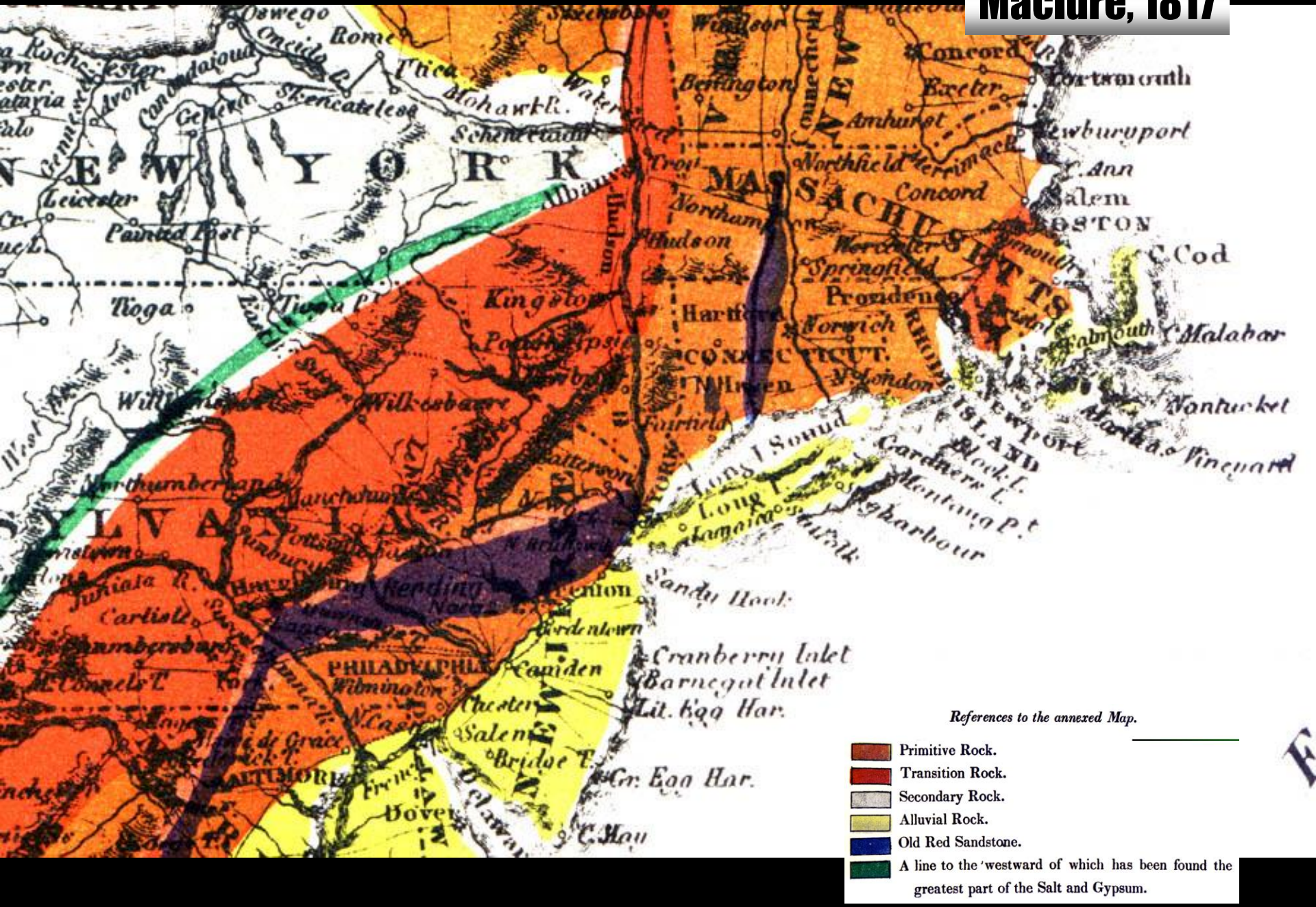
Orange County Mineral Society

Geology and Mineralogy of the Hudson Highlands and Bear Mountain

Charles Merguerian
Duke Laboratories
Stone Ridge, NY

DUKE

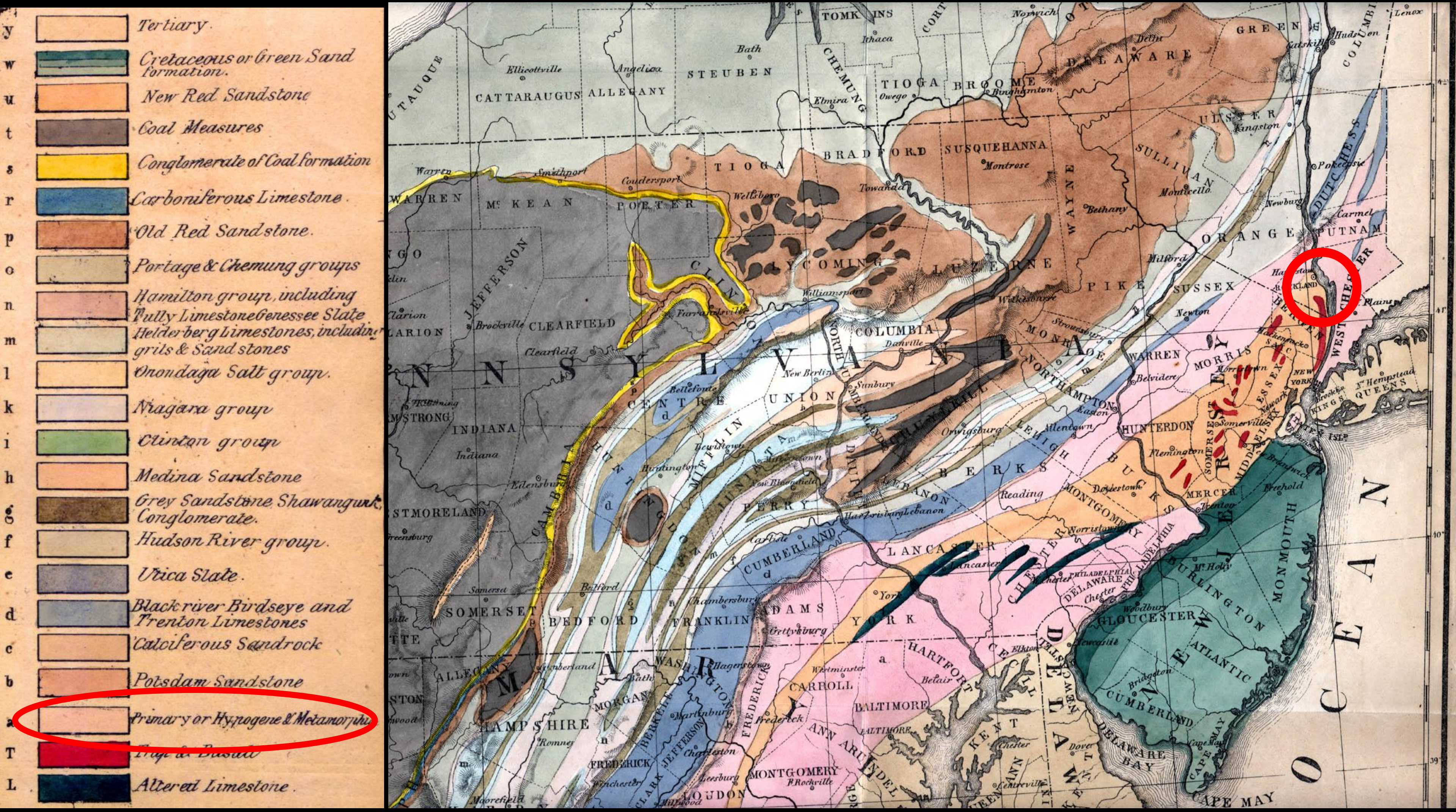
Maclure, 1817



References to the annexed Map.

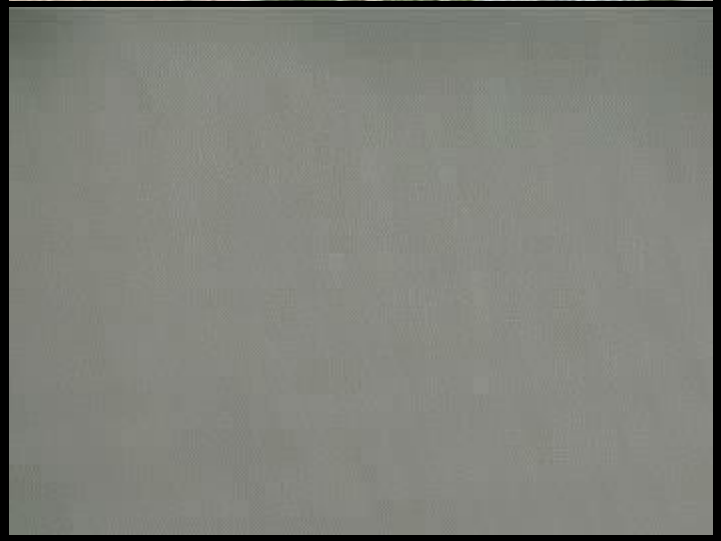
- Primitive Rock.
- Transition Rock.
- Secondary Rock.
- Alluvial Rock.
- Old Red Sandstone.
- A line to the westward of which has been found the greatest part of the Salt and Gypsum.

James Hall [1811-1898]



Hall, 1843


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



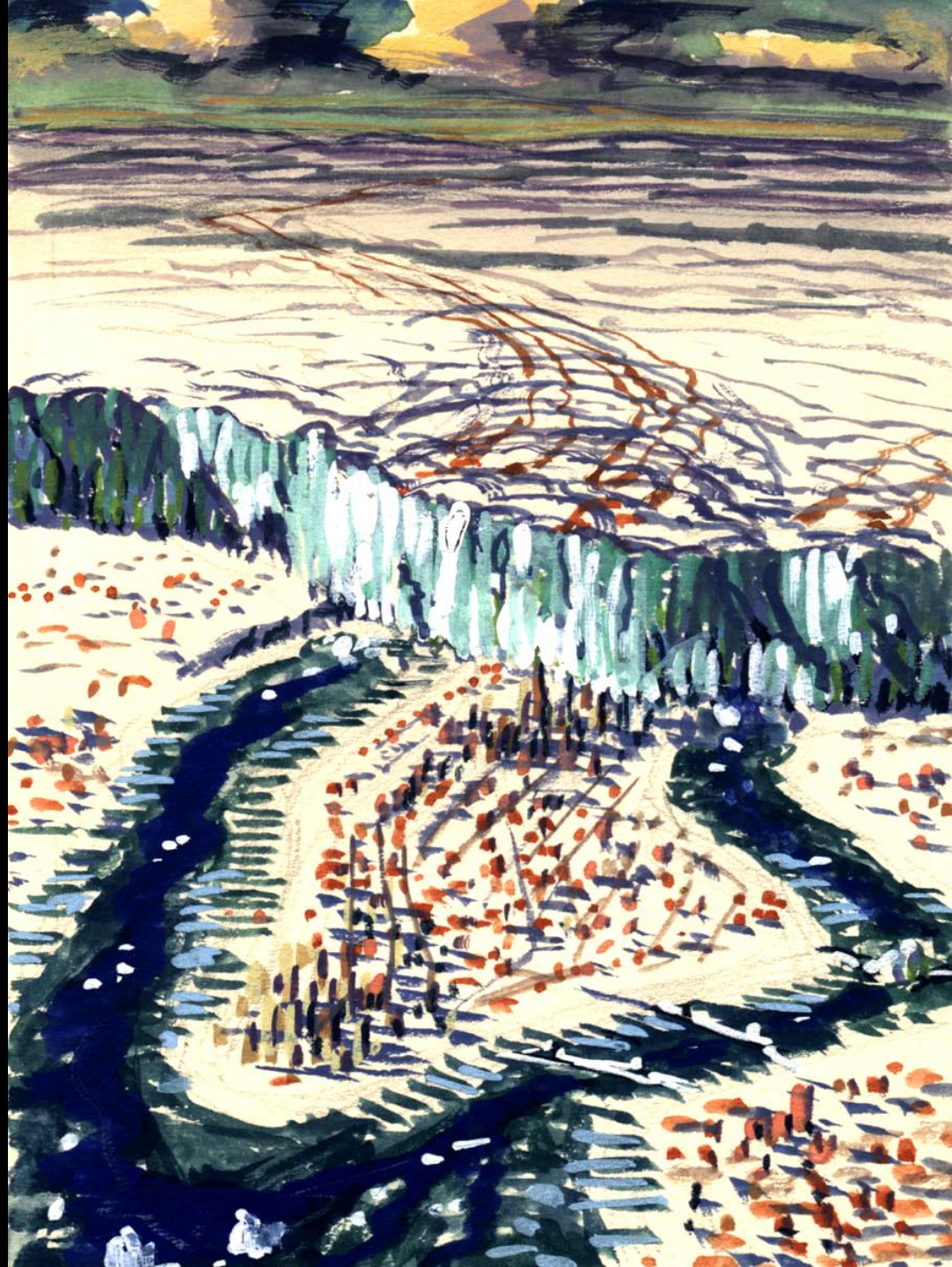
Rock - Paper - Scissors

Paper Covers Rock

Glacier Covers NYC

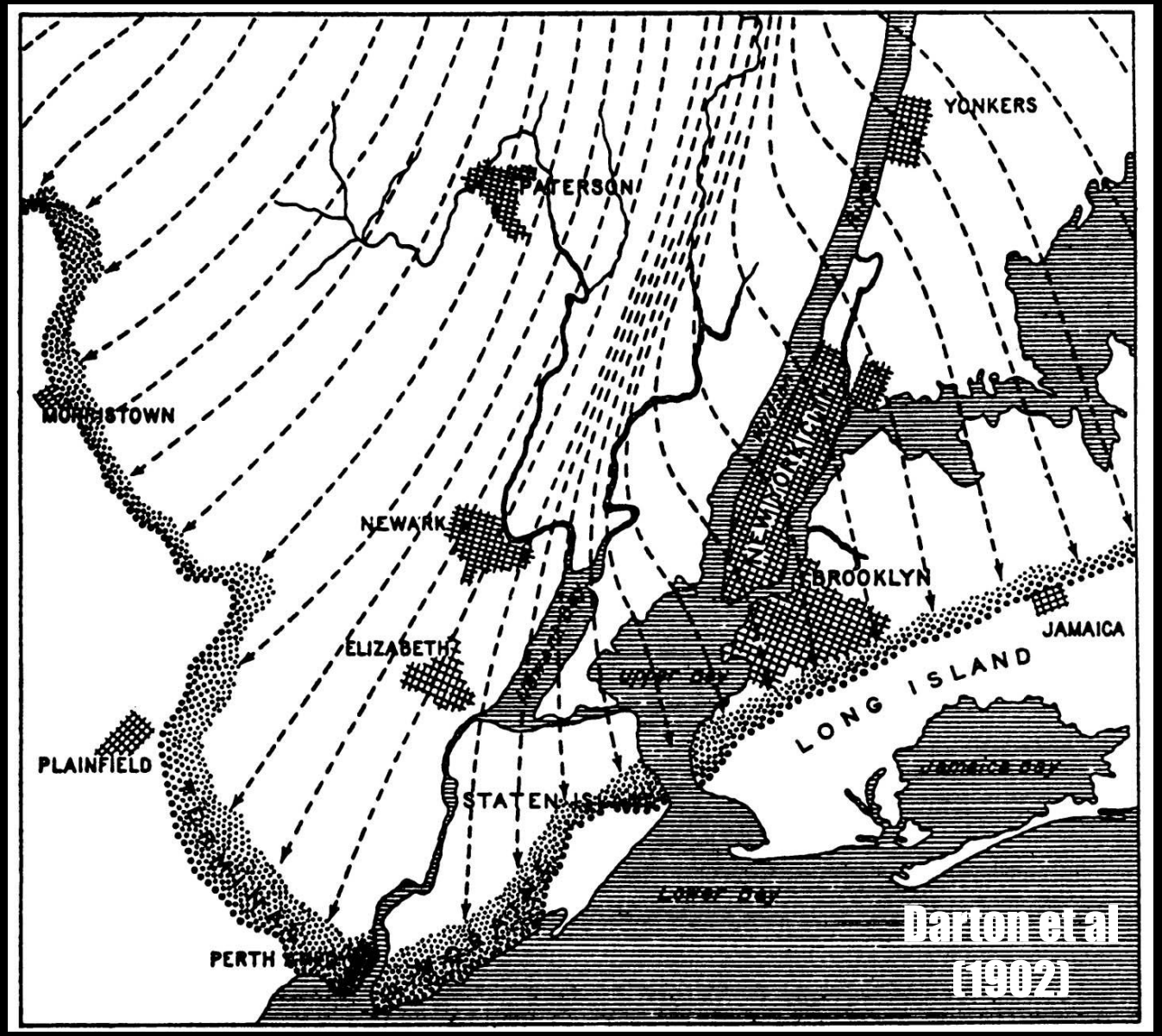
Not a One-Shot Deal!

Multiple Glacial Advances
From Two Directions



Pleistocene Glaciation

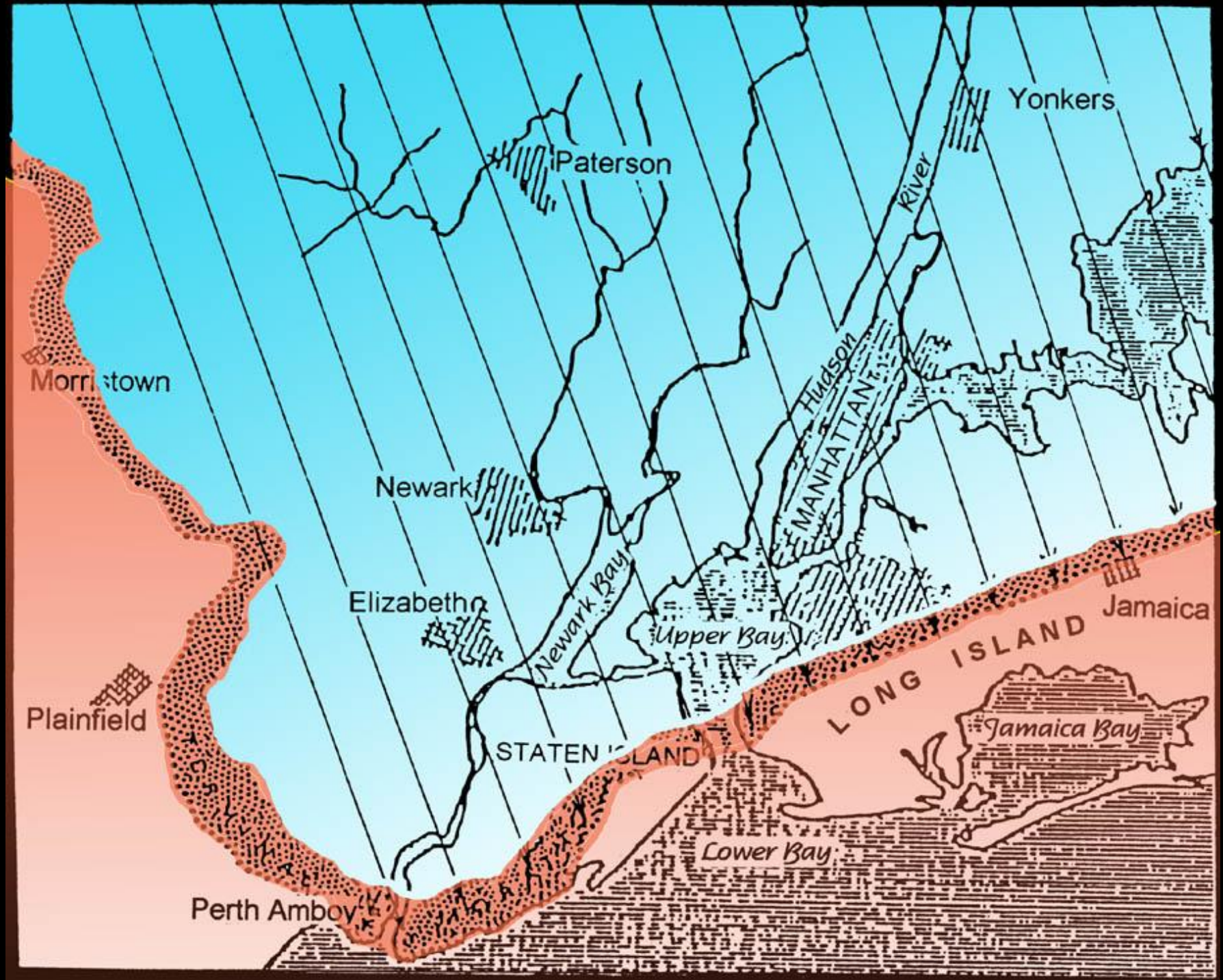
A Tale of Two Tills



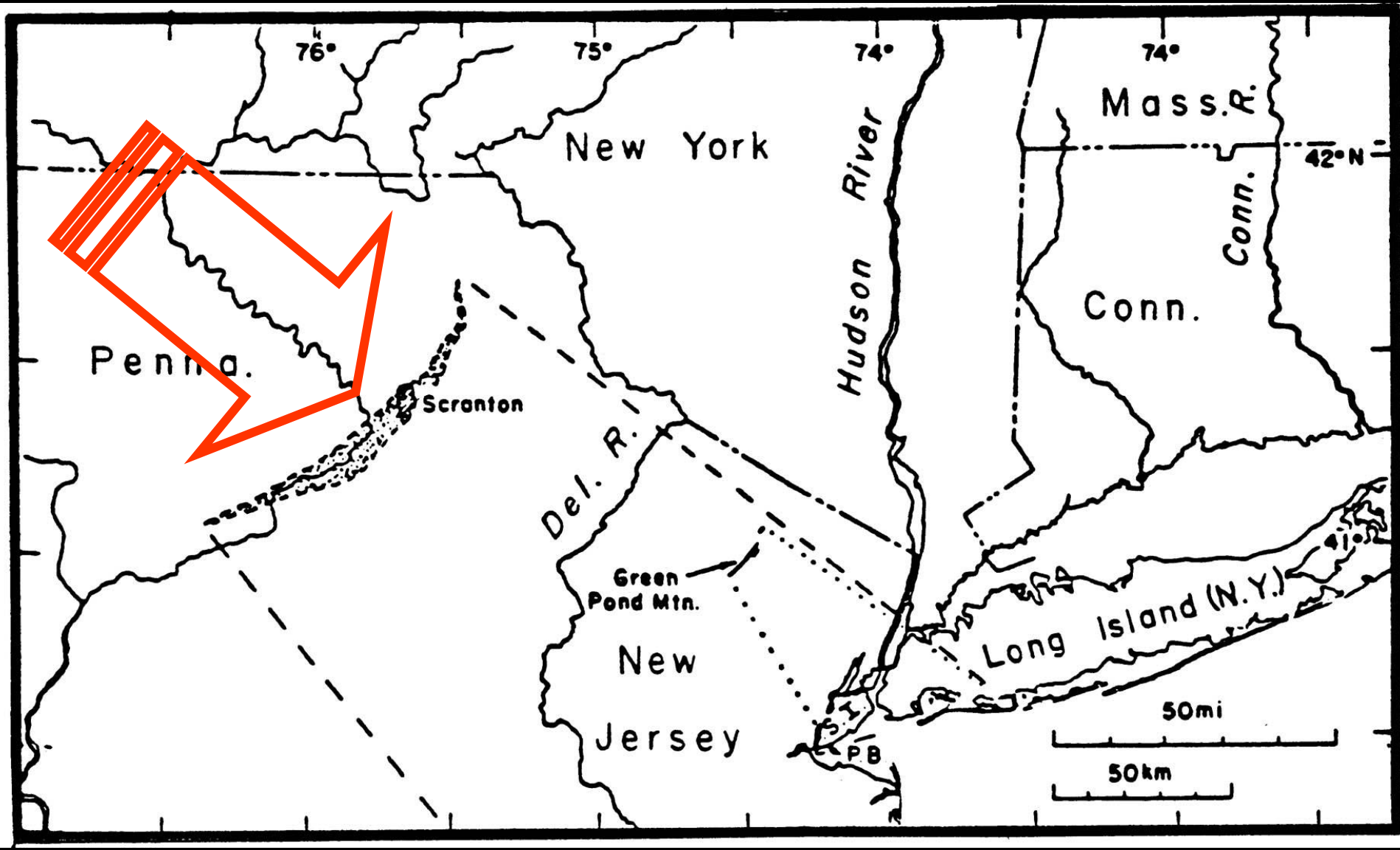
Age	Till No.	Ice-flow Direction	Description; remarks
Late Wisconsinan ("Woodfordian"?)	I	NNE to SSW	Gray-brown till in Westchester Co., Staten Is., Brooklyn, & Queens (but not present on rest of Long Island); Hamden Till in CT with terminal moraine lying along the S coast of CT; gray lake sediments at Croton Point Park, Westchester Co.
Mid-Wisconsinan (?)			Paleosol on Till II, SW Staten Island.
Early Wisconsinan(?)	II	NW to SE	Harbor Hill Terminal Moraine and associated outwash (Bellmore Fm. in Jones Beach subsurface); Lake Chamberlain Till in southern CT.
Sangamonian(?)			Wantagh Fm. (in Jones Beach subsurface).
	IIIA	NW to SE	Ronkonkoma Terminal Moraine and associated outwash (Merrick Fm. in Jones Beach subsurface).
Illinoian(?)	IIIB		Manhasset Fm. of Fuller (with middle Montauk Till Member; in lower member, coarse delta foresets (including debris flows) deposited in Proglacial Lake Long Island dammed in on S by pre-Ronkonkoma terminal moraine.
	IIIC		
Yarmouthian			Jacob Sand, Gardiners Clay.
Kansan(?)	IV	NNE to SSW	Gray till with decayed stones at Teller's Point (Croton Point Park, Westchester Co.); gray till with green metavolcanic stones, Target Rock, LI.
Aftonian(?)			No deposits; deep chemical decay of Till V.
Nebraskan (?)	V	NW to SE	Reddish-brown decayed-stone till and -outwash at AKR Co., Staten Island, and at Garvies Point, Long Island; Jameco Gravel fills subsurface valley in SW Queens.
			Pre-glacial (?) Mannetto Gravel fills subsurface valleys.

Sanders and Merguerian (1998)


Yonkers
Paterson
Hudson River
Morristown
MANHATTAN
Newark
Newark Bay
Elizabeth
Upper Bay
Jamaica
LONG ISLAND
Plainfield
Jamaica Bay
STATEN ISLAND
Perth Amboy
Lower Bay

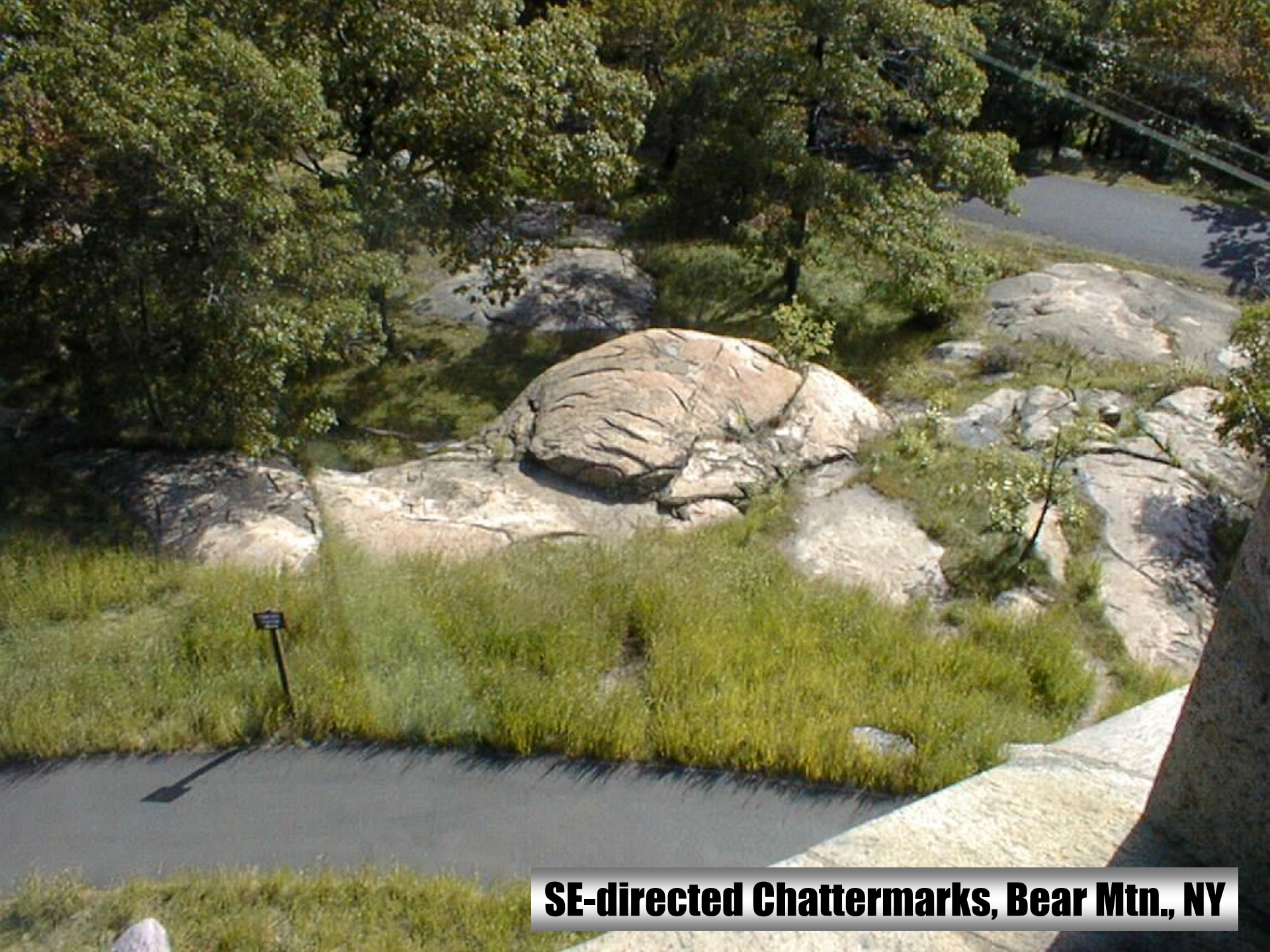

Yonkers
Paterson
Hudson River
MANHATTAN
Morristown
Newark
Newark Bay
Elizabeth
Upper Bay
Jamaica
LONG ISLAND
Plainfield
Jamaica Bay
STATEN ISLAND
Lower Bay
Perth Amboy

SE-Directed Erosion, Glacial Striae and Roche Moutonee, Central Park, NYC



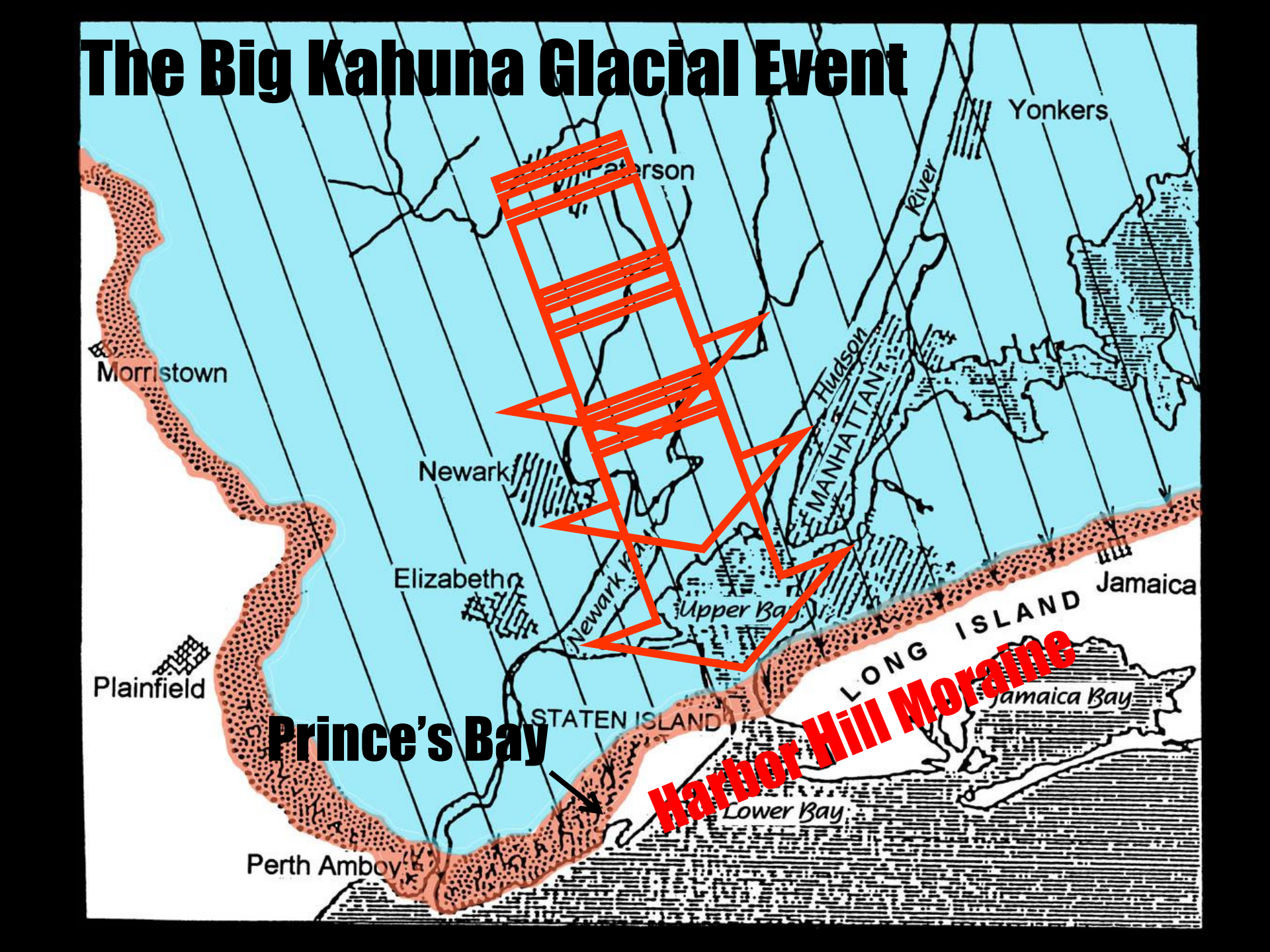
Anthracite and Green Pond Conglomerate Indicator Stones

Friedman and Sanders (1994)

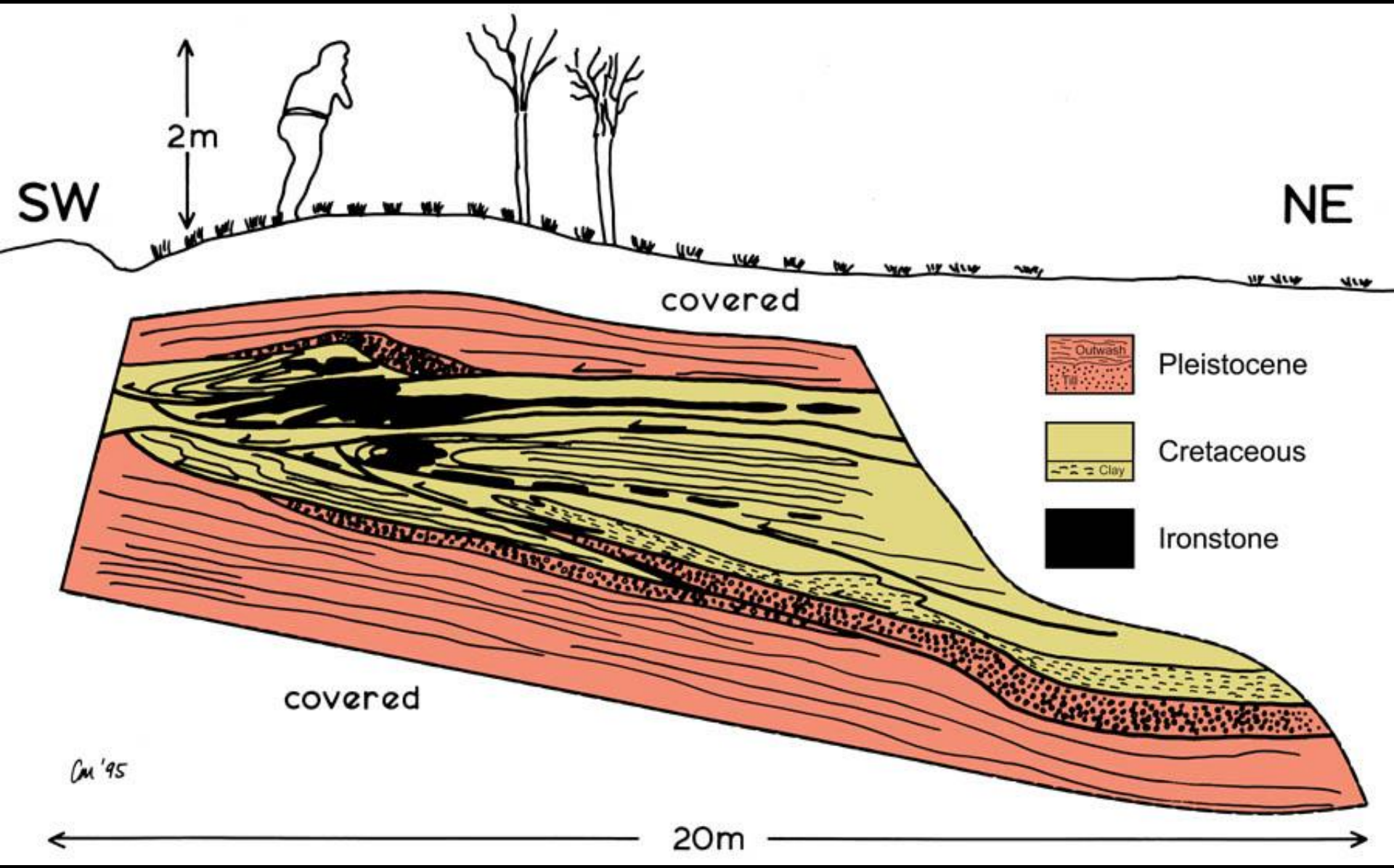

SE-directed Chattermarks, Bear Mtn., NY

Glacial Polish and S55E Chattermarks, Bear Mountain, NY

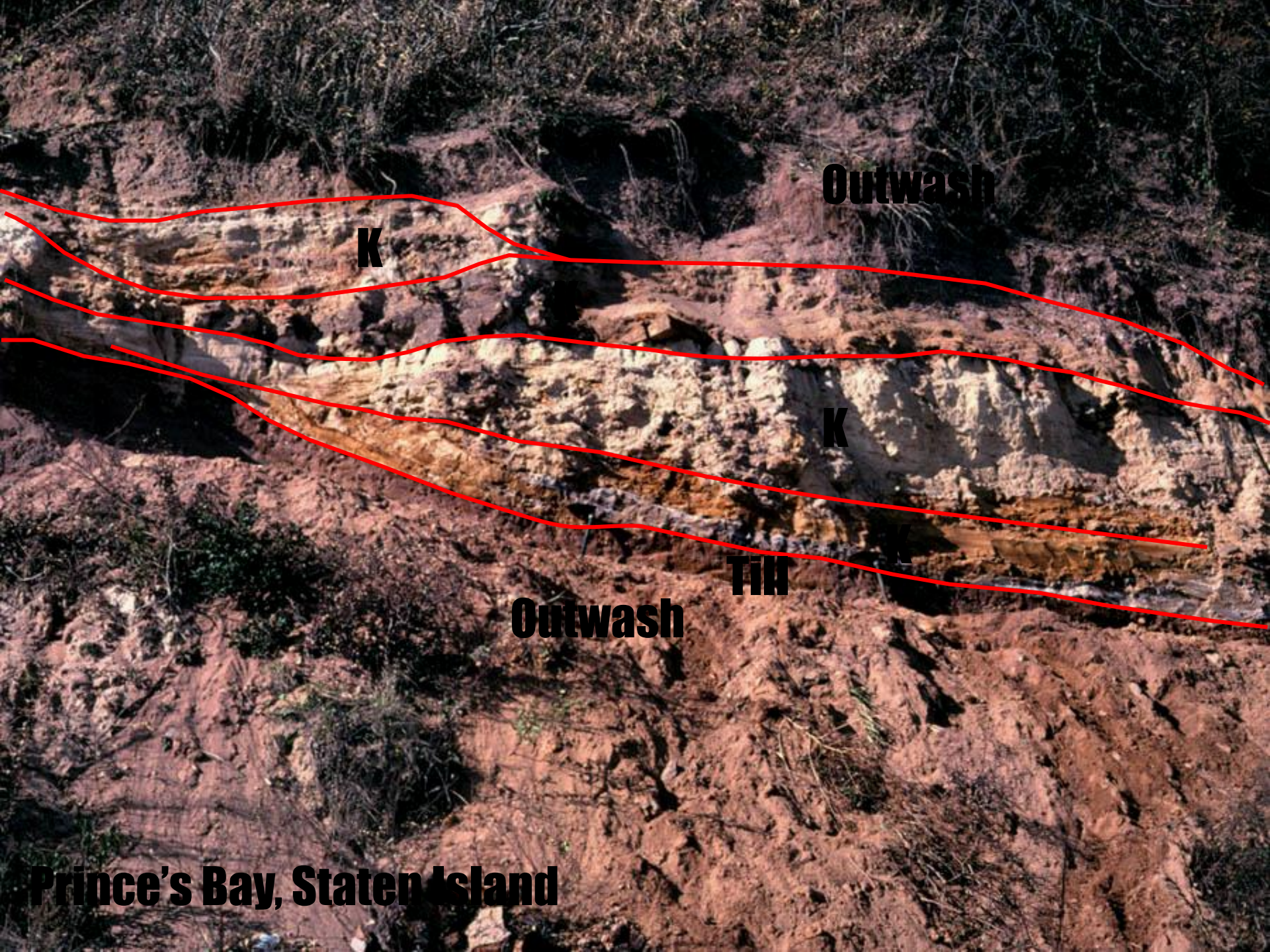
Two More Chattermarks on Bear Mtn., NY

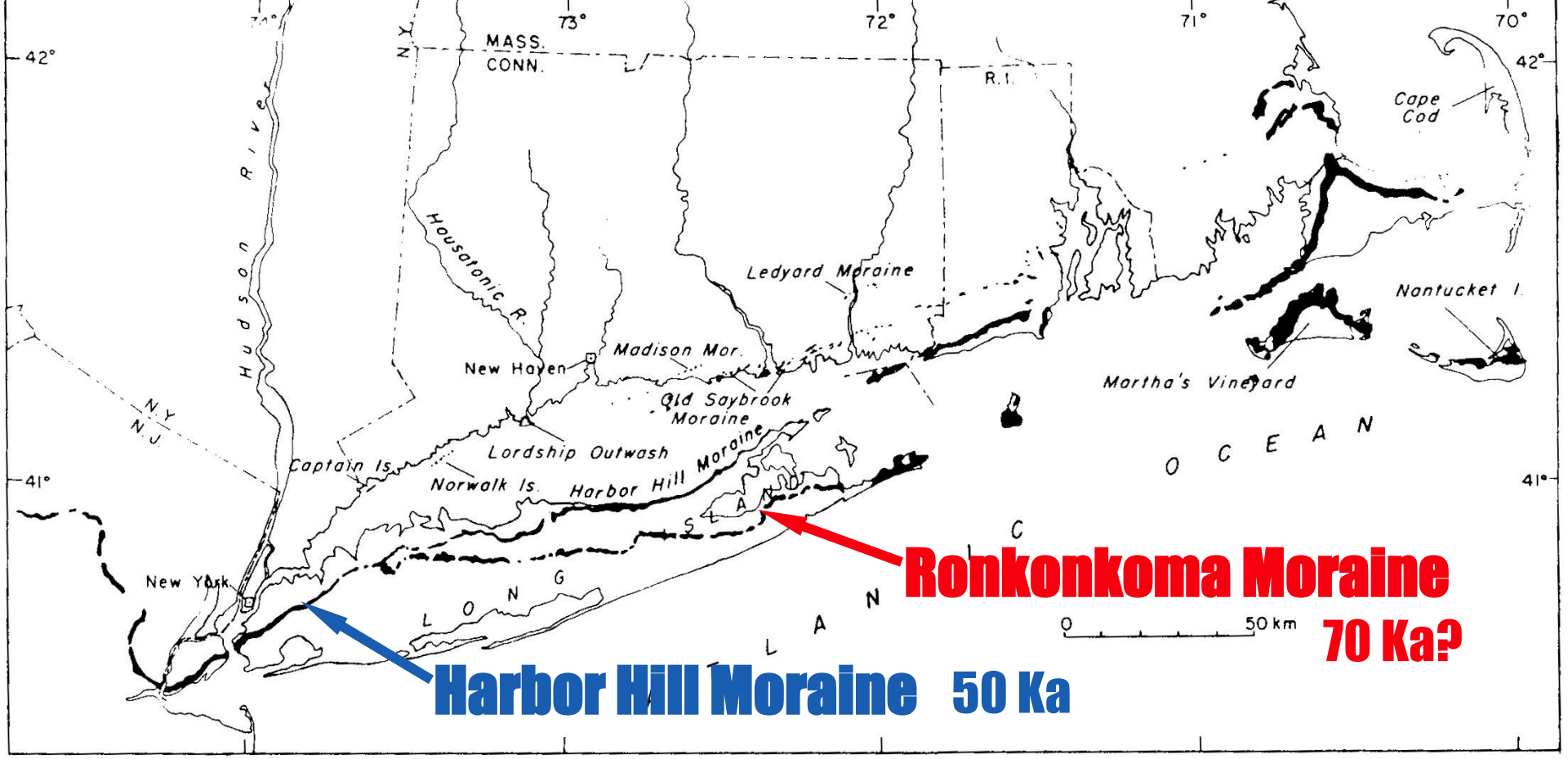

The Big Kahuna Glacial Event
Yonkers
Hudson River
MANHATTAN
Morristown
Newark
Elizabeth
Jamaica
LONG ISLAND
Plainfield
STATEN ISLAND
Jamaica Bay
Prince's Bay
Harbor Hill Moraine
Lower Bay
Perth Amboy


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

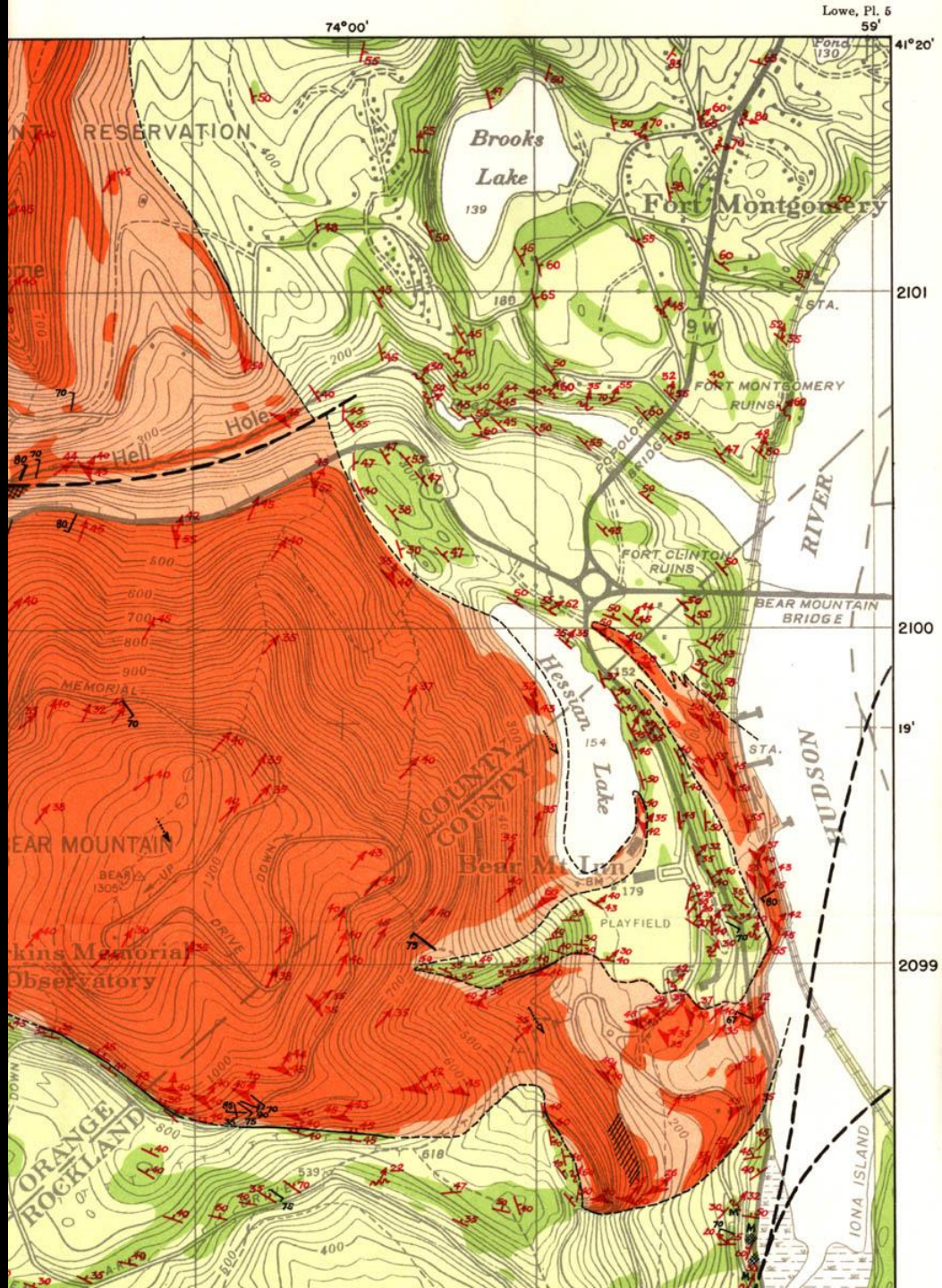

Outwash
K
K
Till
Outwash
Prince's Bay, Staten Island



Most NY Area Glacial Features Are a Product of Advances From the NW

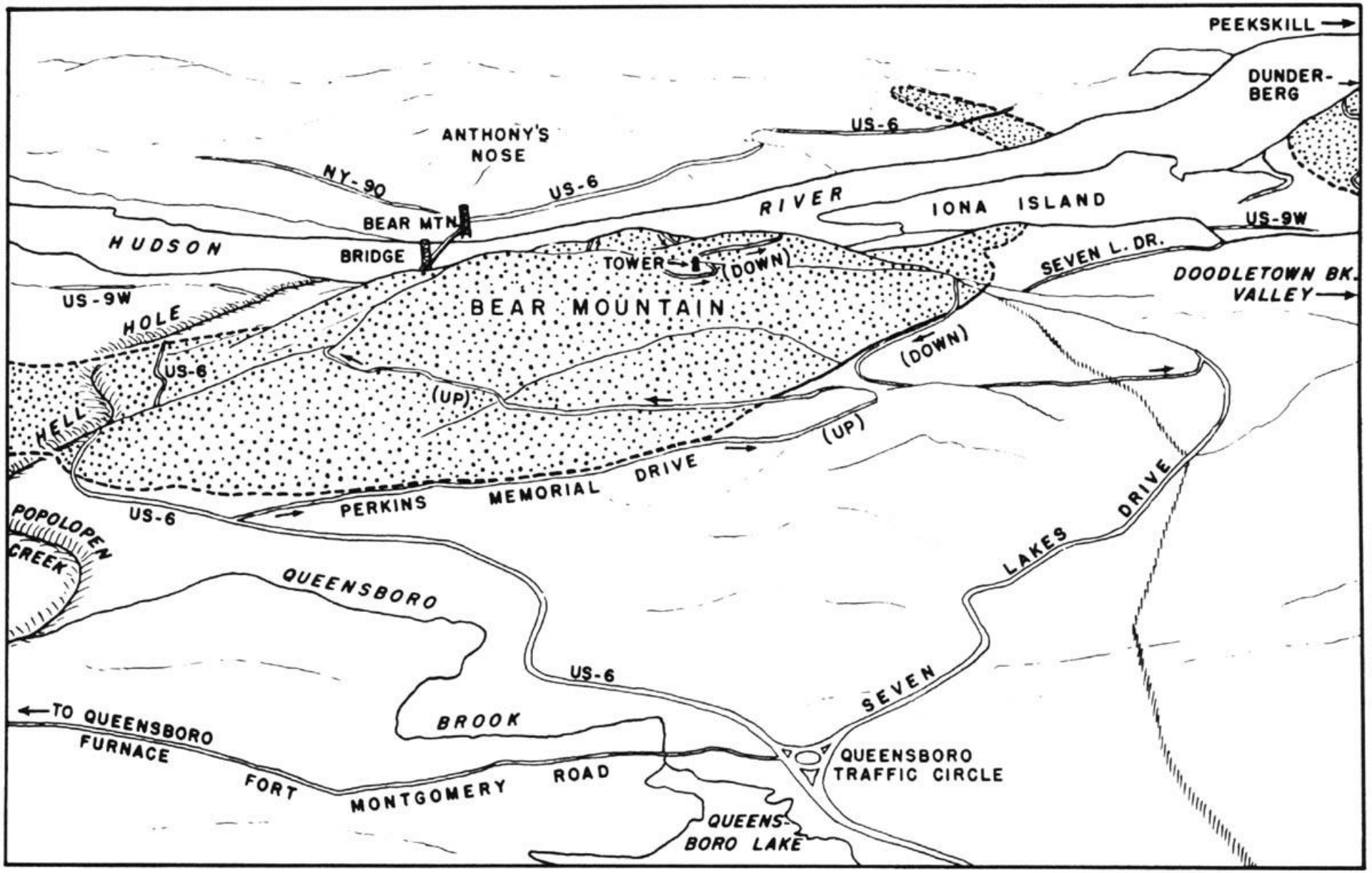
Geologic Map of Bear Mountain

K. E. Lowe (1950)



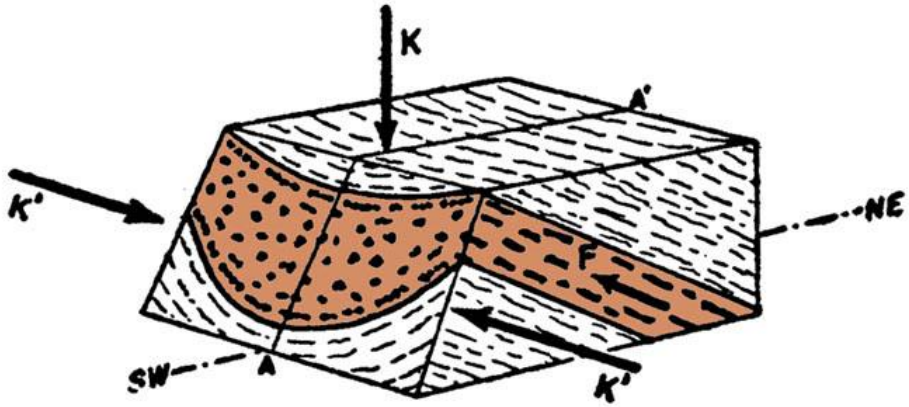
Storm King Granite
~1,174 +/- 8 Ma

K. E. Lowe (1950)

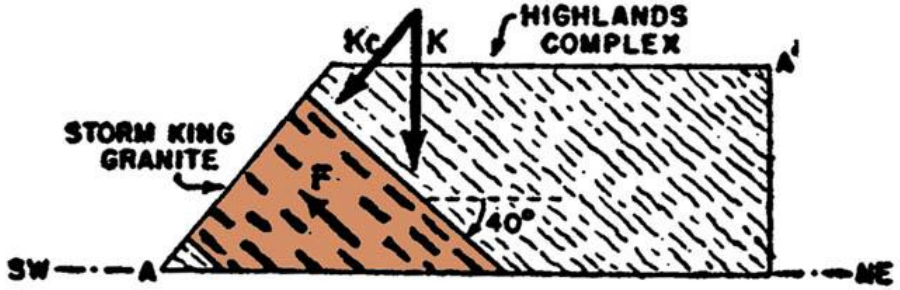

PEEKSKILL
DUNDER-
BERG
ANTHONY'S
NOSE
US-6
NY-90
US-6
RIVER
IONA ISLAND
US-9W
HUDSON
BEAR MTN.
BRIDGE
TOWER
(DOWN)
SEVEN L. DR.
DOODLETOWN BK.
VALLEY
US-9W
BEAR MOUNTAIN
HOLE
US-6
(DOWN)
(UP)
HELL
(UP)
DRIVE
PERKINS MEMORIAL
US-6
POPOLOPEN
CREEK
QUEENSBORO
LAKES
DRIVE
US-6
SEVEN
TO QUEENSBORO
FURNACE
BROOK
QUEENSBORO
TRAFFIC CIRCLE
FORT MONTGOMERY ROAD
QUEENS-
BORO LAKE

K. E. Lowe (1950)

K. E. Lowe (1950)



Perspective View



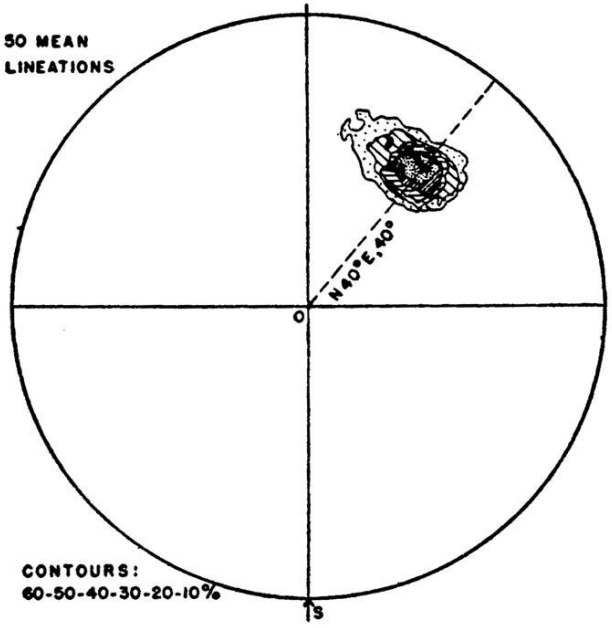
Section AA'

F- DIRECTION OF FLOW DURING INTRUSION

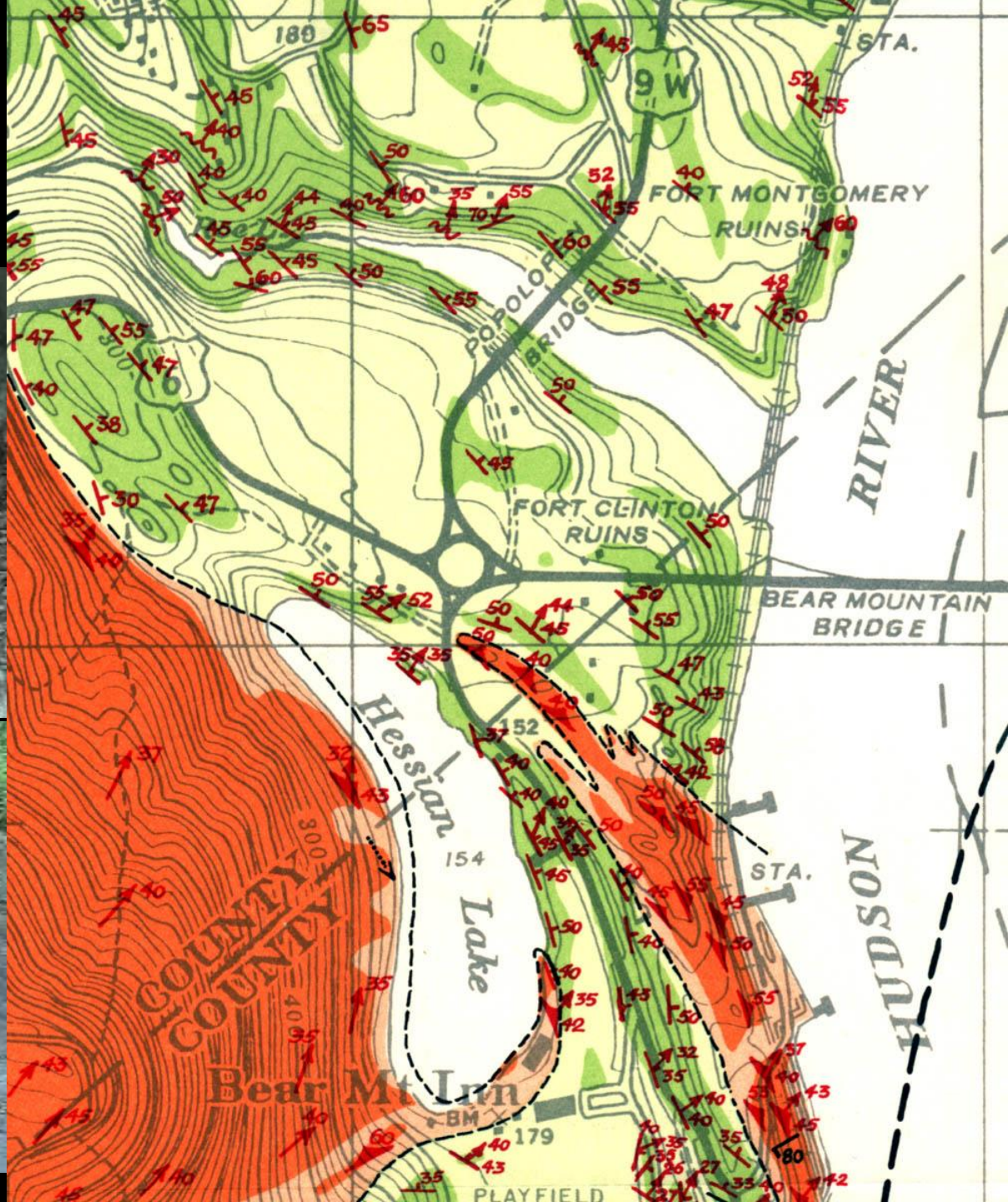
K- UNIFORM LOAD STRESS

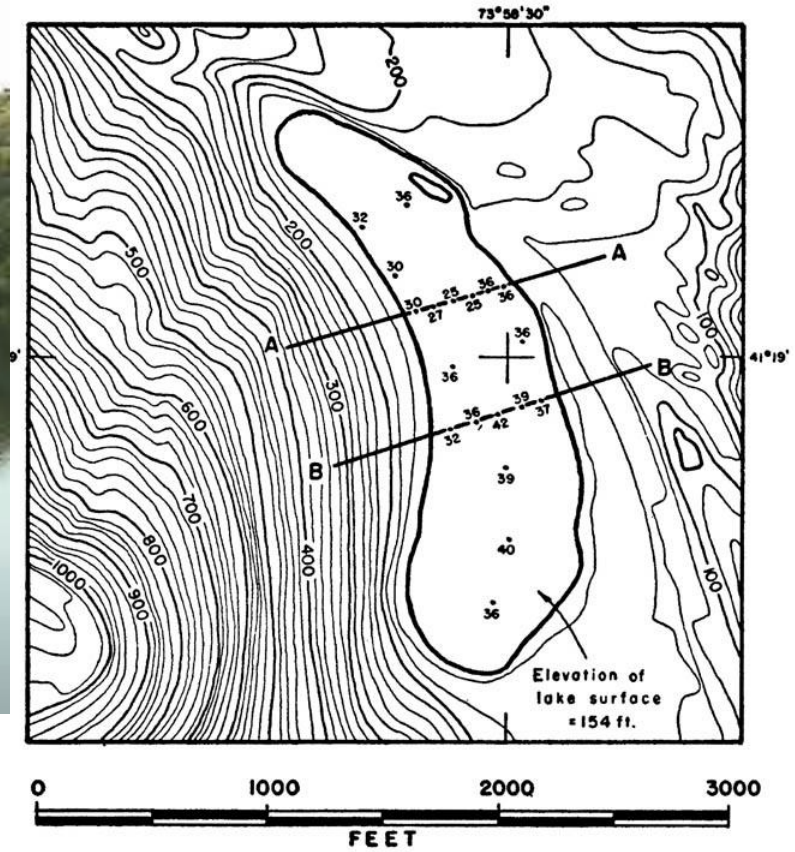
Kc-LOAD STRESS COMPONENT PERPENDICULAR TO FLOW DIRECTION

K'-DIFFERENTIAL OROGENIC STRESS PERPENDICULAR TO FLOW DIRECTION



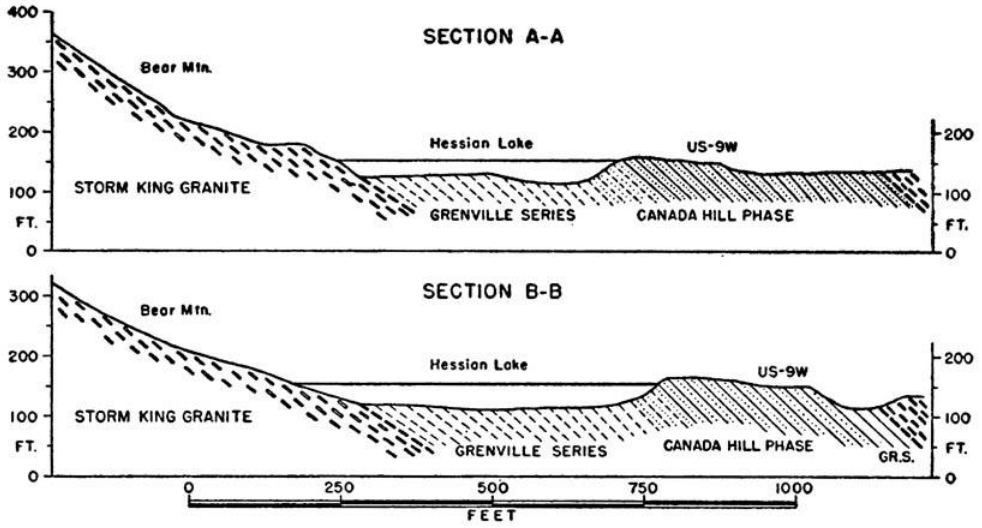
Grenville Metasedimentary Rocks





Hessian Lake

Canada Hill Phase
~ 1,100 Ma



Bear Mountain Bridge

Cable Run Across

Hudson River

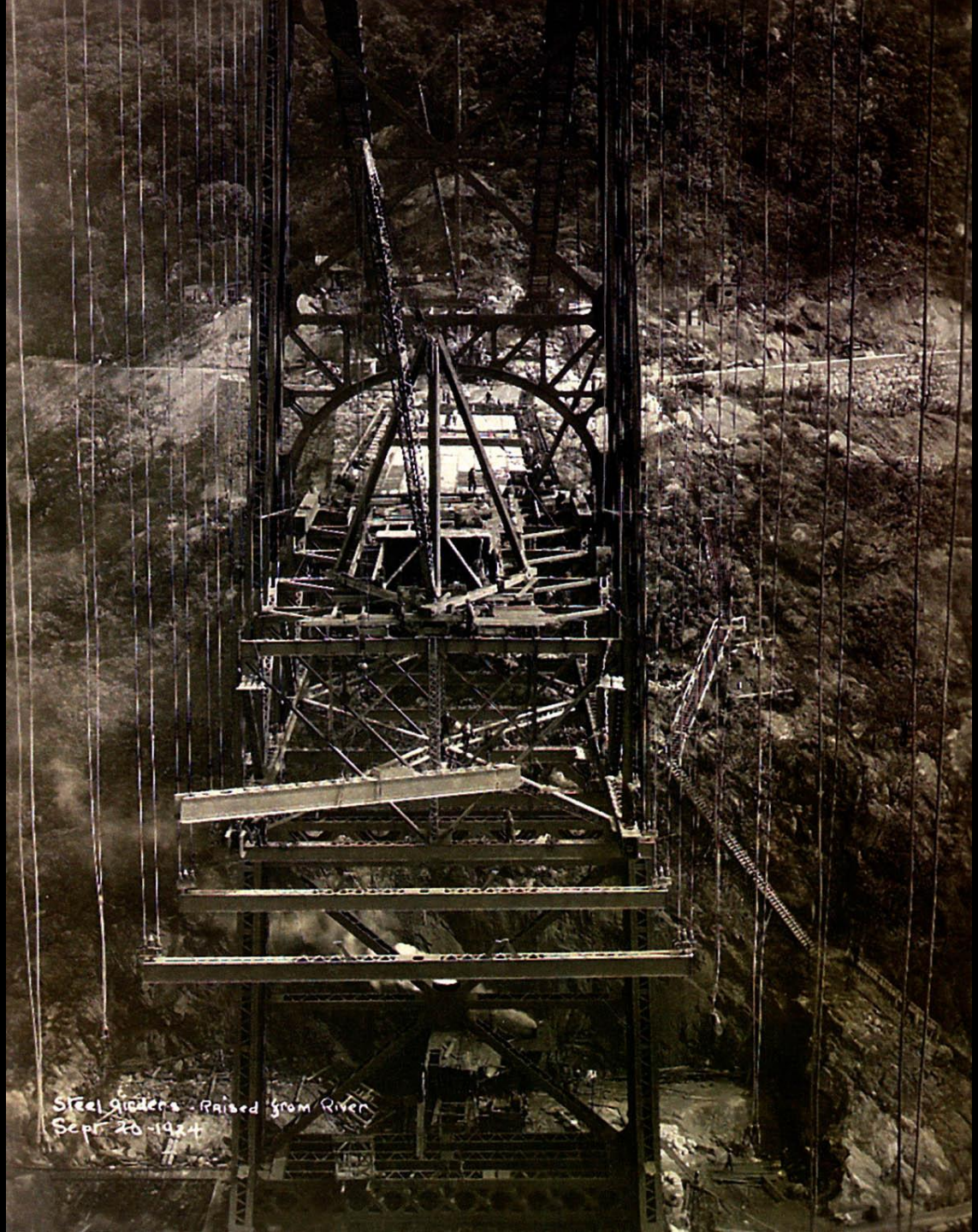
View East Toward

Anthony's Nose

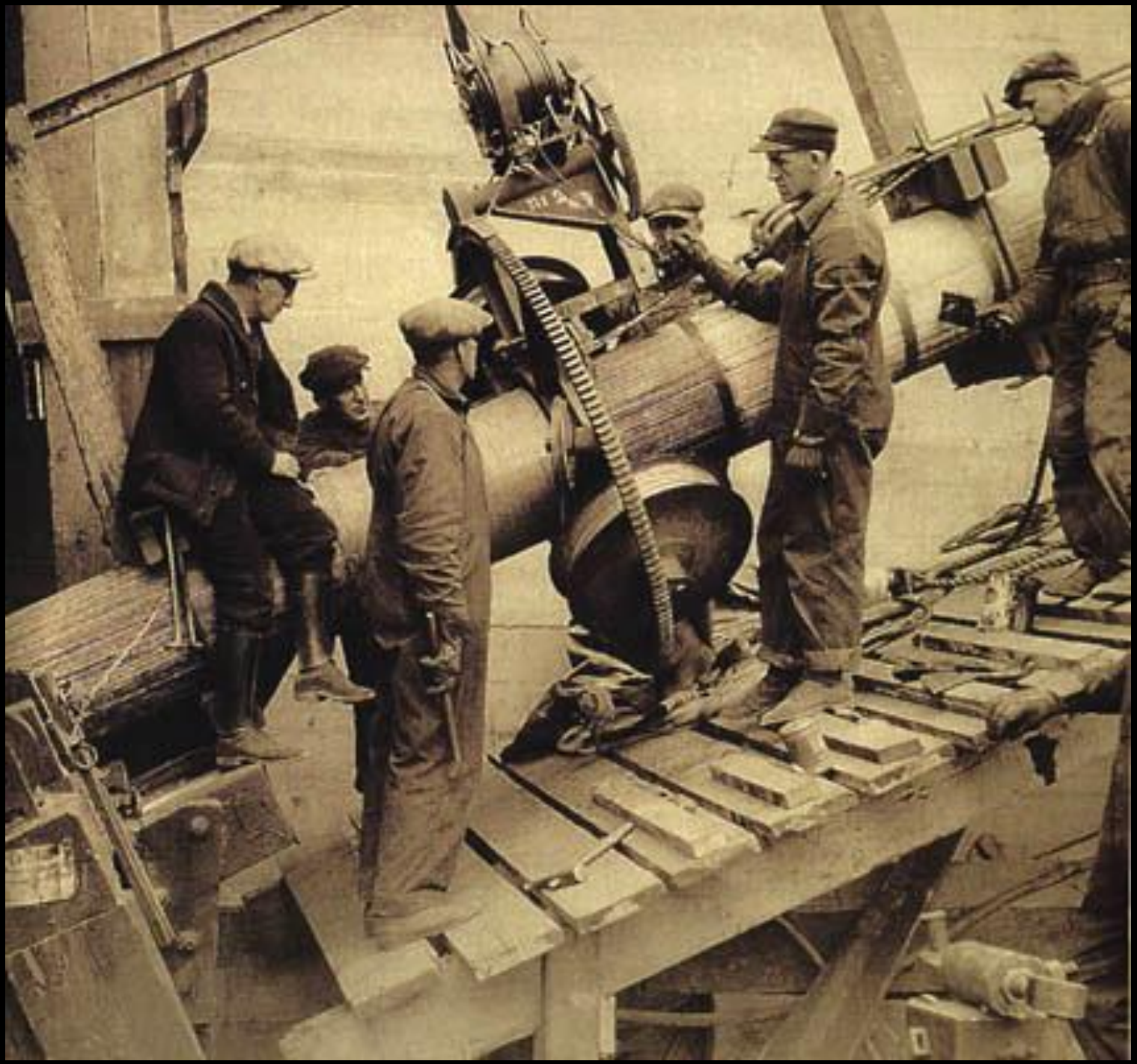
14 Apr 1924

East Highway

April 1924




ROEBLING

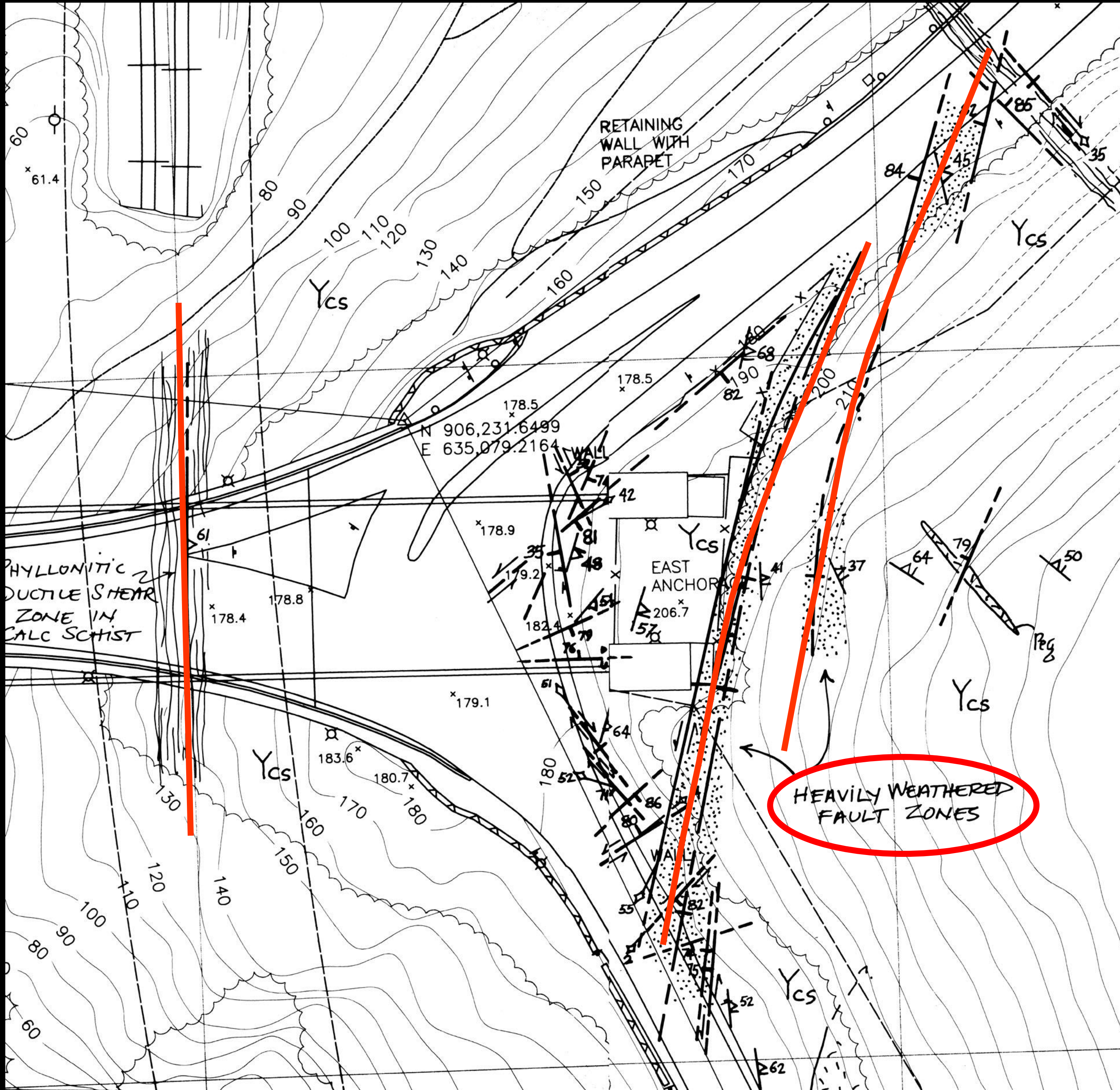



South Anchorage - East Shore

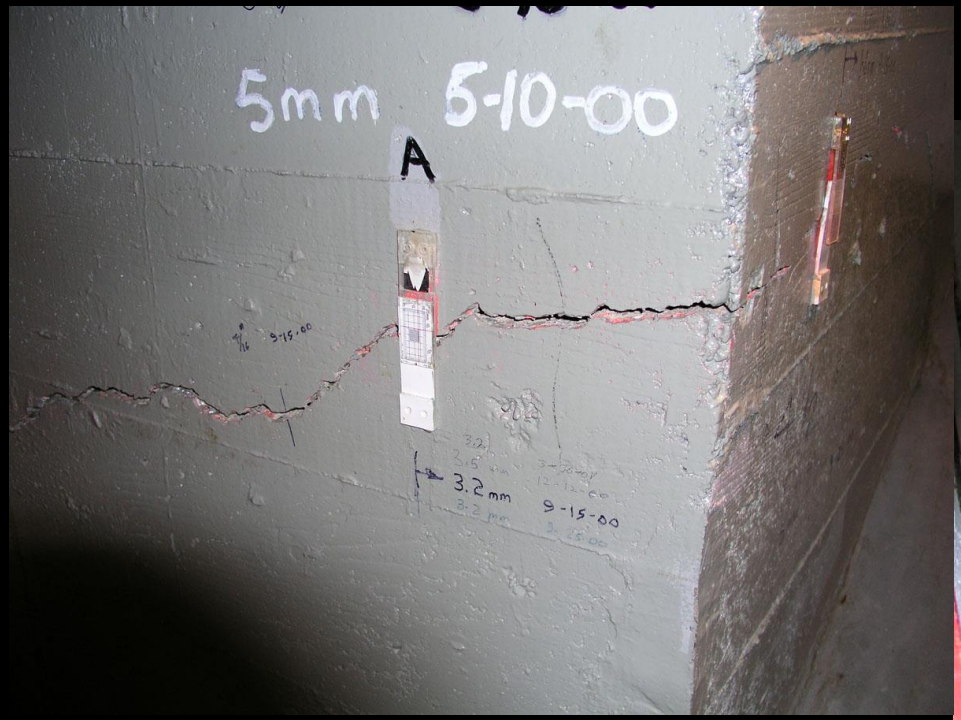

Concreting South Pir
West Anchorage
Sept. 4-1924


Bridge Open
27 November 1924

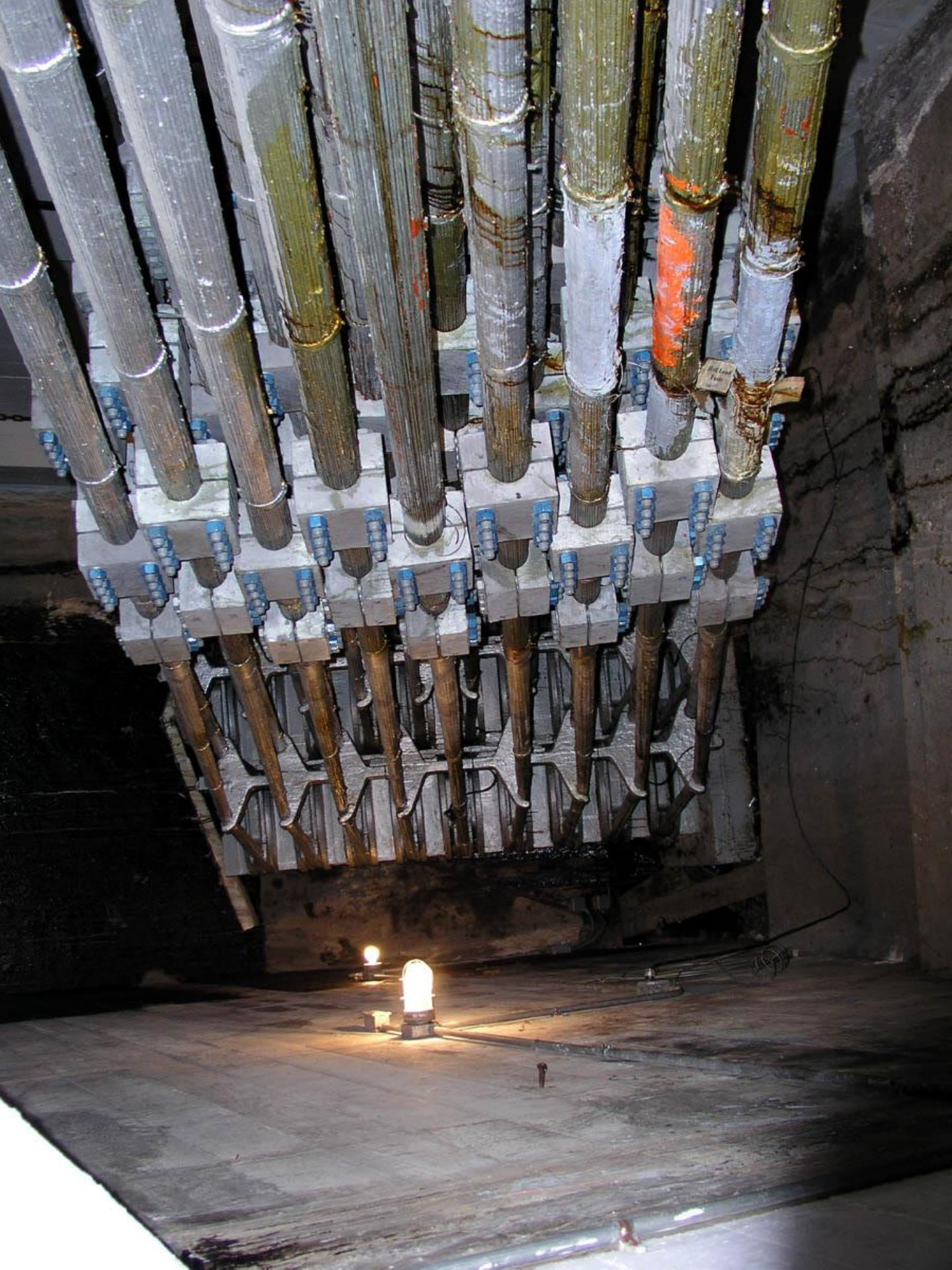
East Anchorage


RETAINING WALL WITH PARAPET
Ycs
PHYLLONITIC DUCTILE SHEAR ZONE IN CALC SCHIST
N 906,231.6499
E 635,079.2164
WALL
EAST ANCHOR
206.7
178.5
178.9
178.4
178.8
179.1
179.2
182.4
183.6
180.7
61.4
HEAVILY WEATHERED FAULT ZONES

West Anchorage




Corroding Cables
and
Shifting Anchorage
SW Anchorage




West Anchorage
E-ZPass

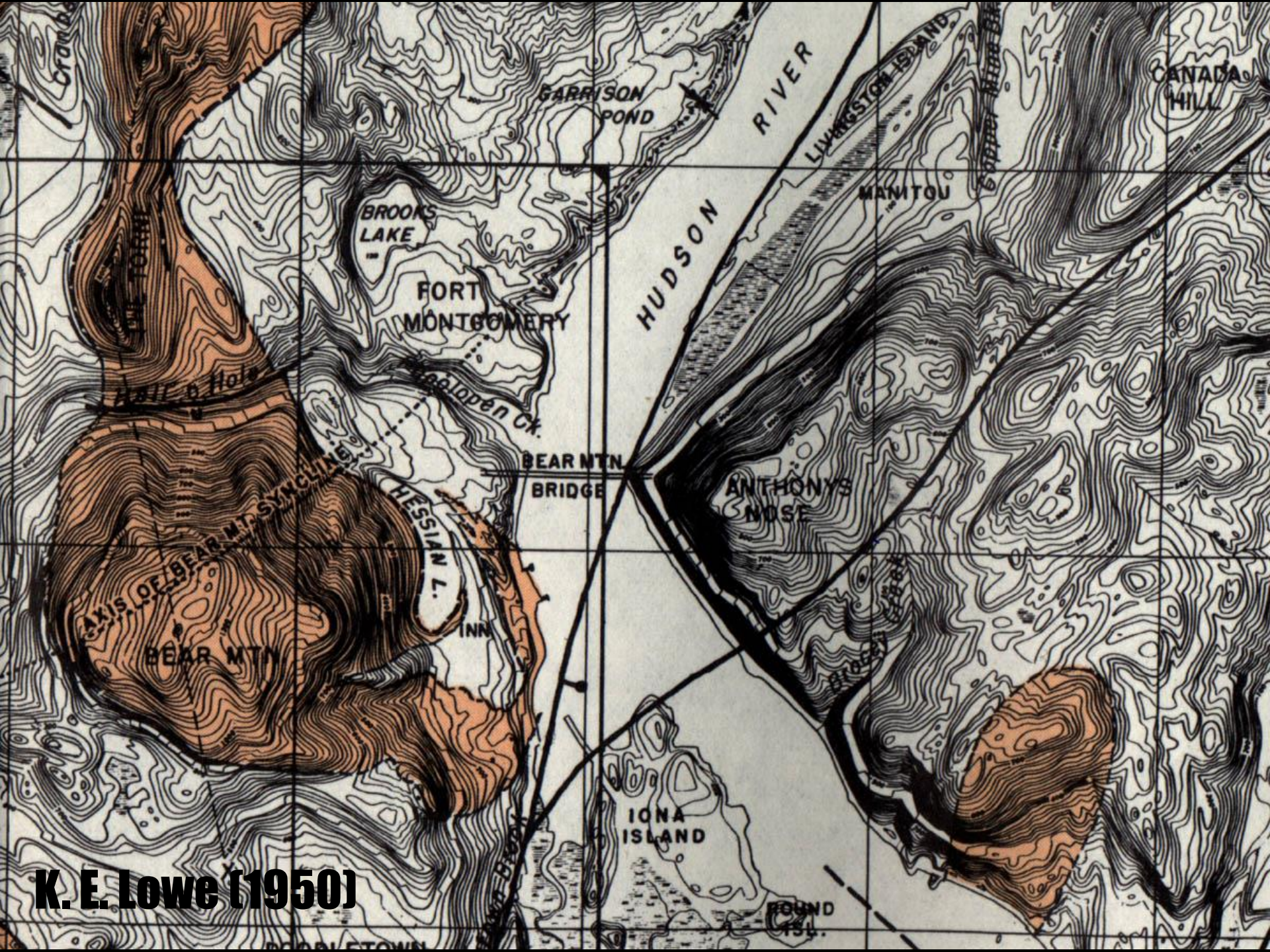

West Anchorage
Garnetiferous Granitoid


BEAR MOUNTAIN HUDSON RIVER BRIDGE, N. Y. 17
VIEW FROM ANTHONY'S NOSE MOUNTAIN, LOOKING WEST

Zig-Zag Course of the Hudson River

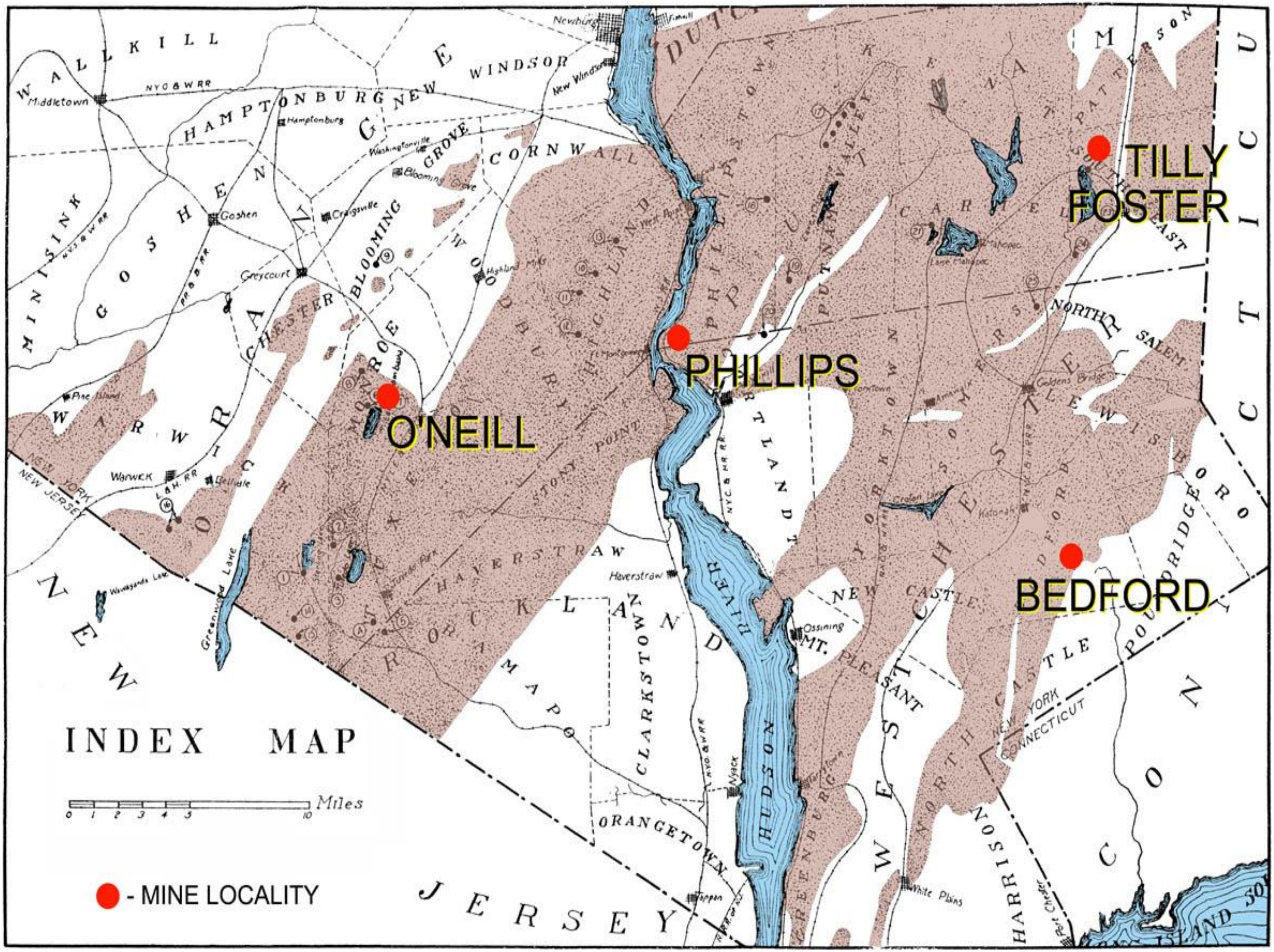
Results from Emphatic Structural Control and Glacial Erosion


293
9W
403
9
Camp
Smith
Camp
Smith
9

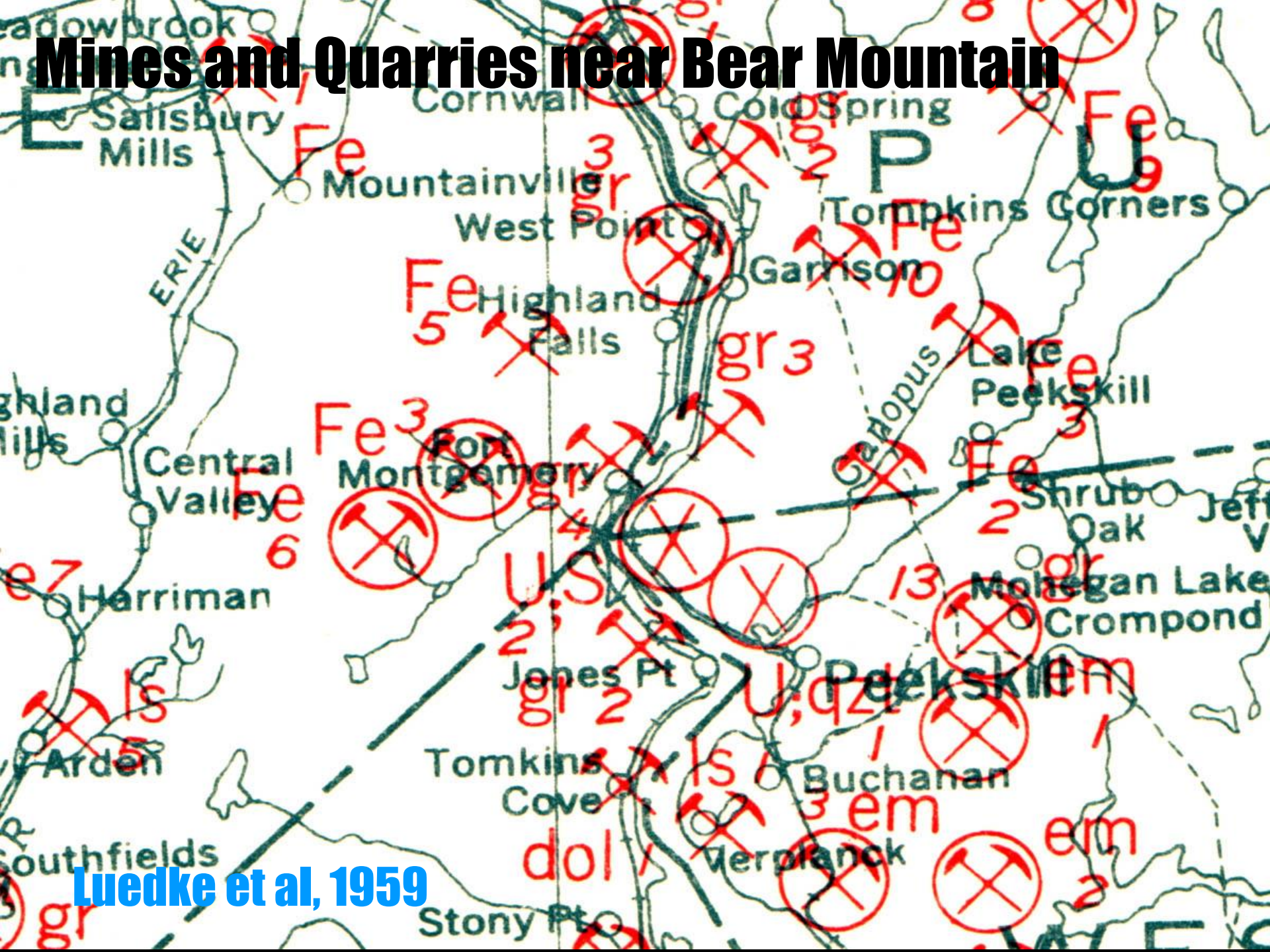

GARRISON POND
HUDSON RIVER
LIVINGSTON ISLAND
CANADA HILL
MANITOU
BROOKS LAKE
FORT MONTGOMERY
Hall o Hole
Dolopen Ck.
BEAR MTN BRIDGE
ANTHONYS NOSE
AXIS OF BEAR MT. SYNCLINE
HESSIAN L.
INN
BEAR MTN
IONA ISLAND
FOUND ISL.

K. E. Lowe (1950)

Granite and Gneiss | *Triassic, Shales and Sandstones* | *Palisade Diabase* | *Sandstones Gneiss* | *Glacial fill of the Hudson Gorge* | *Manhattan Schist and Inwood Limestone* | *Pre-Cambrian Gneiss* | *Schist and Limestone*


TILLY FOSTER
PHILLIPS
O'NEILL
BEDFORD
INDEX MAP
Miles
0 1 2 3 4 5 10
- MINE LOCALITY
HUDSON RIVER
NEW JERSEY
NEW YORK
CONNECTICUT

Mines and Quarries near Bear Mountain



Luedke et al, 1959

Lewis C. Beck, M.D.

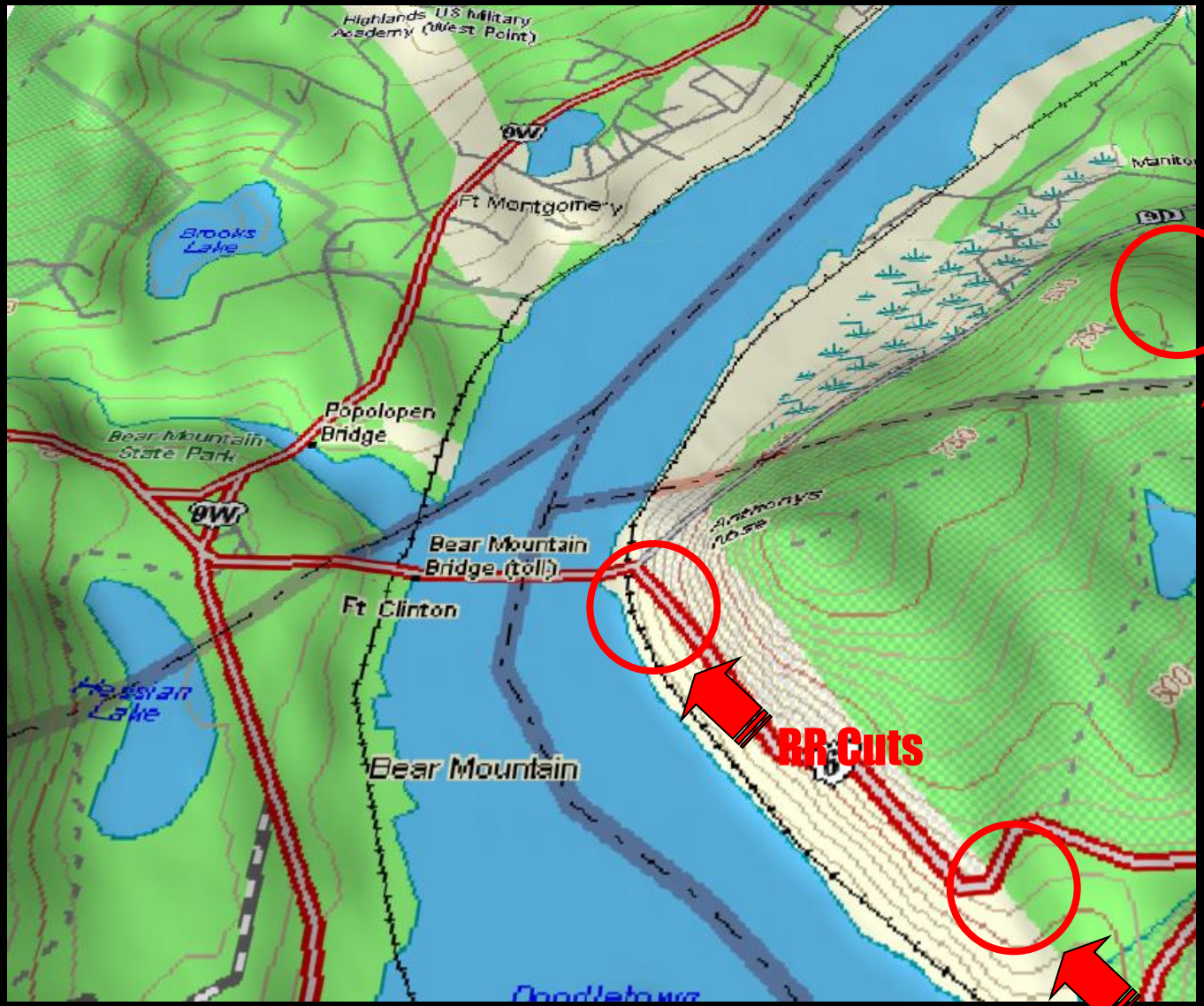
Professor of Chemistry and Natural History, Rutgers University

New York State Geological Survey

Wrote Mineralogy of New York (1842) and two addenda (1849, 1850)
https://www.internetarchive.org

Described mines and minerals from the Hudson Highlands, providing detailed crystallographic drawings

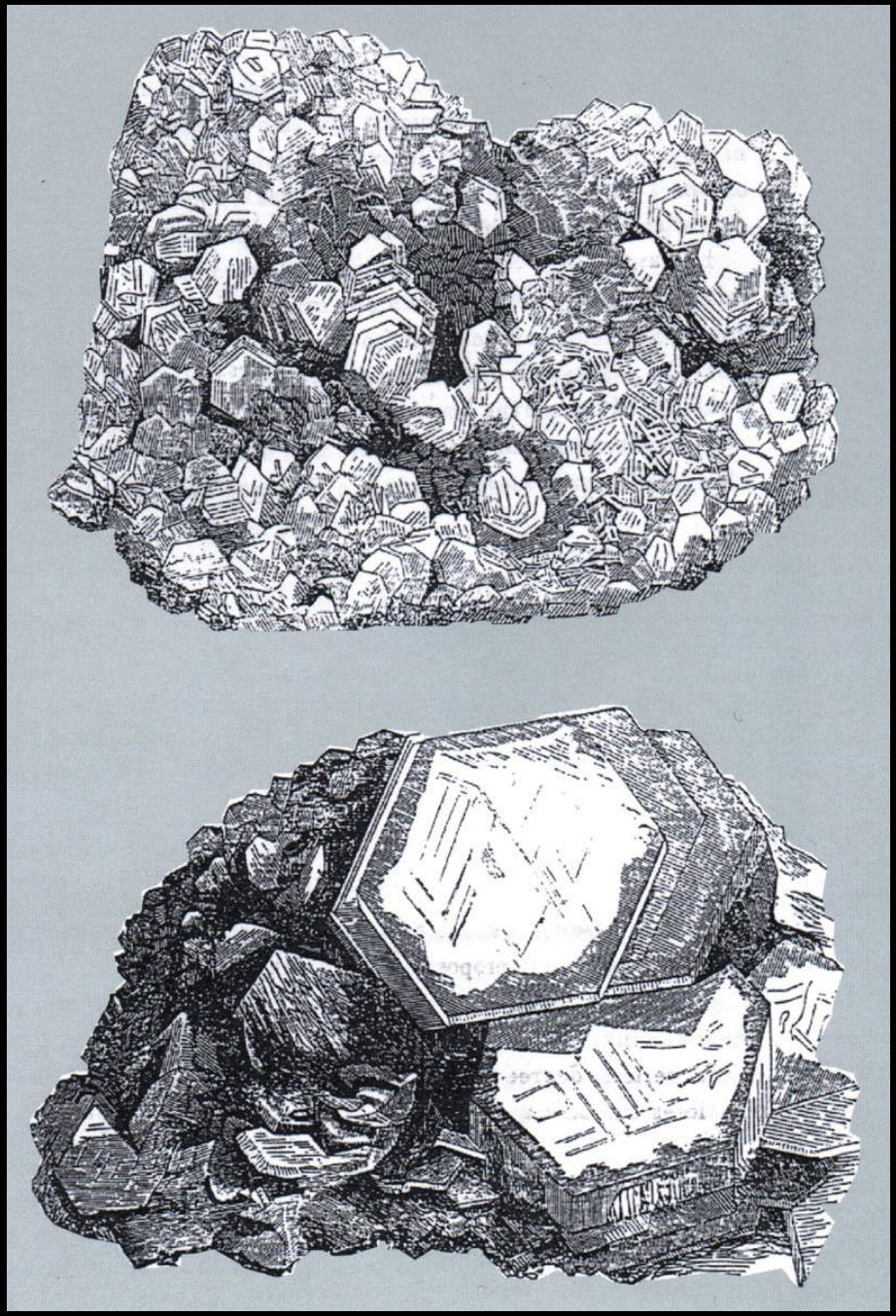
Bear Mountain - Anthony's Nose Area, NY



RR Cut Locality not mentioned in Beck (1842) but described in Beck's (1849) Second Annual Report to the NYS Board of Regents

Drawings from Beck (1850) Third Annual Report to Board of Regents

Lower specimen, donated by John E. Henry, is at the New York State Museum in Albany (Beck, 1850)



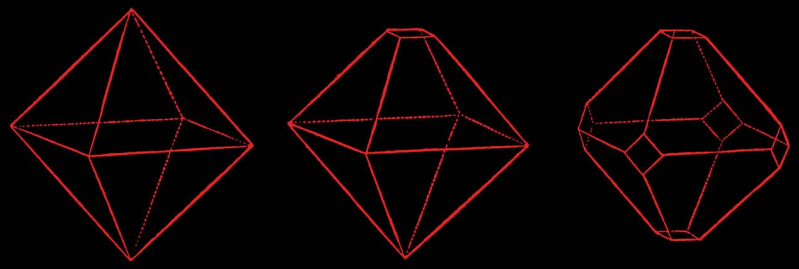
Calcite - 1848 RR Tunnel, Anthony's Nose, Westchester Co., NY


Chabazite - Route 6, Cortlandt, Orange Co., NY
Mike Hawkins Image

Stilbite over Natrolite - Route 6, Cortlandt, Orange Co., NY


Thompsonite - Route 6, Cortlandt, Orange Co., NY
Mike Hawkins Image

Highlands Iron Mines



- Metamorphic minerals include garnet, coccolite (diopside), pyroxene, spinel, hornblende, amianthus (asbestos), glaucophane, epidote, serpentine, calcite, and aragonite

- Highlands ore bodies are strataform, internally layered and consist of finely recrystallized magnetite and gangue minerals = original layering (sed/igneous)

- Highlands orebodies are all associated with intrusives and/or faults in their Grenville-aged (~1 Ga) host rocks

Phillips Mine
Anthony's Nose

Phillips Mine Ice, Winter 1907 (Howell 1934)

Phillips Mine
Anthony's Nose, Putnam Co.

- Oldest mining in Bear Mountain -Anthony's Nose district (1872 Map Hudson River Copper Mine)

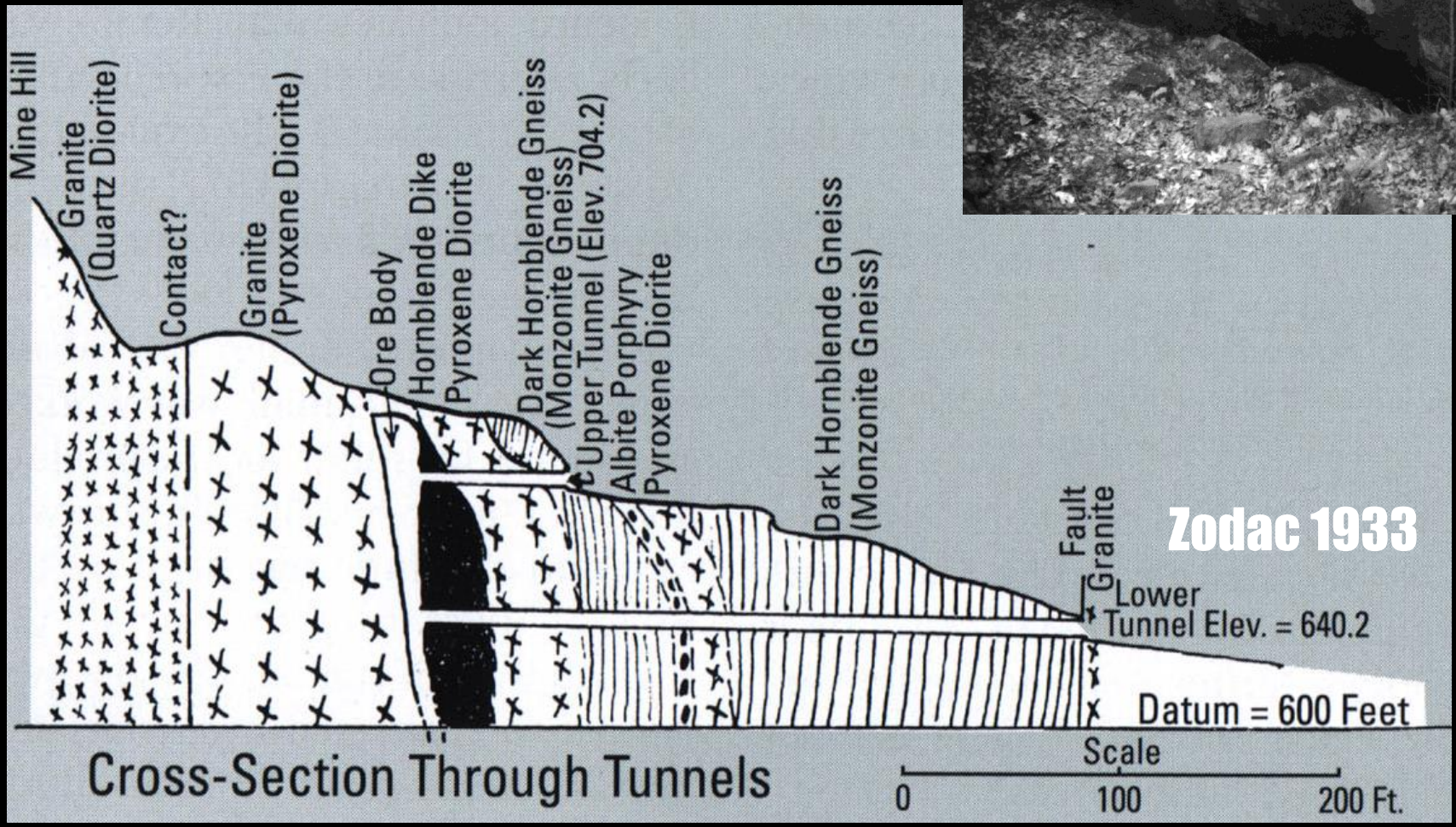
- Beck (1842) describes iron mine as "long ceased operation". Tunnels/mine dump still accessible!!

- Renowned for pyrite, magnetite, pyrrhotite, and fine apatite crystals – 26 species listed by Betts (1997) including fluorapatite, gypsum, magnesio-hornblende

- Mined first for Cu then Fe ore but high sulfide + nickel content ore less desirable than local magnetite mines

- Renewed interest in 1950s for uraninite mining

Phillips Mine
Anthony's Nose, Putnam Co.



Lenticular orebody 100' wide and 300' deep dips NW

Phillips Mine
Anthony's Nose, Putnam Co.

Fluorapatite in Magnetite

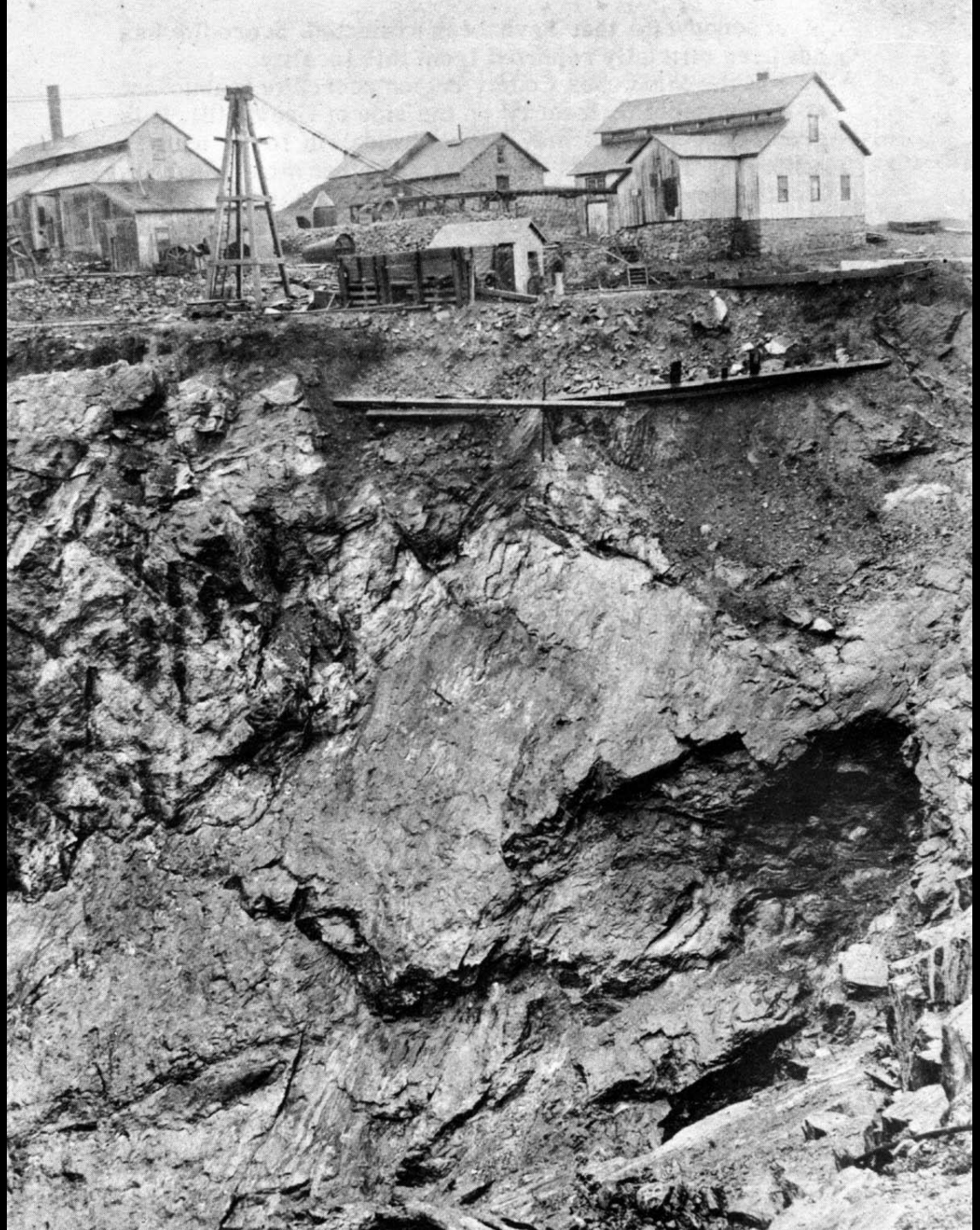
Gypsum

Phillips Mine
Anthony's Nose, Putnam Co.

Magnetite with Magnesio-hornblende

Phillips Mine
Anthony's Nose, Putnam Co.

Pyrrhotite with Fluorapatite



Tilly Foster Mine

Named (in 1860) after
Farmer born in
Carmel, NY
18 April 1793

Mining of iron ore
began 1810 from
surface pit

Mine closed in 1897
after 1895 collapse

Tilly Foster Mine

70° ESE-dipping ore vein
Cut by N-S, E dip steep fault

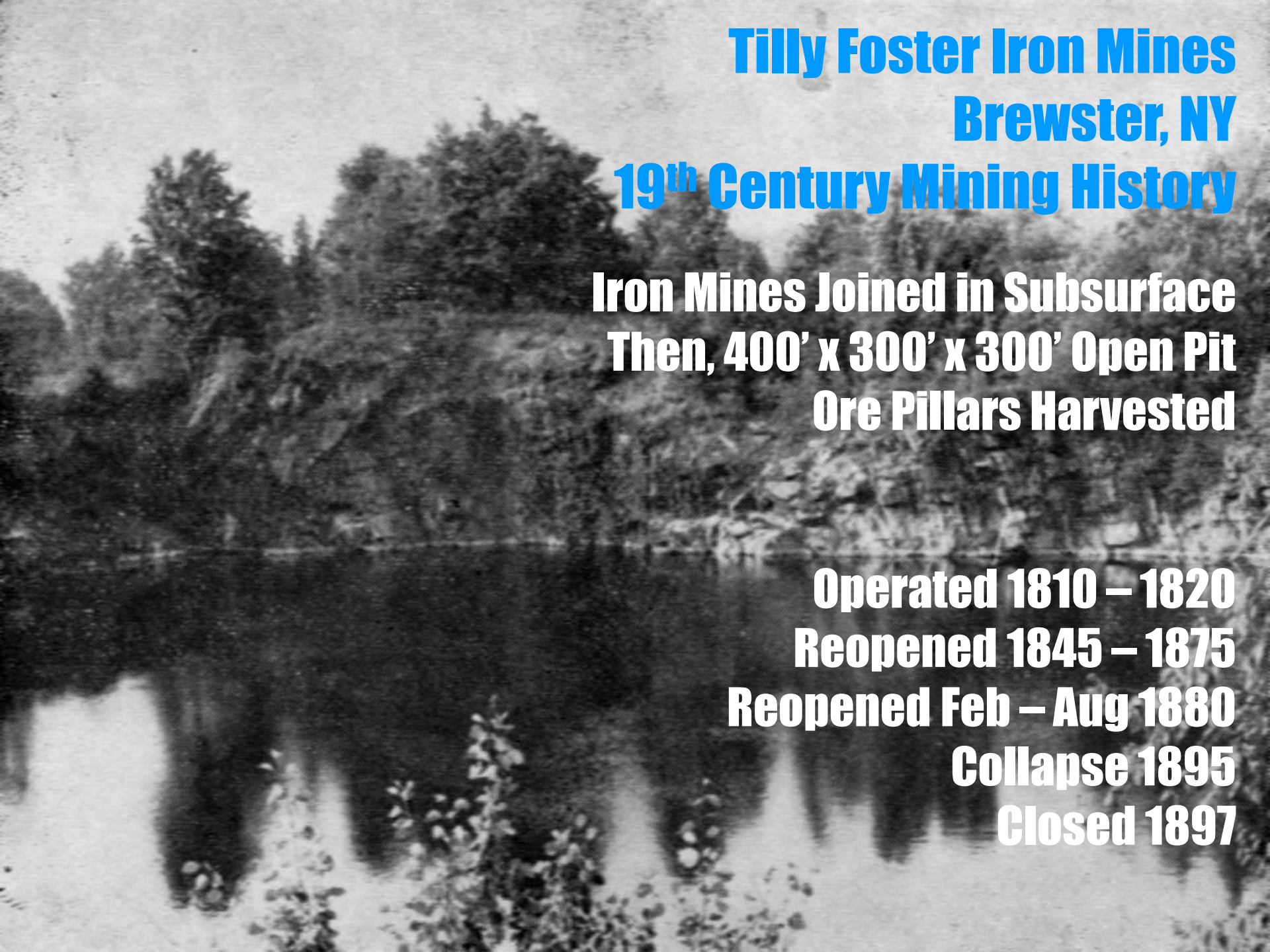
Ore Vein tapers From
160’ to 80’ thick at ends

Dumps renowned
by mineral collectors
for the following:

Magnetite
Chondrodite
Clinochlore
Titanite
Pyrrhotite

Tilly Foster Mine
Brewster, Putnam Co., NY

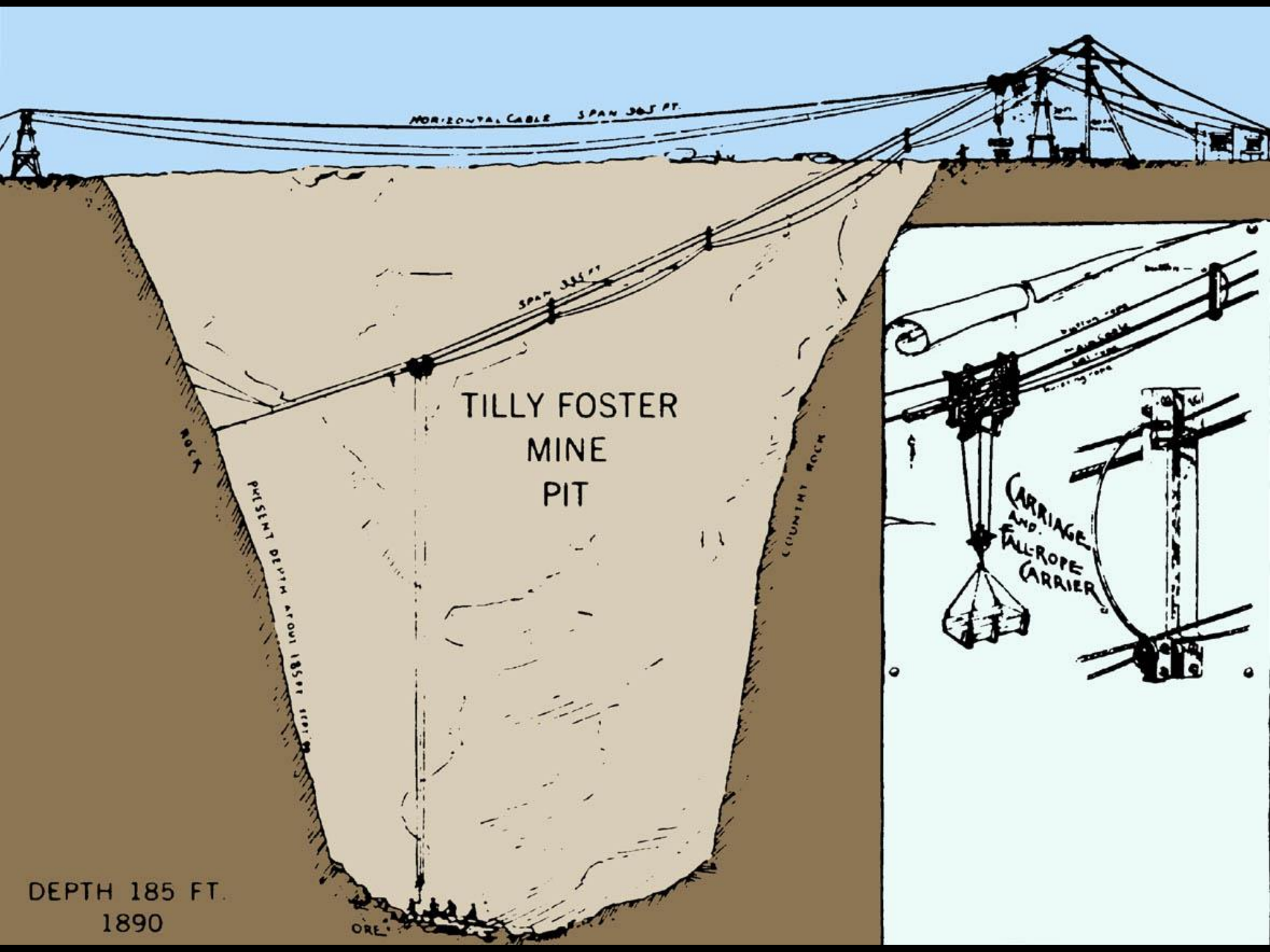
- First mined in 1810 by foundry owner James Townsend
- Revolutionary War chains across Hudson NOT from here
- About 1850, the mineral rights to metallic veins were sold for $100 to Theodosus Secor and Thomas Harvey
- Townsend family sold deed to Harvey Steel and Iron Company in 1853 and was resold in 1863 to Charles Ladd
- Turned over to John Cheever in 1864 under corporate name Tilly Foster Mine

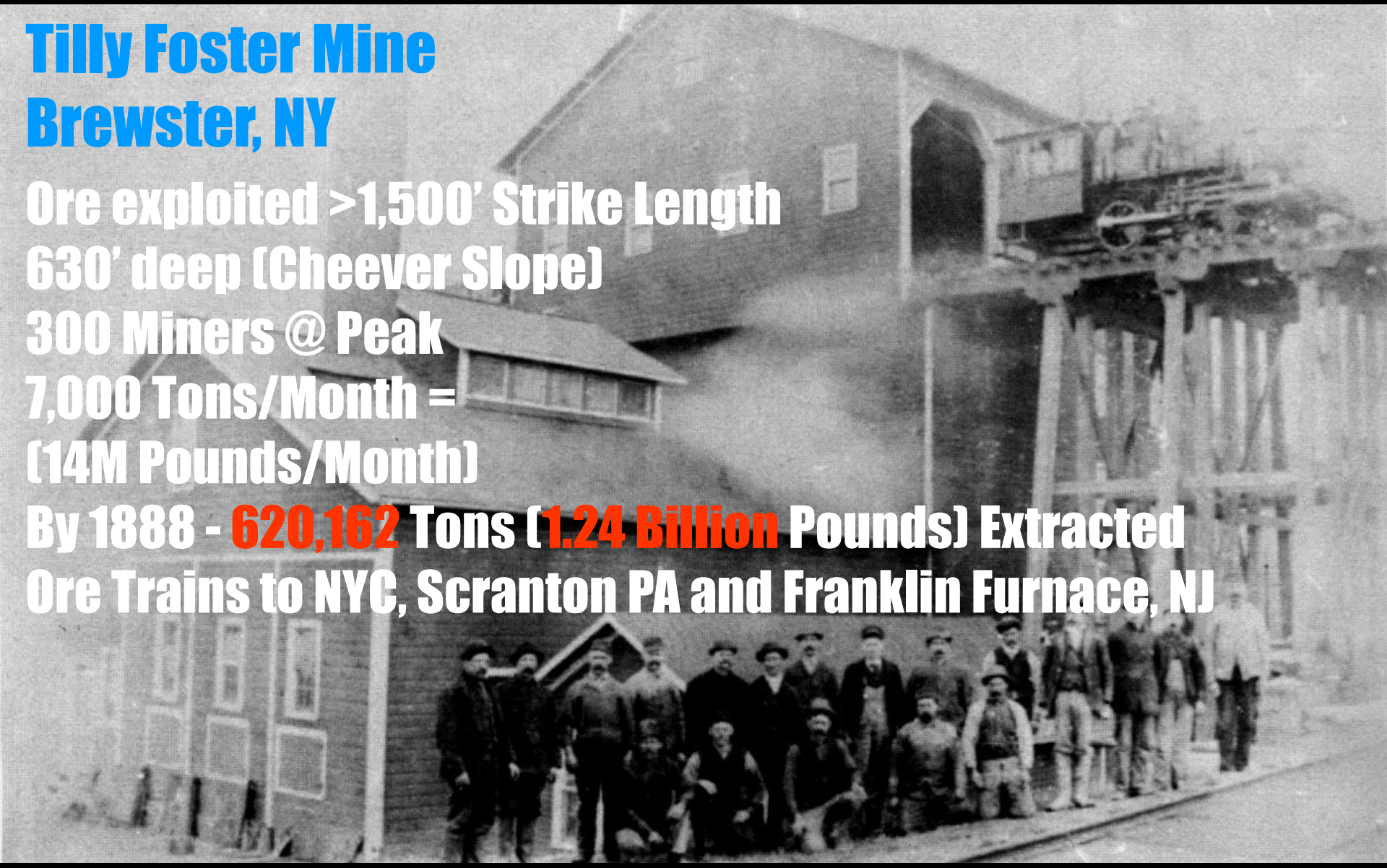


Tilly Foster Iron Mines
Brewster, NY
19th Century Mining History

Iron Mines Joined in Subsurface
Then, 400' x 300' x 300' Open Pit
Ore Pillars Harvested

Operated 1810 – 1820
Reopened 1845 – 1875
Reopened Feb – Aug 1880
Collapse 1895
Closed 1897


HORIZONTAL CABLE SPAN 385 FT.
SPAN 385 FT.
TILLY FOSTER
MINE
PIT
ROCK
PRESENT DEPTH ABOUT 185 FT.
COUNTRY ROCK
ORE
CARRIAGE AND FALL-ROPE CARRIER
DEPTH 185 FT.
1890



Tilly Foster Mine
Brewster, NY

Ore exploited >1,500' Strike Length
630' deep (Cheever Slope)
300 Miners @ Peak
7,000 Tons/Month =
(14M Pounds/Month)
By 1888 - 620,162 Tons (1.24 Billion Pounds) Extracted
Ore Trains to NYC, Scranton PA and Franklin Furnace, NJ

Tilly Foster Mine
Brewster, Putnam Co., NY

- Ore consisted of magnetite intergrown with massive chondrodite

- In the 1890's, after 1 inch dodecahedral magnetite crystals and magnificent crystals of gemmy chondrodite and chlinochlore were found, a world-class mineral locality was firmly established

- Over 100 species are recognized from this locale including many interesting pseudomorphs

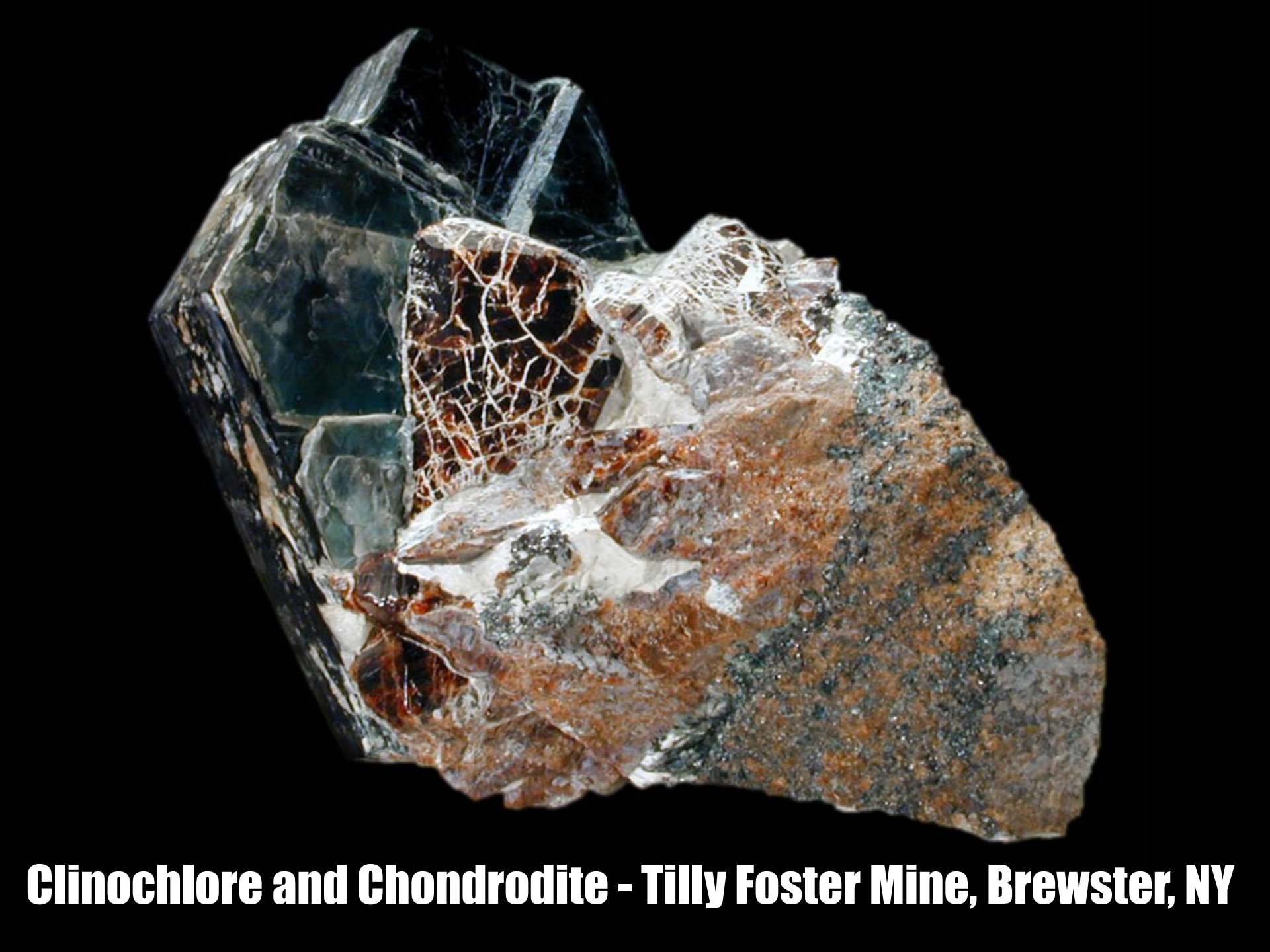
Magnetite - Tilly Foster Mine, Brewster, NY

Chondrodite - Tilly Foster Mine, Brewster, NY

$(Mg,Fe)_5(SiO_4)_2(F,OH,O)_2$

Clinochlore - Tilly Foster Mine, Brewster, NY

$(Mg,Fe)_5 Al_2 Si_3 O_{10} (OH)_8$



Clinochlore and Chondrodite - Tilly Foster Mine, Brewster, NY

Titanite - Tilly Foster Mine, Brewster, NY

$CaTiSiO_5$

Pyrrhotite - Tilly Foster Mine, Brewster, NY

Fe(1-x)S (x = 0 to 0.2)

The Bedford Pegmatite Quarries
Bedford, Westchester Co., NY

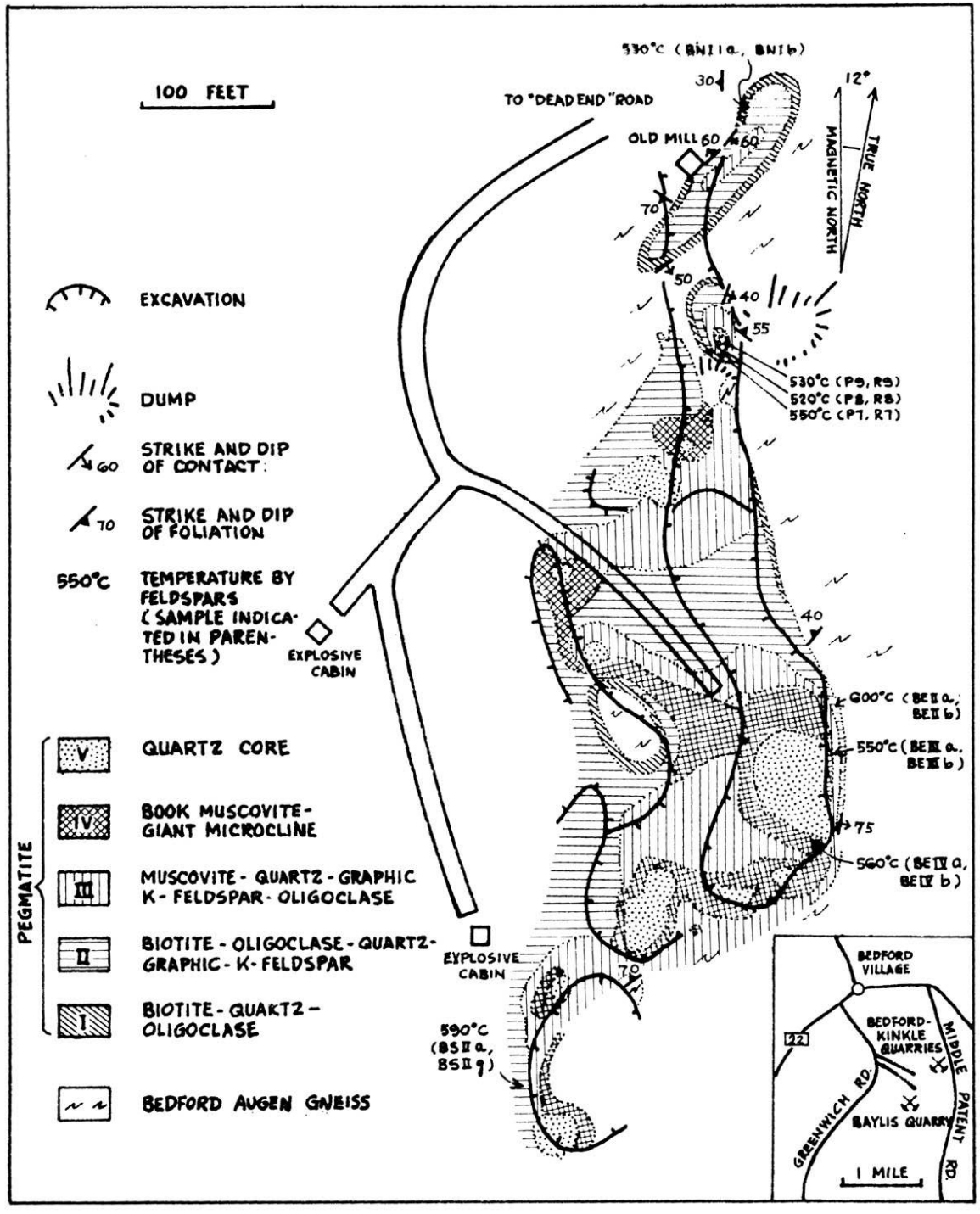
Eight Bedford quarries, opened in 1878, are found within a 2 mile radius of Bedford Village

Baylis
Bullock
Bueresch
Hobby
Kelt
Kinkel (Kinkle)
McDonald
Speranza

- The feldspar was of very high quality and shipped in ground form for use in tile, enamel, and glass
- Total yield several thousand tons/year
- Roughly a ton of Beryl also mined

The Bedford Pegmatites

- **Feldspar** important resource in the late 1800s
- Large quarries in the Adirondacks and near Bedford Village in New York established
- **Potash feldspar** (a perthititc microcline), suitable for ceramics, found in crystals up to 5 feet long; **Cleavlandite** was mined for use in enamel
- High quality **Rose Quartz** from the Baylis Quarry was shipped to Europe and the Orient for carving
- Greenish-yellow **Beryl** up to a foot long at Kinkel Quarry
- **Tourmaline, Cyrtolite** and ~50 other species reported

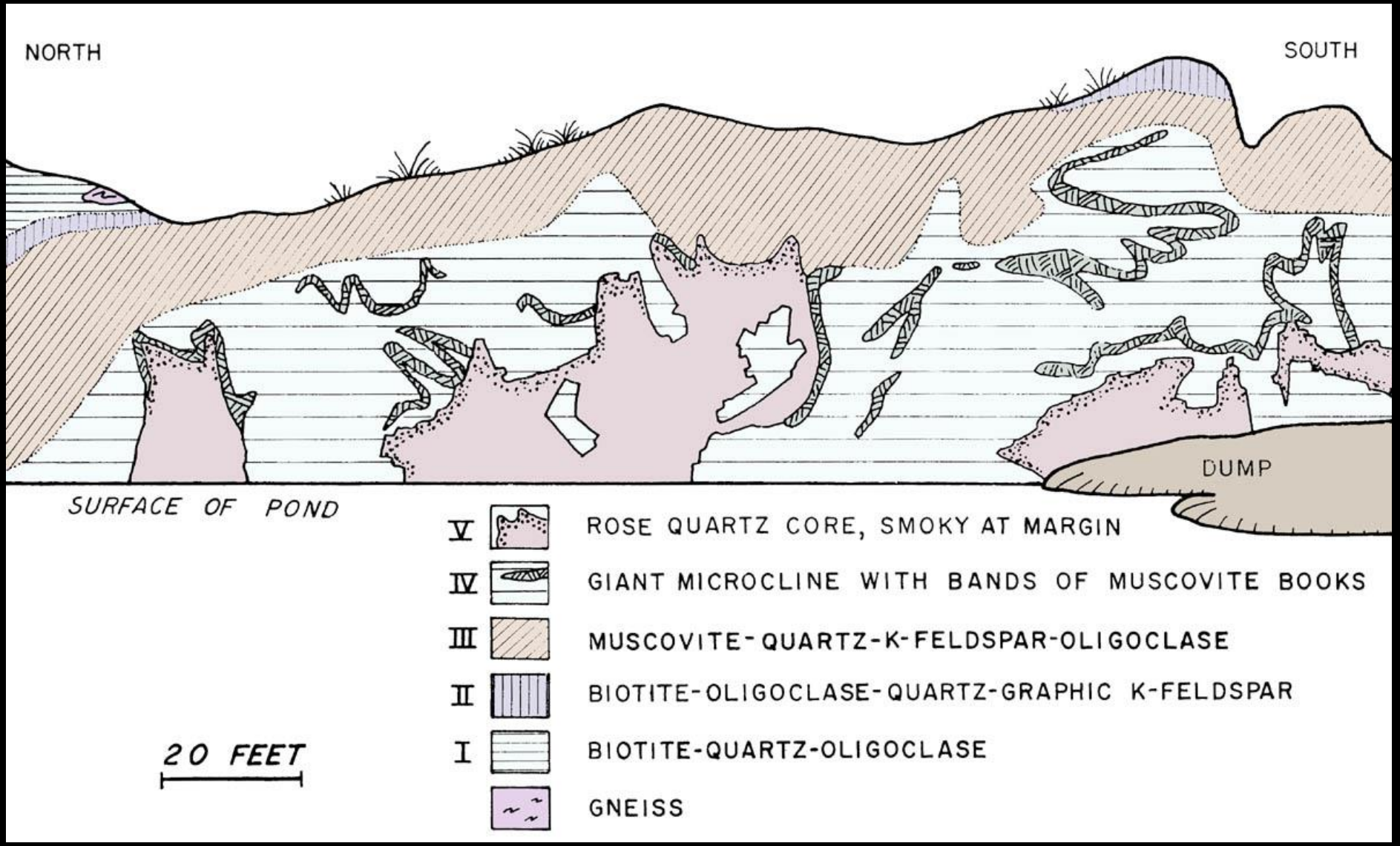


Baylis Quarry

Bedford Pegmatites are zoned and show replacement by Li, F, Be, and B

Minerals include:

Beryl
Molydbenite
Bismuthinite
Pyrolusite
Cyrtolite
Epidote
Bertrandite
Adularia
Calcite



Baylis Quarry, Bedford, NY

Agar, 1933

Orbicular Structure in Pegmatite – Kinkel Quarry

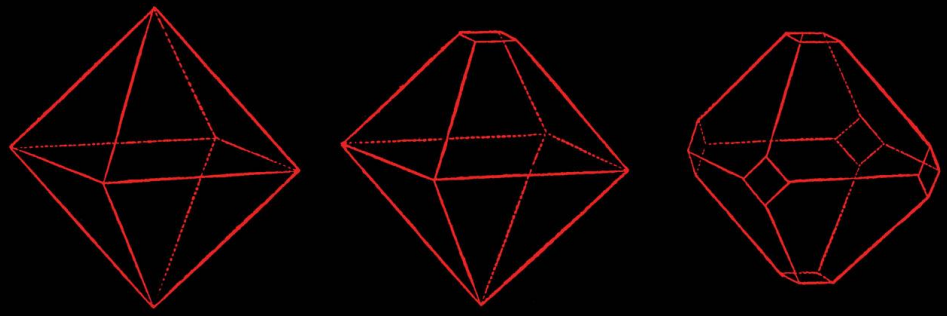

Microcline - Bedford, Westchester Co., NY

Manchester
Specimen
at AMNH

Smoky Quartz - Bedford, Westchester Co., NY

Columbite - Bedford, Westchester Co., NY

O'Neill Mine
Monroe, Orange Co., NY



- Locality described by Beck (1842) as consisting of magnetite (modified octahedra and rare cubic crystals)

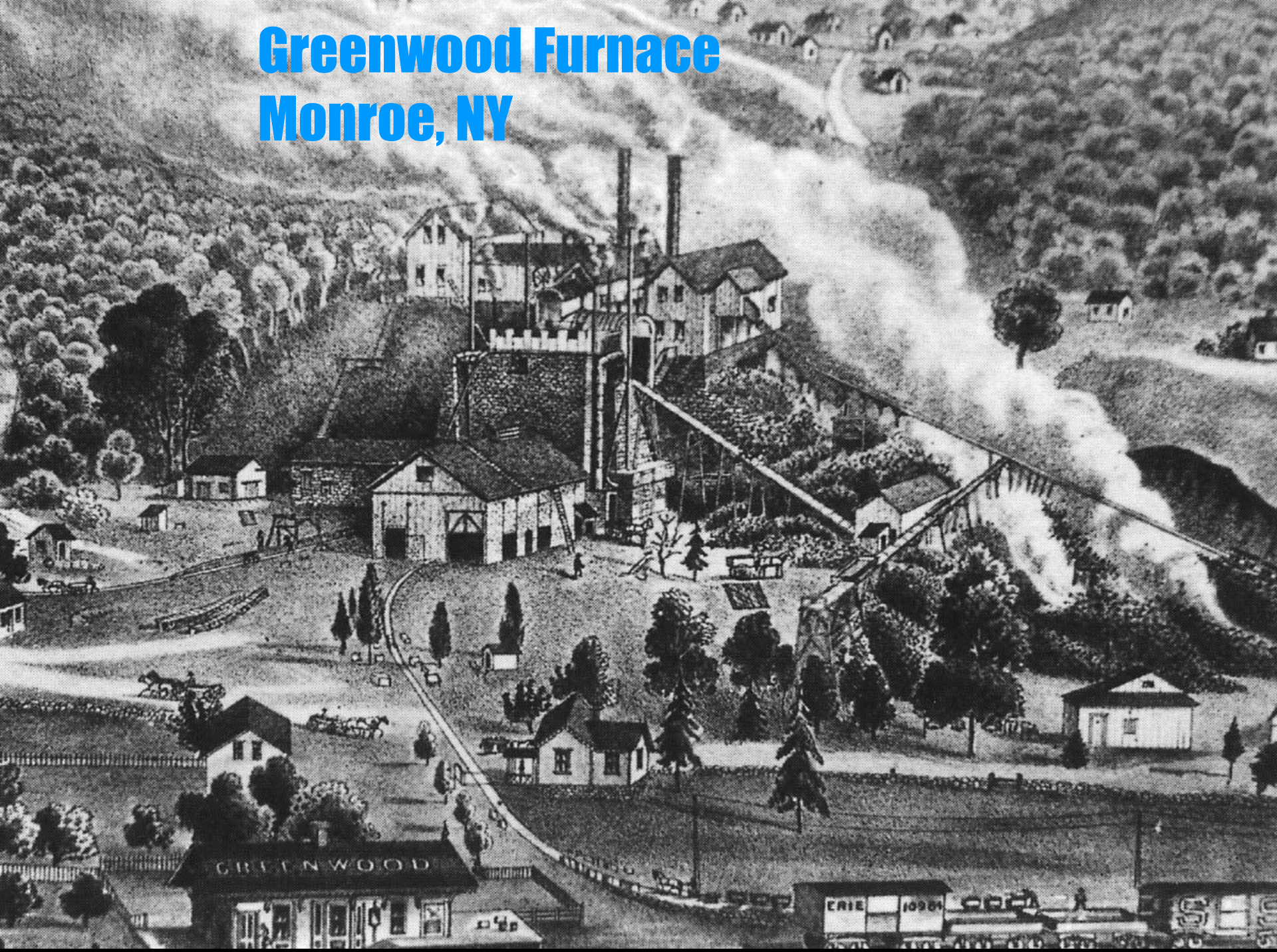
- Described as a "vast bed of the magnetic oxide of iron" that was extensively worked and contained iron pyrites

- Associated minerals - calcite, garnet, coccolite, pyroxene, hornblende, amianthus, serpentine, aragonite

- Open cuts are on strike with magnetite orebody of the Forshee Mine, roughly 0.25 mile to the SW

Magnetite - O'Neill Mine, Monroe, NY

Greenwood Furnace
Monroe, NY




Greenwood Furnace #2
Clove Furnace, Monroe, NY
1860

Edenville District
Orange Co., NY

Fluorapatite - Edenville, Orange Co., NY

Chondrodite - Edenville, Orange Co., NY

Fluorpargasite on Diopside - Edenville, Orange Co., NY

Spinel - Monroe, NY

Allanite - Edenville, Orange Co., NY

DUKE

www.Dukelabs.com


Erases