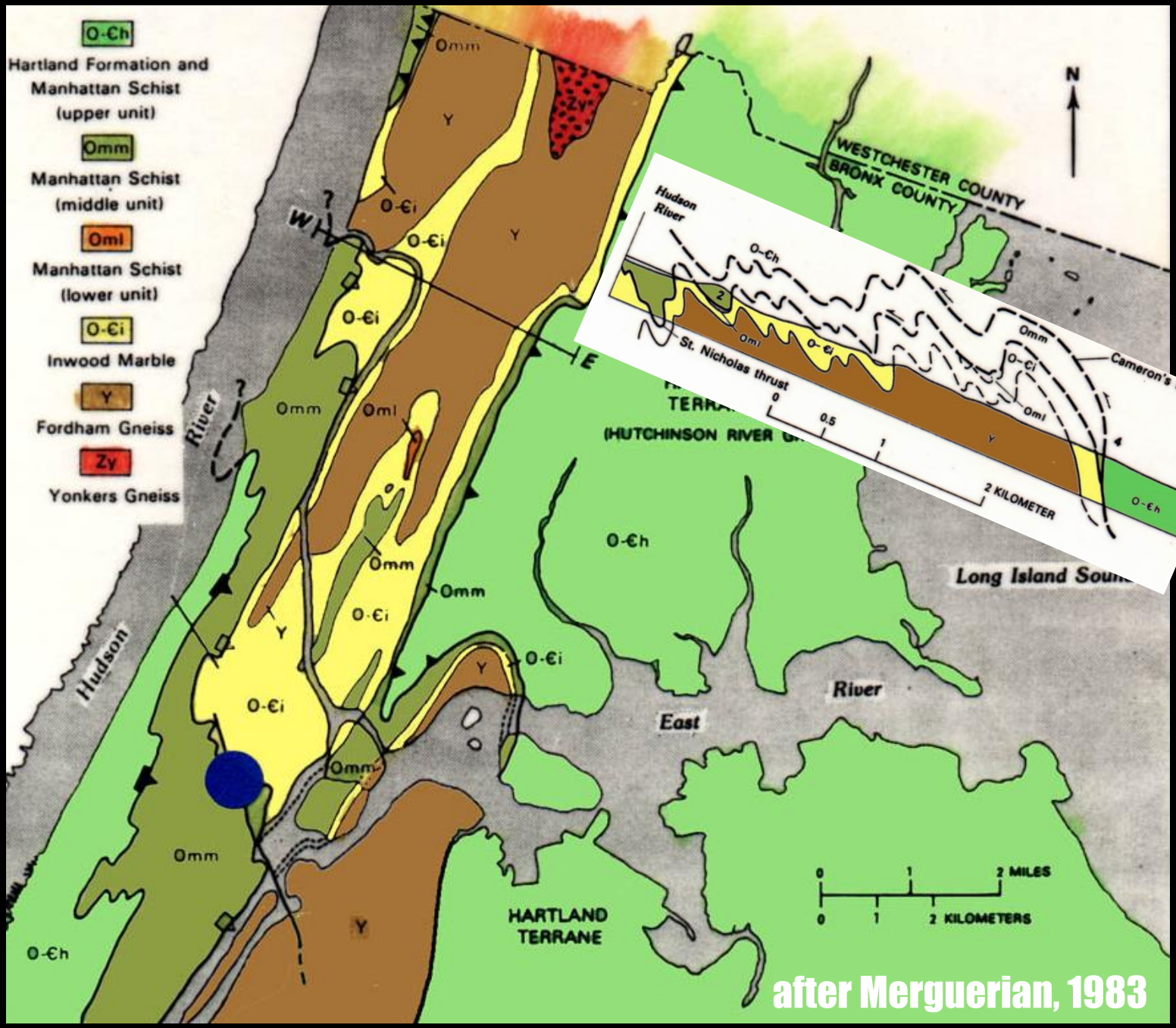


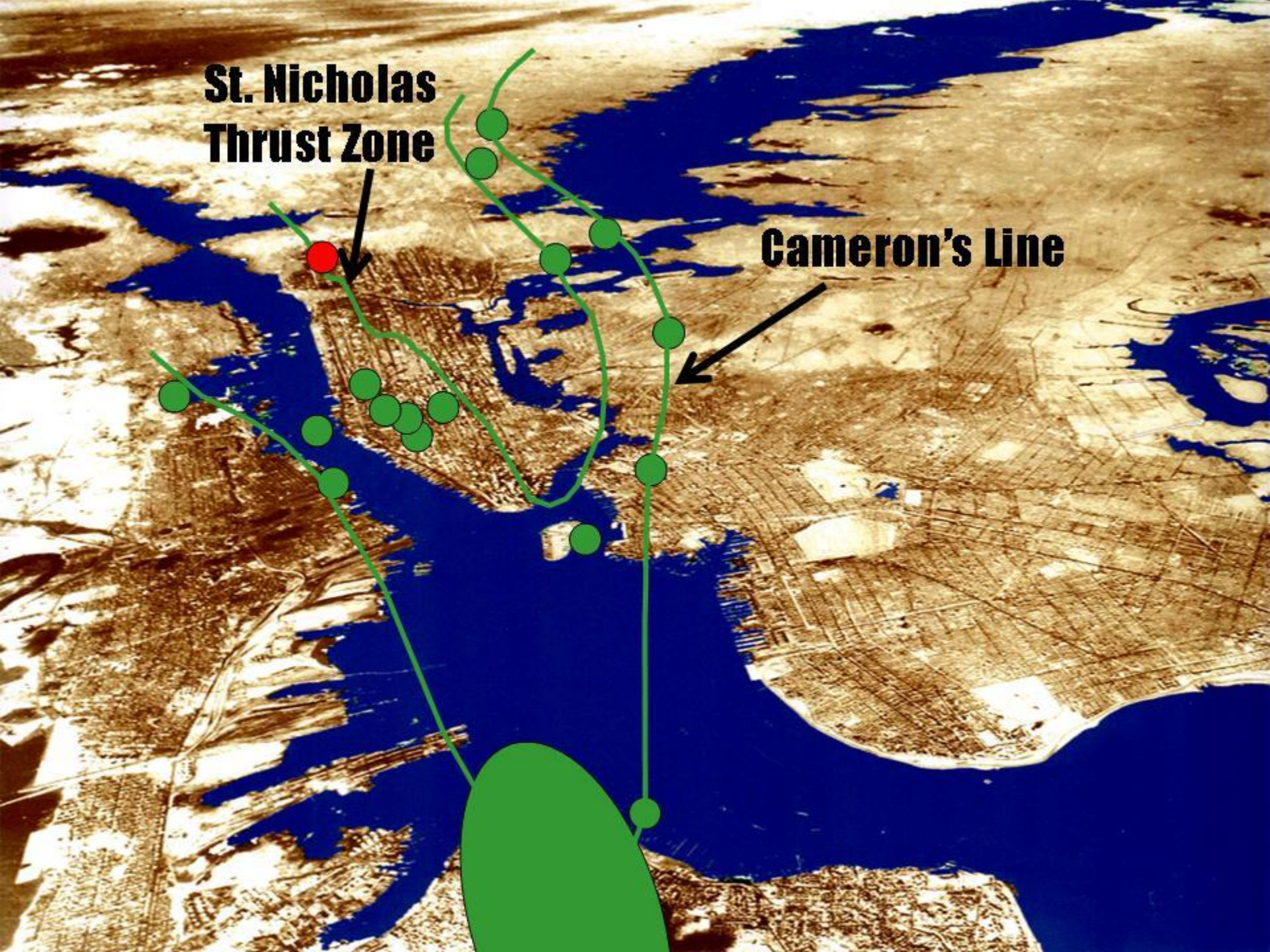
N125 – 112th Street, Riverside Park



N624 – Warren Street (C-Oh)


Hartland Amphibolite N567
TrJns
Jp
Camel
Line
St Nicholas Thrust
Ow
Zn
Yf


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
TERRANE
(HUTCHINSON RIVER
Long Island Sound
River
East
HARTLAND TERRANE
0 1 2 MILES
0 1 2 KILOMETERS
after Merguerian, 1983


St. Nicholas
Thrust Zone
Cameron's Line

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

Excessive Fines
Blocky Ground
Unstable Headings and Sidewalls
Low Penetration Rates

Excessive Fines

Blocky Ground

Desirable Kerf Pattern in Hard Rocks


Collapsed Crown and Sidewalls
Short Stand-up Times
Station 153+30

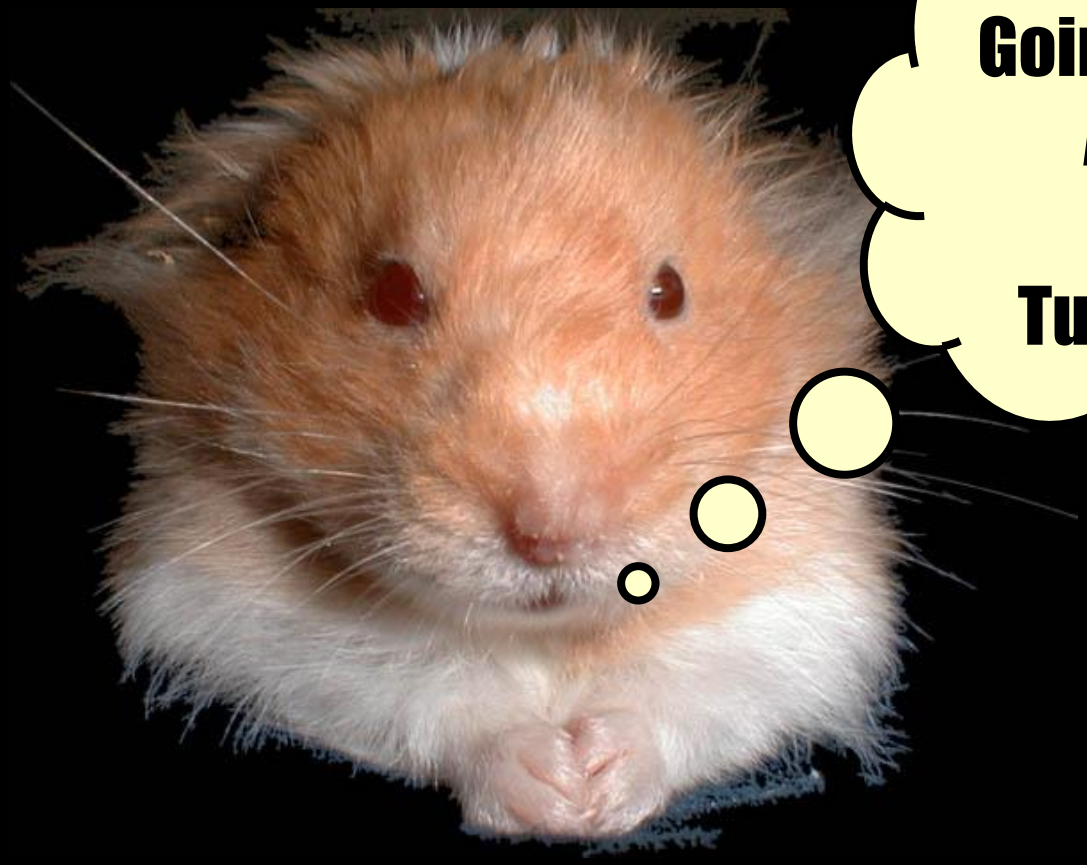
Rainy Conditions

Station 140+60

Short Stand-up Times

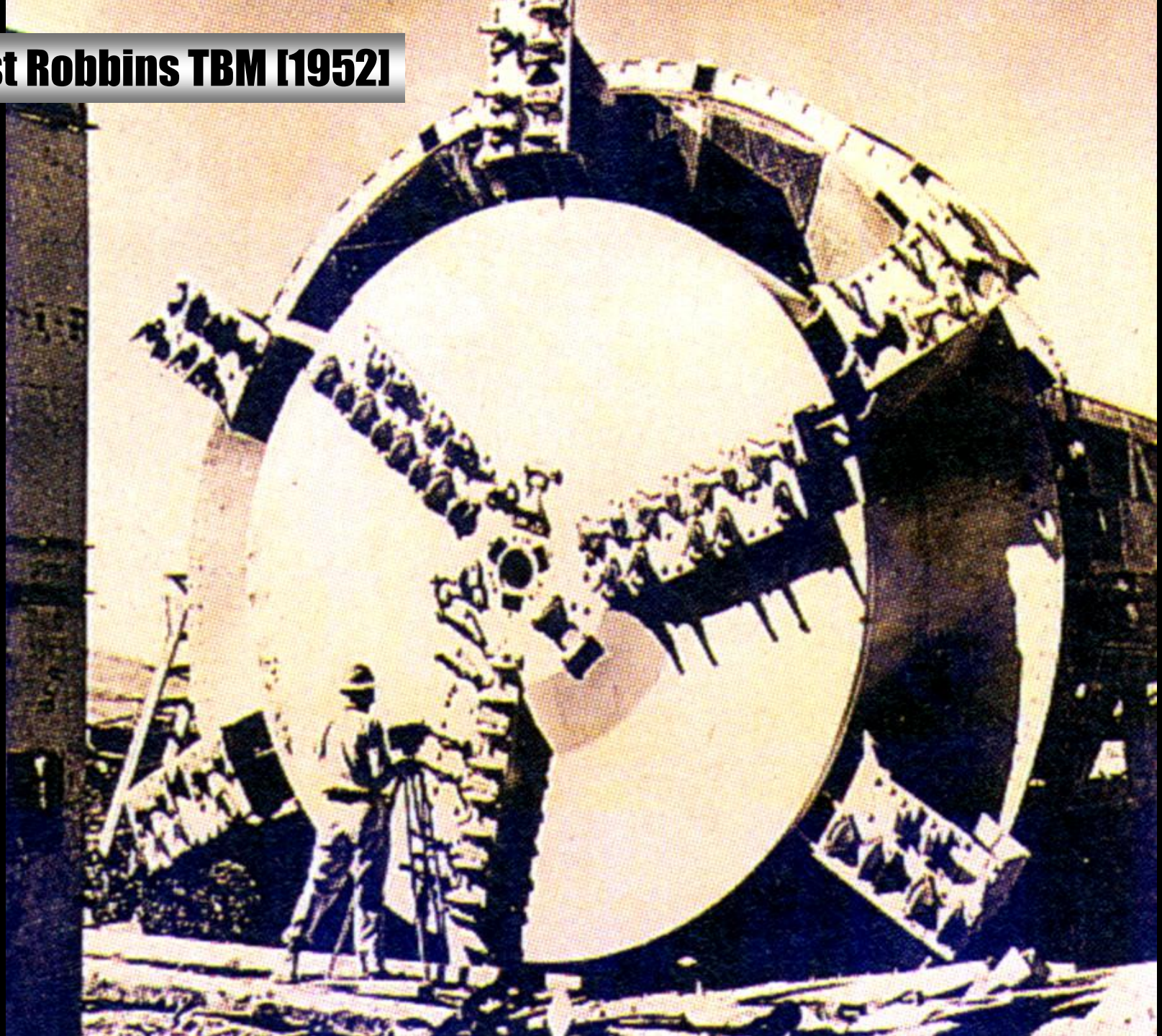
Unforseen Tunneling Problems

Can Geologic Studies Help Predict TBM Penetration Destiny?


Finally, He's
Going to Talk
About
TBM
Tunneling

TBM Tunneling

First Robbins TBM [1952]



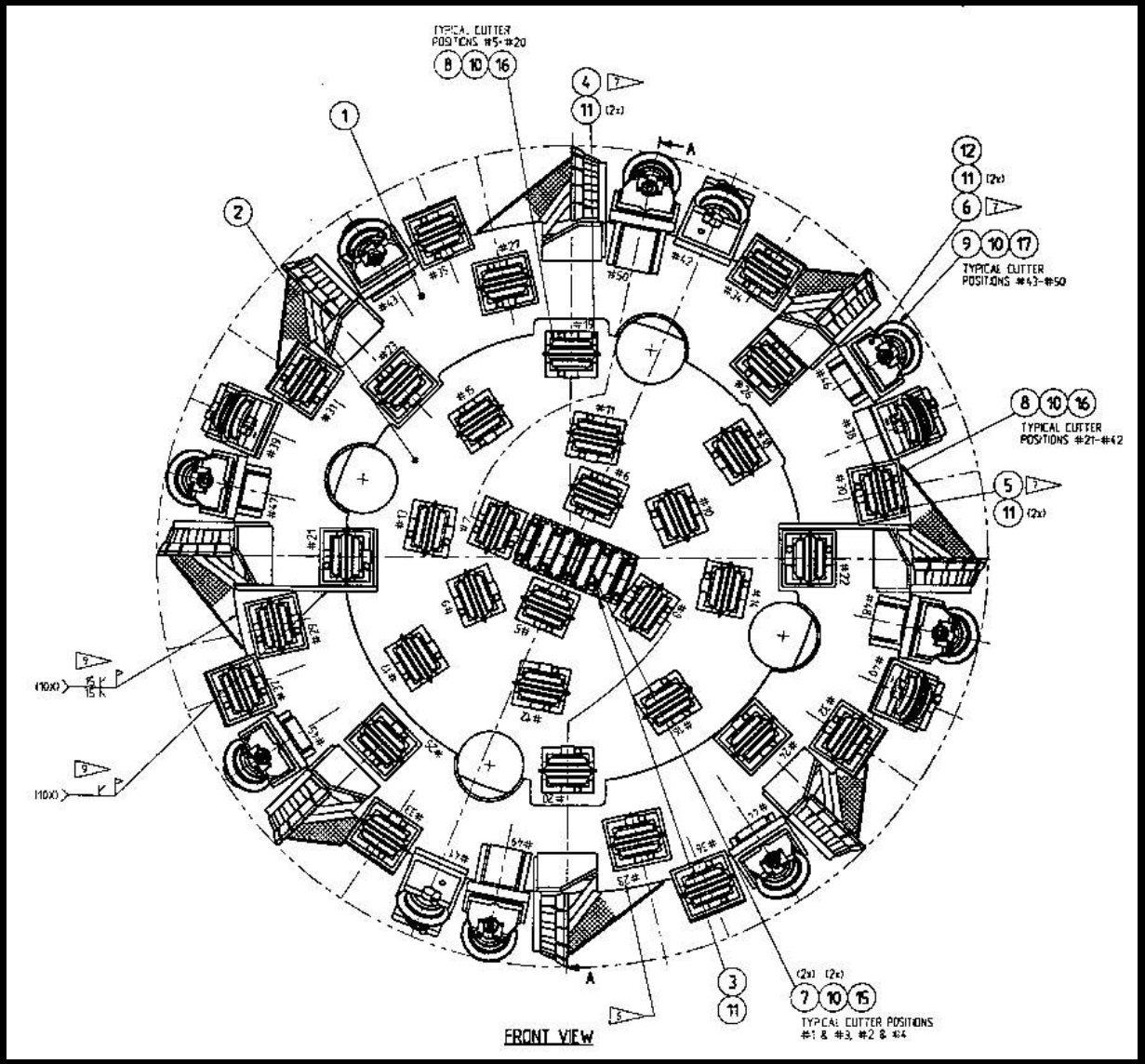
Holing Through North Tunnel, Hudson Tubes, French Line Dock (1904)

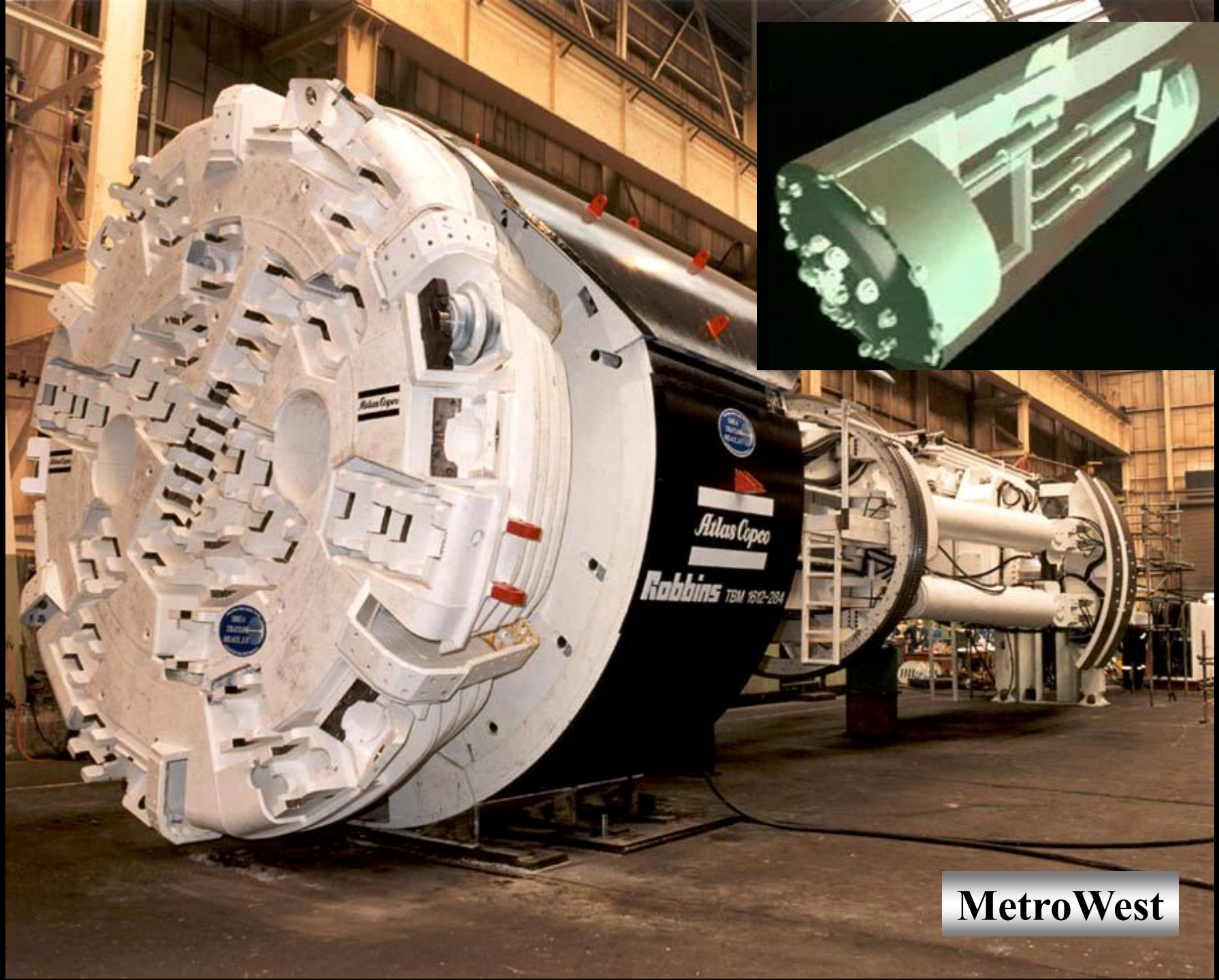
Sorenberg, Switzerland - Herrenknecht TBM

Robbins 235-282 HP Hard Rock Main Beam TBM

Chesterfield, England - 1996

TBM Chip Production




Atlas Copco
Robbins TBM 160-284
MetroWest


Normal TBM Chips

In the Belly of the Beast

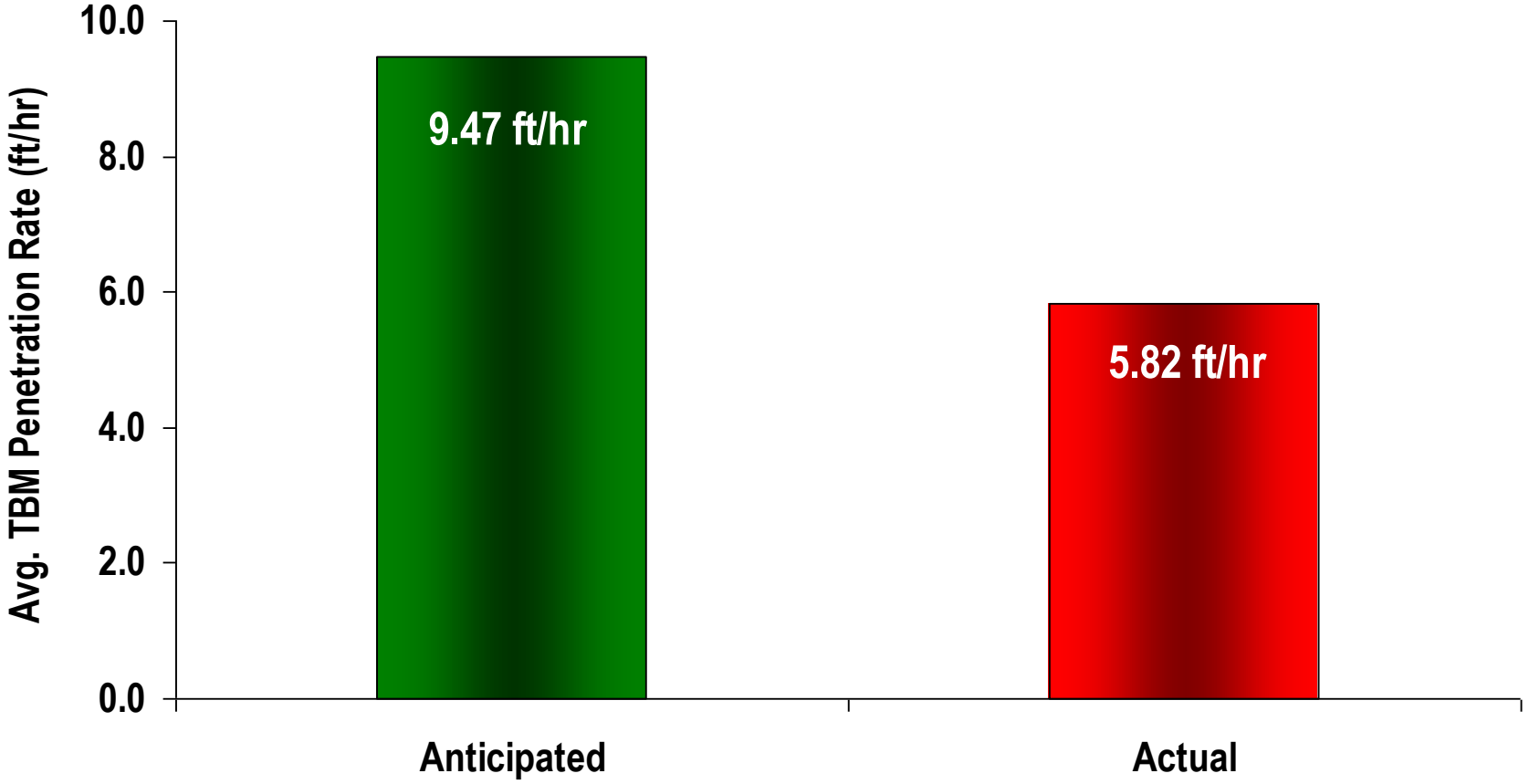

TBM-Bored Tunnel

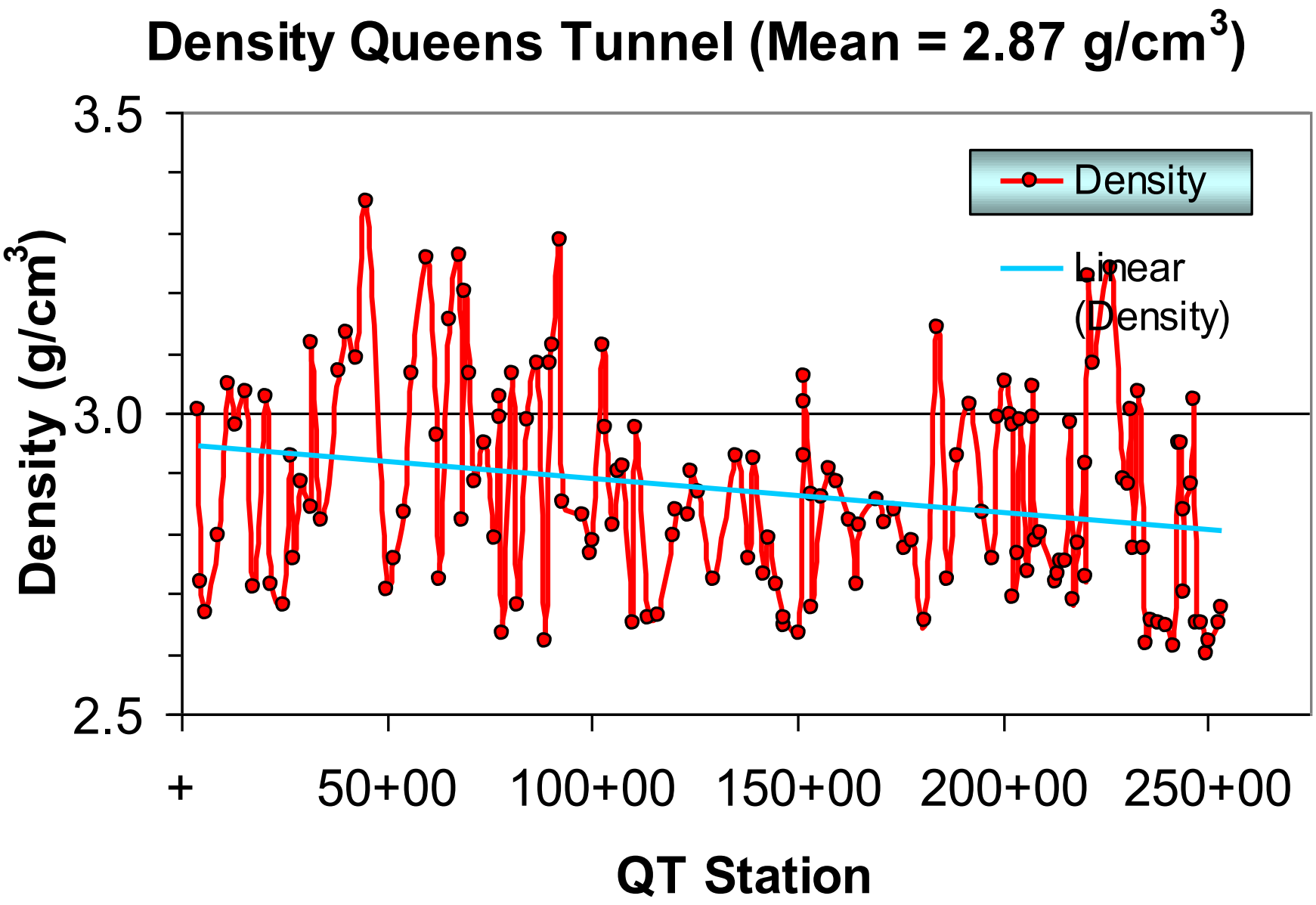
Pre-Bid Analysis Should Include:

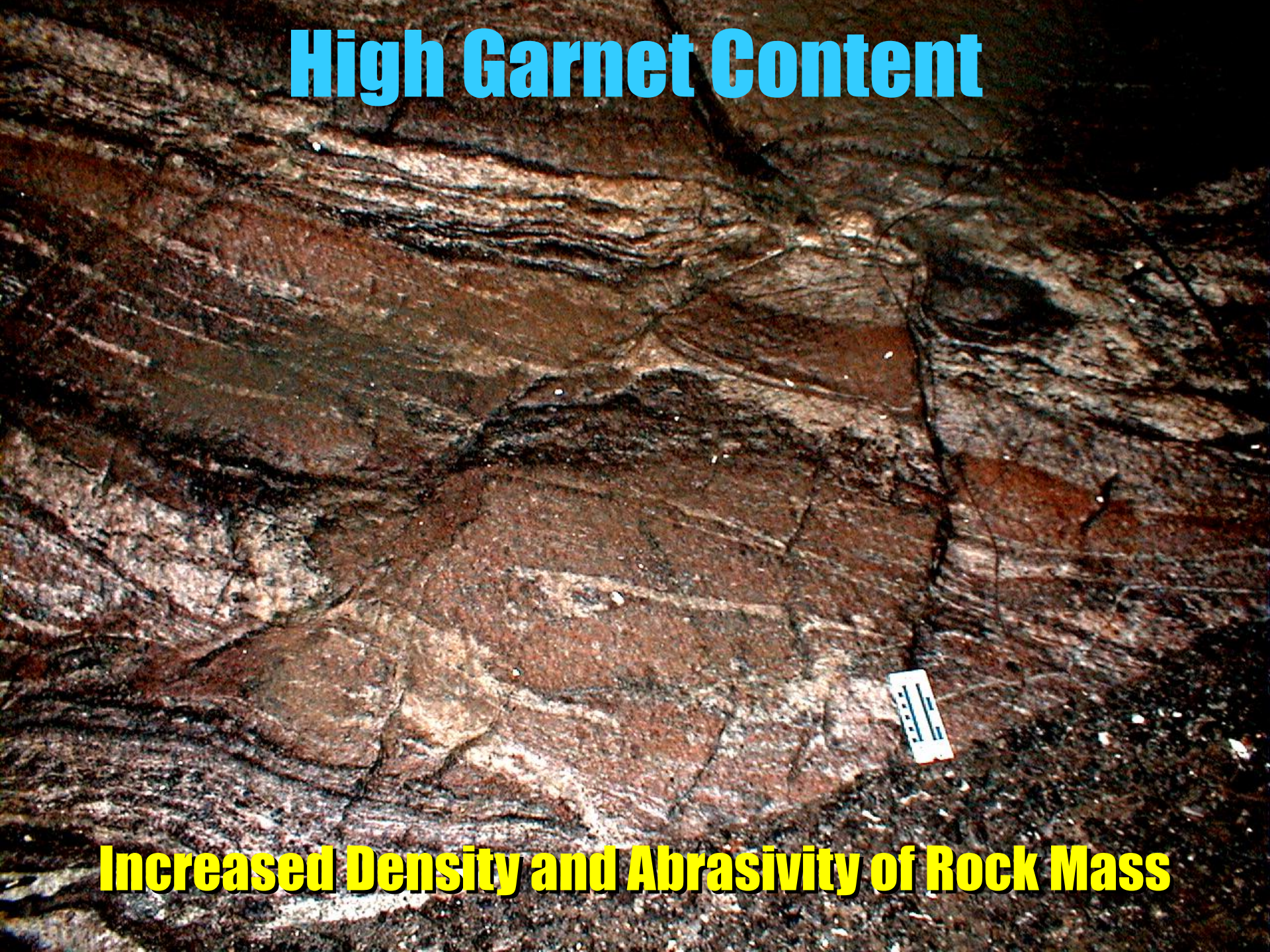
- Published Maps and Reports
- Boring Analysis
  - Fractures
  - Rock Types
  - Rock Fabrics
  - Density Studies
  - Petrographic Studies
- Rock Fabric Studies
  - Mineralogy and Texture
  - Structure
  - Orientation
  - Metamorphism

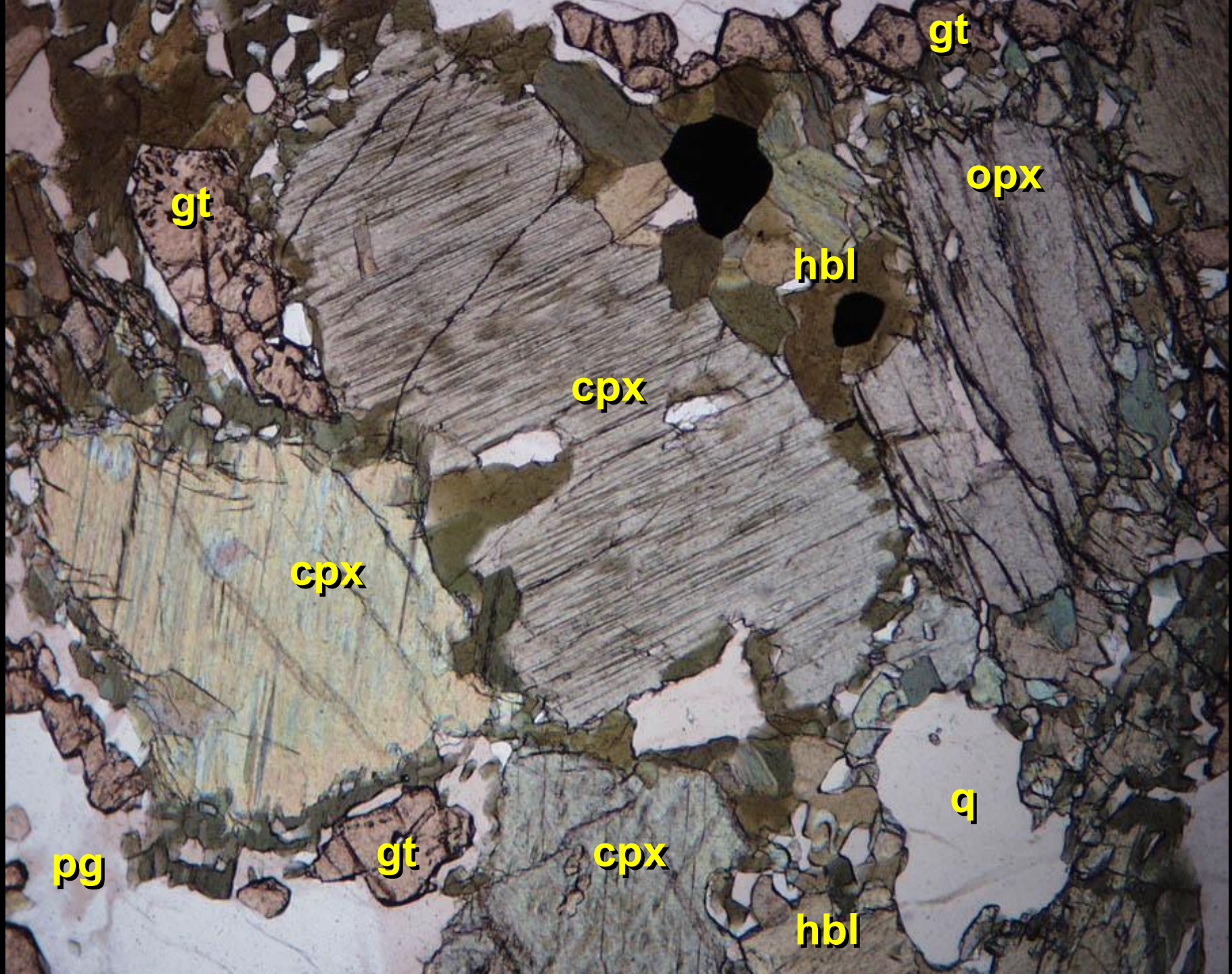
Merguerian's Queens Tunnel Field Office

Anticipated vs. Actual Penetration Rate

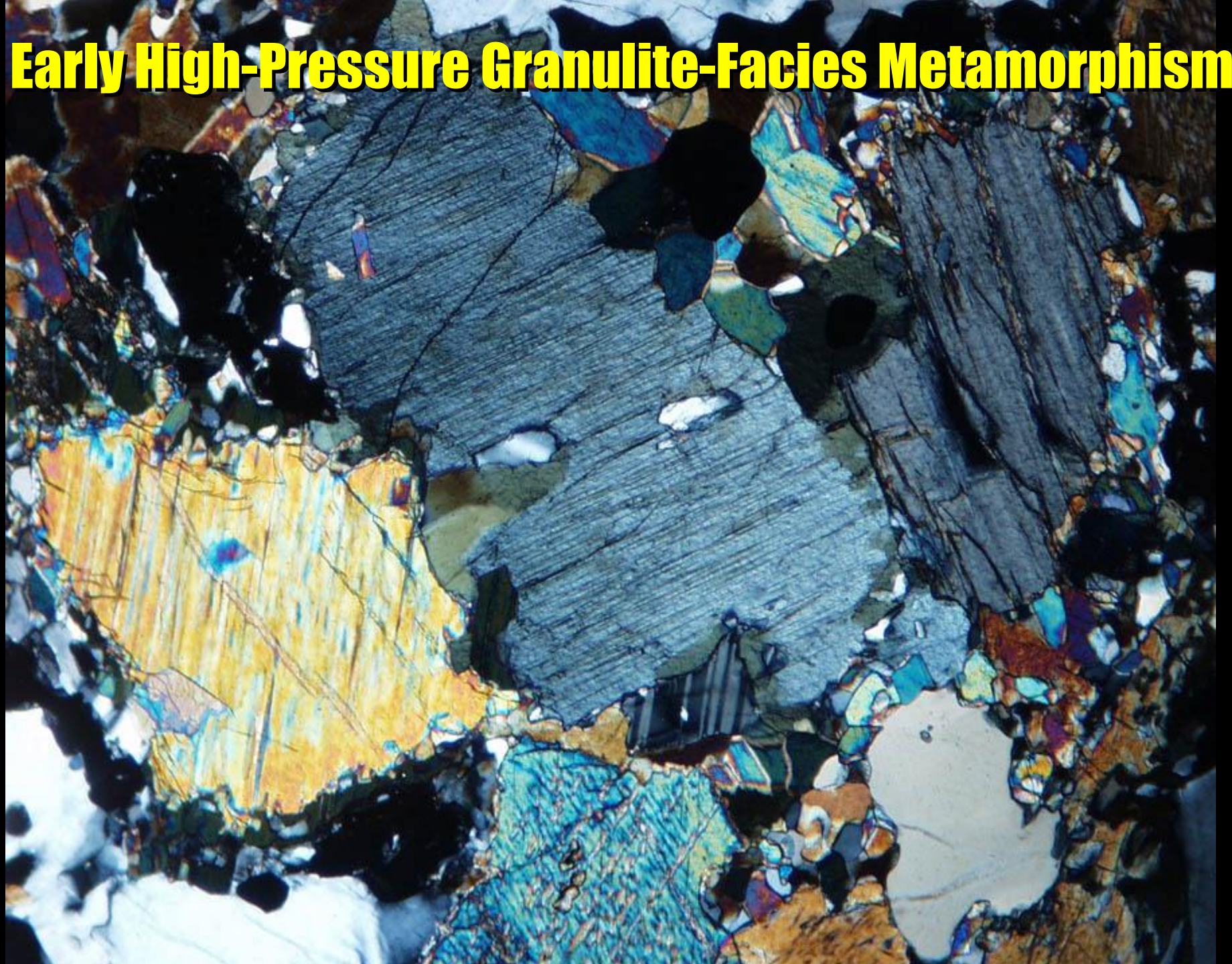



Density Queens Tunnel (Mean = 2.87 g/cm3)
Density (g/cm3)
3.5
3.0
2.5
Density
Linear (Density)
+
50+00
100+00
150+00
200+00
250+00
QT Station

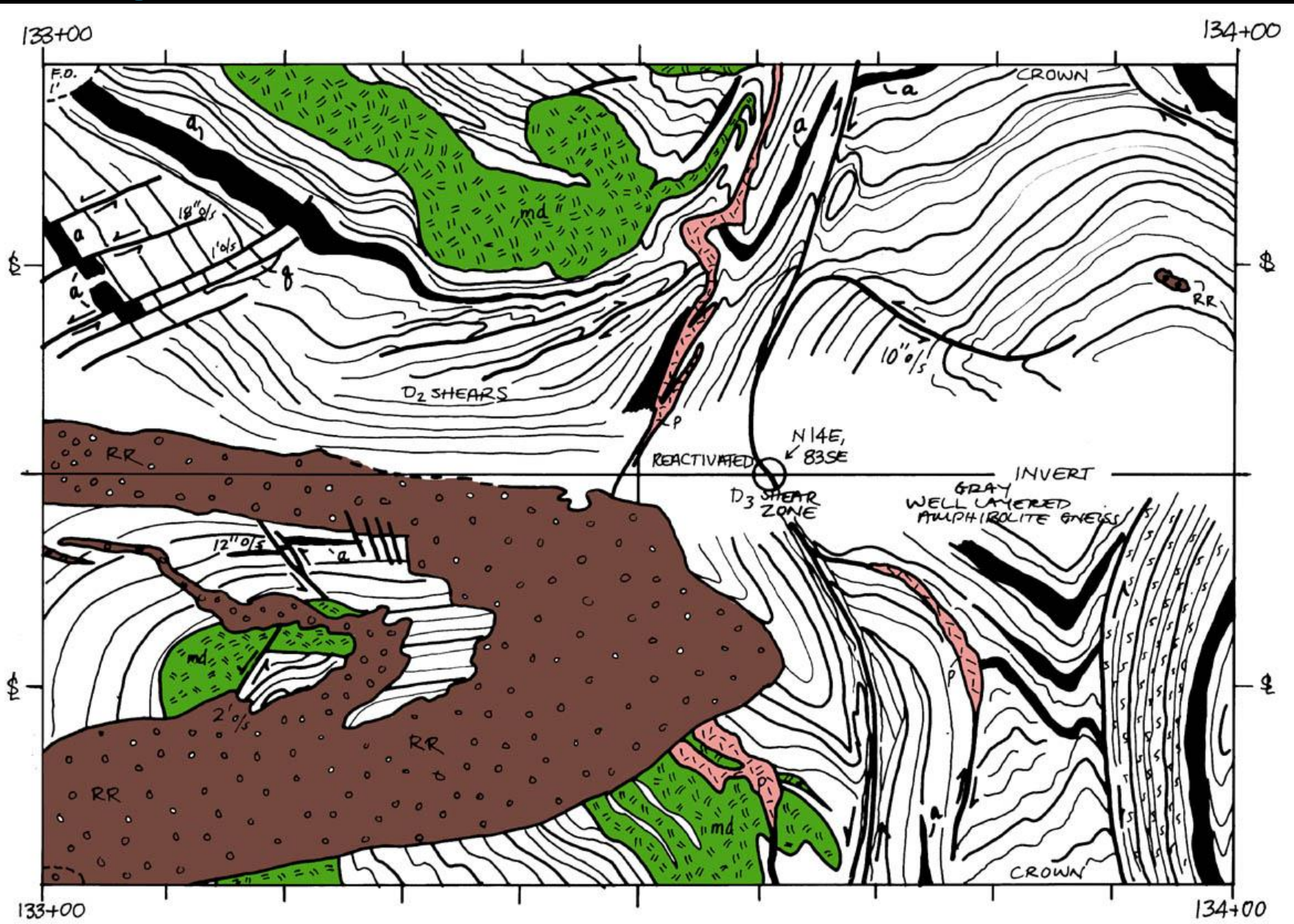

High Garnet Content
Increased Density and Abrasivity of Rock Mass


gt
opx
gt
hbl
cpx
cpx
q
pg
gt
cpx
hbl

Early High-Pressure Granulite-Facies Metamorphism



Dike 4


133+00
134+00
F.O.
1'
a
18"o/s
1'o/s
md
D2 SHEARS
CROWN
RR
10"o/s
N14E,
83SE
REACTIVATED
D3 SHEAR ZONE
INVERT
GRAY
WELL LAYERED
AMPHIBOLITE GNEISS
12"o/s
2'o/s
RR
CROWN
133+00
134+00

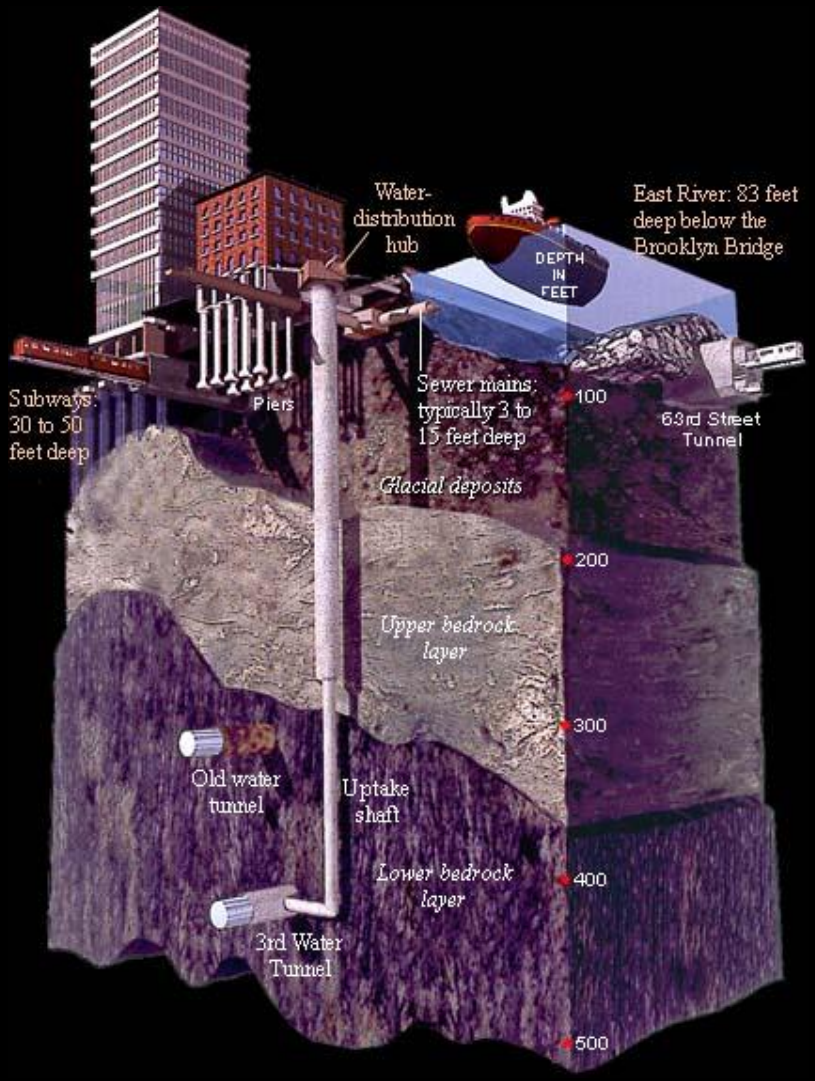

12:05PM
5/15/1998
00:15

Major Lithologic Contrasts

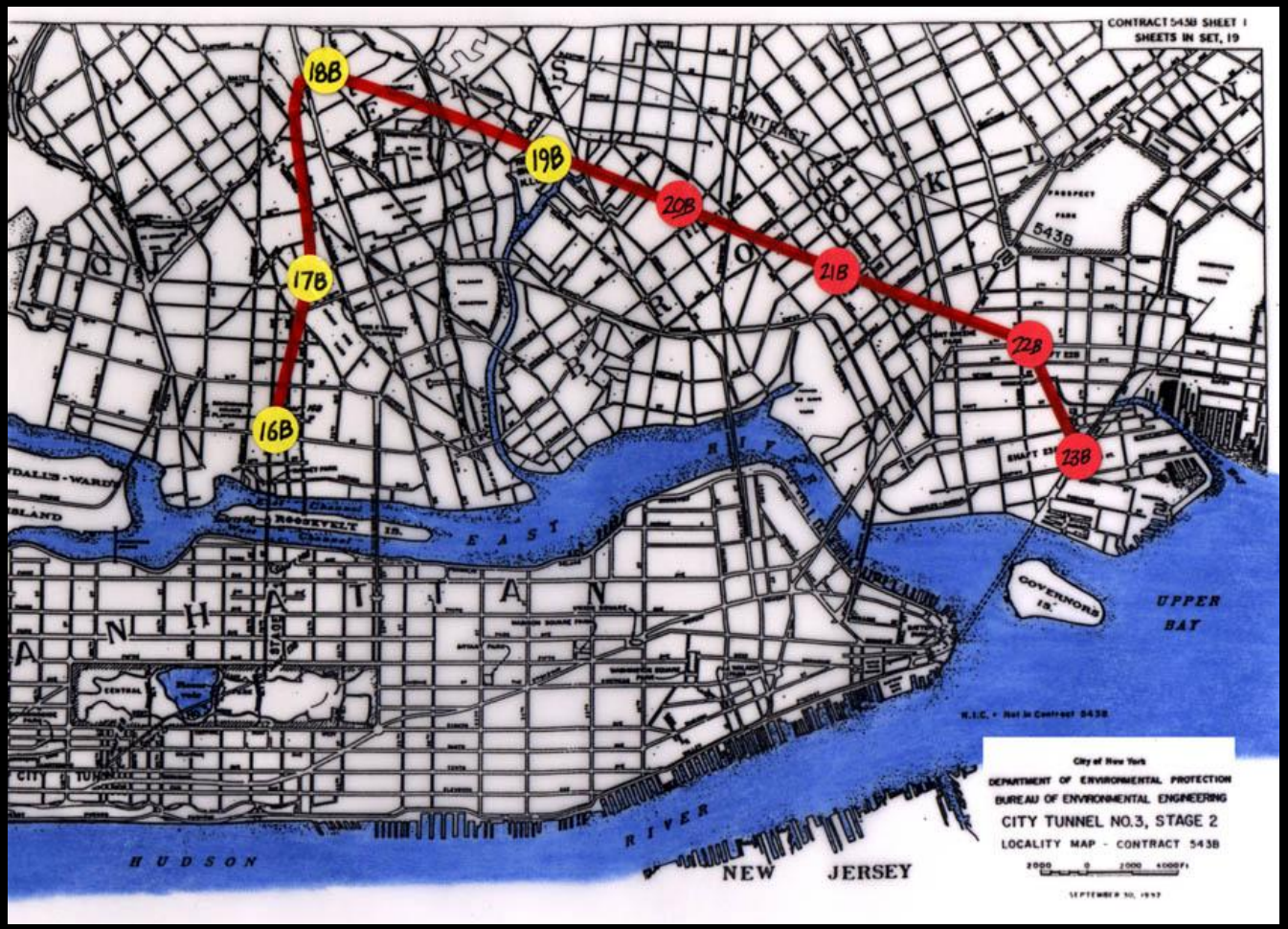

Remember Doc, You're Nothing Without Me!
Finally, He's Going to Talk About Mega-Construction Projects

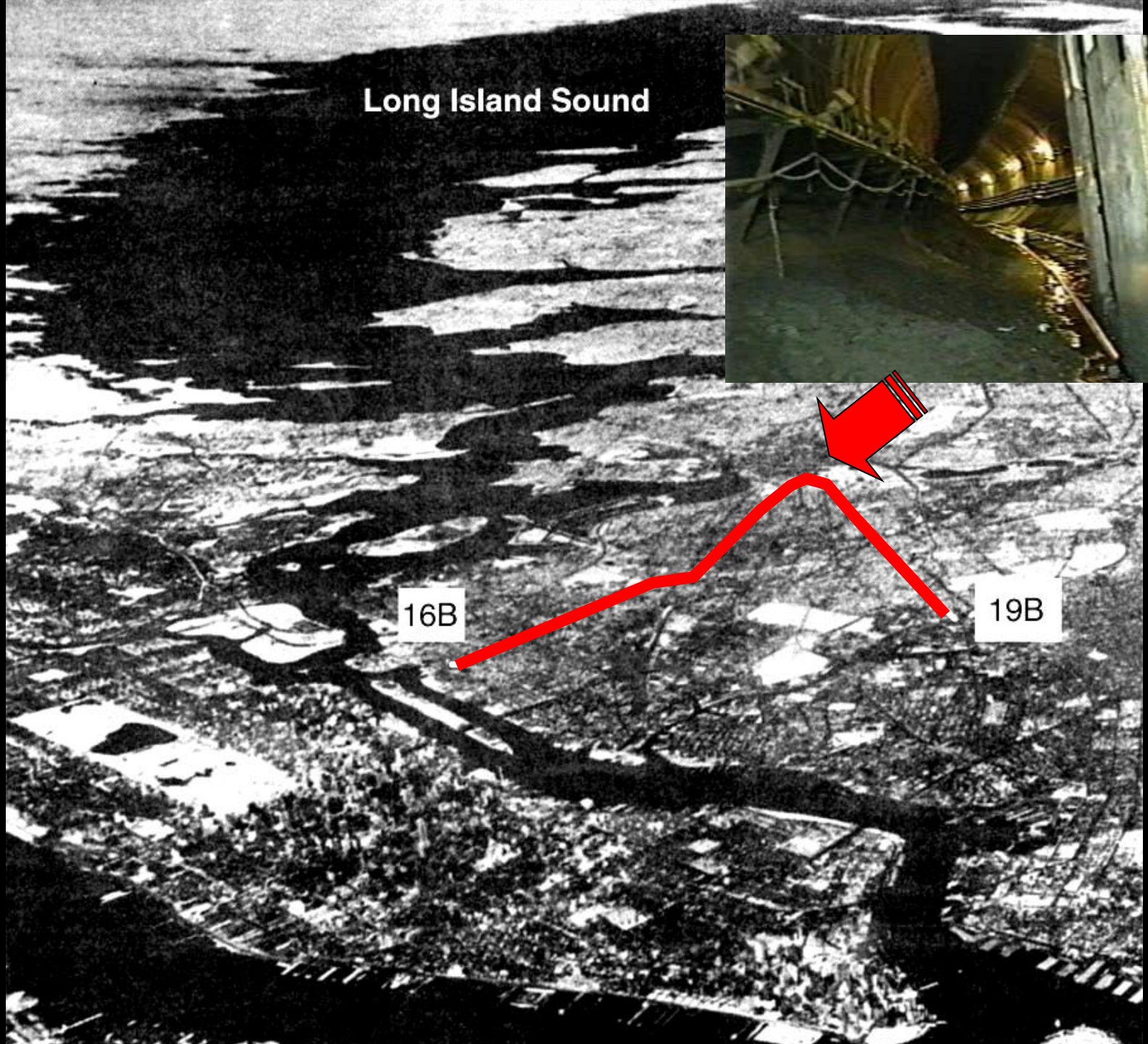
Mega-Construction Projects

- Queens Water Tunnel
- Con Edison Steam Tunnel
- Manhattan Water Tunnel
- East Side Access Project
- Second Avenue Subway
- IRT #7 Line Extension
- LI Cross Sound Link Tunnel



Construction of the Queens Tunnel
NYC Water Tunnel #3
Oct 1996 – Oct 1999




Long Island Sound
16B
19B


QUEENSTUNNEL


Con Edison
Utility Tunnel
Pierpont Morgan Library
Stern College
Yeshiva University
United Nations Headquarters
Belmont Island
Fashion Institute of Technology
Little Church around the Corner
American Academy of Dramatic Arts
Touro College
Madison Square Park
Bellevue Hospital Center
Baruch College
St Francis College
Parsons School of Design
School of Visual Arts
Police Academy Museum
Cabrini Medical Center
Stuyvesant Square
Con Edison Energy Museum
Beth Israel Medical Center
New York University
State Board of Tourism
St Marks Church in the Bowery
Murphy Park
The Bowery
Tompkins Square
Dukelabs © 2003

Con Edison Steam Tunnel TBM

Robbins HP 215-257 Hard Rock Machine
Capable of 5’ stroke

TBM at Con Ed Tunnel

30 Street and 1st Avenue

10 Oct 2002


Southern Heading
Shallow NW Dip

TBM Starter Tunnel


Starter Tunnel to South Heading

CT3, Stage2 Manhattan Water Tunnel

Shaft 26B

10 Oct 2002

Bottom of Shaft 26B

580’ Deep


NEW JERSEY
13B
MAIN TUNNEL (Central Park)
24B
MAIN TUNNEL (West Side)
25B
33B
CROSSTOWN TUNNEL (Mid-town)
26B
32B
MAIN TUNNEL (West Side)
27B
MANHATTAN
28B
31B
29B
30B
MAIN TUNNEL (South Loop)
Excavated
To be Excavated
Shafts


26B South Heading

Manhattan Tunnel TBM

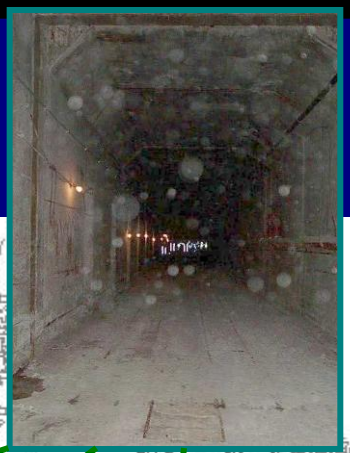
Rebuilt Robbins HP 215-257 hard rock machine (first used at Con Ed Utility Tunnel on 1st Avenue)

East Side Access

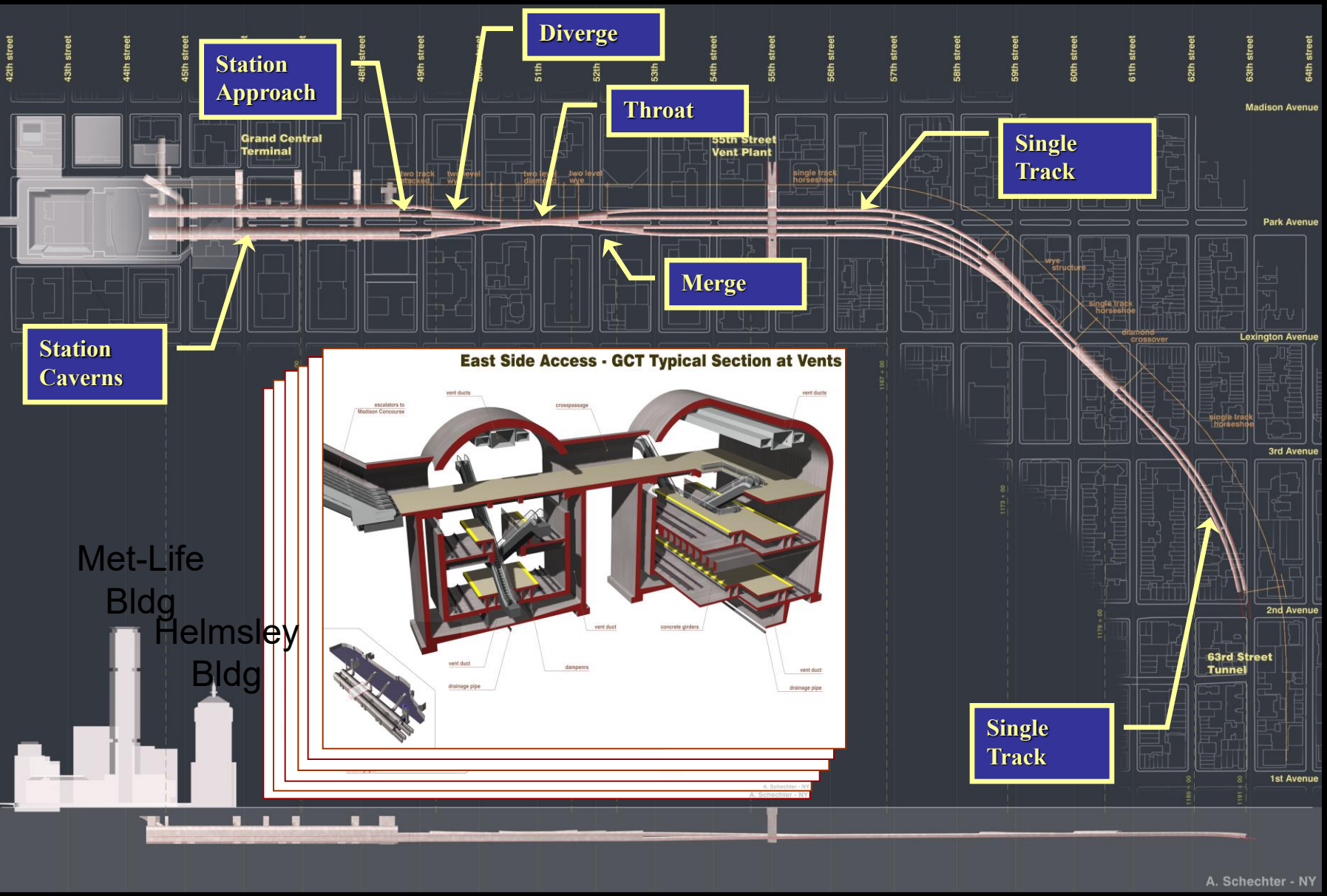
LIRR/MTA


Central Park
Metro-North Railroad
8,600ft
(17,200 Linear Ft.)
63rd Street Tunnel
63rd St
41st Ave
29th Ave
Northern Blvd
25A
AMTRAK
LIRR Port Washington Branch
5,500ft
(11,200 Linear Ft.)
Sunnyside Yard
Queens Blvd
25
Queensborough Bridge
Mid-Day Storage Yard
Harold Interlocking
QUEENS
Roosevelt Island
Northern Blvd
Sunnyside Station
Arch Street Yard
& Shop Facility
7,200ft
(24,000 Linear Ft.)
53rd St
Grand Central Terminal
42nd St
Long Island Expressway
Queens-Midtown Tunnel
LIRR Montauk Branch
EAST RIVER
MANHATTAN
BROOKLYN
Legend
Existing LIRR Tunnel Structure
Tunnel Structure to Be Built

Existing 63rd Street Tunnel



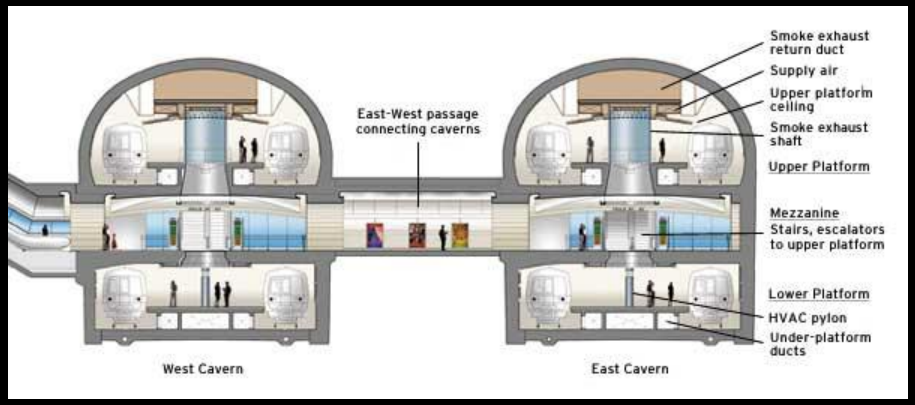
East Side Access Project Plans

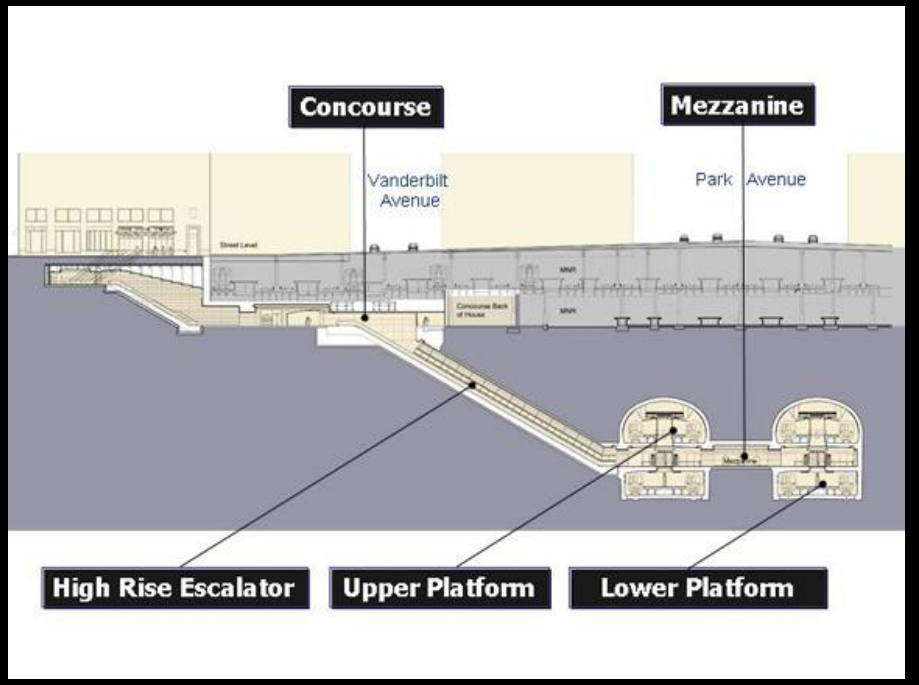



13 Aug 2007


28 Nov 2007

Construction Will Take Place Under Existing GCT





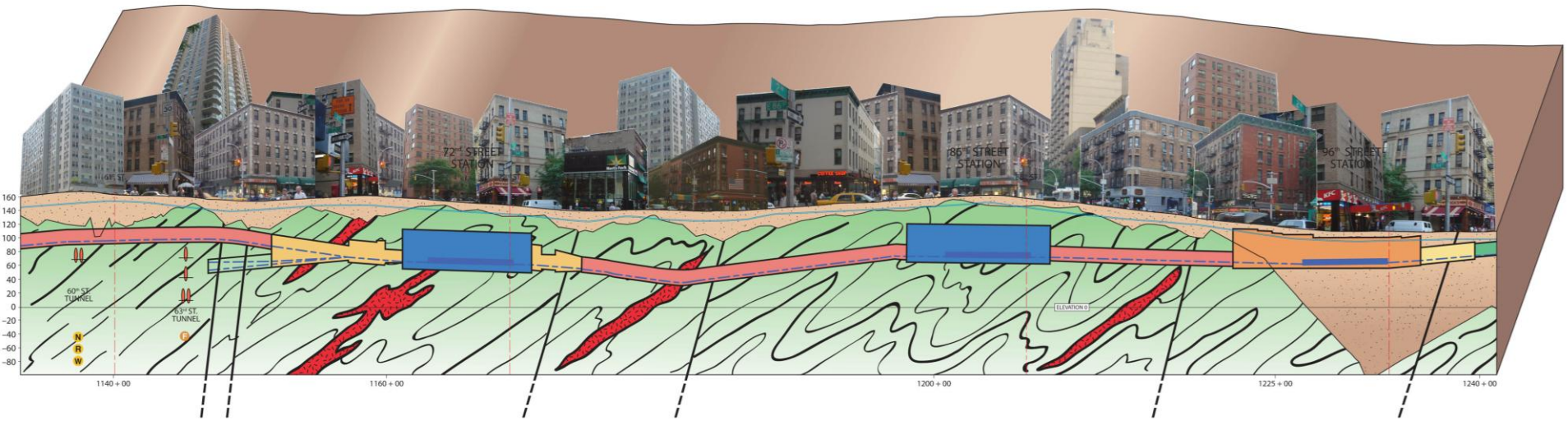

AH
30+05

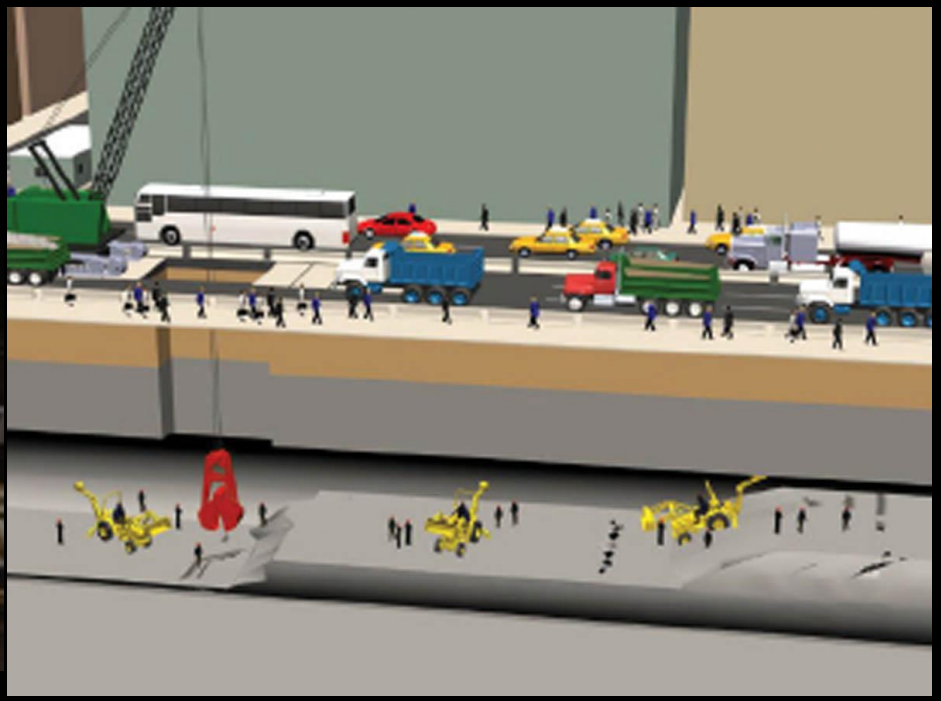
304
CUT 10'

IRT #7 Line Extension

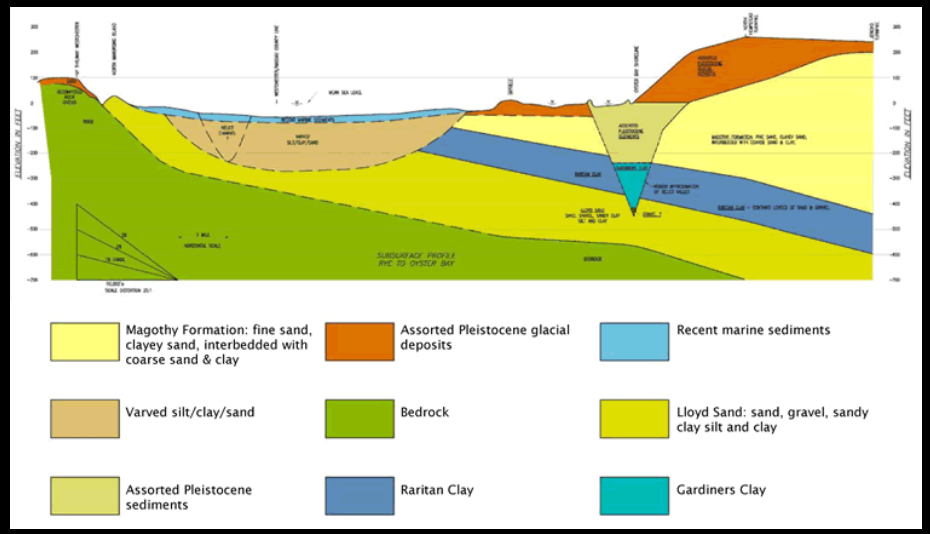
Second Avenue El

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

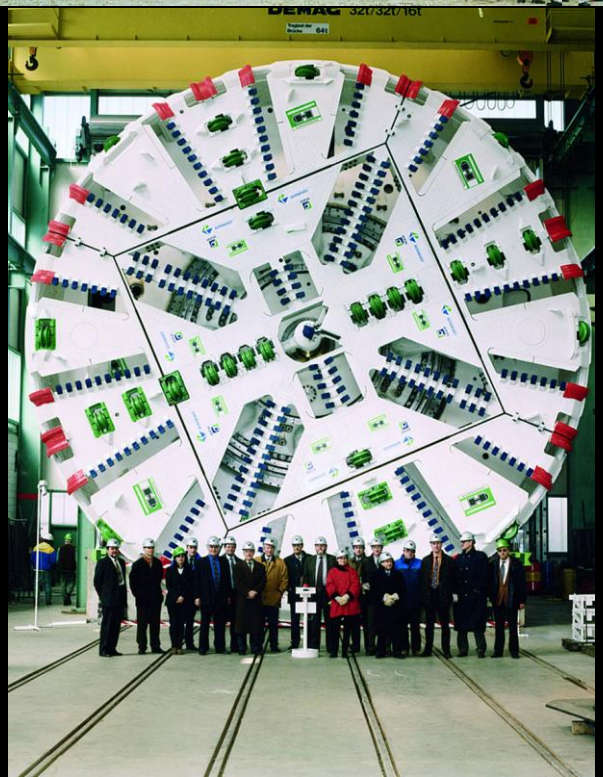

72nd STREET STATION
86th STREET STATION
96th STREET STATION
60th ST. TUNNEL
63rd ST. TUNNEL
N
R
W
ELEVATION 0
160
140
120
100
80
60
40
20
0
−20
−40
−60
−80
1140 + 00
1160 + 00
1200 + 00
1225 + 00
1240 + 00

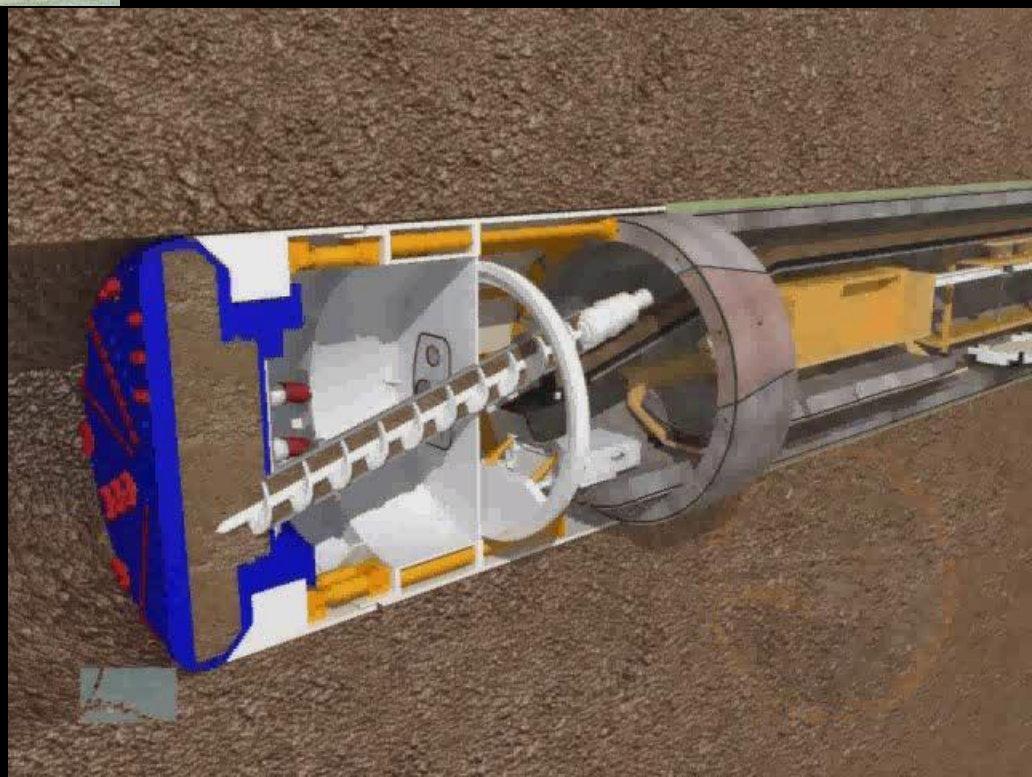


Cross Sound Link Project



Soft Ground TBMs





HERRENKNECHT TBM ADVERTISEMENT

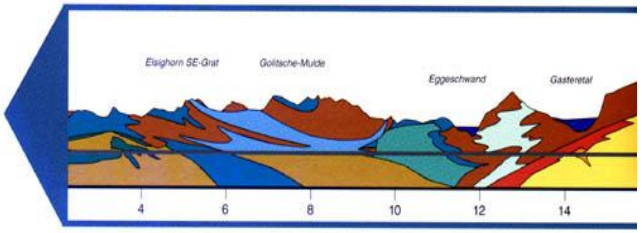
Rock Does Not Equal Rock

At Herrenknecht, maximum tunnelling performance and the greatest possible safety are the ultimate goals for the development of tunnelling machines. Expert analysis of the geological conditions result in a "tailored hard rock machine".

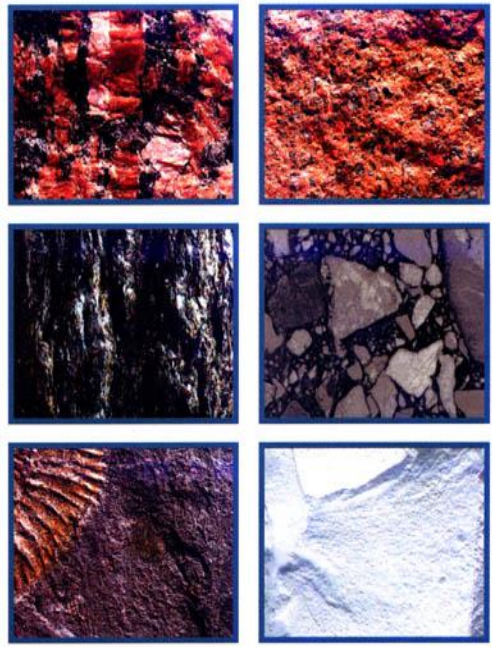
Whether it is solid rock, abrasive rock or rock under high pressure, weathered transition zones with high ground water pressure or caverns, the variety of the geological conditions in a planned tunnel route is virtually unlimited. At Herrenknecht, the geological analysis of the ground conditions is always taken into consideration in the machine design. Cutters and cutterhead are ideally adapted to the varying degrees of hardness and abrasion in sedimentary, metamorphic or igneous rock.

All Experts On One Team

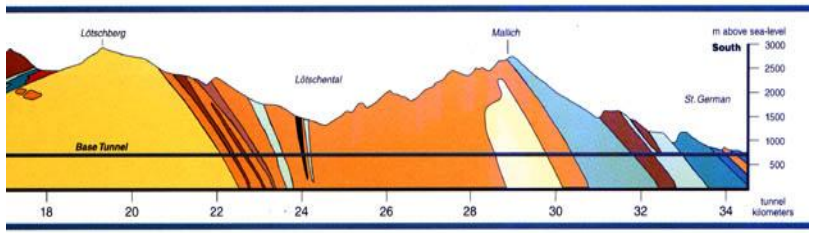
The excavation process in hard rock takes place in the peak state of the shear and compression resistance as well as tensile strengths of the rock. At the same time, the best possible tunnelling performance has to be achieved. At Herrenknecht, a team of internal specialists from the disciplines of rock mechanics, mechanical engineering and process technology find the optimum project solution for developing the machine design.



Mechanical rock excavation is confronted by rock with varying degrees of hardness, e.g. with extremely hard gneiss (top left) and granite (top right), medium hard mica schist (center left), breccia (center right) and claystone (bottom left) as well as limestone (bottom right).



The formation of each mountain range is unique. Lötschberg in Switzerland consists of a wide variety of rock formations along the tunnel route. Herrenknecht supplied two single gripper machines (Ø 9.43 m), which enable mechanical rock stabilization as close as 4.2 m behind the cutterhead.



Download NYC Geology Publications @

www.hofstra.edu

www.dukelabs.com