Stratigraphy, Structure and Rock Mass Properties of the Hartland Formation, Second Avenue Subway, NYC, NY

Charles Merguerian
Hofstra Geology
J. Mickey Merguerian
Univ. Texas @ El Paso
24 Mar 2014

NYC TBM Projects

Second Avenue Subway

1929 – NYC BOT Proposes Second Avenue Subway

1931 – Plans Postponed for Depression Era

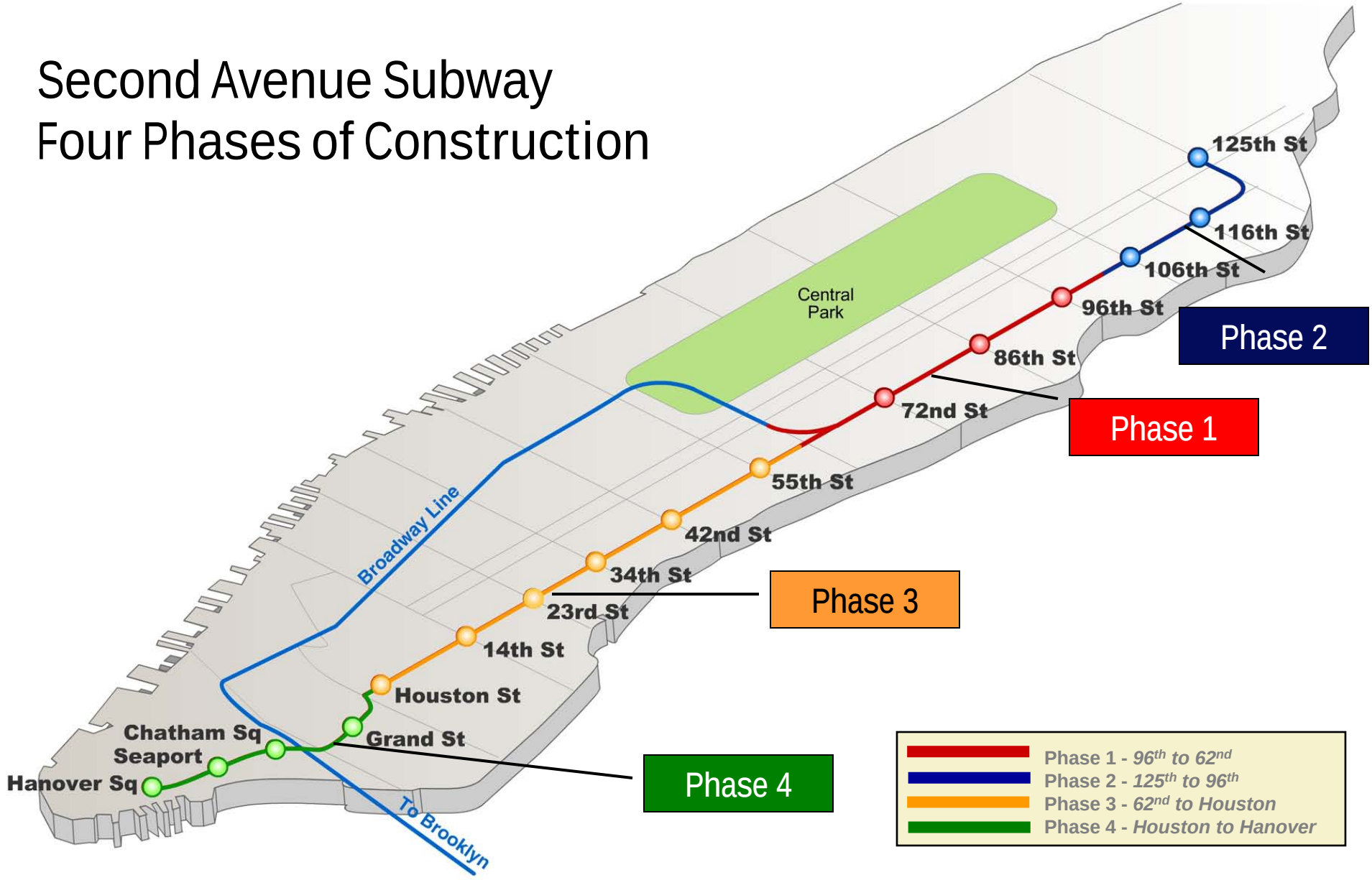
$86M → $249M → $500M

By 1948 – Abandonment

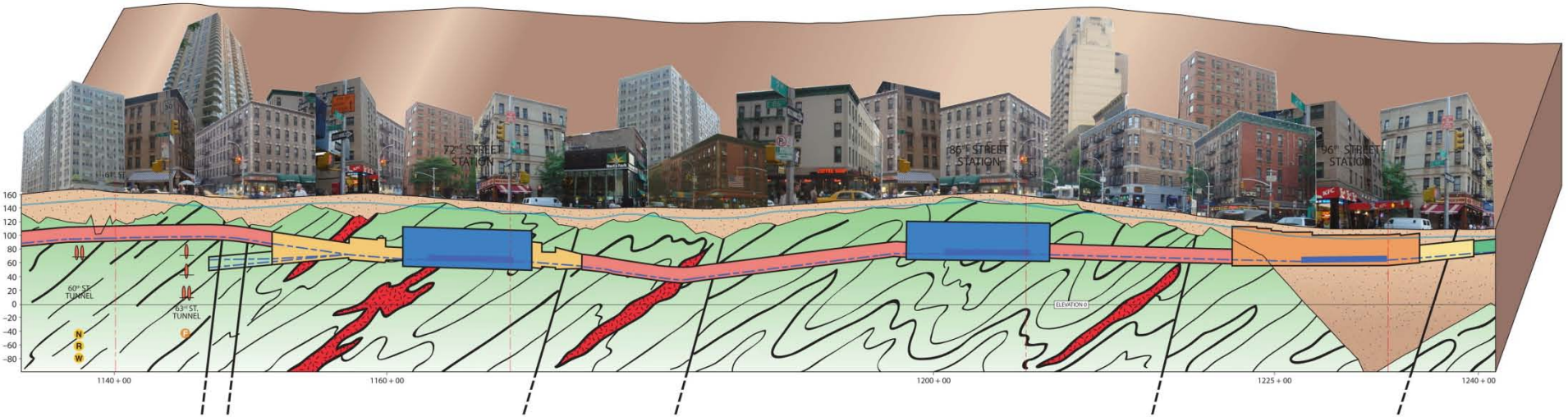
June 2010 – TBM Starts S Tube

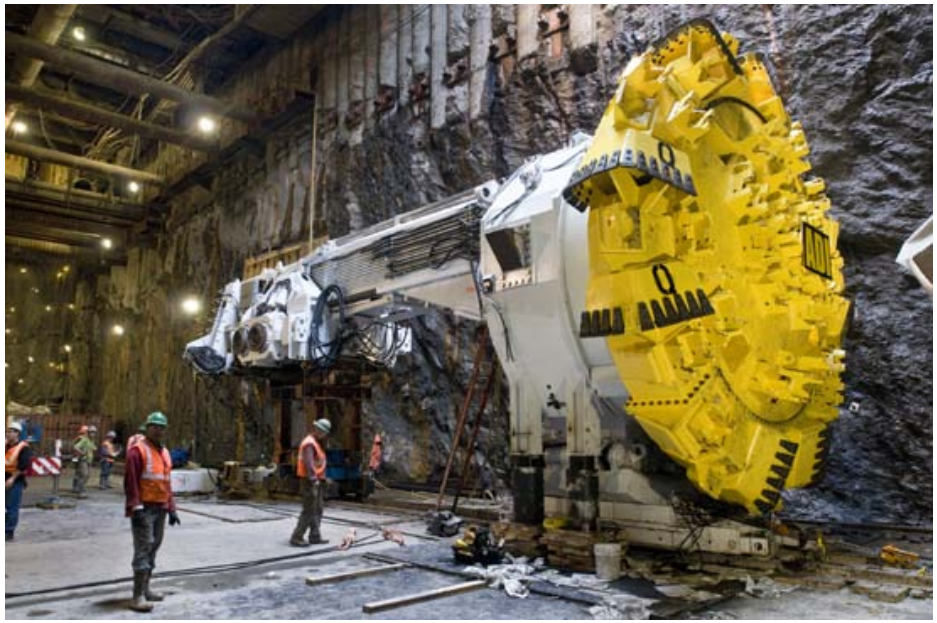
2013 – Station Complexes

Second Avenue Subway
Four Phases of Construction



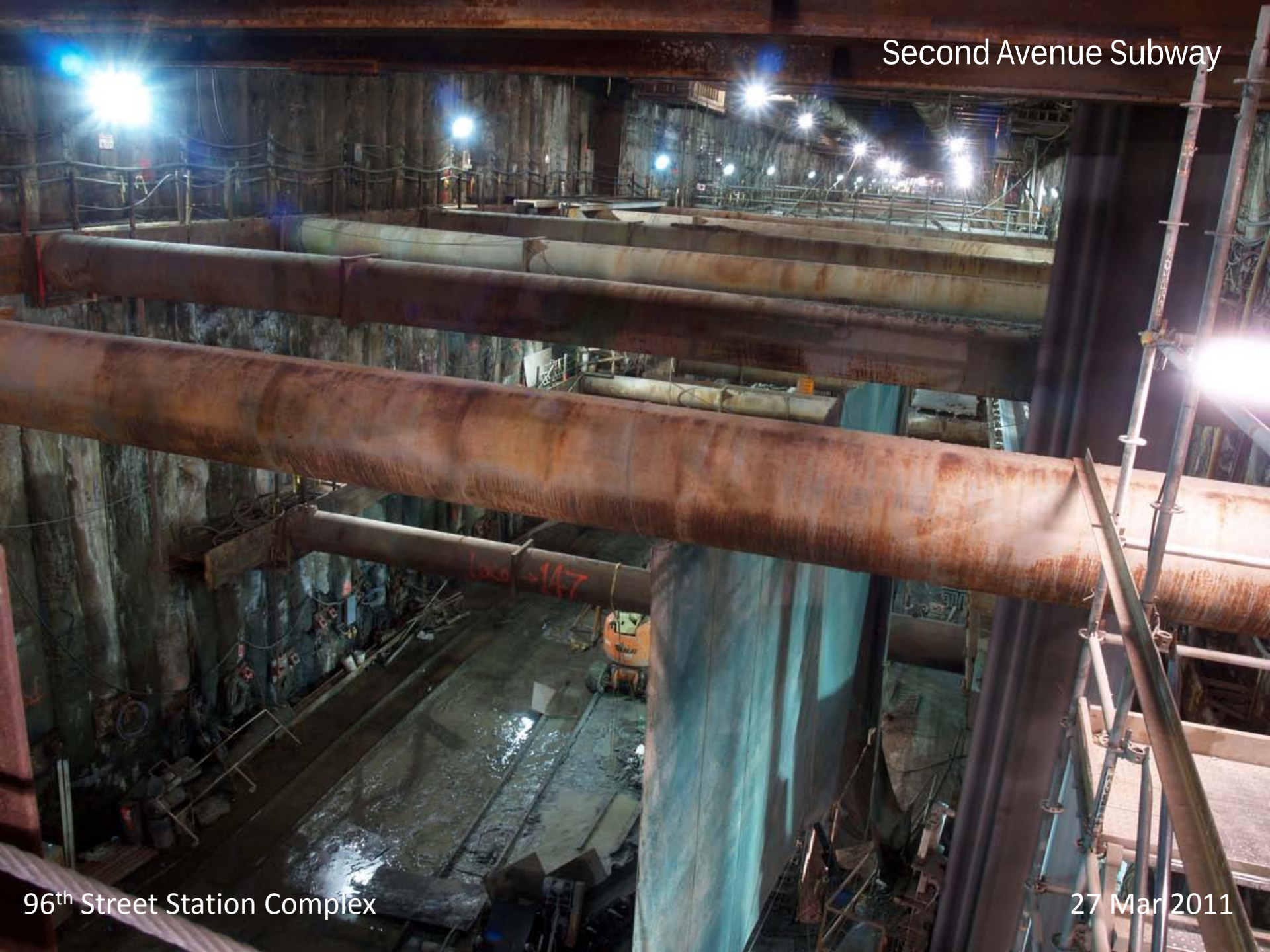
Phase 1 - Threading The Needle

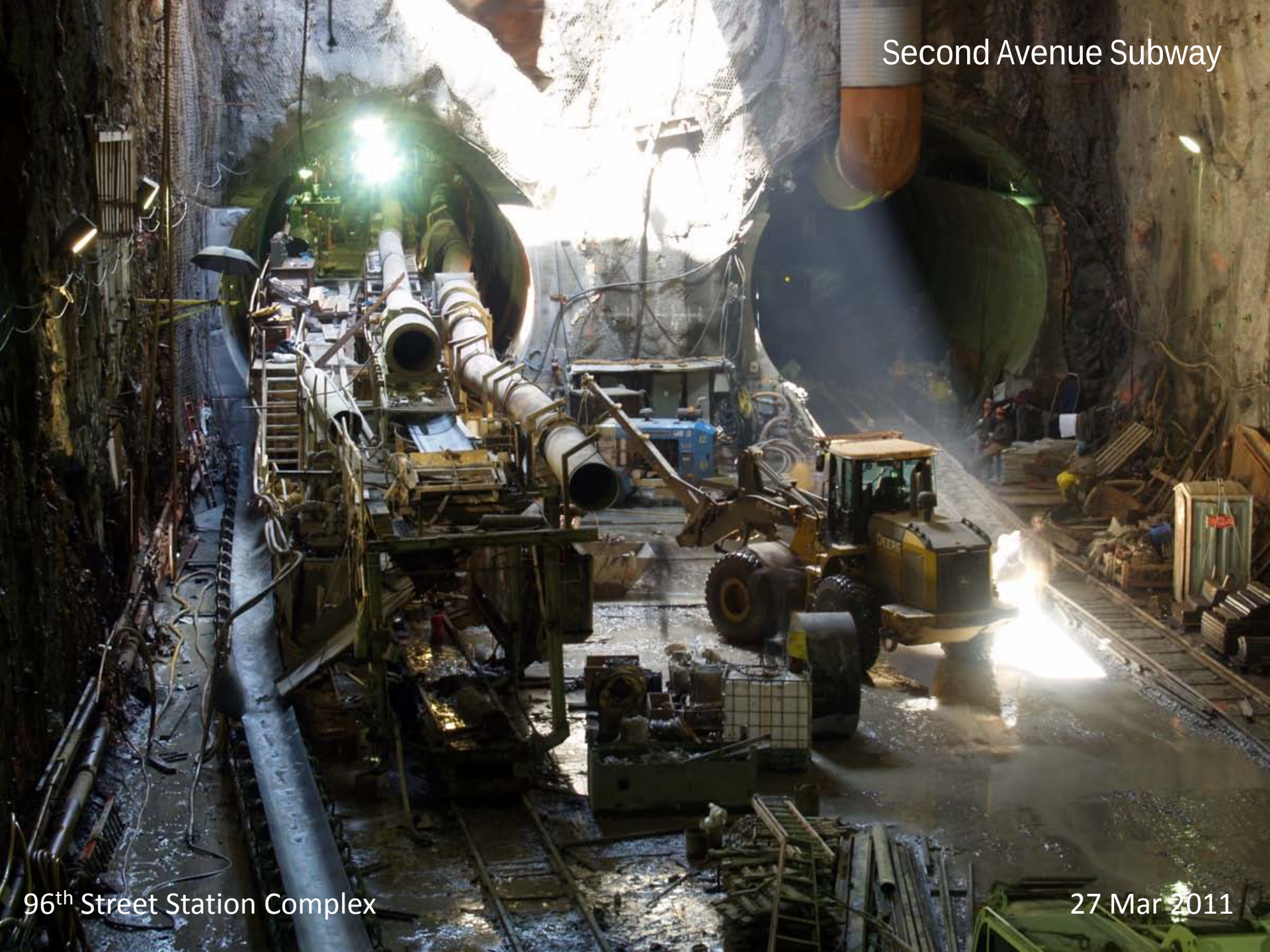




April 2010

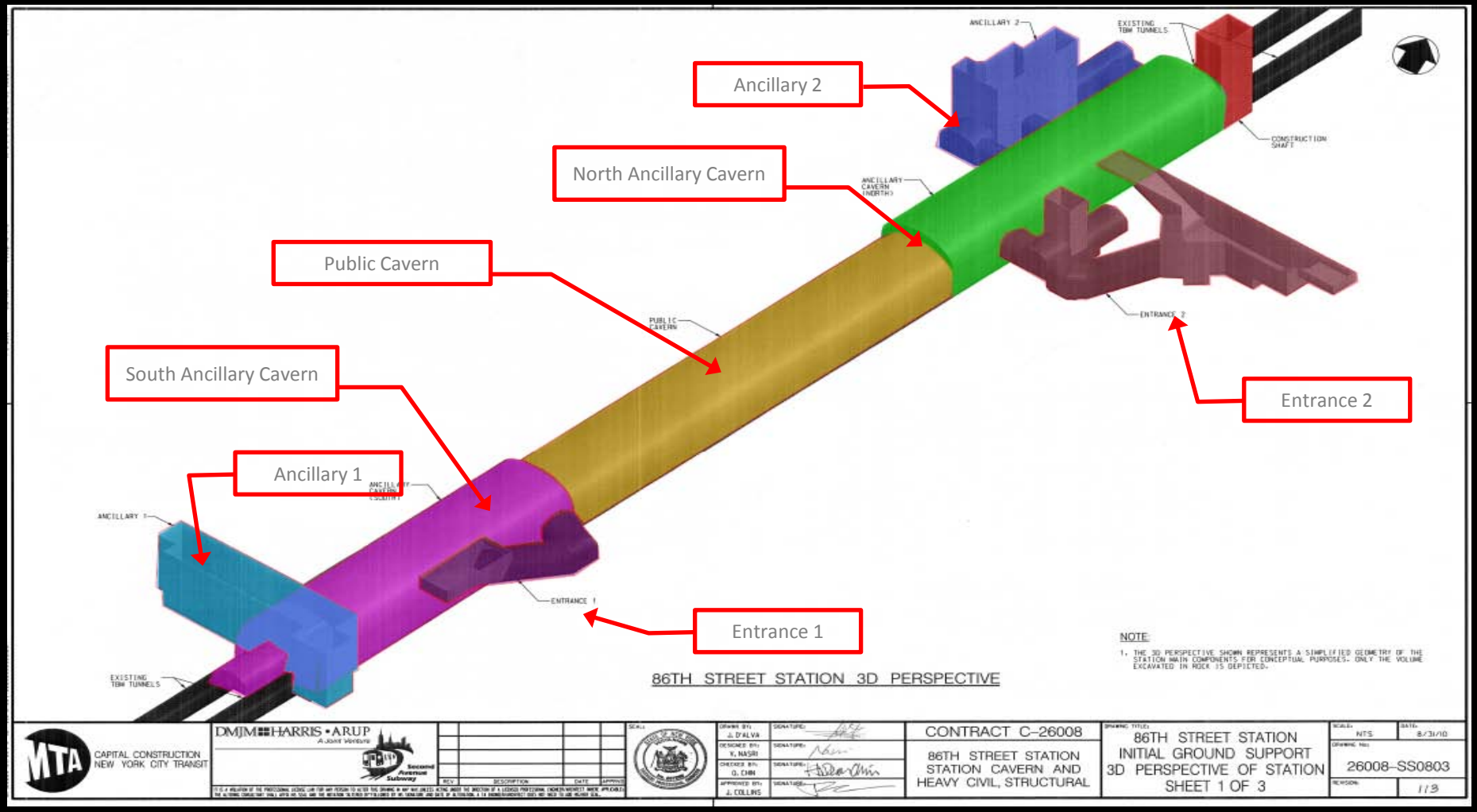
May 2010


Second Avenue Subway
96th Street Station Complex
27 Mar 2011


Second Avenue Subway
96th Street Station Complex
27 Mar 2011

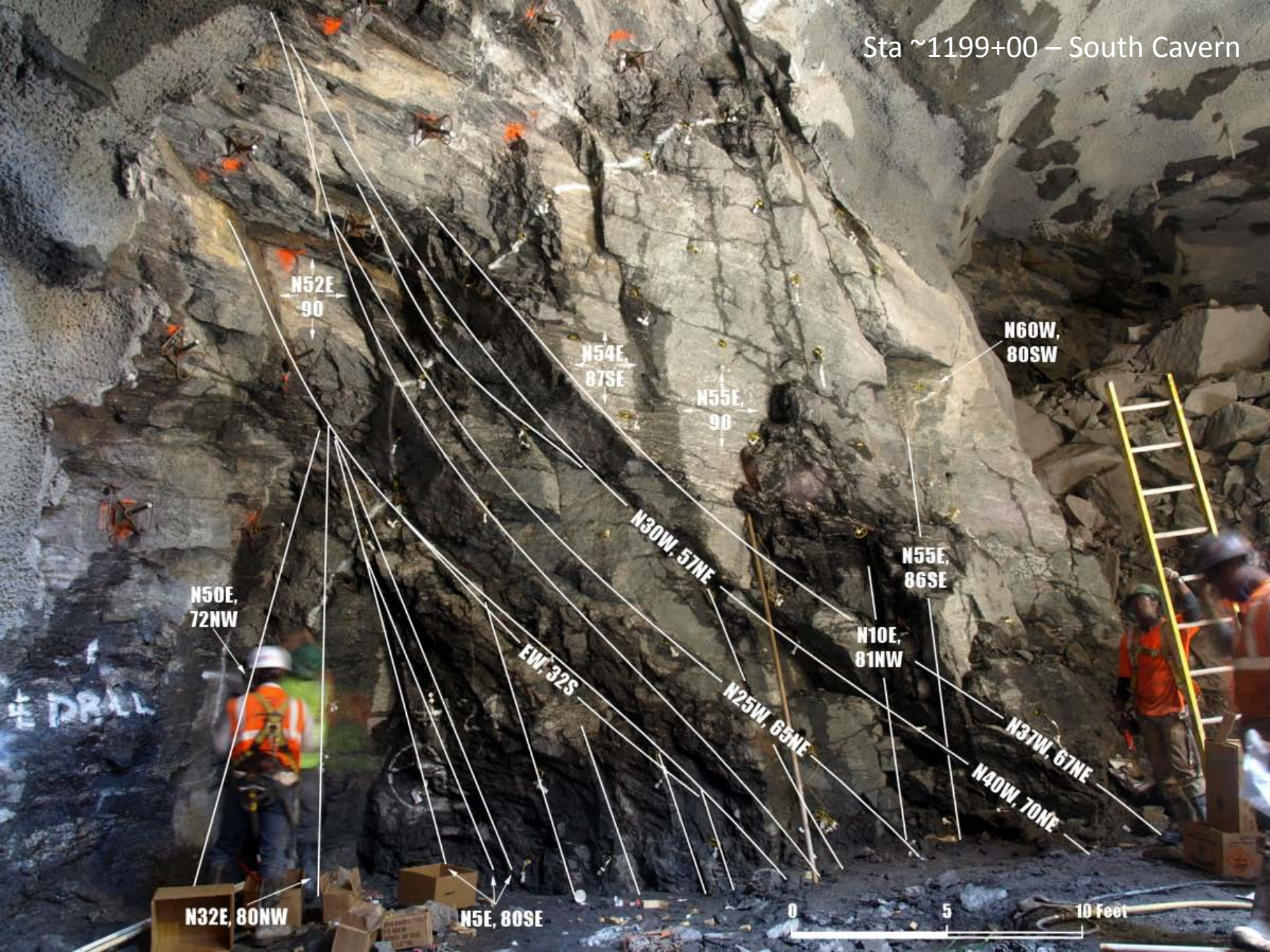

Second Avenue Subway
South Tube – Sta. 1172+80
27 Mar 2011

86th Street Station Cavern Excavation



Stations 1198+00 to 1209+00 = ~1,100’


Second Avenue Subway
Sta ~1199+00 – South Cavern
0
5
10 Feet

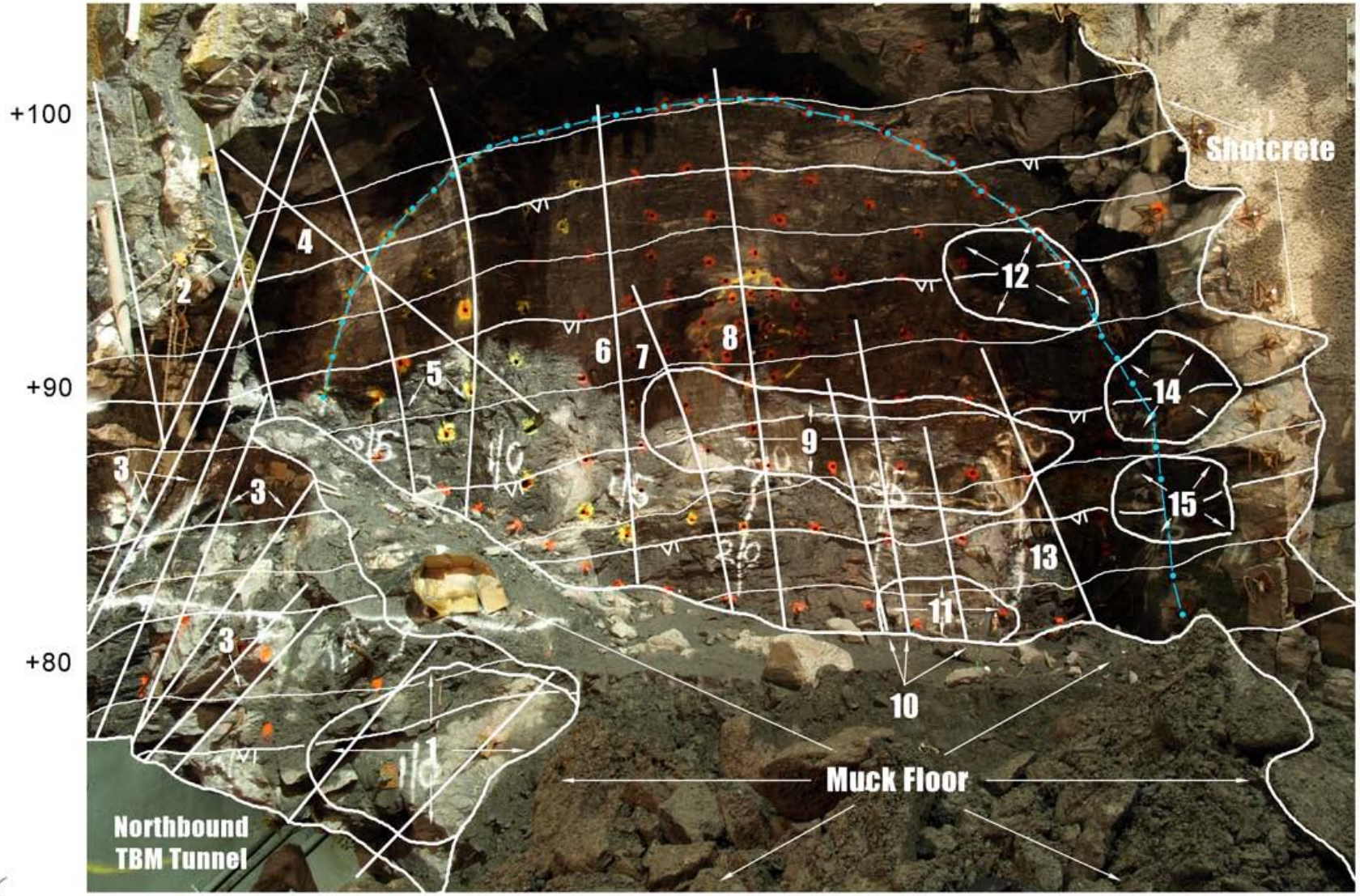

Sta ~1199+00 – South Cavern
N52E
90
N54E,
87SE
N55E,
90
N60W,
80SW
N30W, 57NE
N55E,
86SE
N50E,
72NW
N10E,
81NW
EW, 32S
N25W, 65NE
N37W, 67NE
N40W, 70NE
N32E, 80NW
N5E, 80SE
0
5
10 Feet

North Cavern

Finished North Ancillary and Public Cavern


Second Avenue Subway
Unfinished Public Cavern
Sta 1203+95


Second Avenue Subway
Sta 1198+75 – CIR Room



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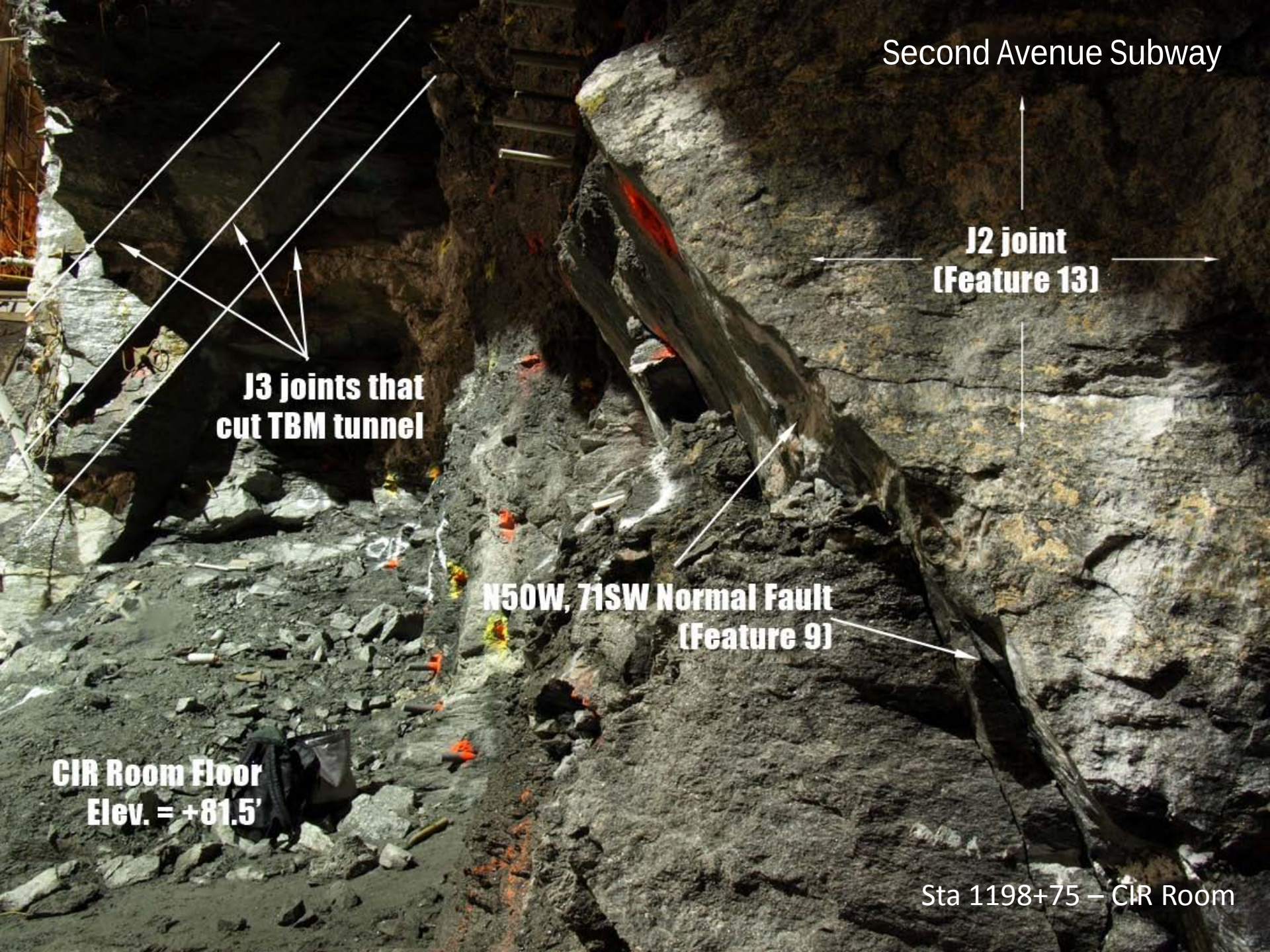
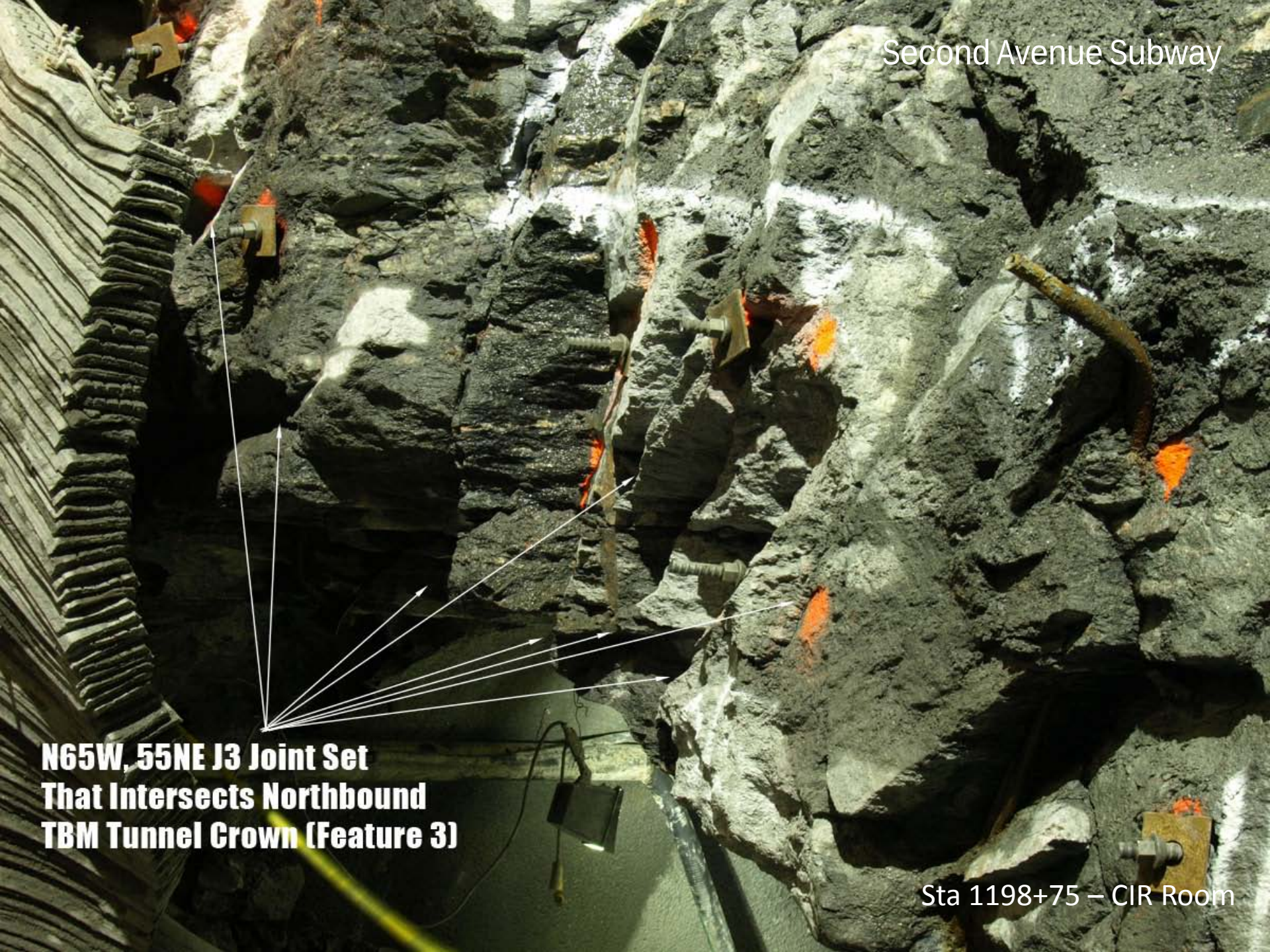
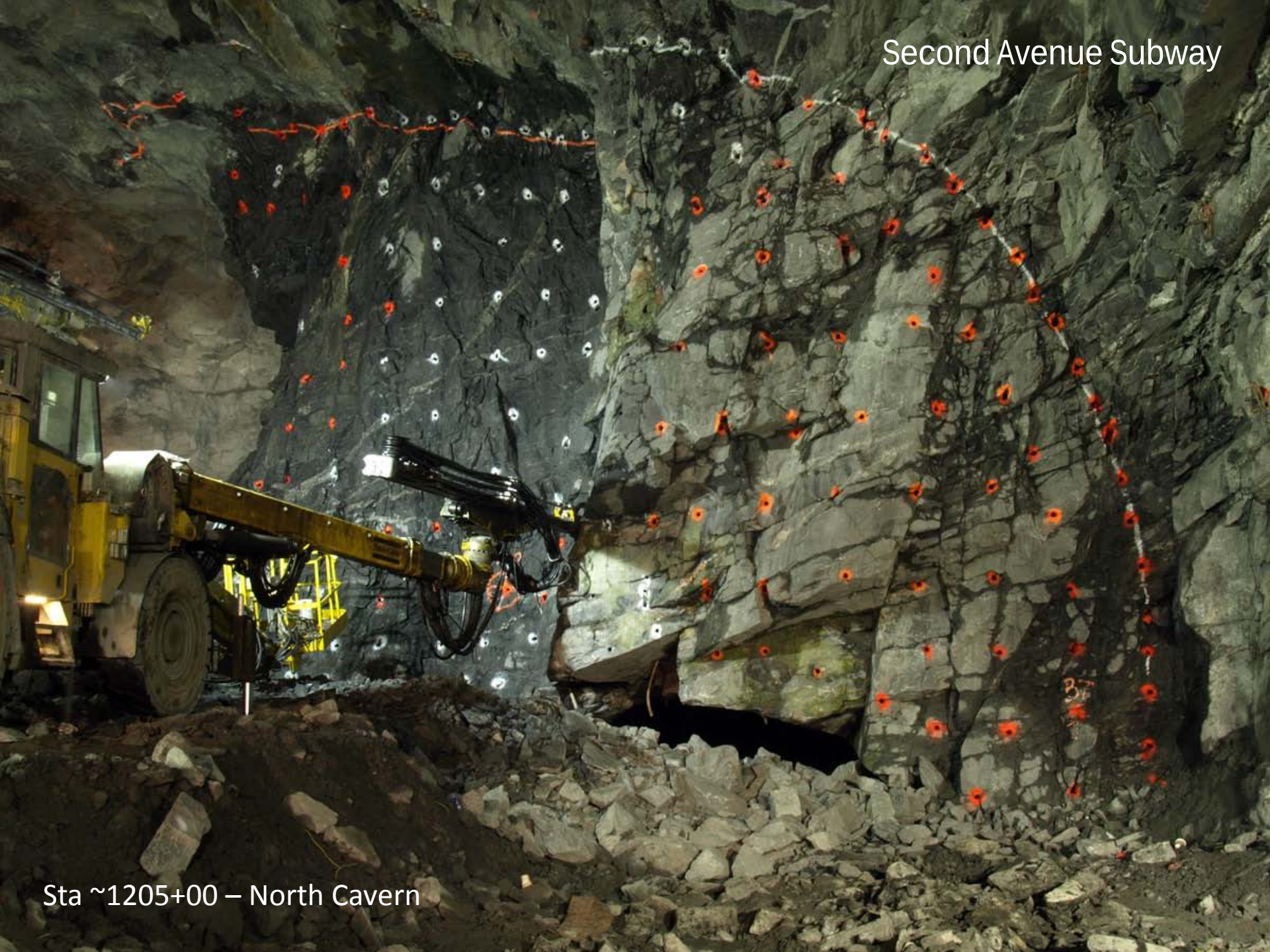
Mapped 28 February 2013


Second Avenue Subway
CIR Room Floor
Elev. = +81.5'
Sta 1198+75 – CIR Room


Second Avenue Subway
J2 joint
(Feature 13)
J3 joints that
cut TBM tunnel
N50W, 71SW Normal Fault
(Feature 9)
CIR Room Floor
Elev. = +81.5'
Sta 1198+75 – CIR Room

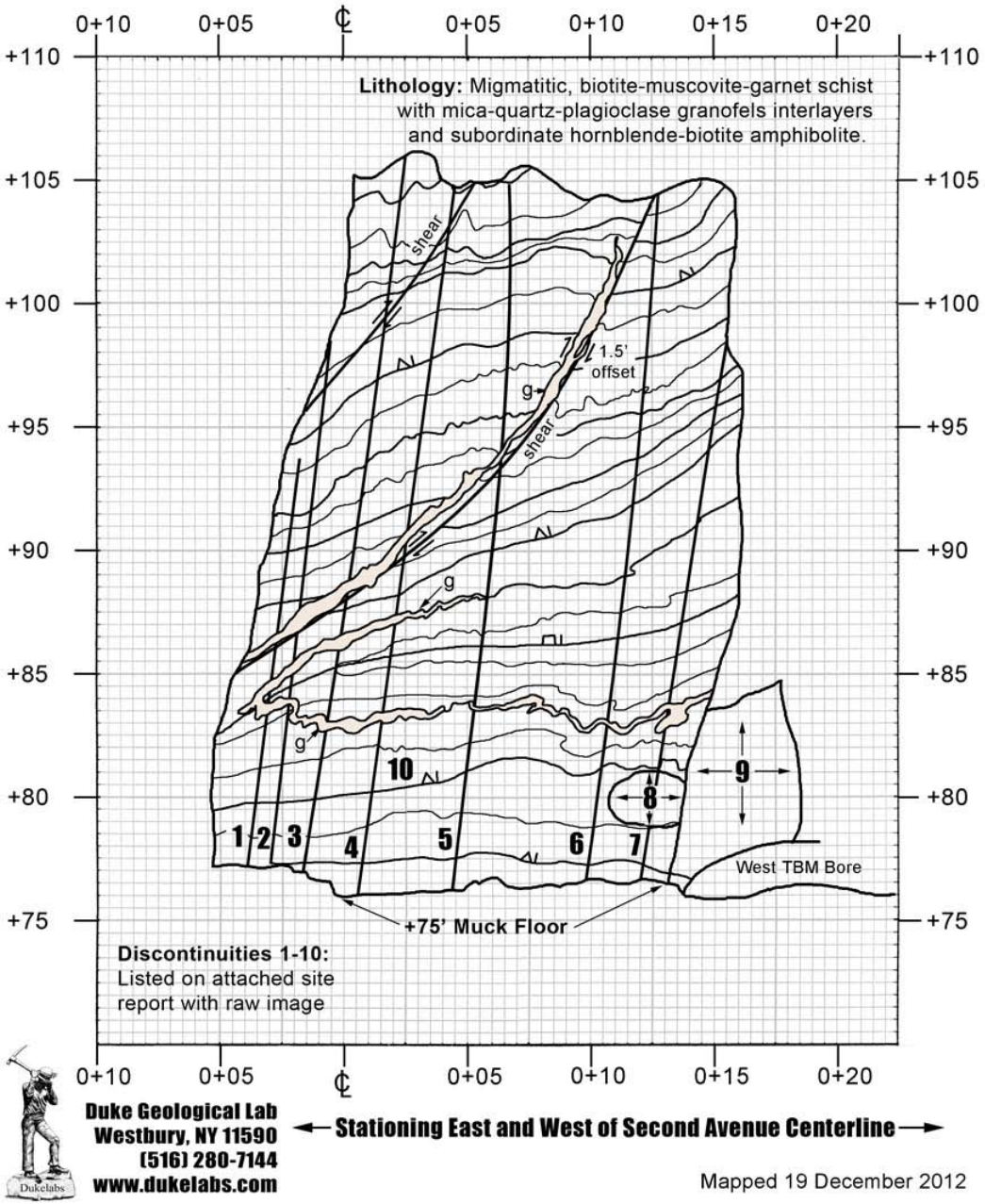

Second Avenue Subway
N65W, 55NE J3 Joint Set
That Intersects Northbound
TBM Tunnel Crown (Feature 3)
Sta 1198+75 – CIR Room


Second Avenue Subway
Sta ~1205+00 – North Cavern

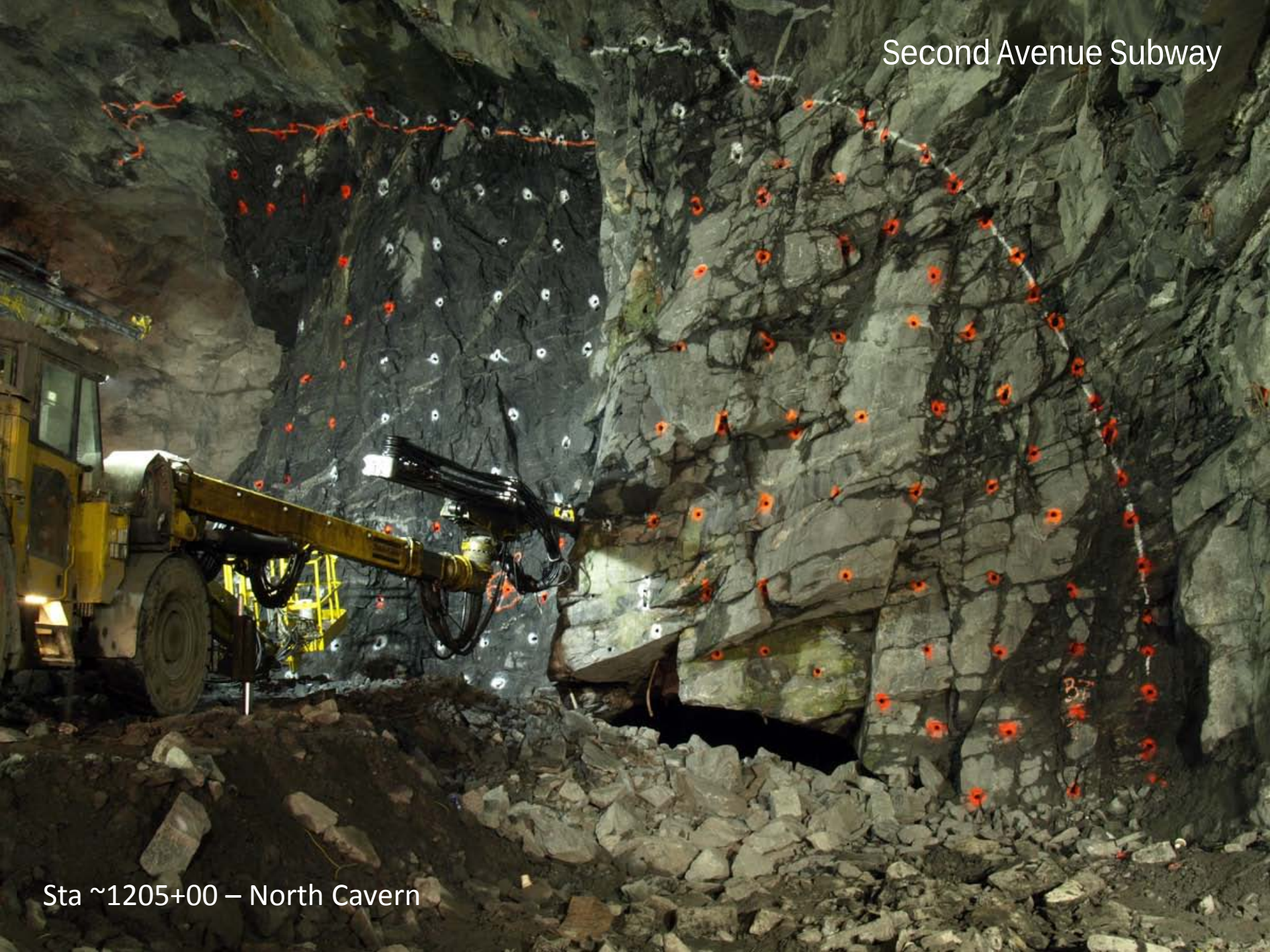
Second Avenue Subway

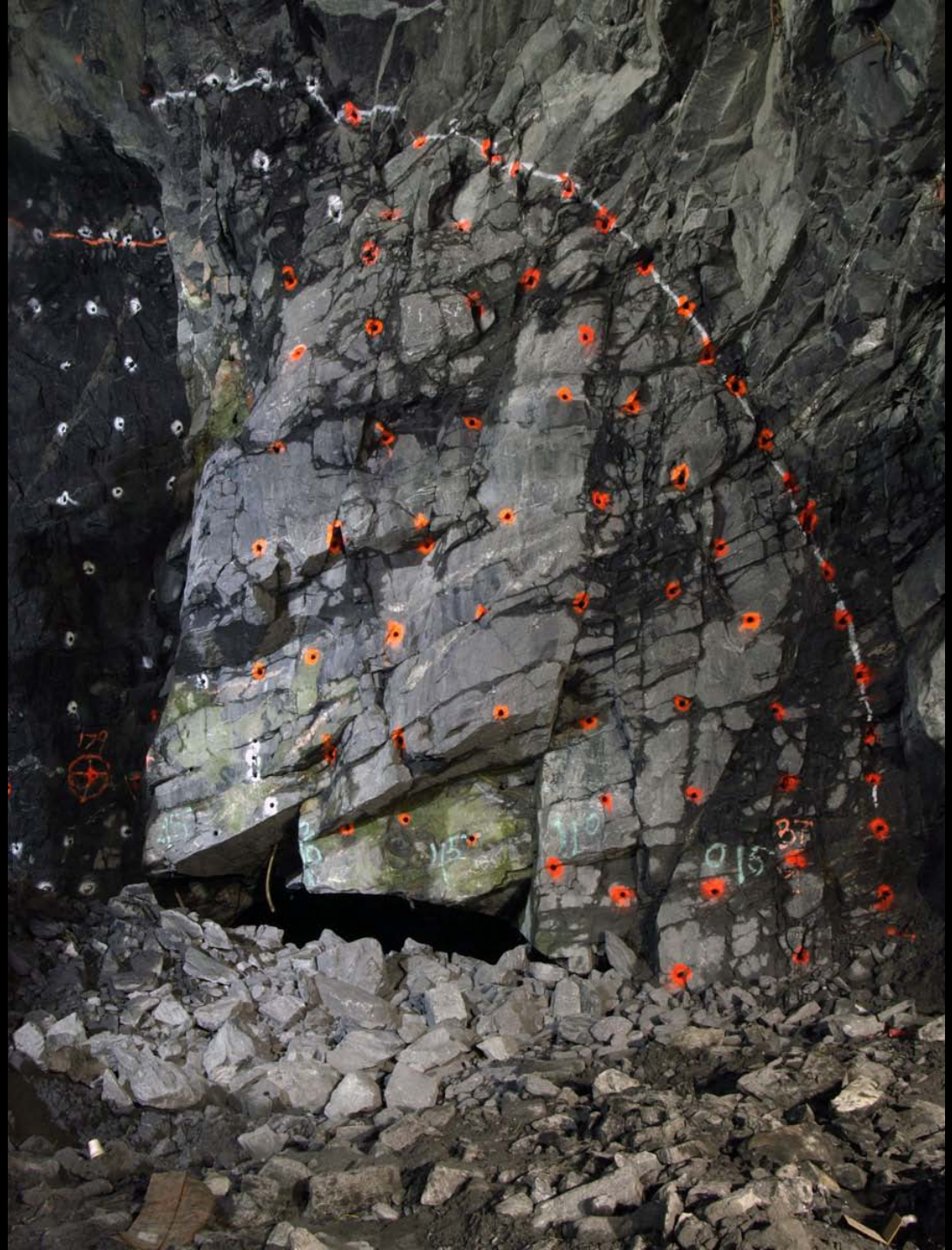
Sta 1204+90
North Cavern Center Slash

Second Avenue Subway



Sta 1204+90
North Cavern Center Slash

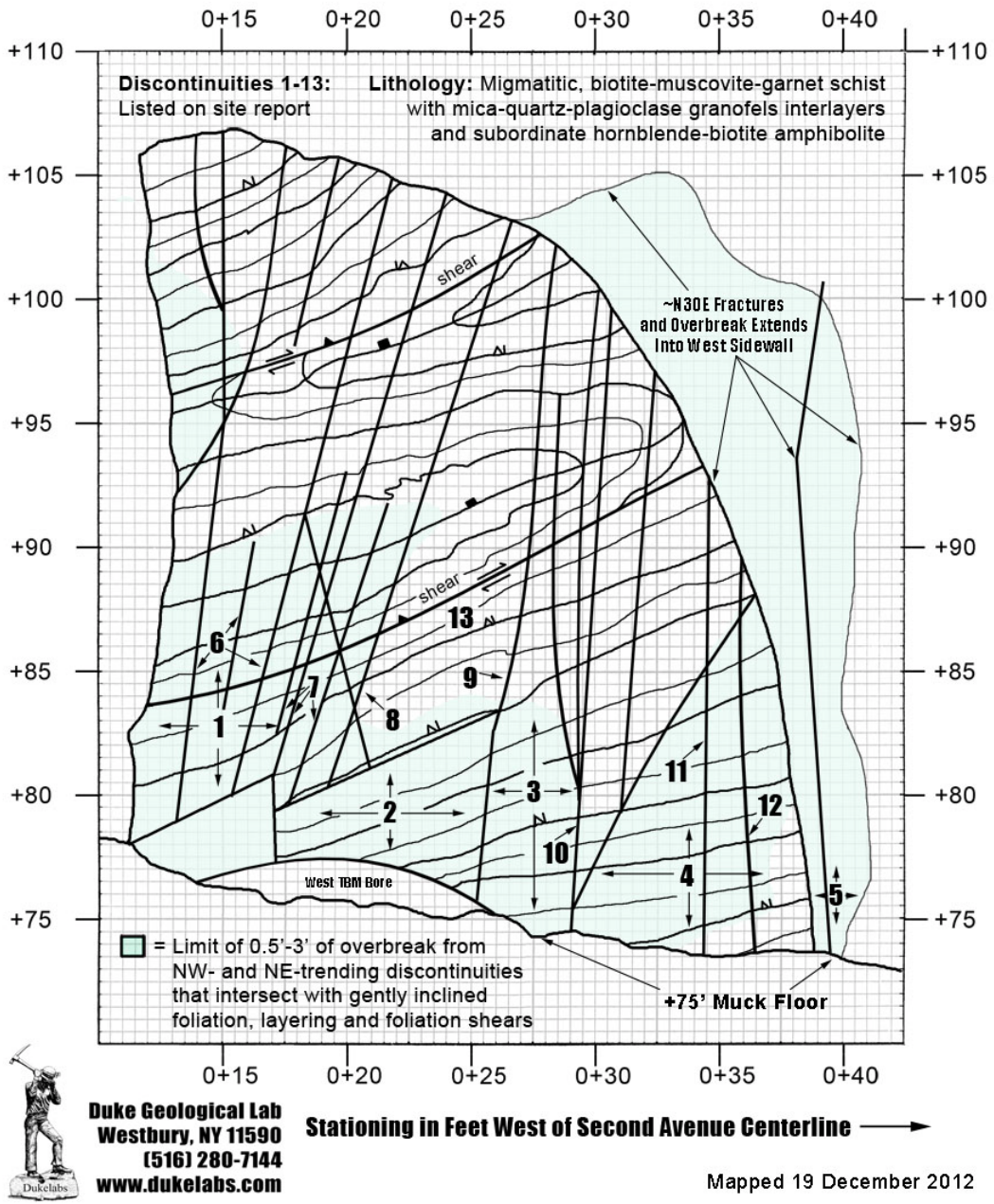

Second Avenue Subway
Sta ~1205+00 – North Cavern



Second Avenue Subway

Sta 1205+10 – North Cavern

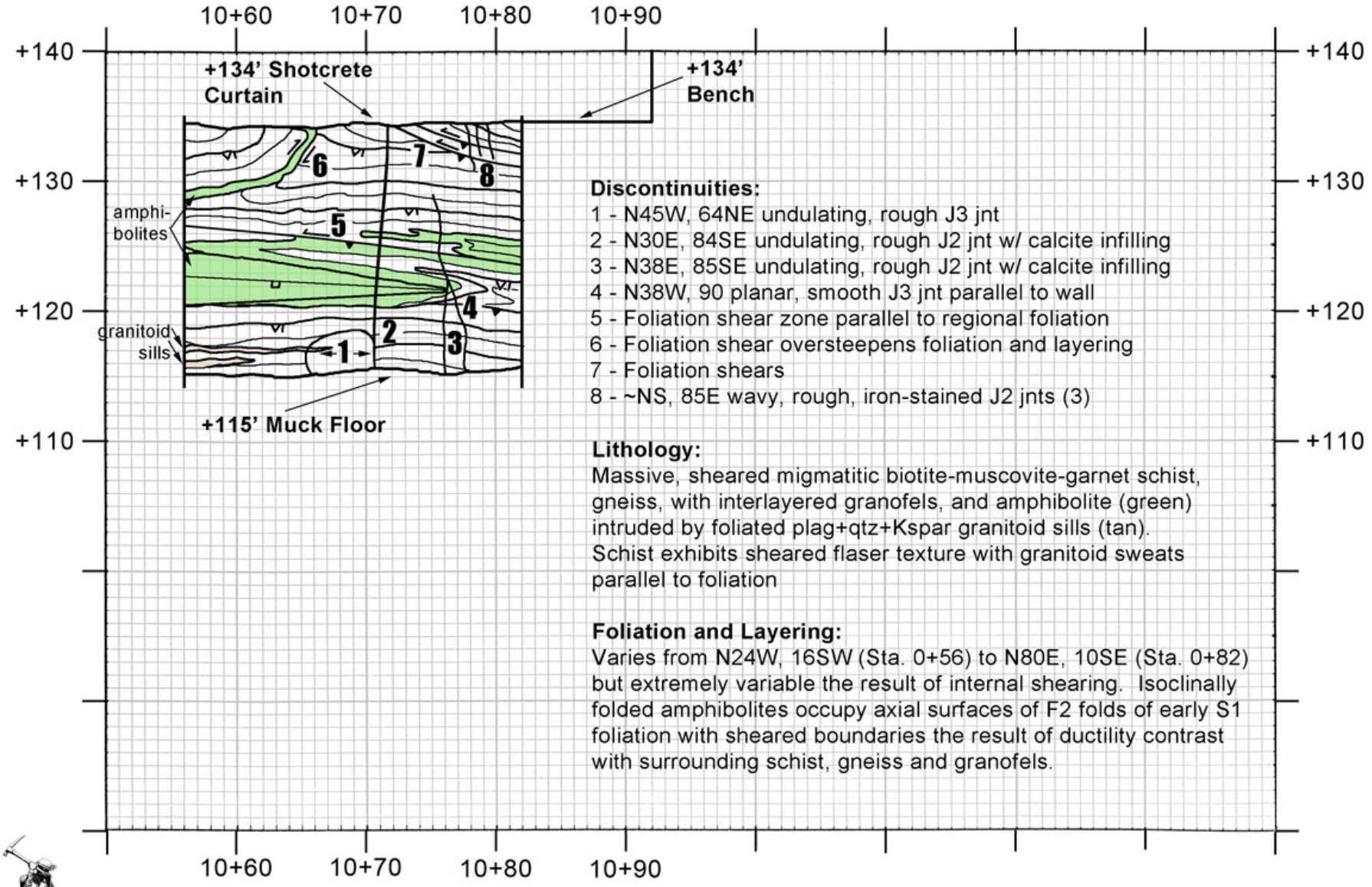
Second Avenue Subway



Sta 1205+10 – North Cavern


Second Avenue Subway
Sta 1205+10 – North Cavern

Second Avenue Subway - Elevator Shaft 86th Street, North Wall, Sta. 10+56 to 10+82 East of Centerline



Discontinuities:
1 - N45W, 64NE undulating, rough J3 jnt
2 - N30E, 84SE undulating, rough J2 jnt w/ calcite infilling
3 - N38E, 85SE undulating, rough J2 jnt w/ calcite infilling
4 - N38W, 90 planar, smooth J3 jnt parallel to wall
5 - Foliation shear zone parallel to regional foliation
6 - Foliation shear oversteepens foliation and layering
7 - Foliation shears
8 - ~NS, 85E wavy, rough, iron-stained J2 jnts (3)

Lithology:
Massive, sheared migmatitic biotite-muscovite-garnet schist, gneiss, with interlayered granofels, and amphibolite (green) intruded by foliated plag+qtz+Kspar granitoid sills (tan). Schist exhibits sheared flaser texture with granitoid sweats parallel to foliation

Foliation and Layering:
Varies from N24W, 16SW (Sta. 0+56) to N80E, 10SE (Sta. 0+82) but extremely variable the result of internal shearing. Isoclinally folded amphibolites occupy axial surfaces of F2 folds of early S1 foliation with sheared boundaries the result of ductility contrast with surrounding schist, gneiss and granofels.

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Stationing in Feet East of 86th Street Centerline →

Sta 1206+62 – Elevator Shaft

Mapped 21 January 2013


Second Avenue Subway
Sta 1206+62 – Elevator Shaft


Second Avenue Subway
Sta 1206+62 – Elevator Shaft

Second Avenue Subway
86th Street Station Complex
Ancillary #2

06 Nov 2012

Second Avenue Subway
86th Street Ancillary #2
Southward View of South Wall
Elevation +155' to +133'

Plate 2

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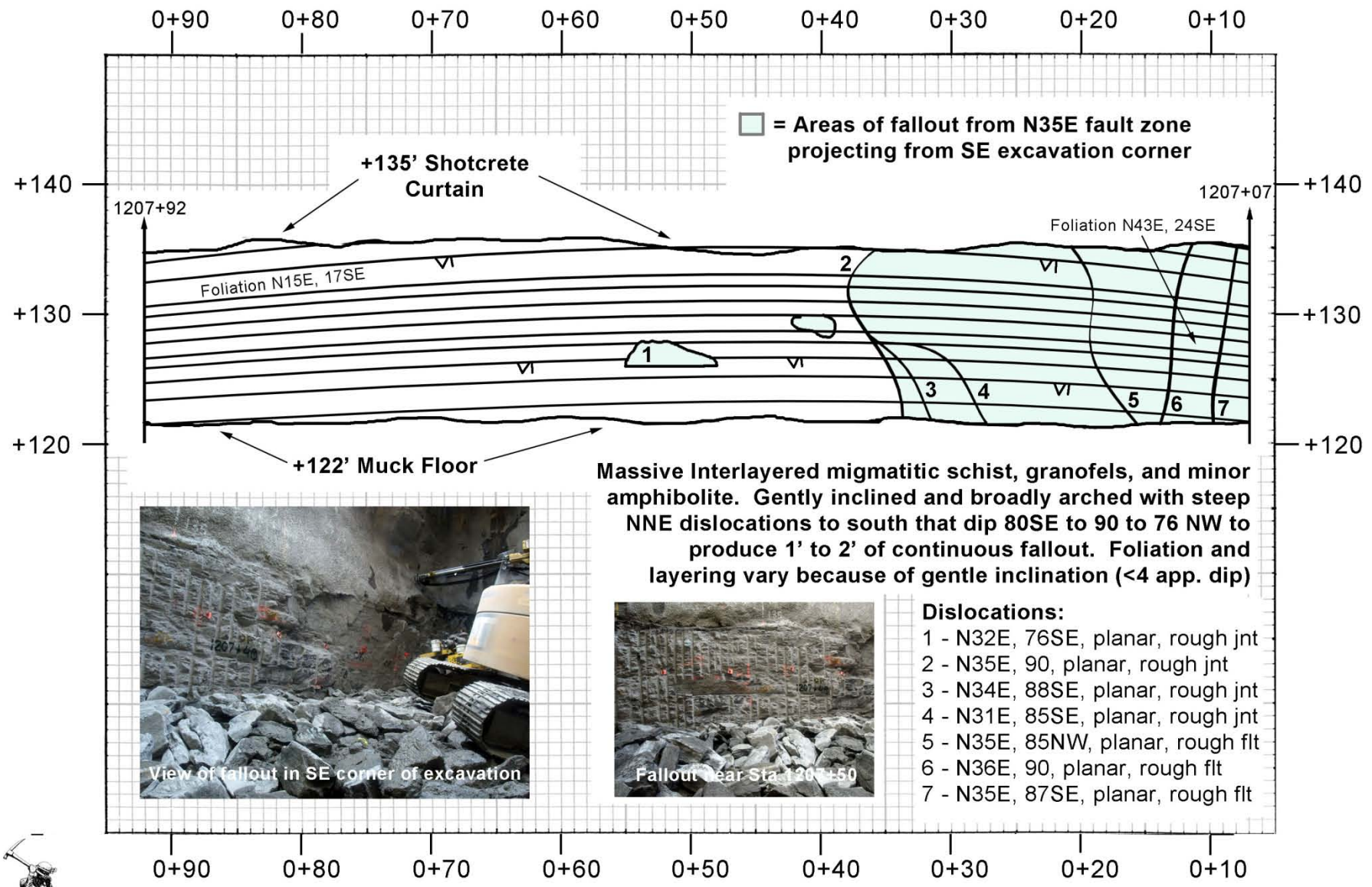
Second Avenue Subway - Ancillary #2 East Wall (Sta. 1207+07 to 1207+92); Elev. +135' to +122'



Massive Interlayered migmatitic schist, granofels, and minor amphibolite. Gently inclined and broadly arched with steep NNE dislocations to south that dip 80SE to 90 to 76 NW to produce 1' to 2' of continuous fallout. Foliation and layering vary because of gentle inclination (<4 app. dip)

View of fallout in SE corner of excavation

Fallout near Sta 1207+50

Dislocations:

1 - N32E, 76SE, planar, rough jnt
2 - N35E, 90, planar, rough jnt
3 - N34E, 88SE, planar, rough jnt
4 - N31E, 85SE, planar, rough jnt
5 - N35E, 85NW, planar, rough flt
6 - N36E, 90, planar, rough flt
7 - N35E, 87SE, planar, rough flt

Stationing in Feet North Along East Wall

(Map Drawn Parallel to Sta 0+50 West of Second Avenue Centerline)

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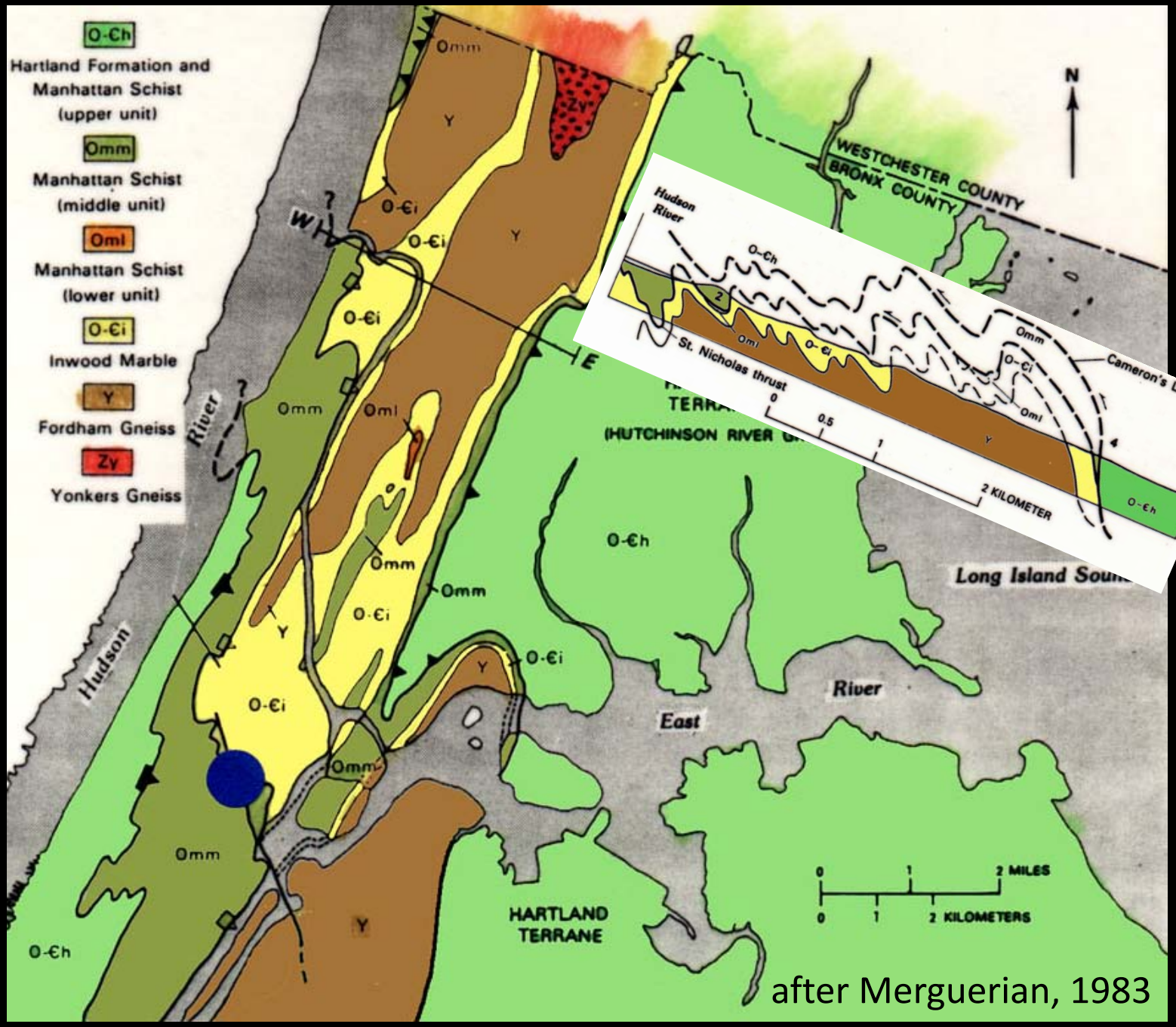
Mapped 21 November 2012

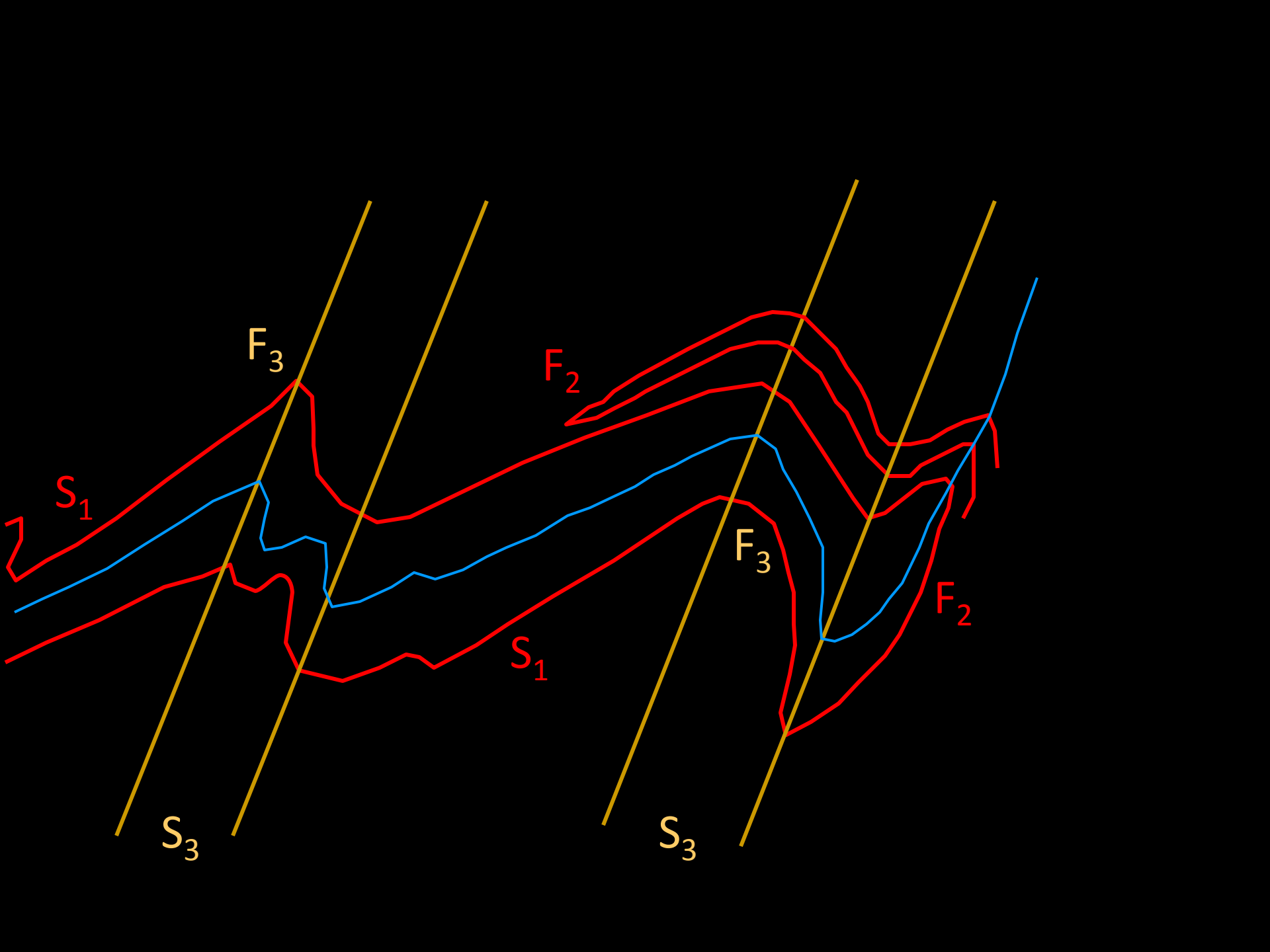
Sta 1207+50 – Ancillary #2 West Wall


Second Avenue Subway
Sta 1207+50 – Ancillary #2 West Wall

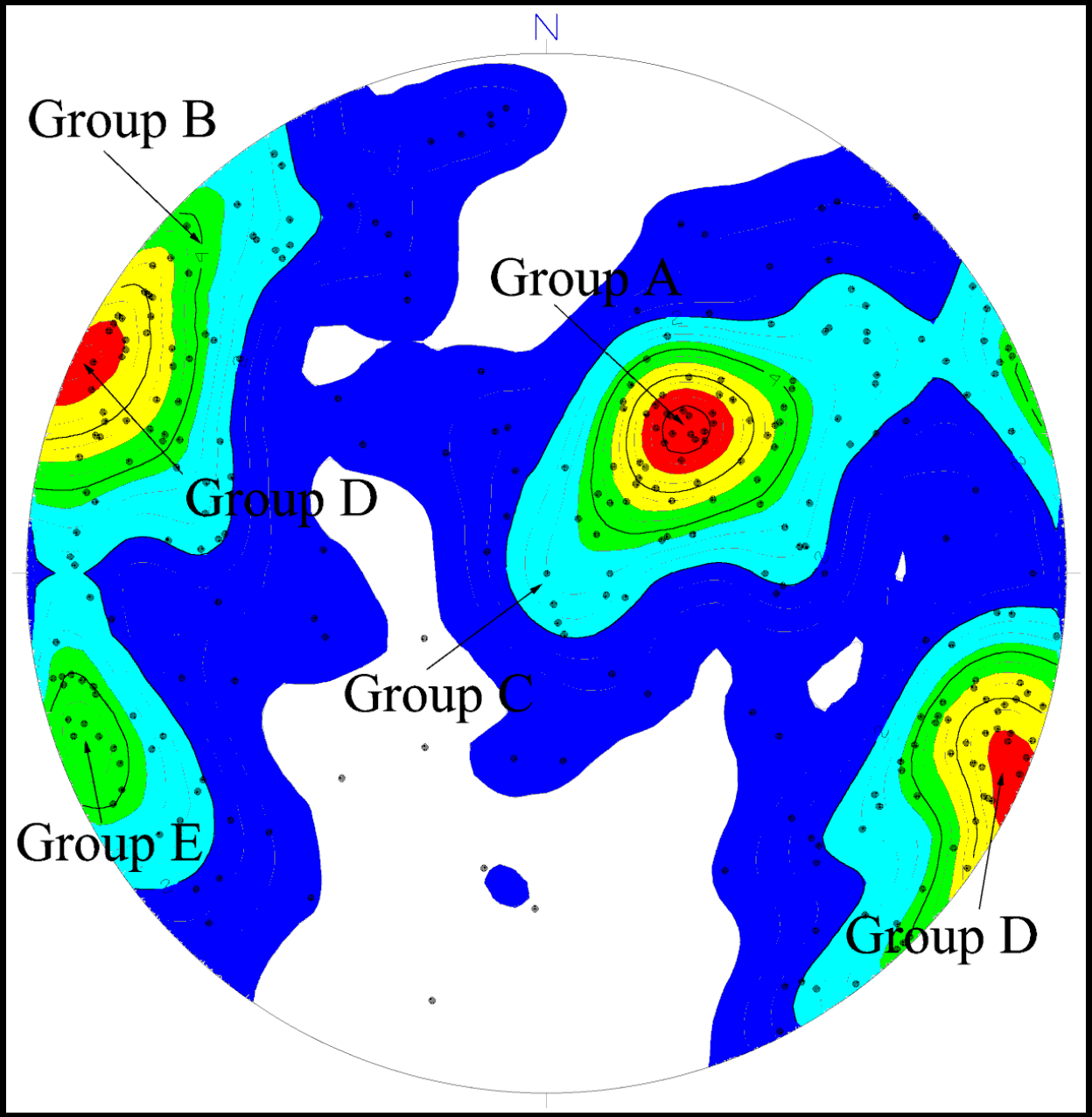

O-Ch
Hartland Formation and Manhattan Schist (upper unit)
Omm
Manhattan Schist (middle unit)
Oml
Manhattan Schist (lower unit)
O-€i
Inwood Marble
Y
Fordham Gneiss
Zy
Yonkers Gneiss
N
WESTCHESTER COUNTY
BRONX COUNTY
Hudson River
O-Ch
Oml
O-€i
St. Nicholas thrust
Omm
Cameron's Line
0
0.5
1
2 KILOMETER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

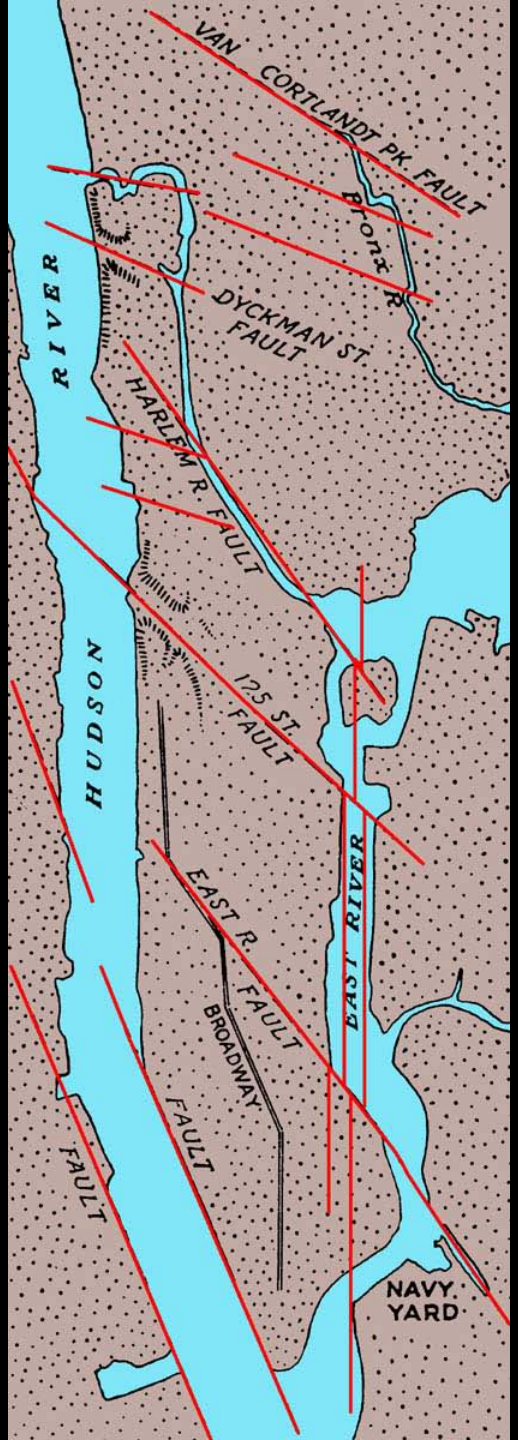
Polydeformed Bedrock – Central Park, NYC

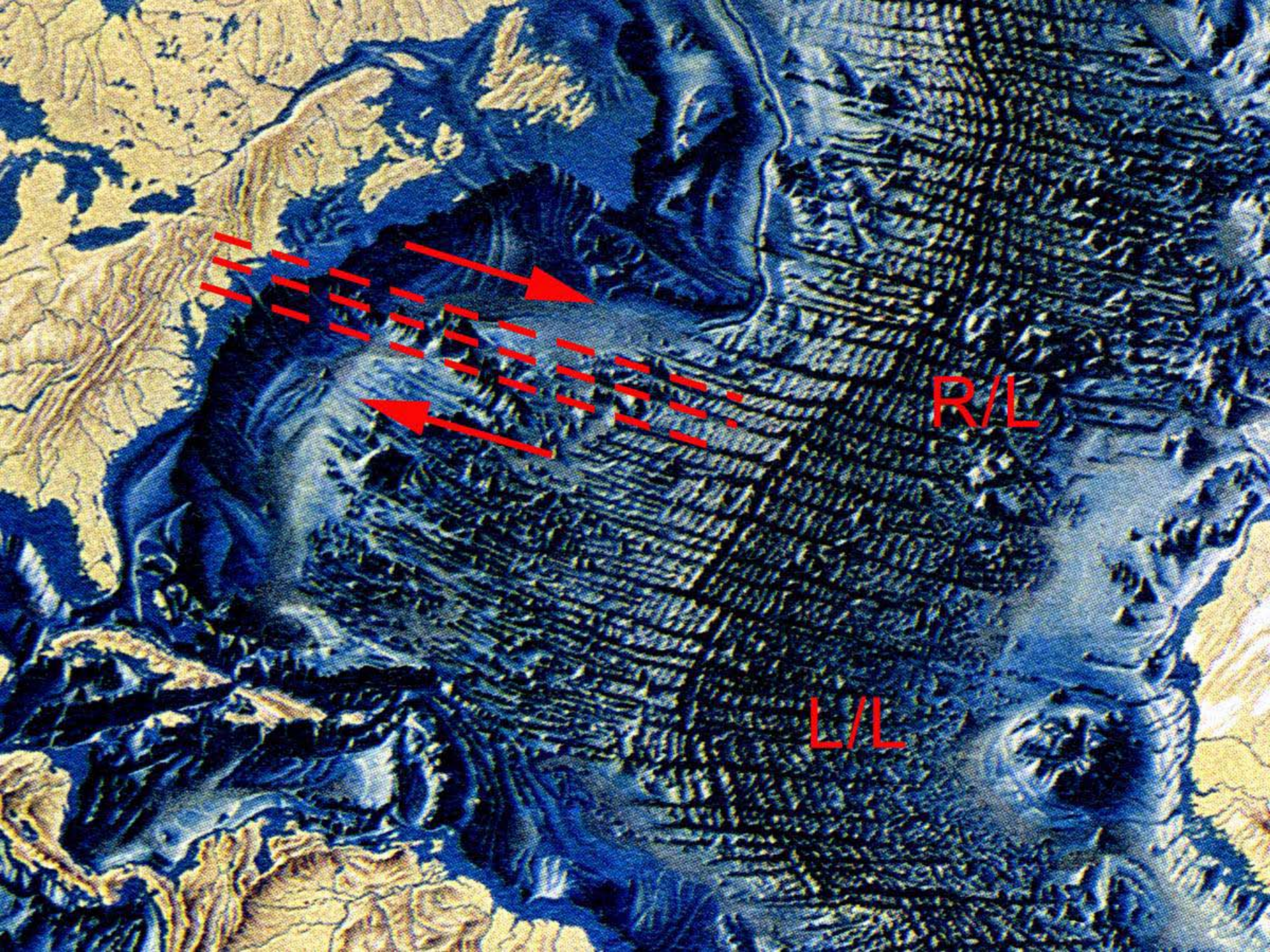
Polydeformed Bedrock – Central Park, NYC


F3
F2
S1
S3
F3
F2
S1
S3

NYC Faults and Joints




VAN CORTLANDT PK. FAULT
Bronx R.
DYCKMAN ST. FAULT
HARLEM R. FAULT
125 ST. FAULT
EAST R. FAULT
BROADWAY FAULT
FAULT
HUDSON RIVER
EAST RIVER
NAVY YARD


R/L
L/L


OK, That's It! I've Heard Enough!
H. Manne