Megaconstruction Projects in New York City

Charles Merguerian





Merguerian's Early Field Work on Manhattan Island

In The Days When He Was Limber

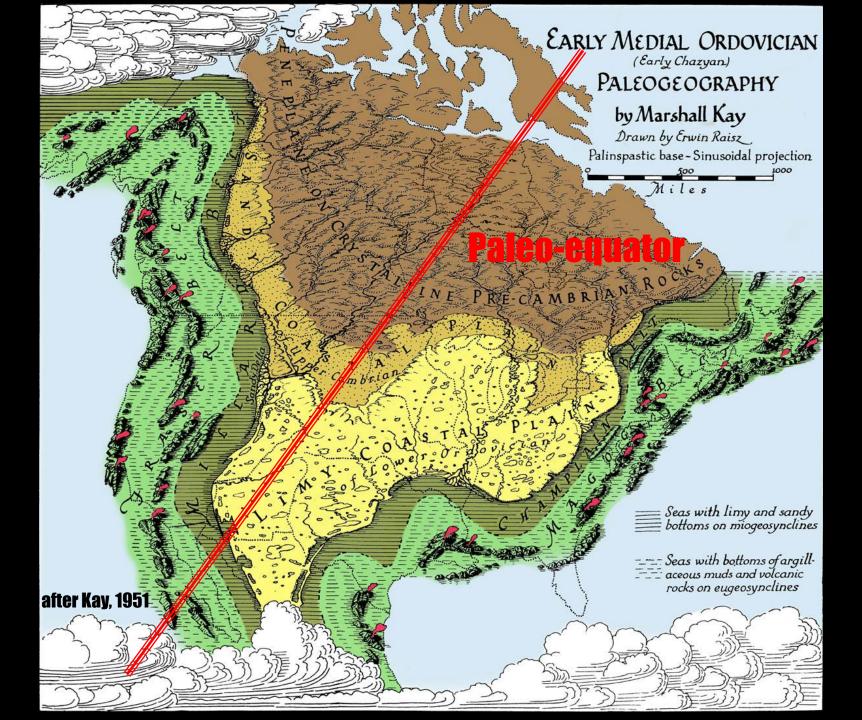


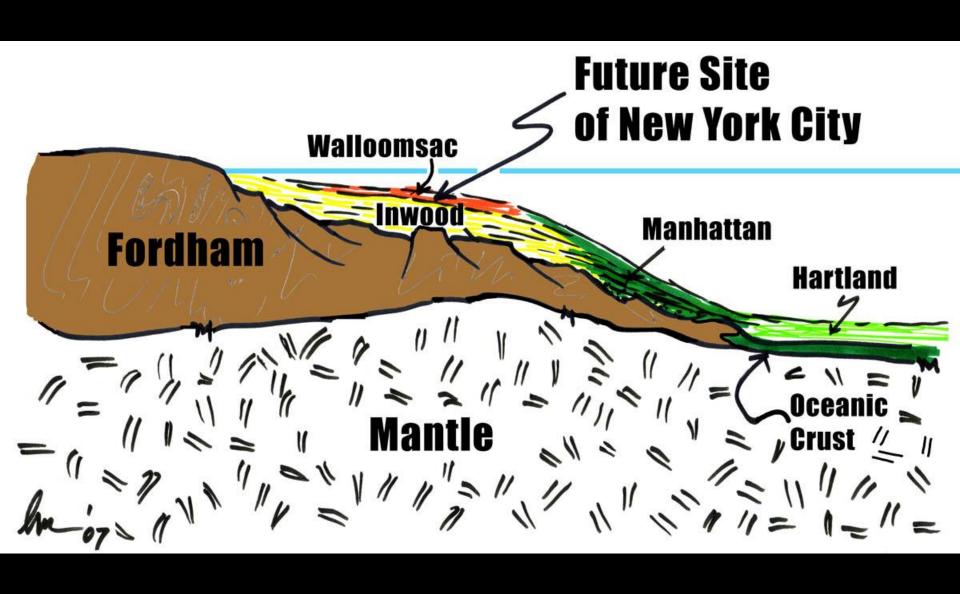




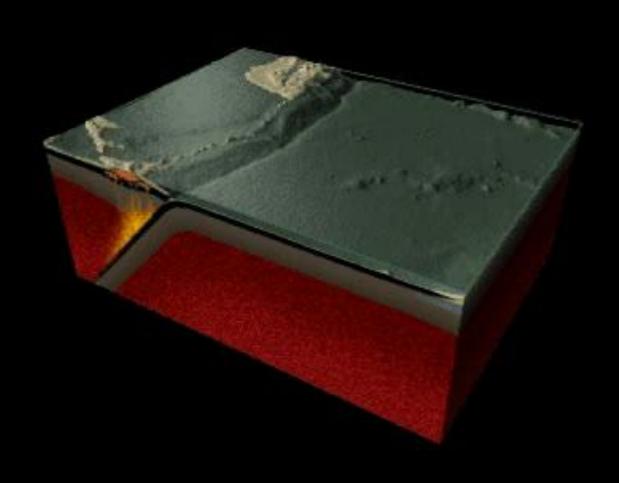
Merguerian Has Spent Most of his Career Mapping the Surface and Subsurface Geology of NYC

> Proper Field Attire For NYC

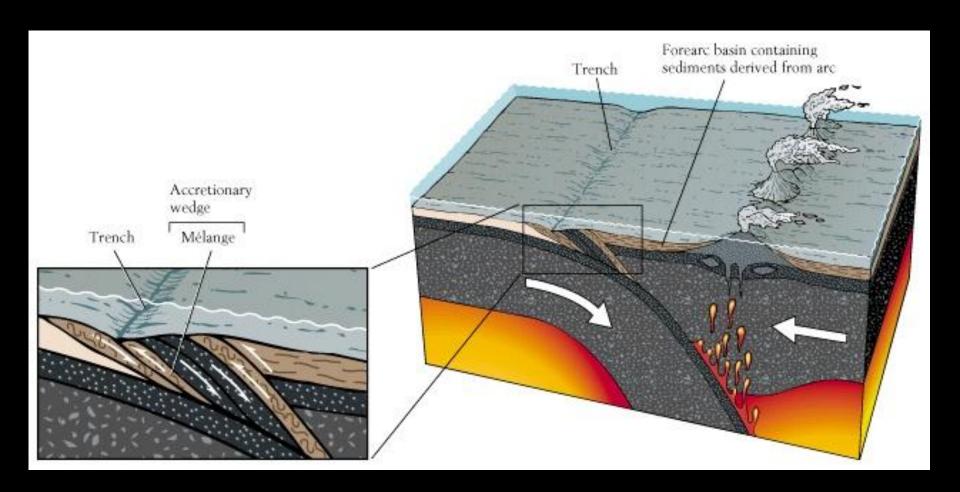


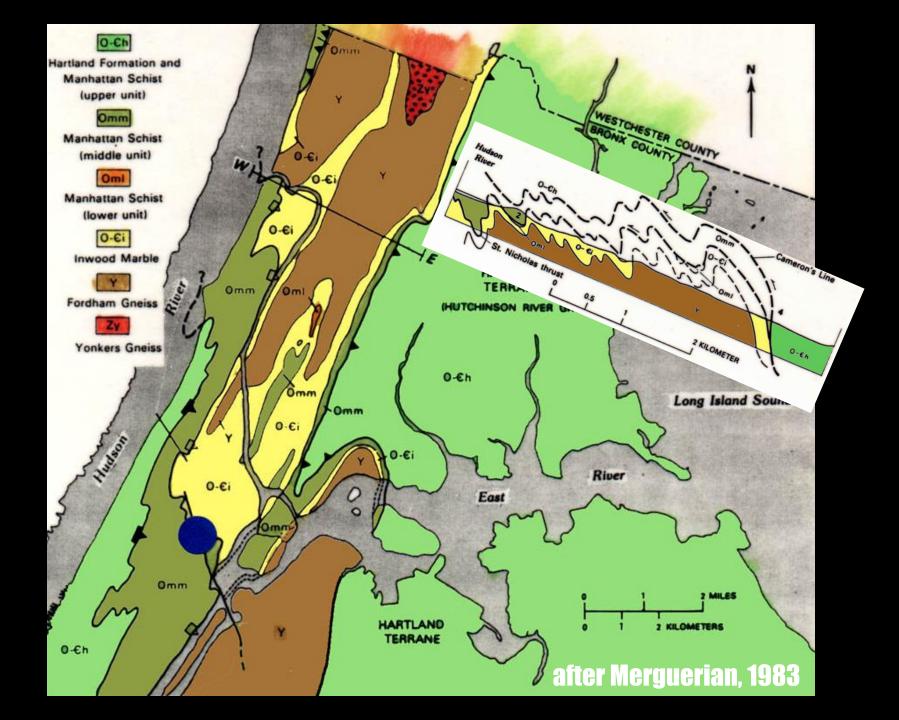


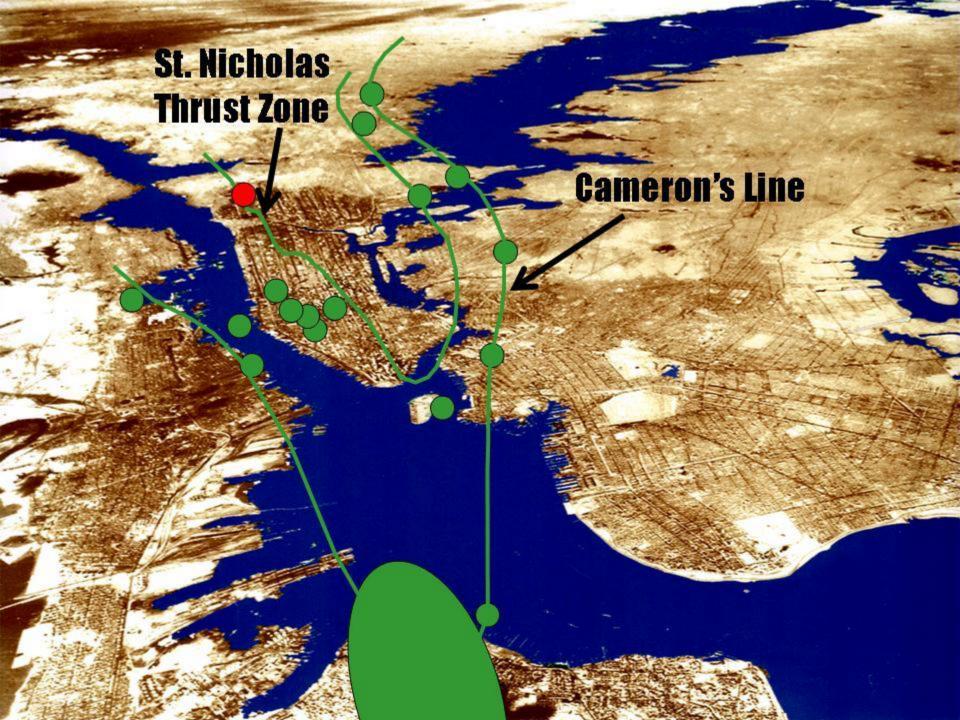
~ 450 Ma Taconic Arc — Passive Margin Collision

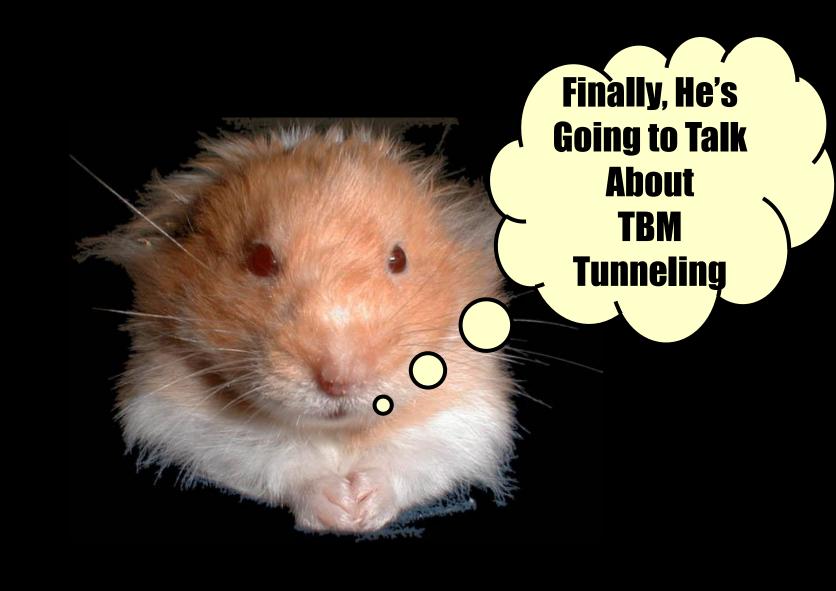


Taconian Accretionary Prism















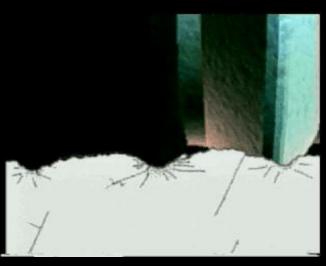
Holing Through North Tunnel, Hudson Tubes, French Line Dock (1904)

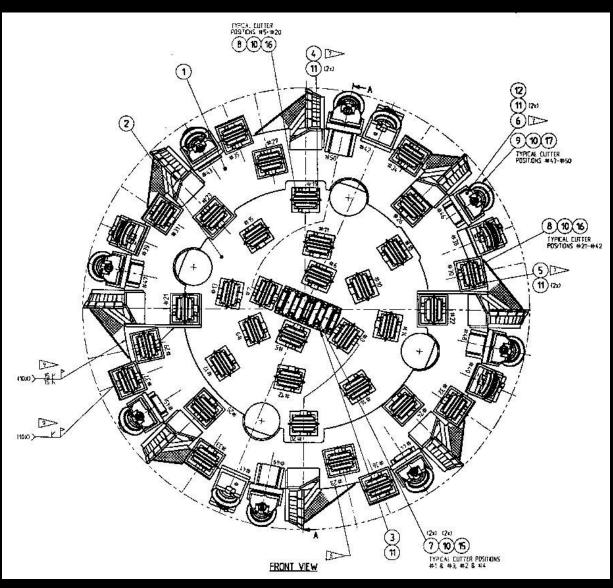


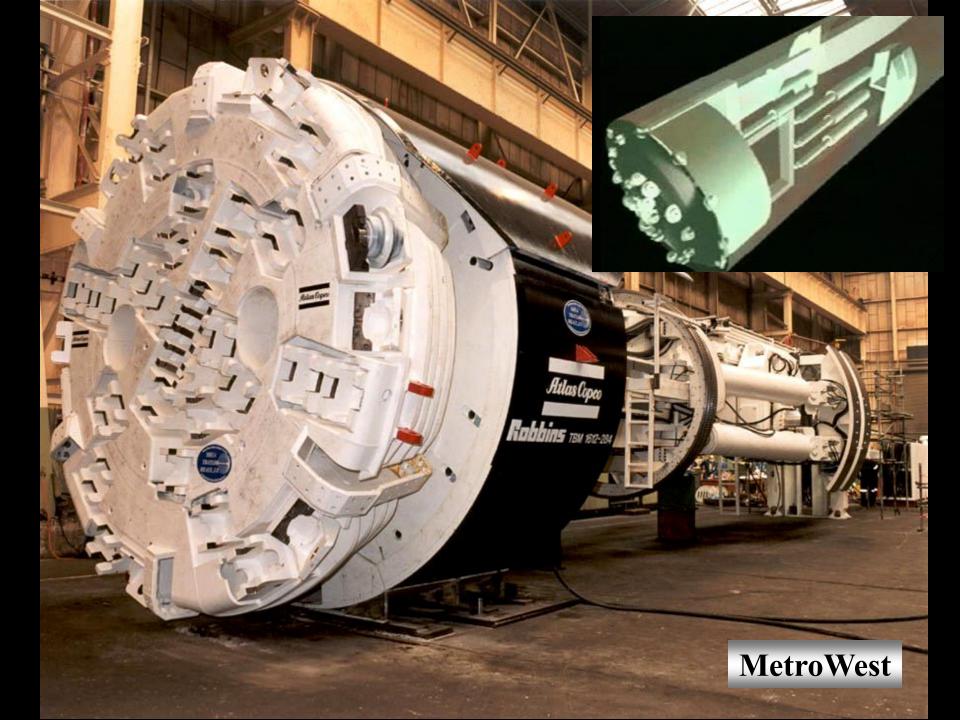


TBM Chip Production

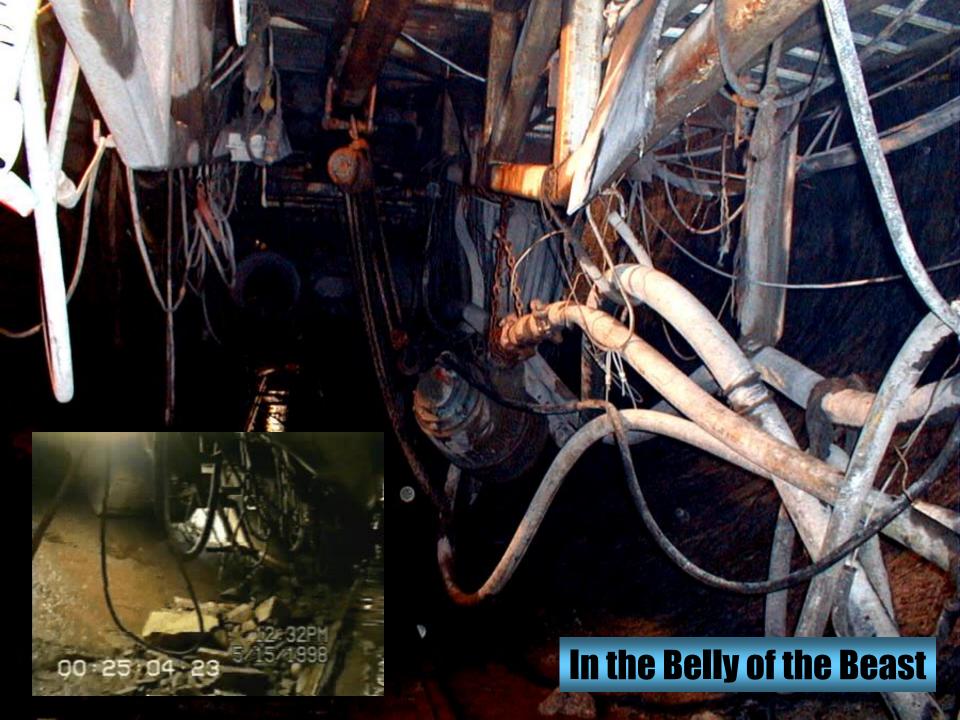












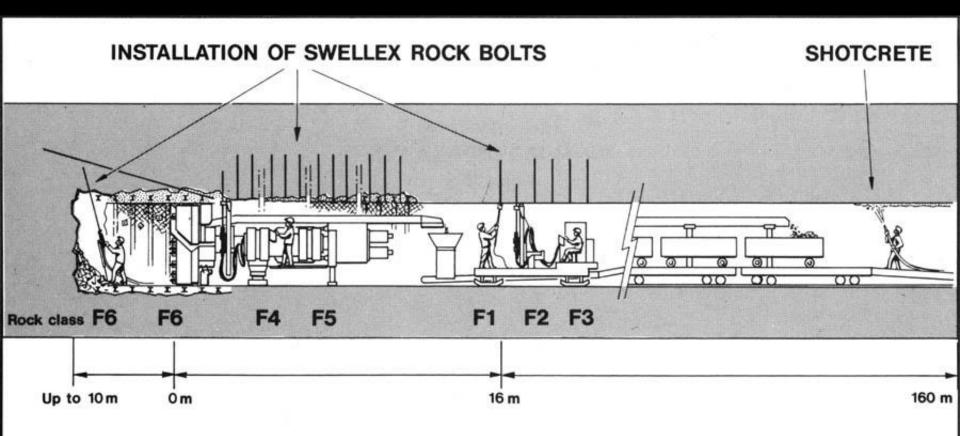


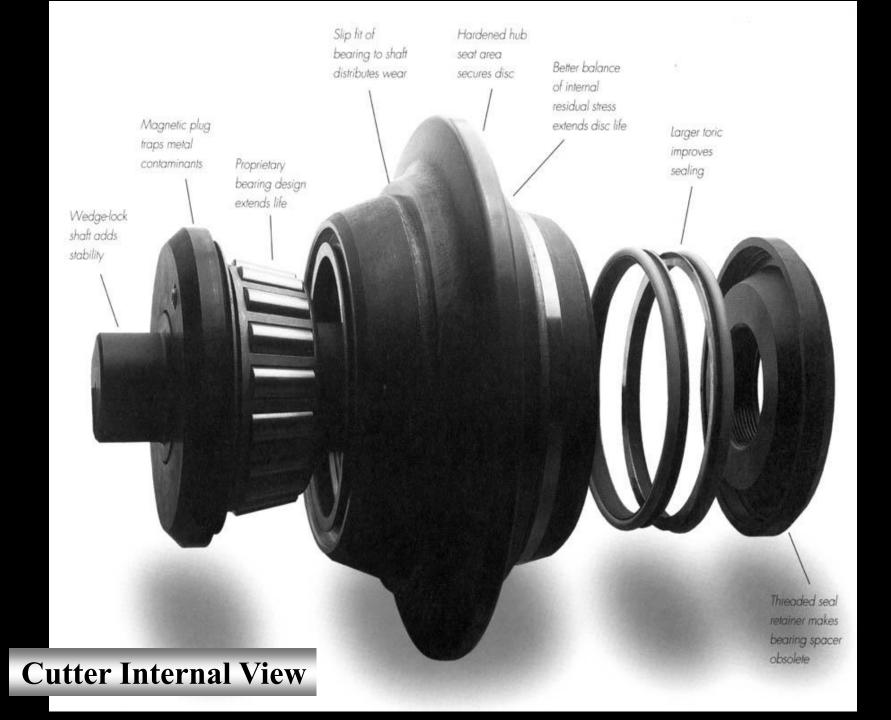
Kerf Pattern in Hard Rock





Swellex Rock Bolts







Before



After



CT3, Drill and Shoot Tunnel

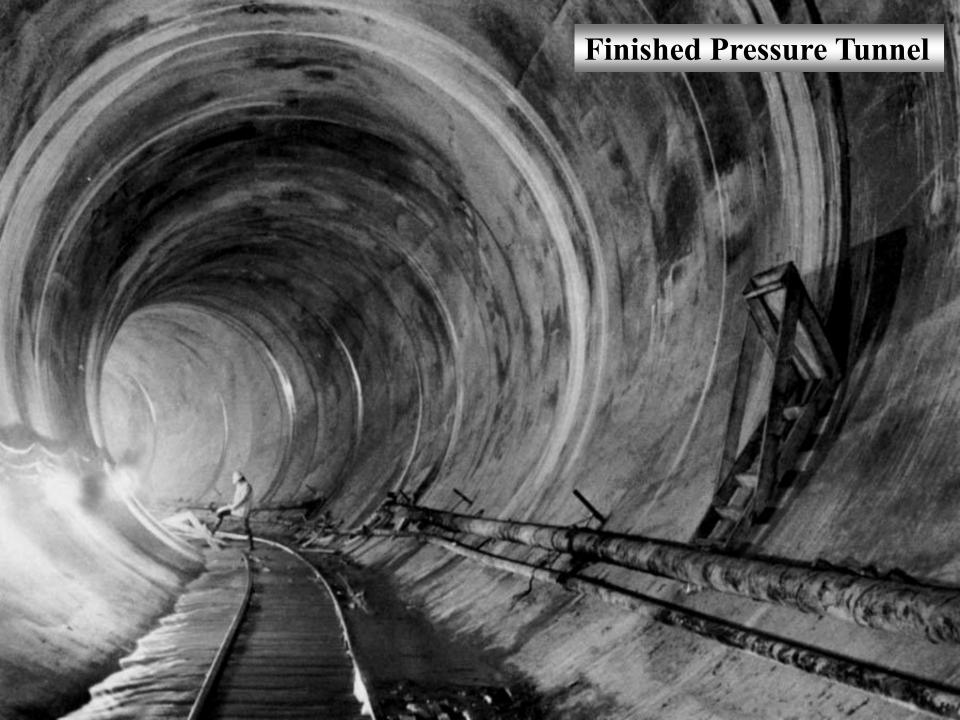


CT3, Scaling Drill and Shoot Tunnel

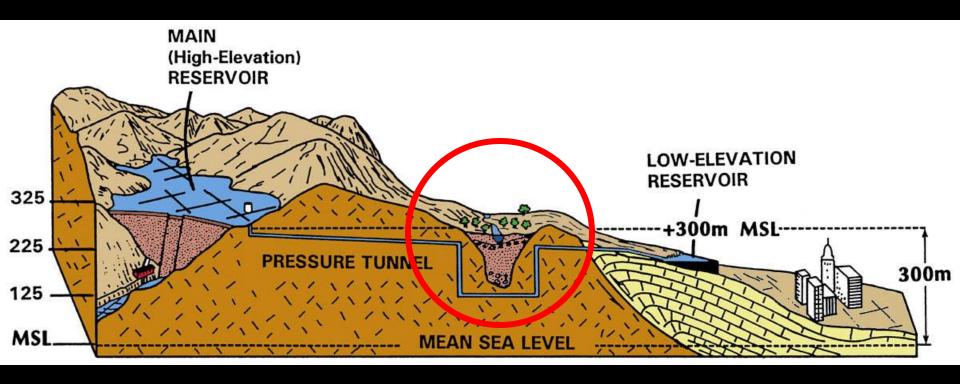




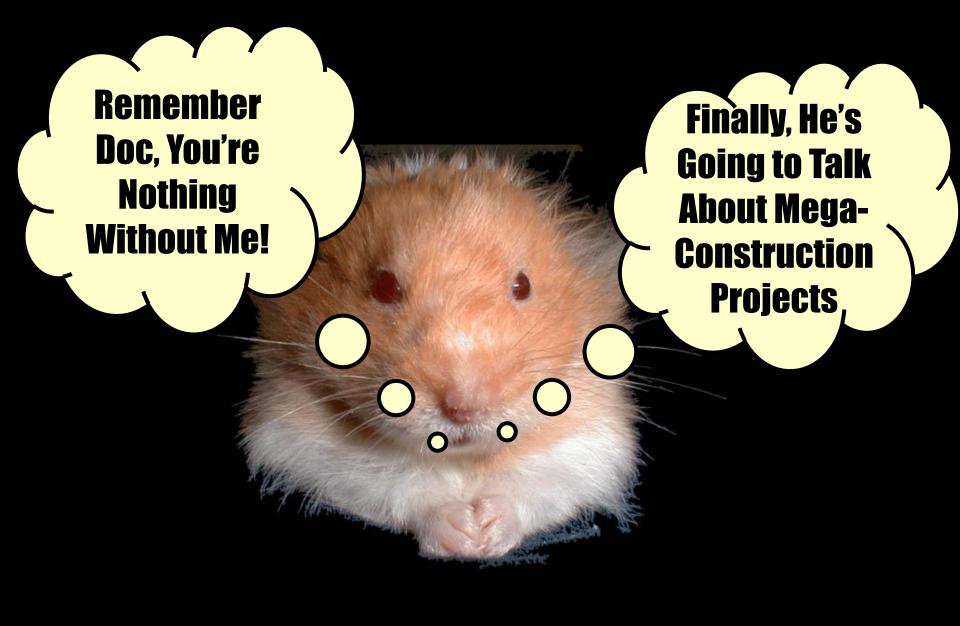




NYC Aqueduct Gravity Feed System — No Pumps



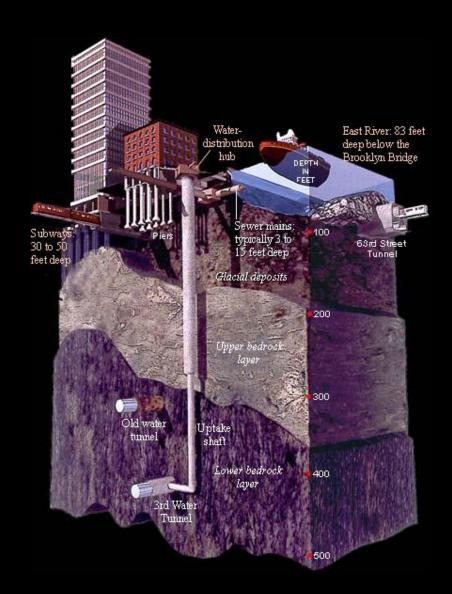




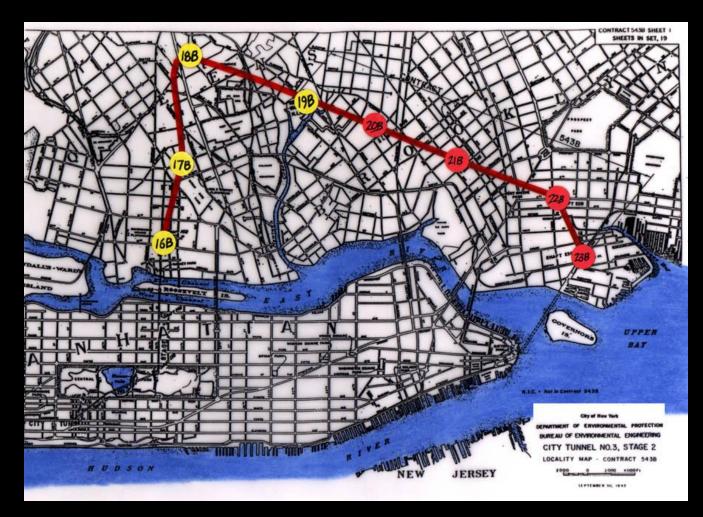
Mega-Construction Projects

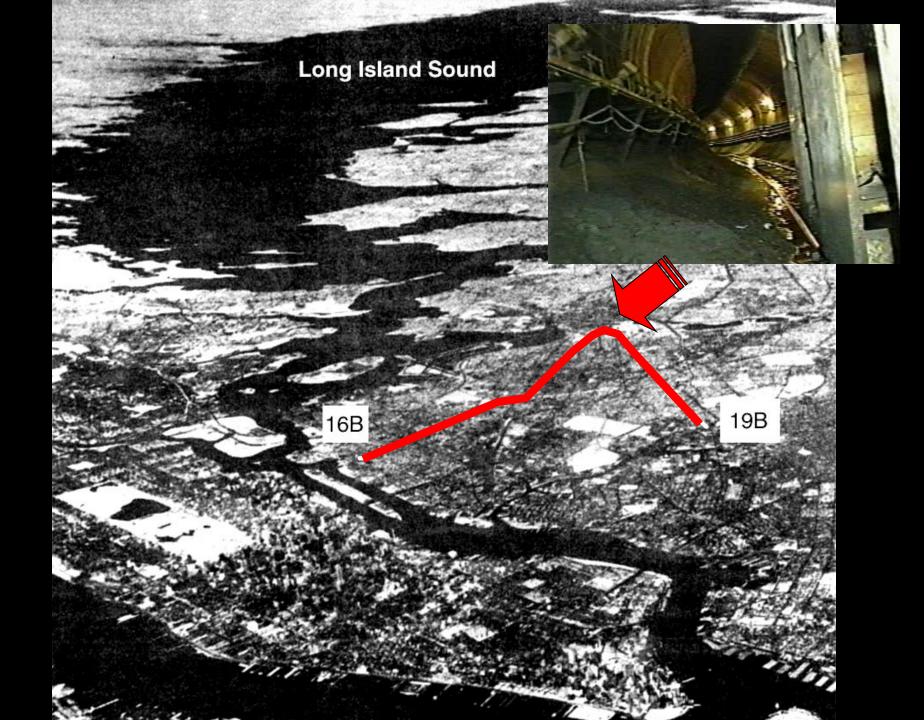
- Queens Water Tunnel
- Con Edison Steam Tunnel
- Manhattan Water Tunnel
- East Side Access Project
- Second Avenue Subway
- IRT #7 Line Extension
- LI Cross Sound Link Tunnel





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









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











CT3, Stage2 Manhattan Water Tunnel

Shaft 26B









Bottom of Shaft 26B 580' Deep





Manhattan Tunnel TBM

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









East Side Access IIRR/MTA



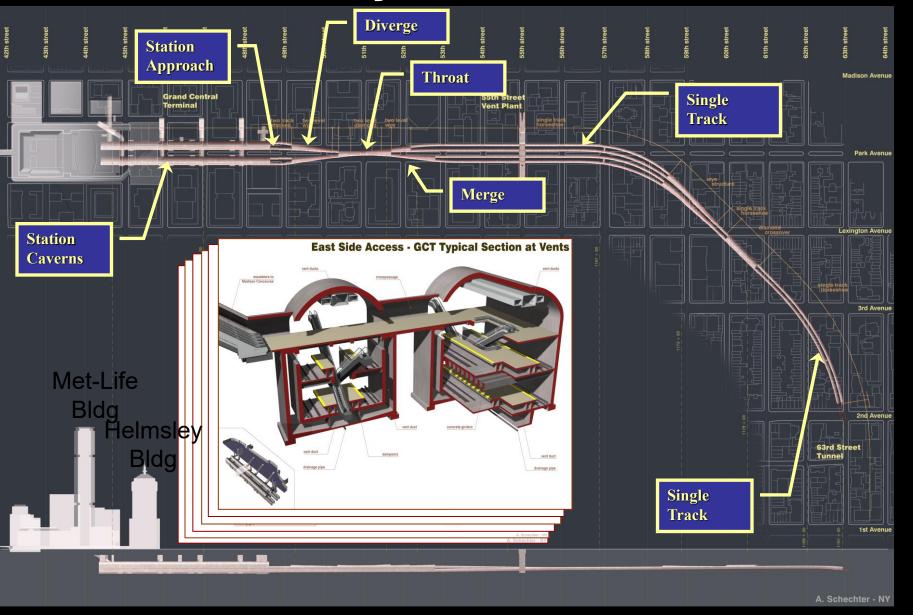
Existing 63rd Street Tunnel







East Side Access Project Plans

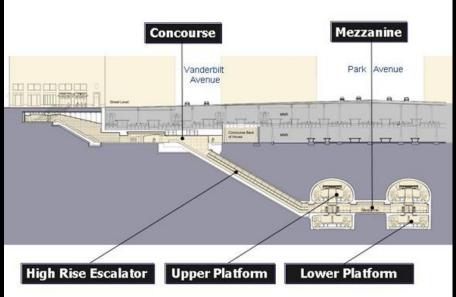


Construction Will Take Place Under Existing GCT







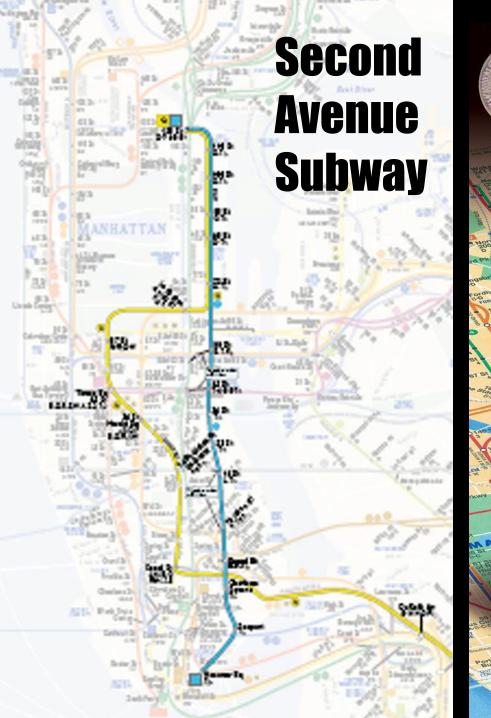


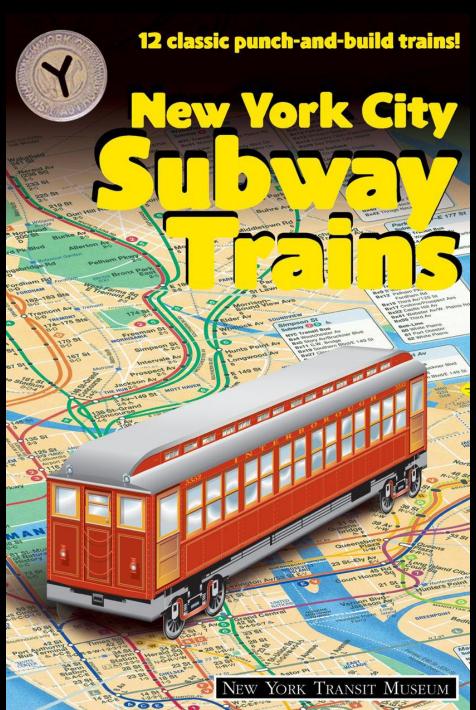
Second Avenue El

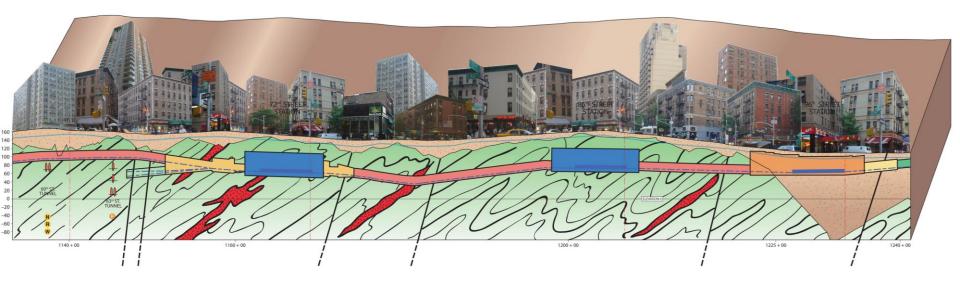


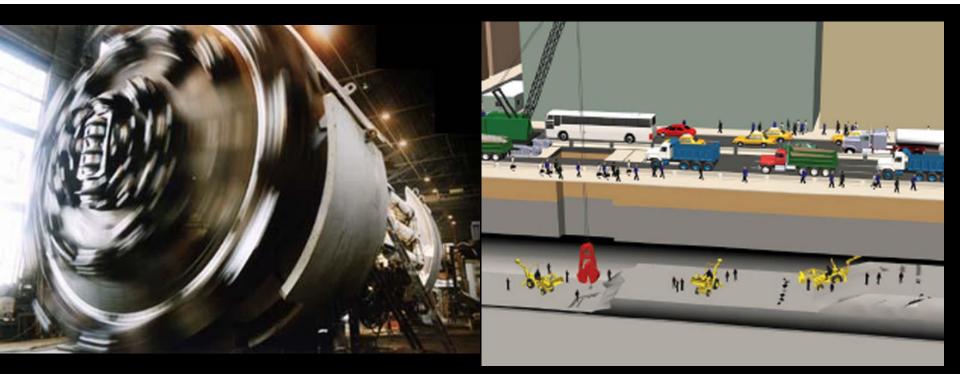


1929 - NYC BOT Proposes
Second Avenue Subway
1931 - Plans Postponed
Depression Era
\$86M → \$249M → \$500M
By 1948 - C Abandonment











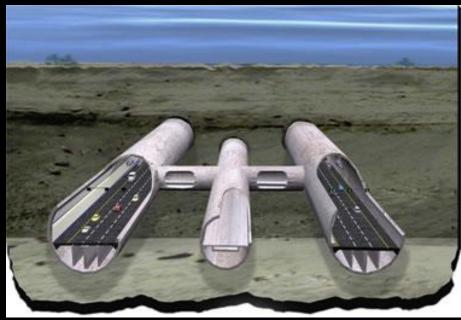
IRT #7 Line Extension

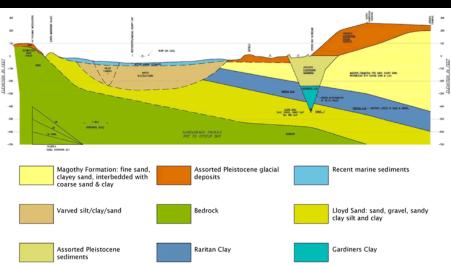


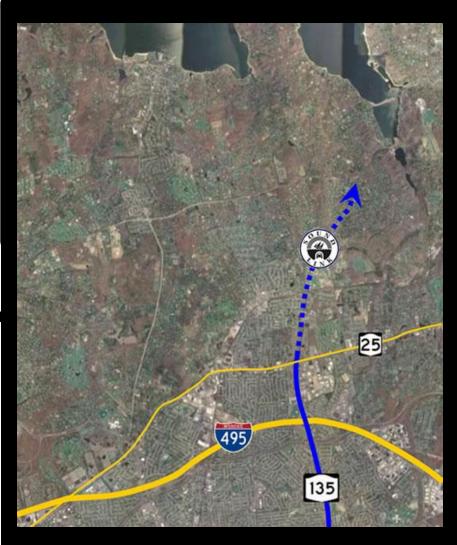




Cross Sound Link Project



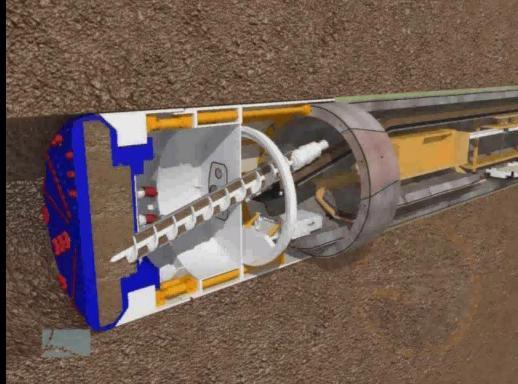






Soft Ground TBMs







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











Unforseen Tunneling Problems







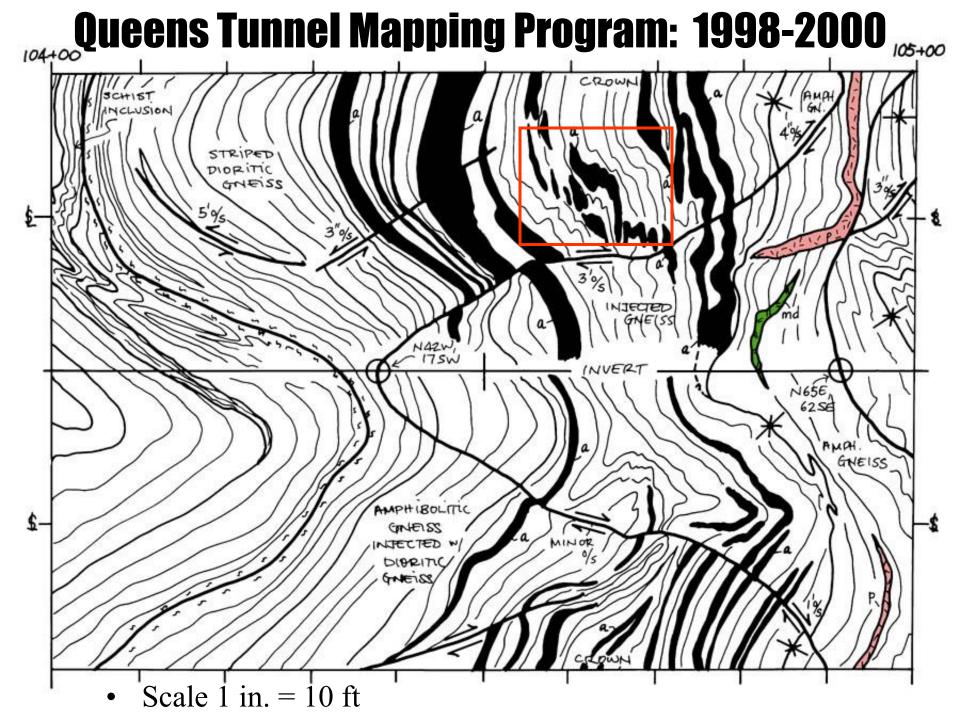






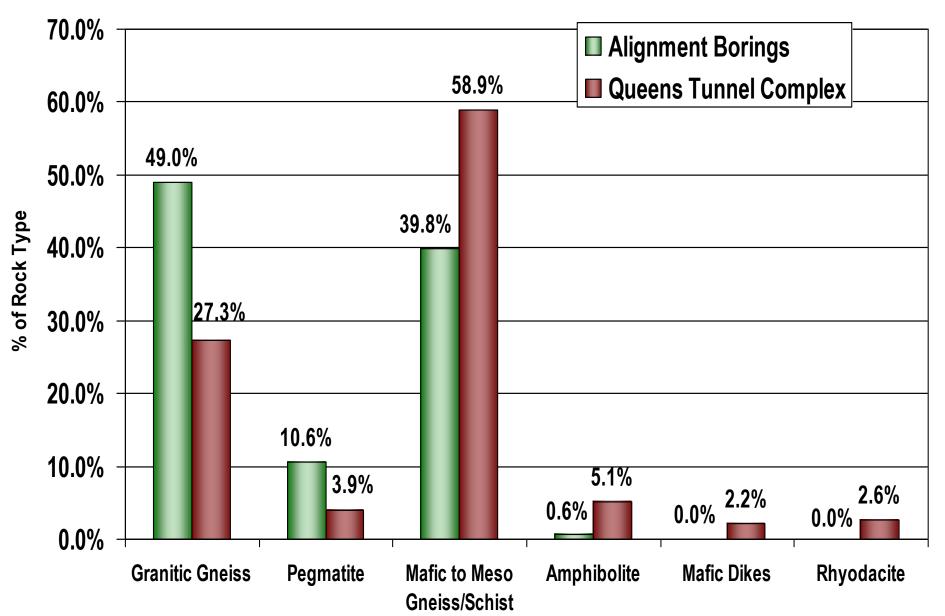


Merguerian's Queens Tunnel Field Office





Comparative Lithologic Analysis

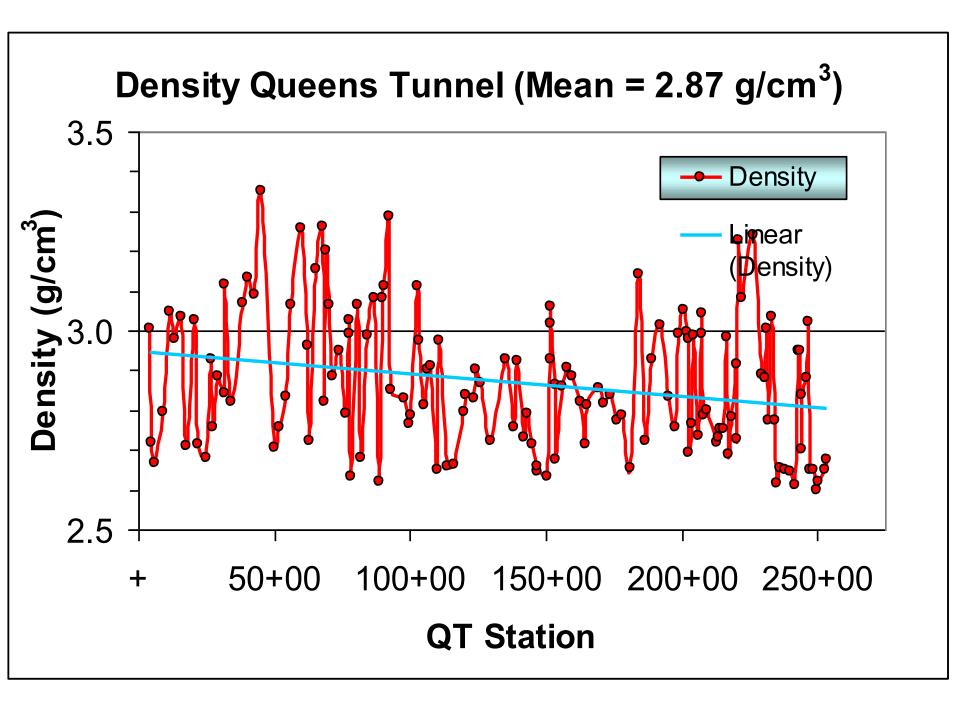


The Queens Tunnel Complex

- I. Garnet-Clinopyroxene-Plagioclase Rocks
 +/- Hornblende, Quartz, K-feldspar
 - II. Leuco- to Mesocratic Gneiss

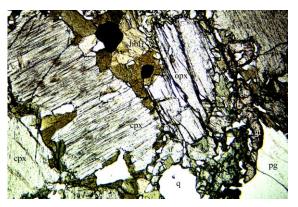
III. Mafic to Mesocratic Rocks

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



Petrographic Analysis (92 Samples)

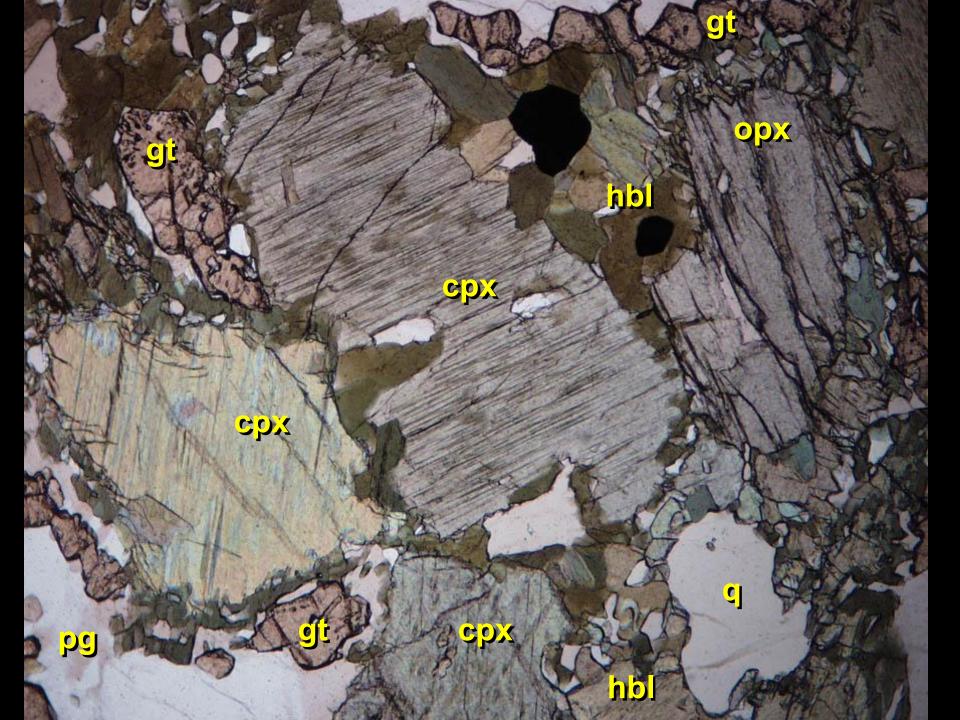
- Texture
- Mineralogy
- Internal Structure
- Metamorphism

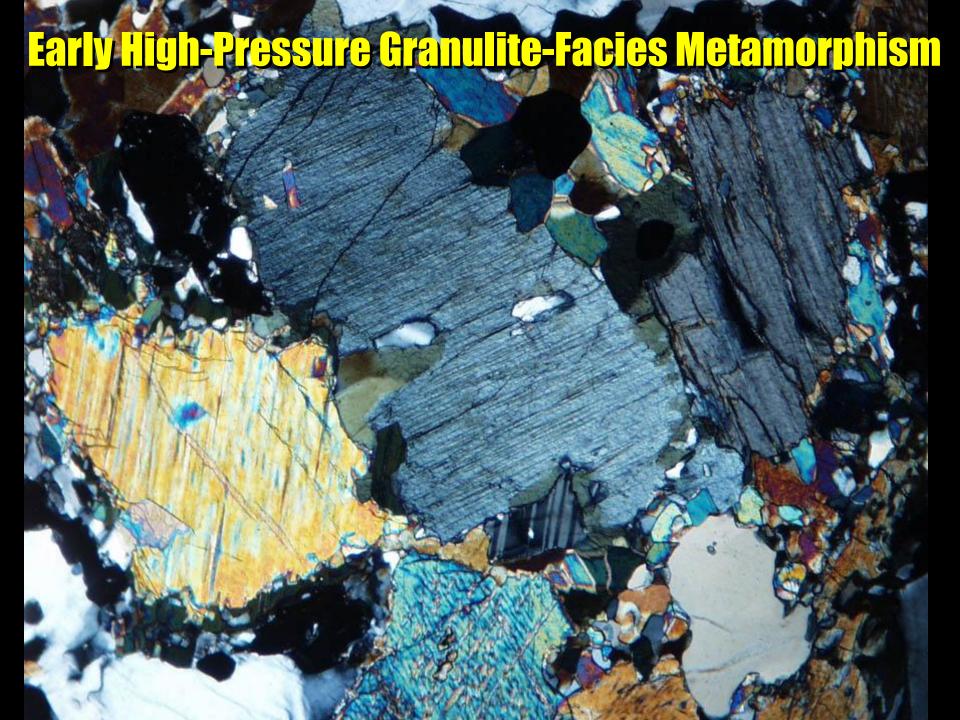


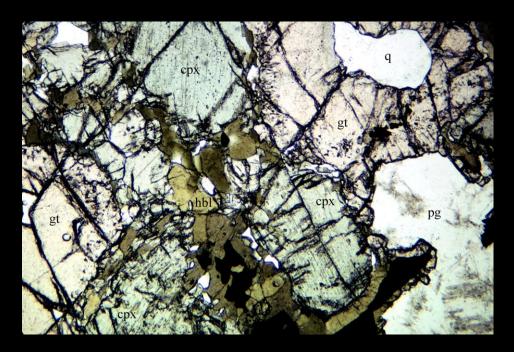
Thin section photomicrograph

Number	Location	Color	Densi	yQtz	Kspar	Plagio/	An	Орх	Срх	Hbld	Bio	Garnet	Opaque
Q109	004+80					М	35	M		M			
Q109	004+80	25	2.72	М		М	35			m	m	m	
Q110	006+42	10	2.66	М	tr+AP	М					m gnbk	tr	tr
Q111	009+25	25	2.79	М		М		m		tr	m	M py encl Q	tr
Q112	011+60	35	3.05	m		М	51		M exsol	m gnkh		М ру	
Q114	015+90	45	3.03	m		М	53-39r	n Mns omeEx	o l s∕loExsol	mgnkh		m necklace	tr
Q115	017+70	10	2.71	М	tr AP	М				m bugn sieve	m rbn	m porange	tr
Q117a	022+25	15	2.72	М	tr	m	27			m dgygn	m rbn	m porange siev	etr
Q119	026+65	45	2.93	m 10	De 1 15	М	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		М		tr	М	M gnkh	m red	М	m
Q129	049+95	25	2.71	М	M	М	low				M kh	M	
Q130	051+83	15	2.76	40	tr	М					m obn	M.vermic/sieve	trims
Q133	059+95	55	3.26	m		М	38-29		М	Mkhtan	m	M	m
Q134	062+45	60	3.17	m		М	28-40F	Rev Zoning	М	M bugn some	vermic wi Qtz	M fine sieve/ve	m110cverm
068+10	068+10	5:50		М		M	55	m	М	m gn		m vermic with p	lang
070+60	070+60	45		М		М	45+	?	core?	m. Gn	m	M	m
Q141	071+80	30	2.9	5		M sieve	•	M sieve		tr gn	M okh	M sieve	2

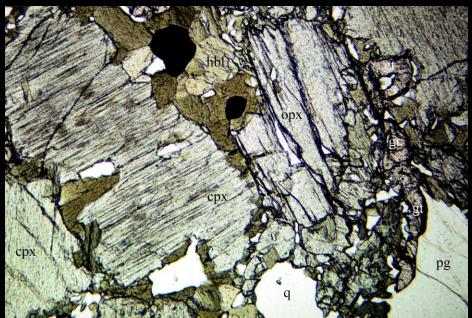
Petrographic Data Sheet

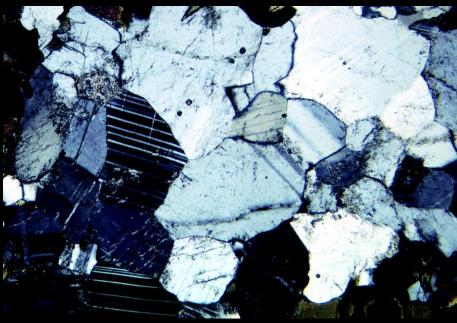






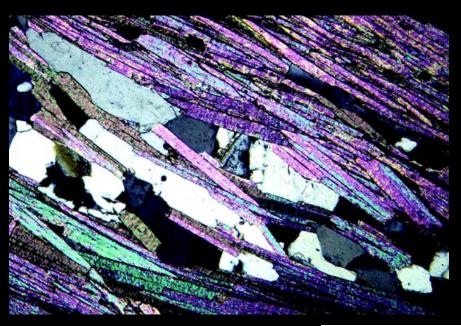
Granulite Facies Gneisses Found in the Queens Tunnel Granoblastic Textures Tough Rocks for Tunneling

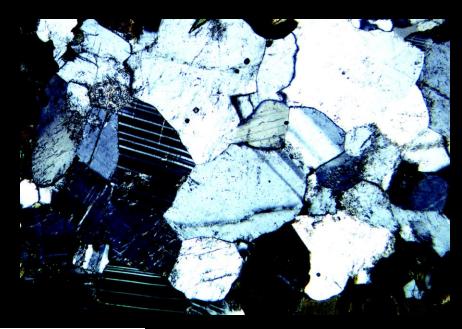




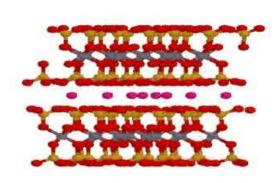
Mica Content of Rock Fabric

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

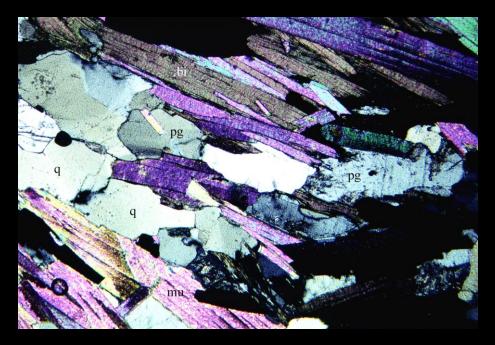




Foliated



Non-Foliated



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





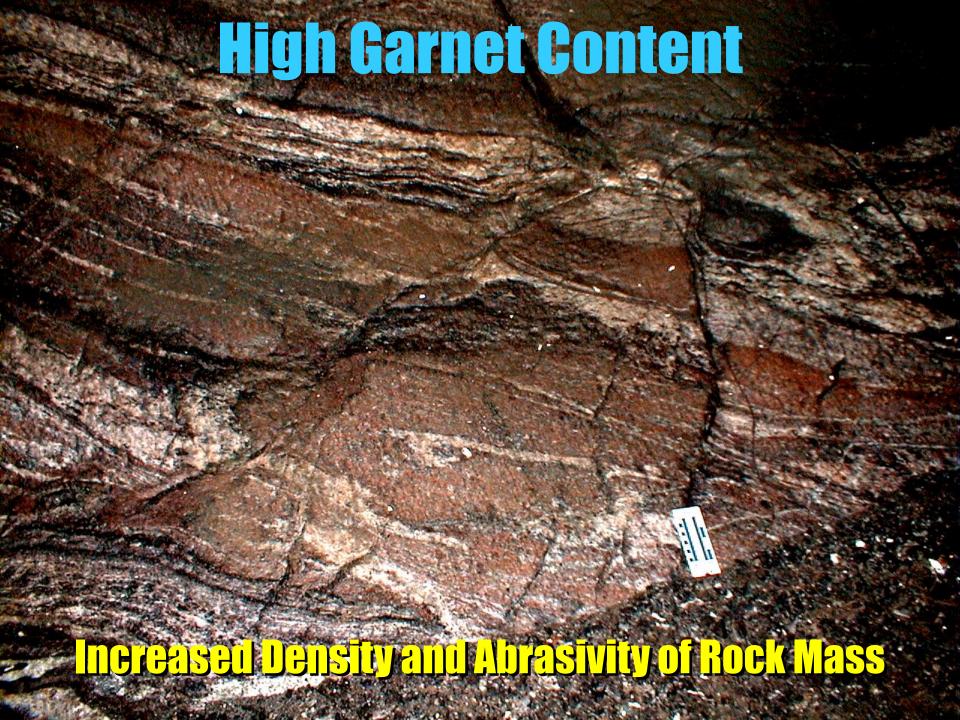
Orientation of Rock Layering

NE strike and moderate 57° dip anticipated [Based on borings, Chesman, Tarkoy]

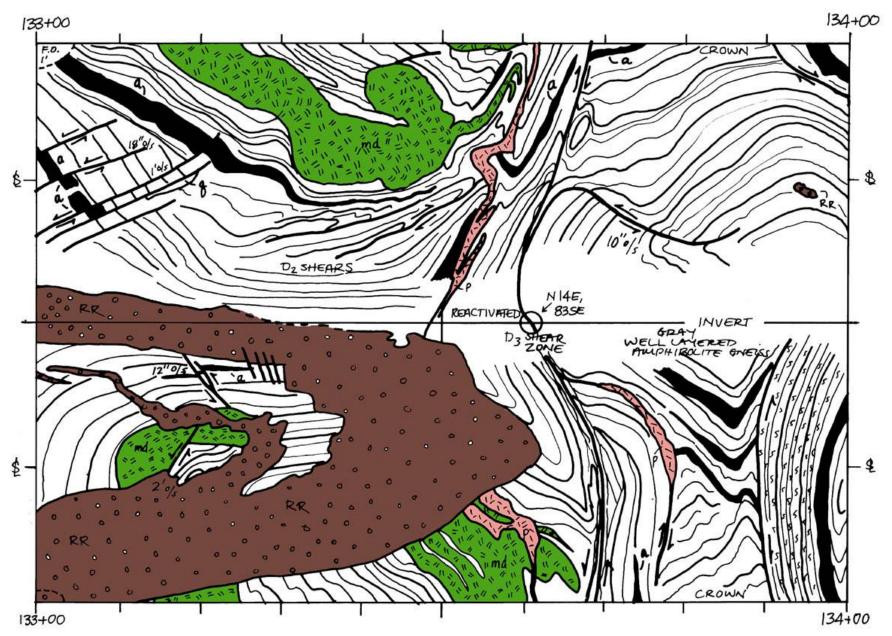
Highly variable trends found **Extended reaches of tunnel exhibited gentle dips**

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

	NE	Leg	NW Leg		
Gentle Dips	17/93	18%	44/139	32%	
Moderate Dips	34/93	37%	28/139	20%	
Steep Dips	42/93	45%	67/139	48%	



Dike 4









Lava Flows in Woodside?



