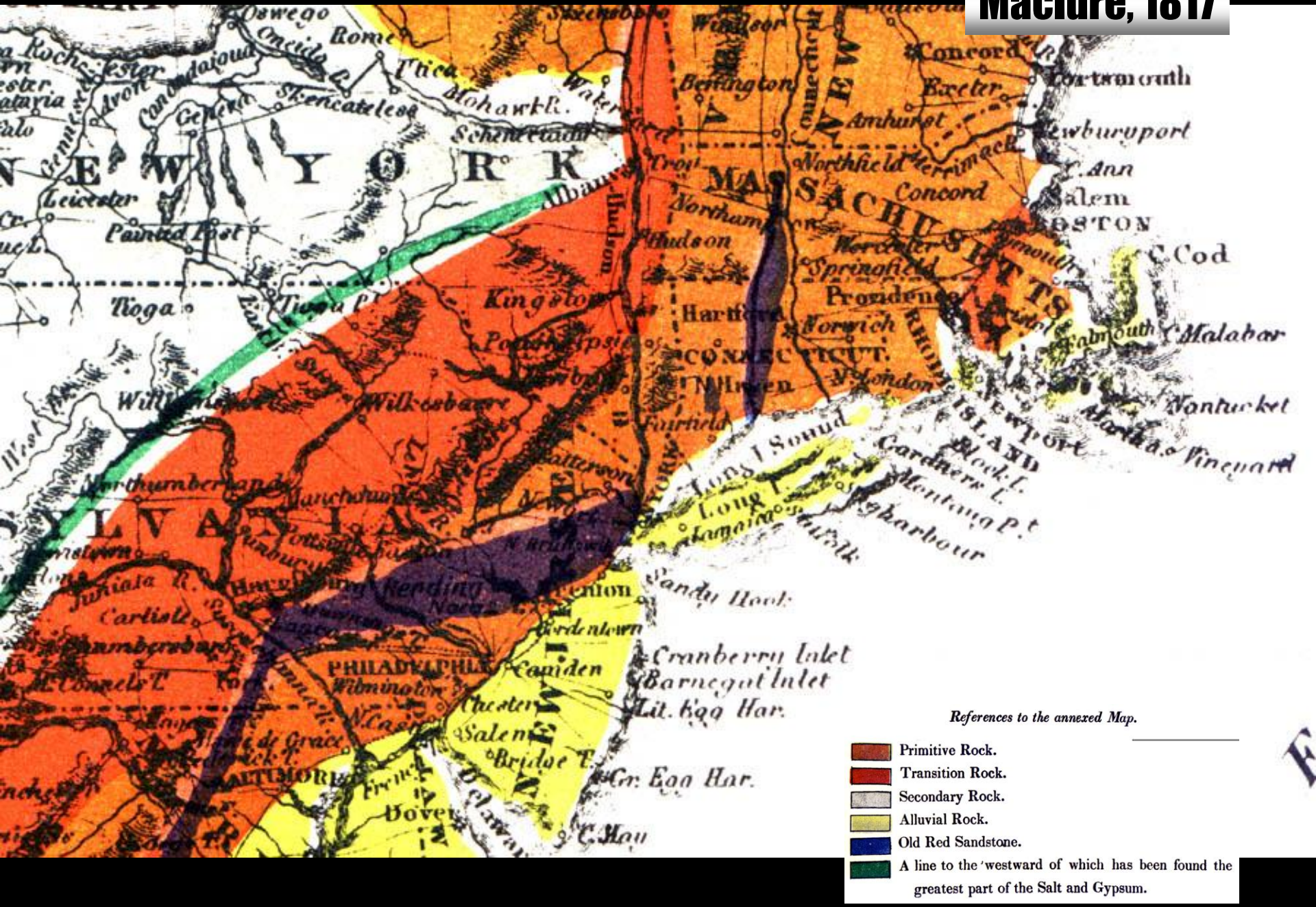
Geology and Scenery of the Hudson Highlands and Bear Mountain

Charles Merguerian
Hofstra University and
Duke Laboratories

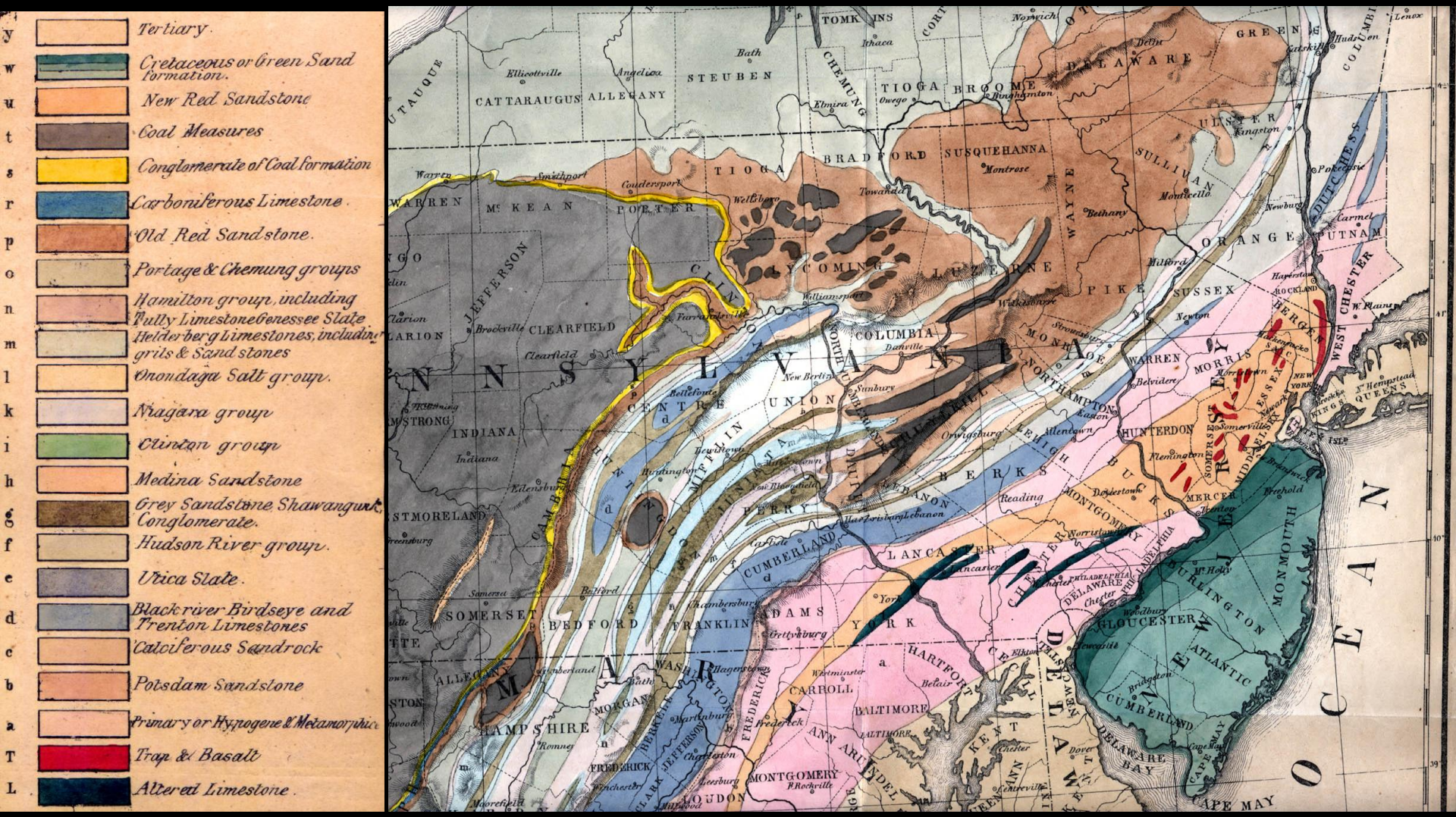
Maclure, 1817



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

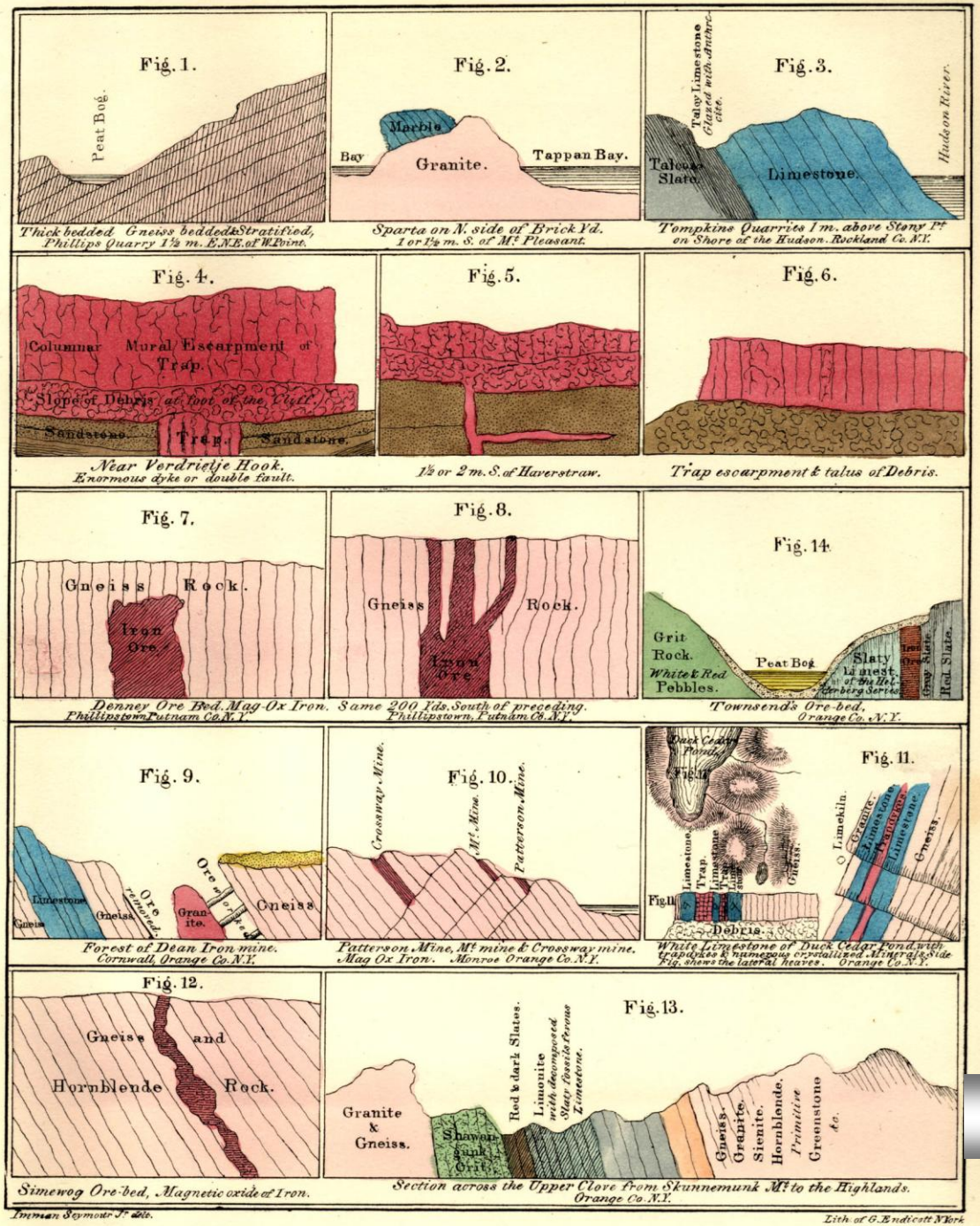


Fig. 1.
Peat Bog.
Thick bedded Gneiss bedded & Stratified, Phillips Quarry 1½ m. E.N.E. of W. Point.
Fig. 2.
Marble
Bay
Granite.
Tappan Bay.
Sparta on N. side of Brick Yd. 1 or 1½ m. S. of Mt. Pleasant.
Fig. 3.
Talcy Limestone Glazed with Anthracite.
Hudson River.
Talcose Slate.
Limestone.
Tompkins Quarries 1 m. above Stony Pt on Shore of the Hudson. Rockland Co. N.Y.
Fig. 4.
Columnar Mural Escarpment of Trap.
Slope of Debris at foot of the Cliff.
Sandstone.
Trap.
Sandstone.
Near Verdrietje Hook. Enormous dyke or double fault.
Fig. 5.
1½ or 2 m. S. of Haverstraw.
Fig. 6.
Trap escarpment & talus of Debris.
Fig. 7.
Gneiss Rock.
Iron Ore.
Donner Ore Bed. Mag-Ox Iron. Phillipstown Putnam Co. N.Y.
Fig. 8.
Gneiss Rock.
Iron Ore
Same 200 Yds. South of preceding. Phillipstown, Putnam Co. N.Y.
Fig. 14.
Grit Rock.
White & Red Pebbles.
Peat Bog
Slaty Limest. of the Helderberg Series.
Red Slate.
Townsend's Ore-bed. Orange Co. N.Y.
Fig. 9.
Limestone
Gneiss
Ore
Granite.
Gneiss
Forest of Dean Iron mine. Cornwall, Orange Co. N.Y.
Fig. 10.
Crossway Mine.
Mt. Mine.
Patterson Mine.
Patterson Mine, Mt mine & Crossway mine. Mag Ox Iron. Monroe Orange Co. N.Y.
Fig. 11.
Duck Cedar Pond
Limestone
Trap
Gneiss
Limekiln.
Granite.
Limestone
Gneiss.
Debris.
White Limestone of Duck Cedar Pond with trap dykes & numerous crystalized Minerals. Side Fig. shews the lateral heaves. Orange Co. N.Y.
Fig. 12.
Gneiss and Hornblende Rock.
Simewog Ore-bed, Magnetic oxide of Iron.
Fig. 13.
Granite & Gneiss.
Red & dark Slates.
Limonite with decomposed Slaty fossiliferous Limestone.
Shawangunk Grit.
Gneiss.
Granite.
Sienite.
Hornblende.
Primitive Greenstone &c.
Section across the Upper Clove from Skunnemunk Mt. to the Highlands. Orange Co. N.Y.
Inman Seymour Jr. del.
Lith. of G. Endicott N York

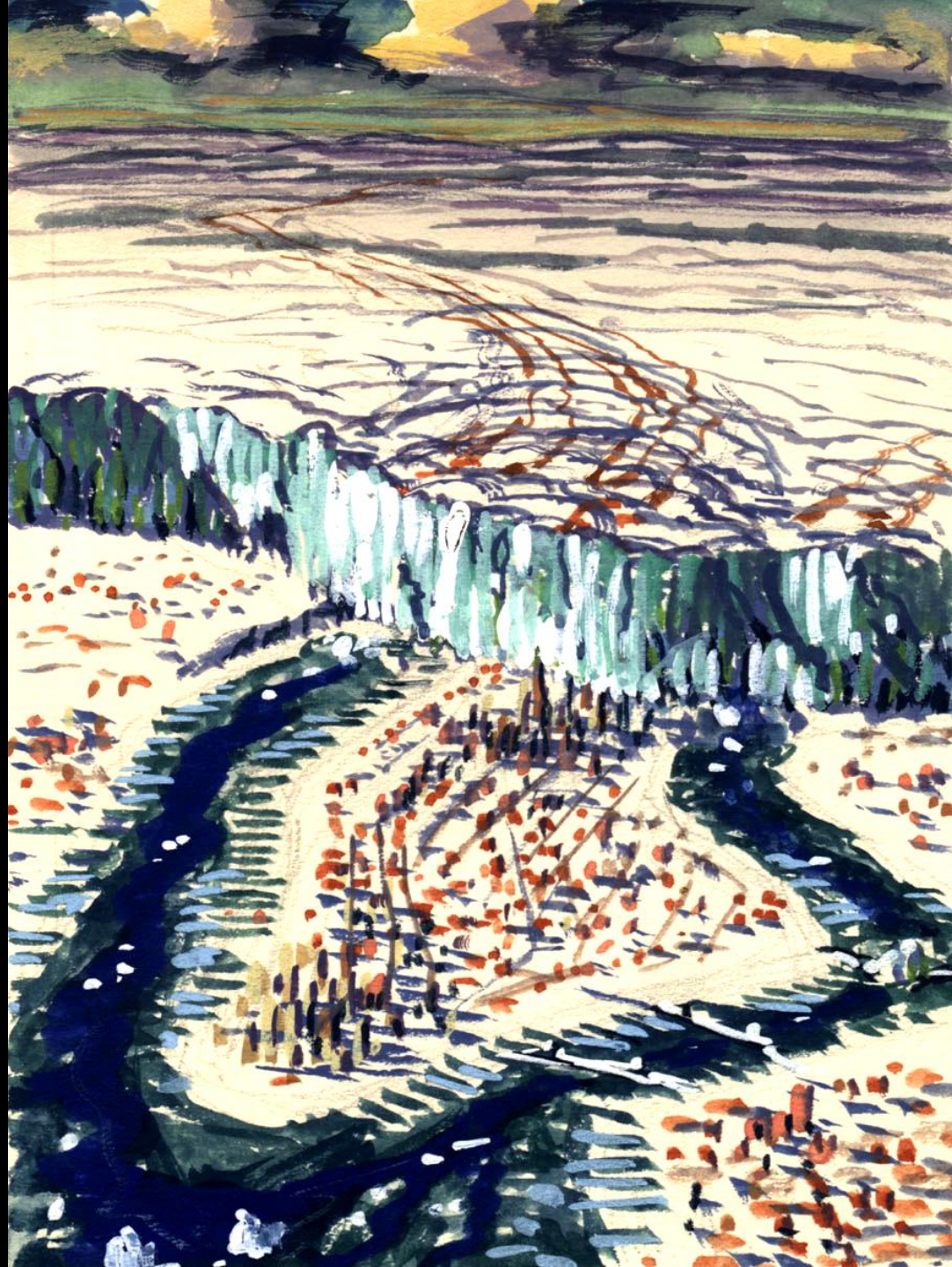
Mather 1843

Rock - Paper - Scissors

Paper Covers Rock

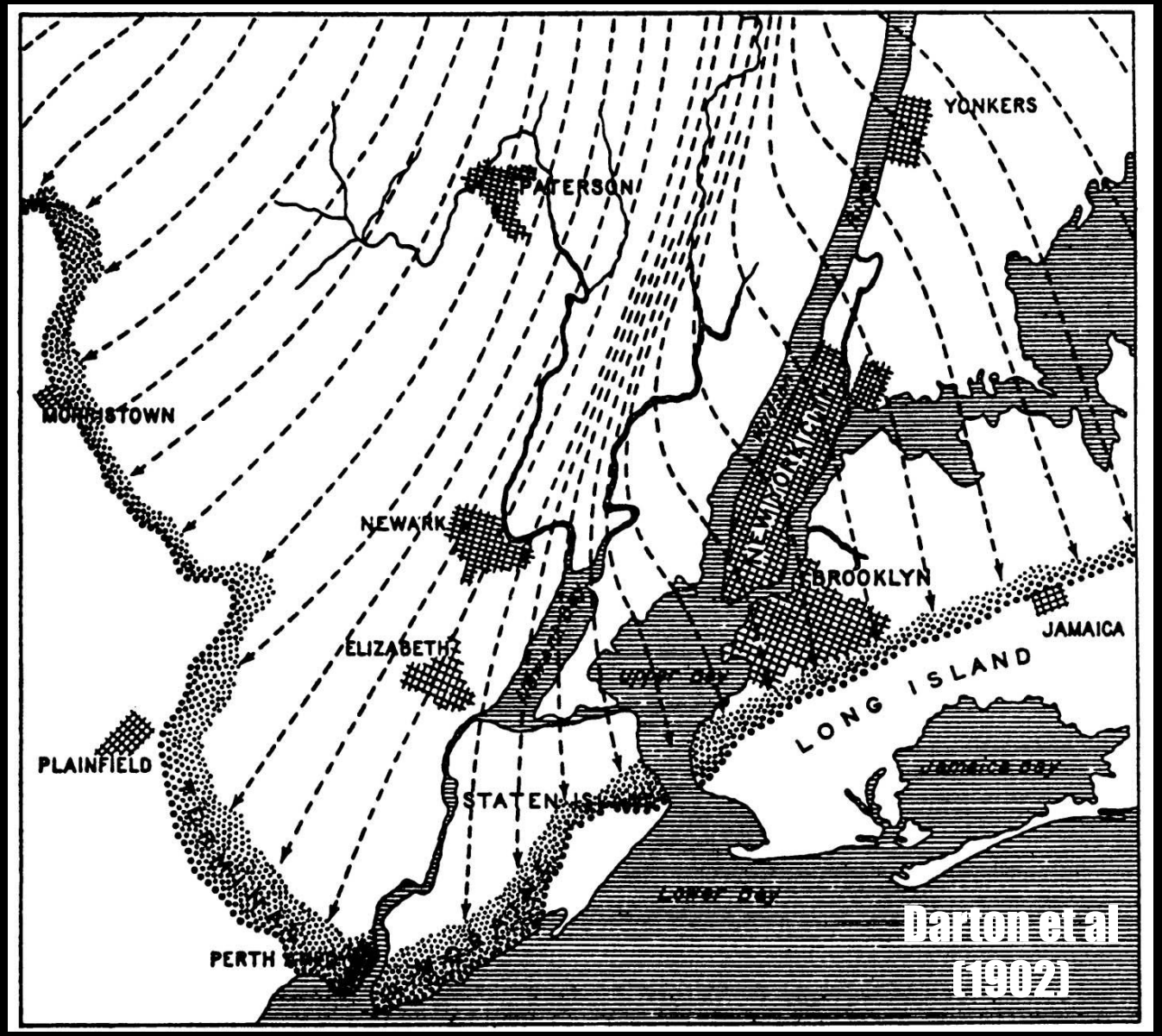
Glacier Covers NYC

Not a One-Shot Deal!



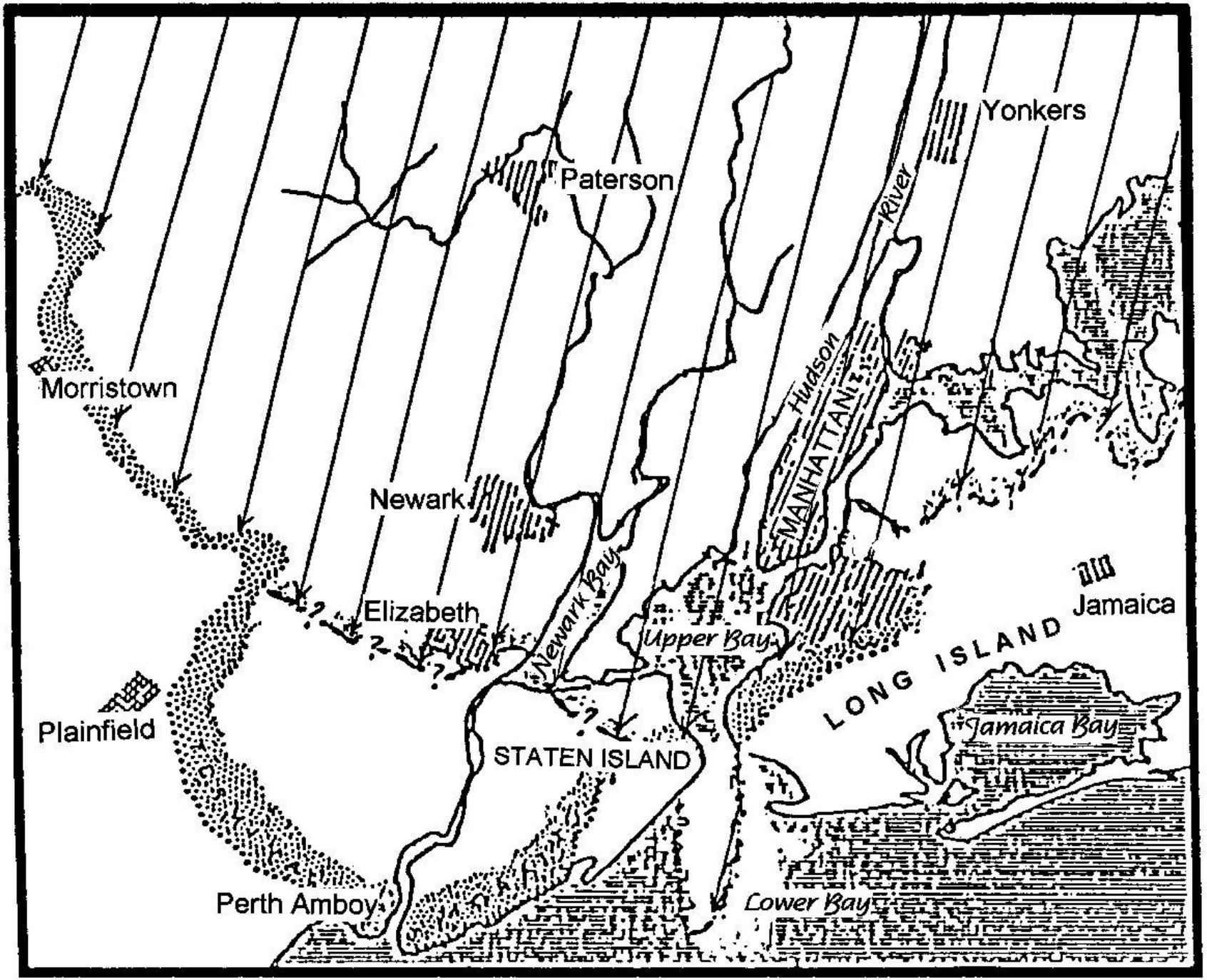
Pleistocene Glaciation

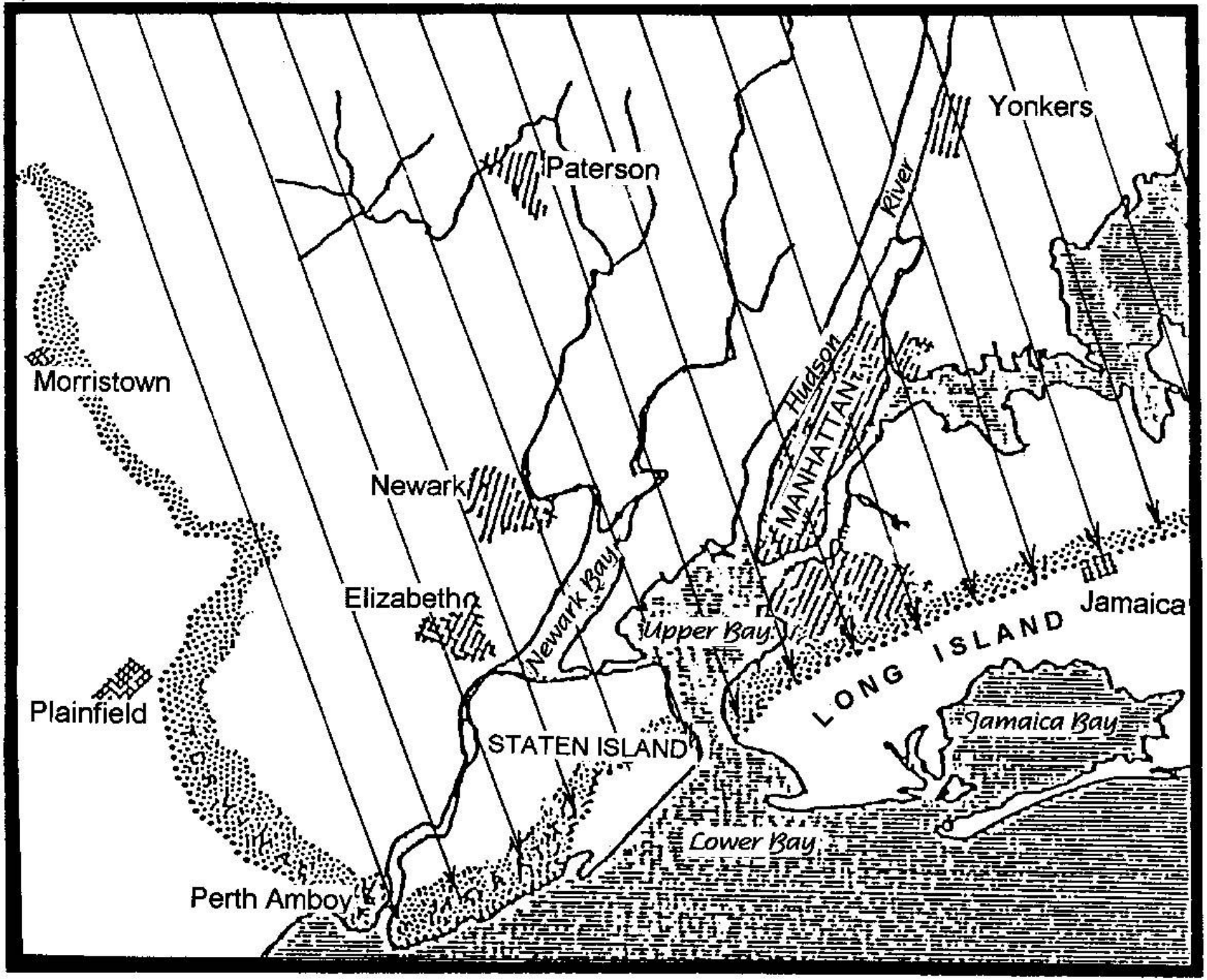
A Tale of Two Tills



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
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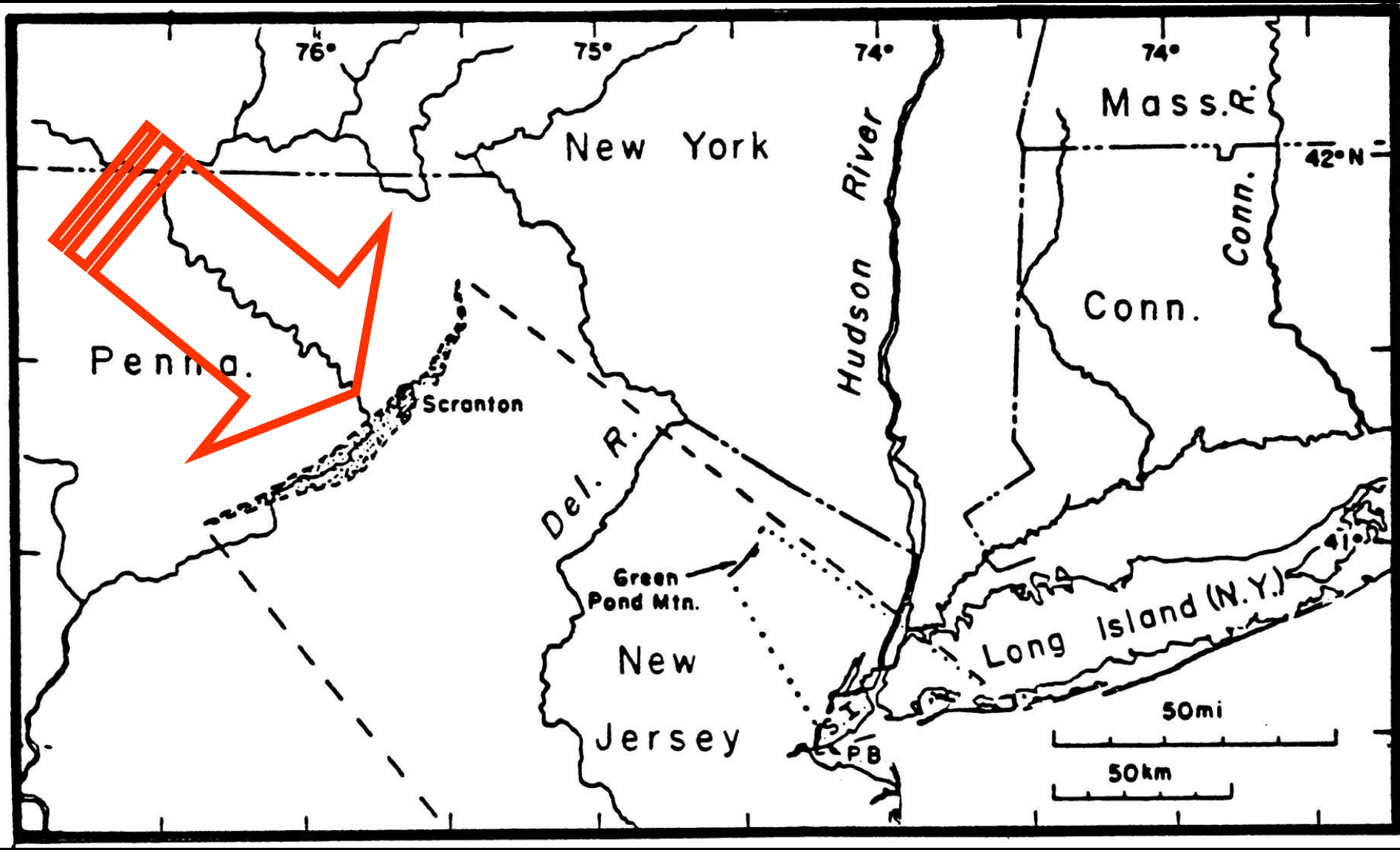
Elizabeth
Upper Bay
Jamaica
LONG ISLAND
Plainfield
Jamaica Bay
STATEN ISLAND
Lower Bay
Perth Amboy

SE-Directed Glacial Striae, Central Park, NYC



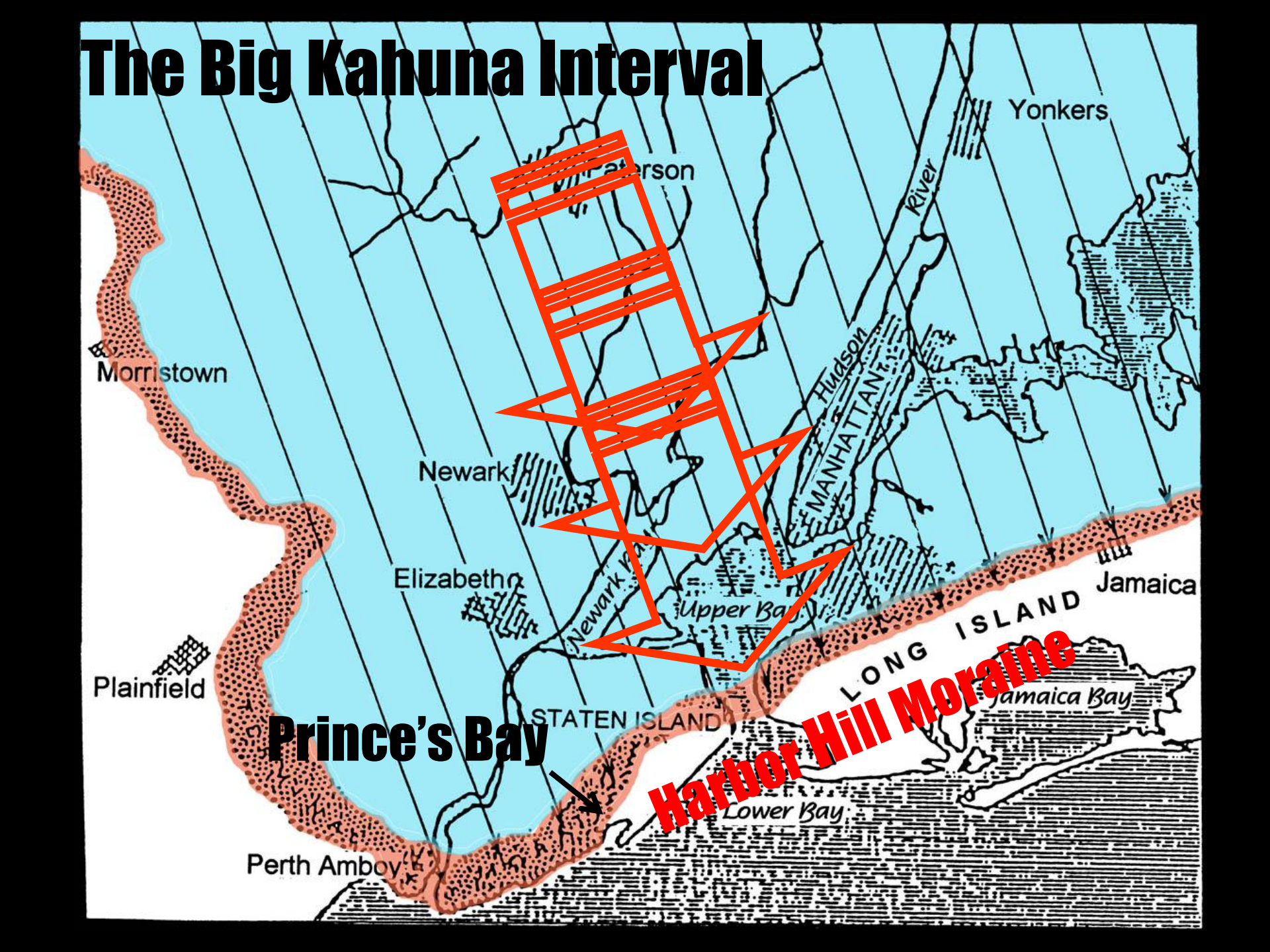
Anthracite and Green Pond Conglomerate Indicator Stones
Friedman and Sanders (1994)

SE-directed Chattermarks, Bear Mtn., NY

Glacial Polish and S55E Chattermarks, Bear Mountain, NY

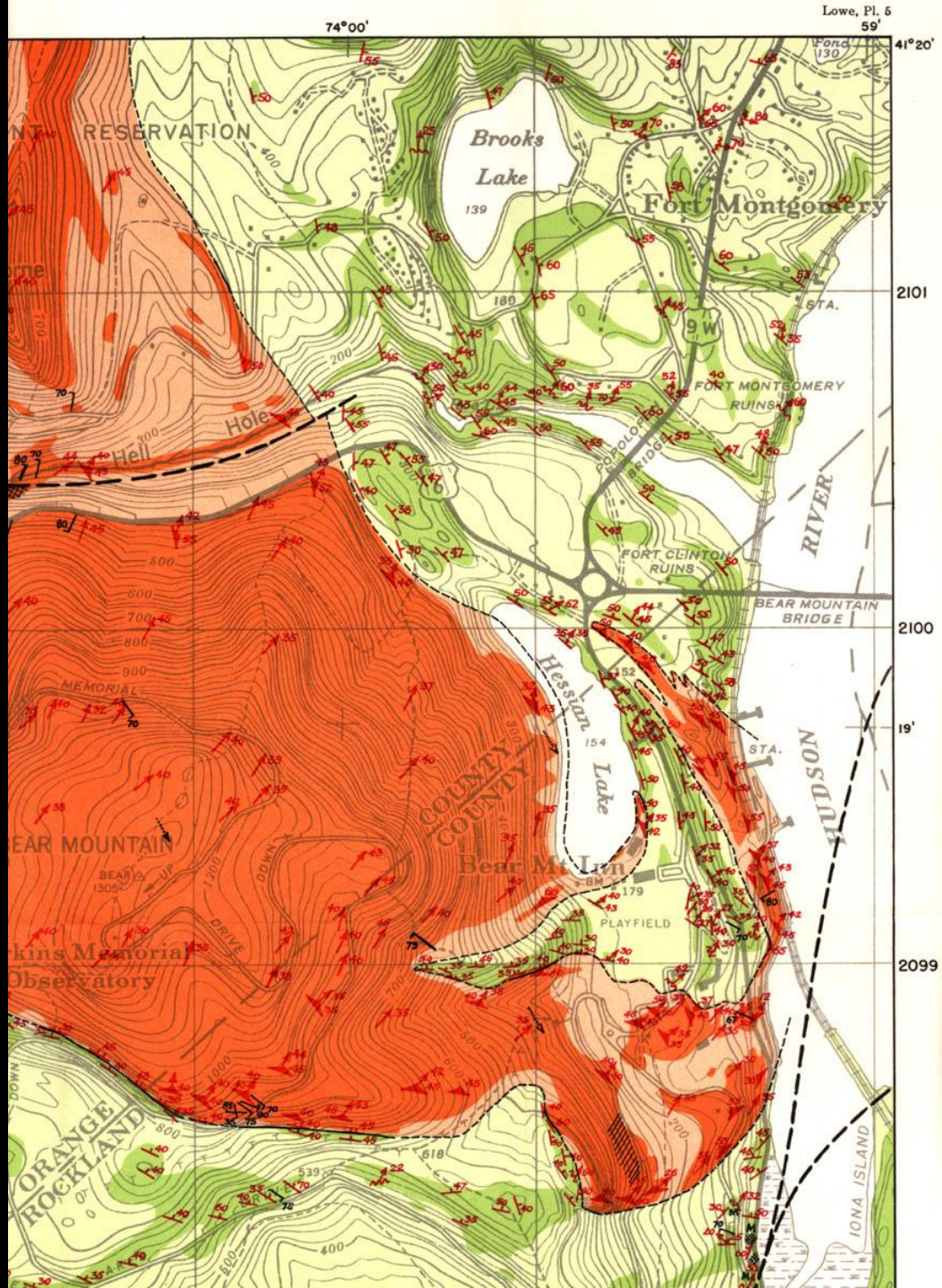

Perkins Tower QTVR

Two More Chattermarks on Bear Mtn., NY

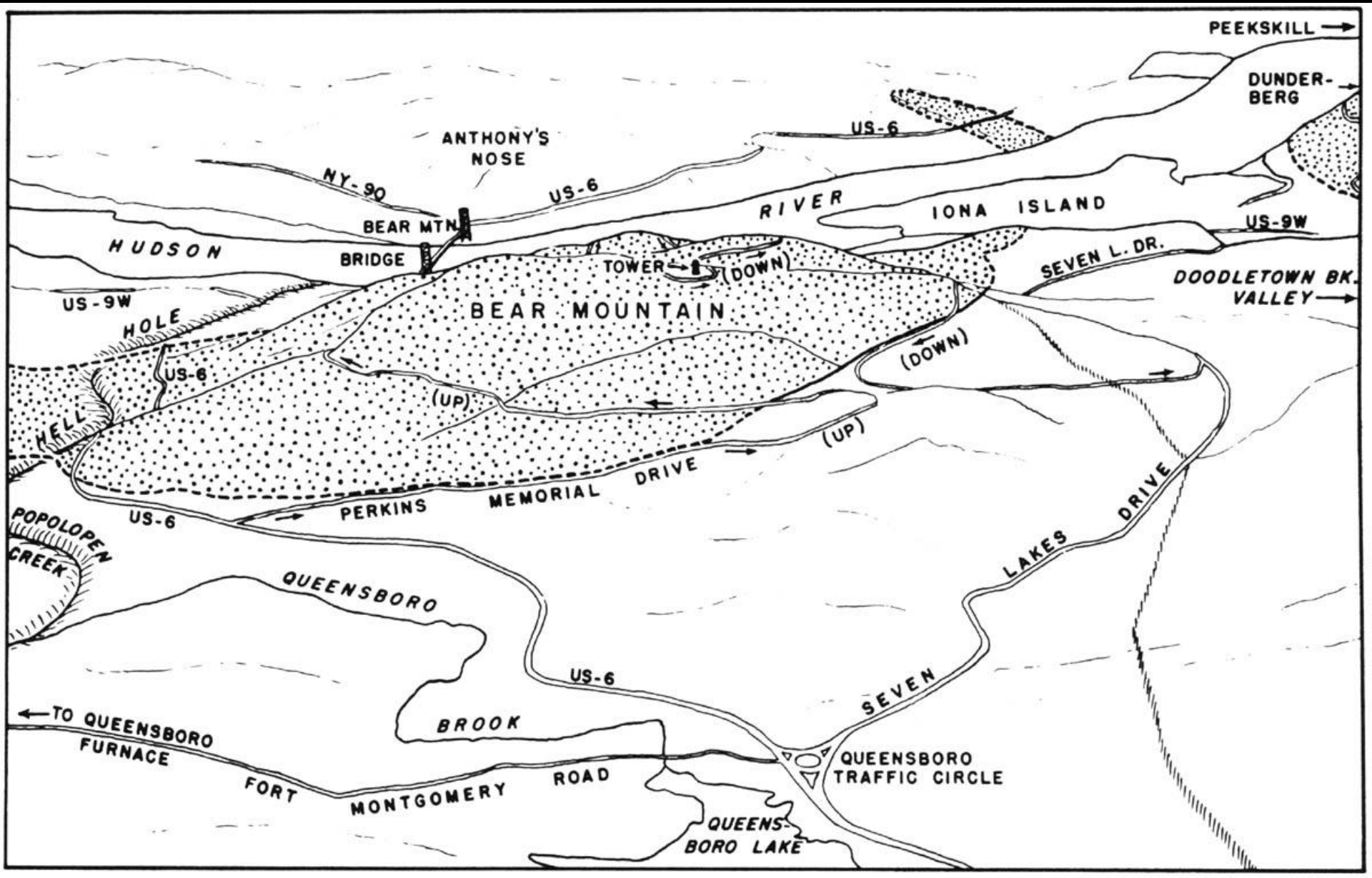

The Big Kahuna Interval
Yonkers
Hudson River
MANHATTAN
Morristown
Newark
Elizabeth
Upper Bay
Jamaica
LONG ISLAND
Plainfield
Jamaica Bay
STATEN ISLAND
Prince's Bay
Harbor Hill Moraine
Lower Bay
Perth Amboy

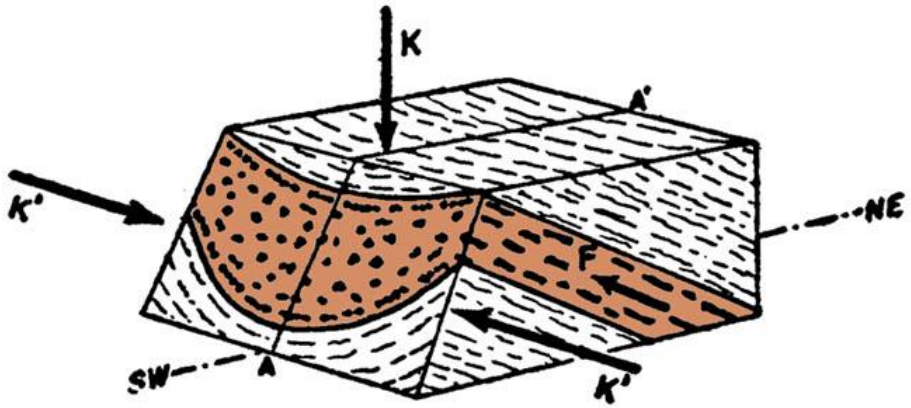
Geologic Map of Bear Mountain

K. E. Lowe (1950)

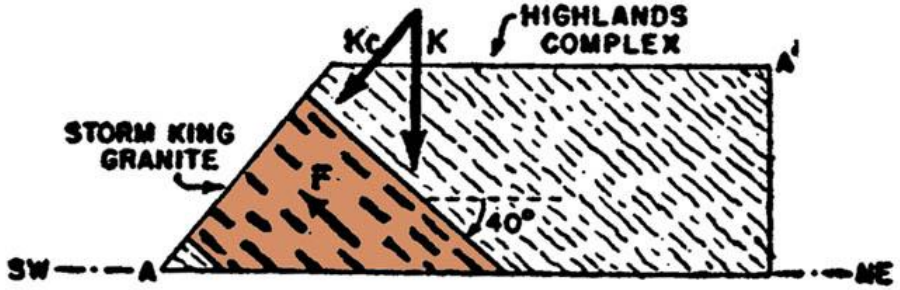


Storm King Granite
~1,150 Ma


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



Perspective View



Section AA'

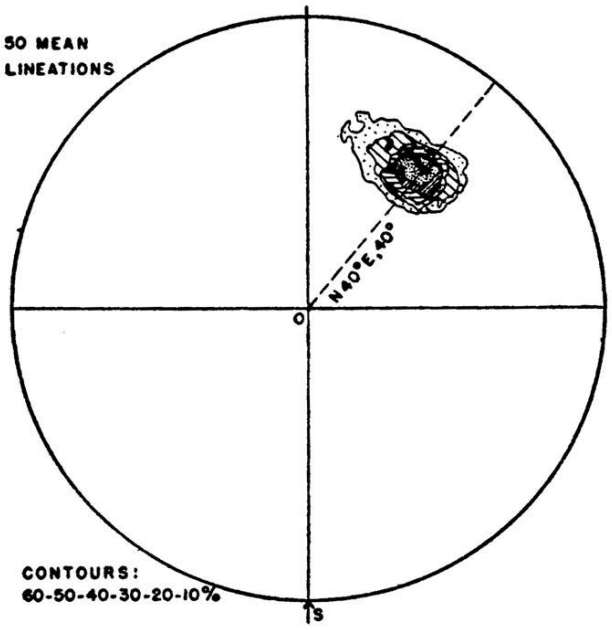
F- DIRECTION OF FLOW DURING INTRUSION

K- UNIFORM LOAD STRESS

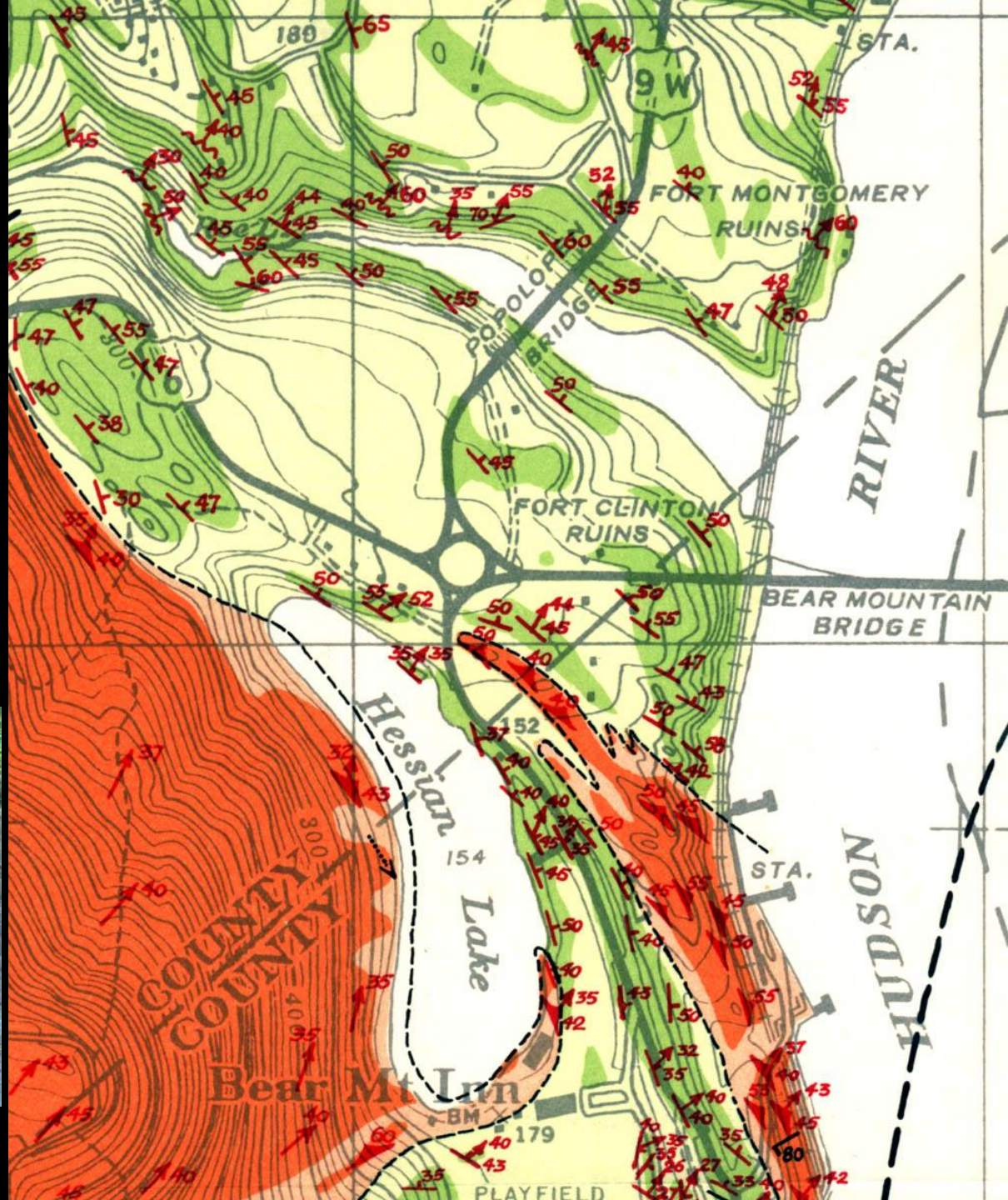
Kc-LOAD STRESS COMPONENT PERPENDICULAR TO FLOW DIRECTION

K'-DIFFERENTIAL OROGENIC STRESS PERPENDICULAR TO FLOW DIRECTION

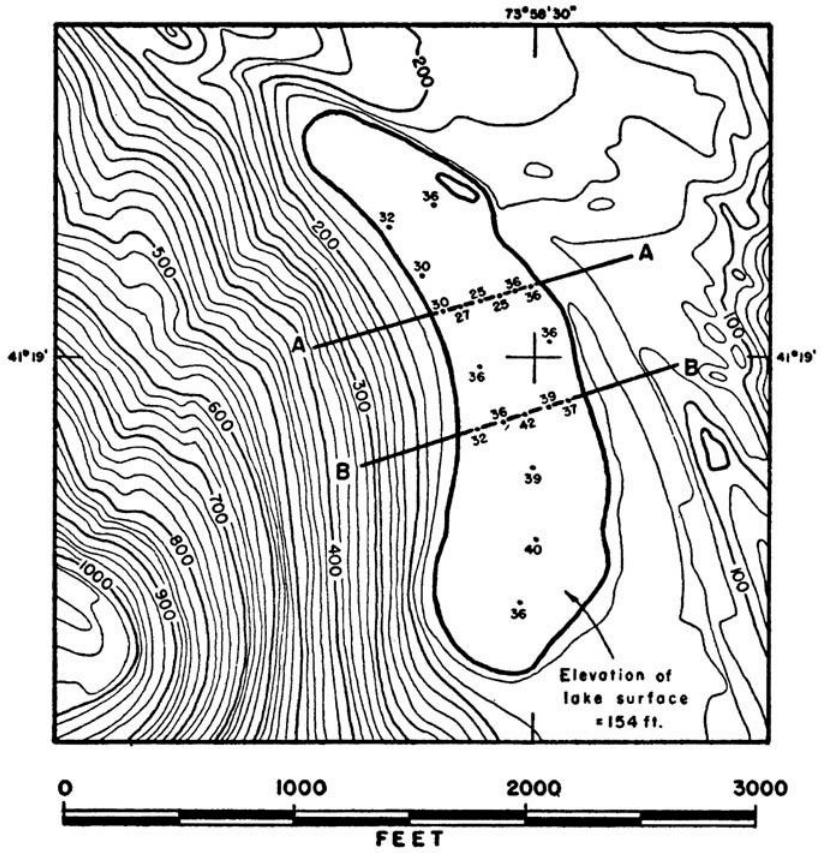
K. E. Lowe (1950)

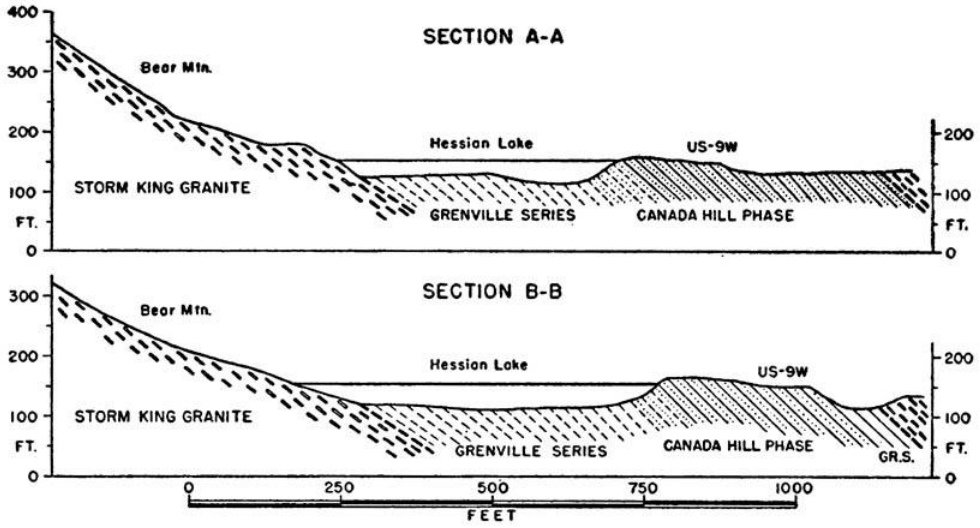


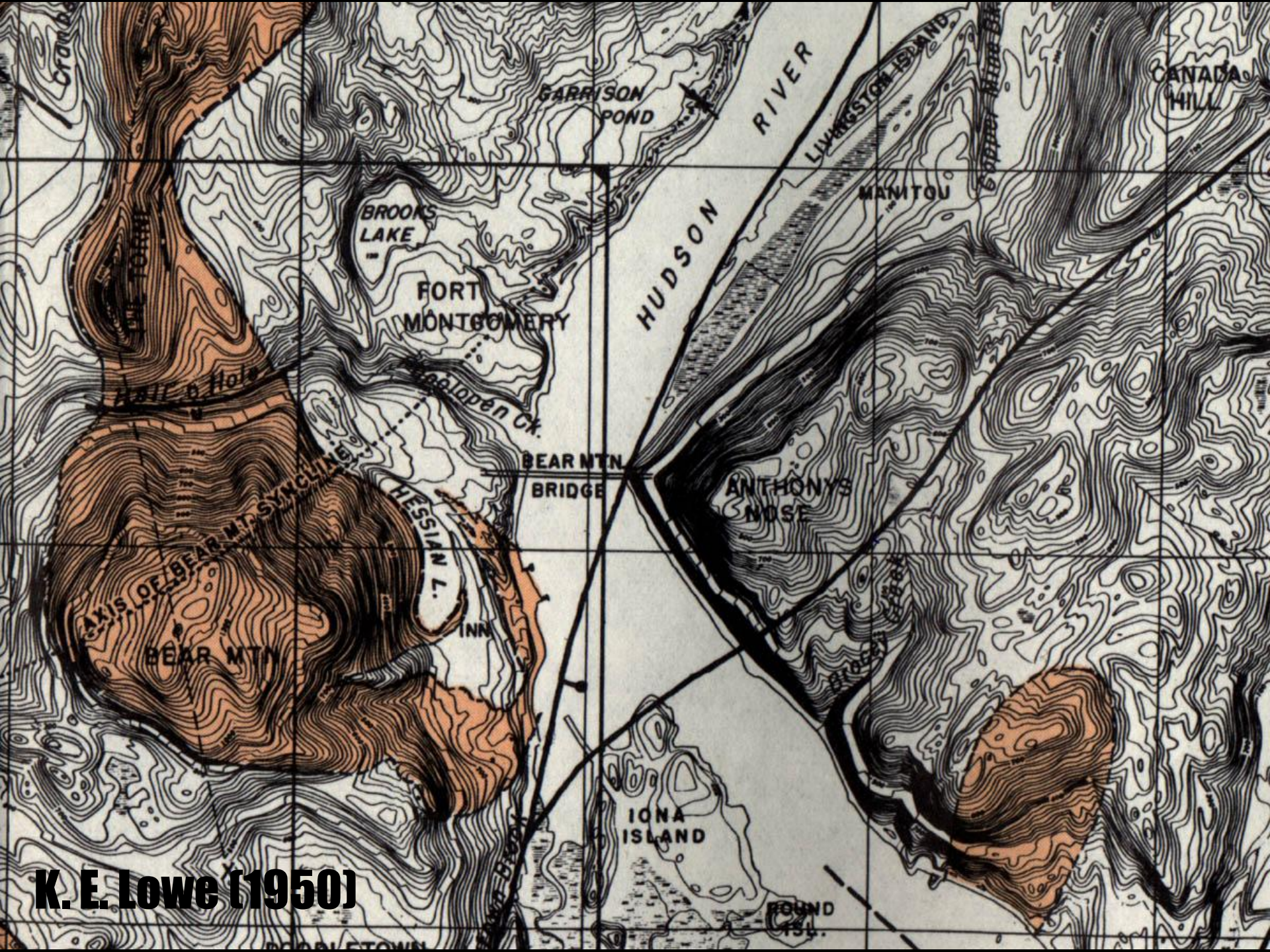
Grenville Metasedimentary Rocks



Hessian Lake






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 GRAVEL

K. E. Lowe (1950)

GARRISON POND

BROOKS LAKE

FORT MONTGOMERY

HUDSON

Half a Hole

Popolopen Ck.

BEAR MTN BRIDGE

ANTHONYS NOSE

AXIS OF BEAR MT. SYNCLINE

HESSIAN L.

INN

BEAR MTN

IONA ISLAND

K. E. Lowe (1950)

The Bear Mountain Bridge

Cable Run Across

Hudson River

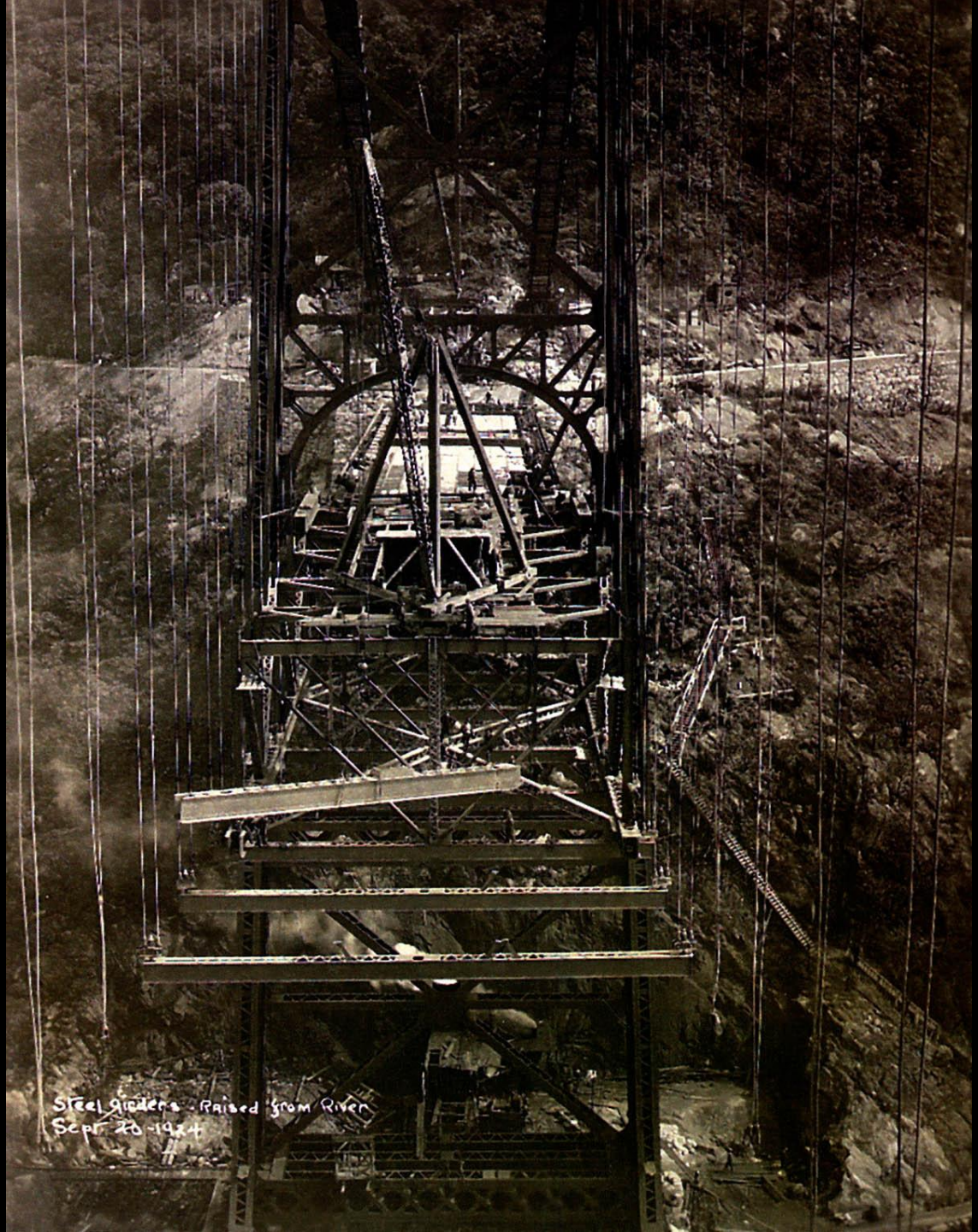
View East Toward

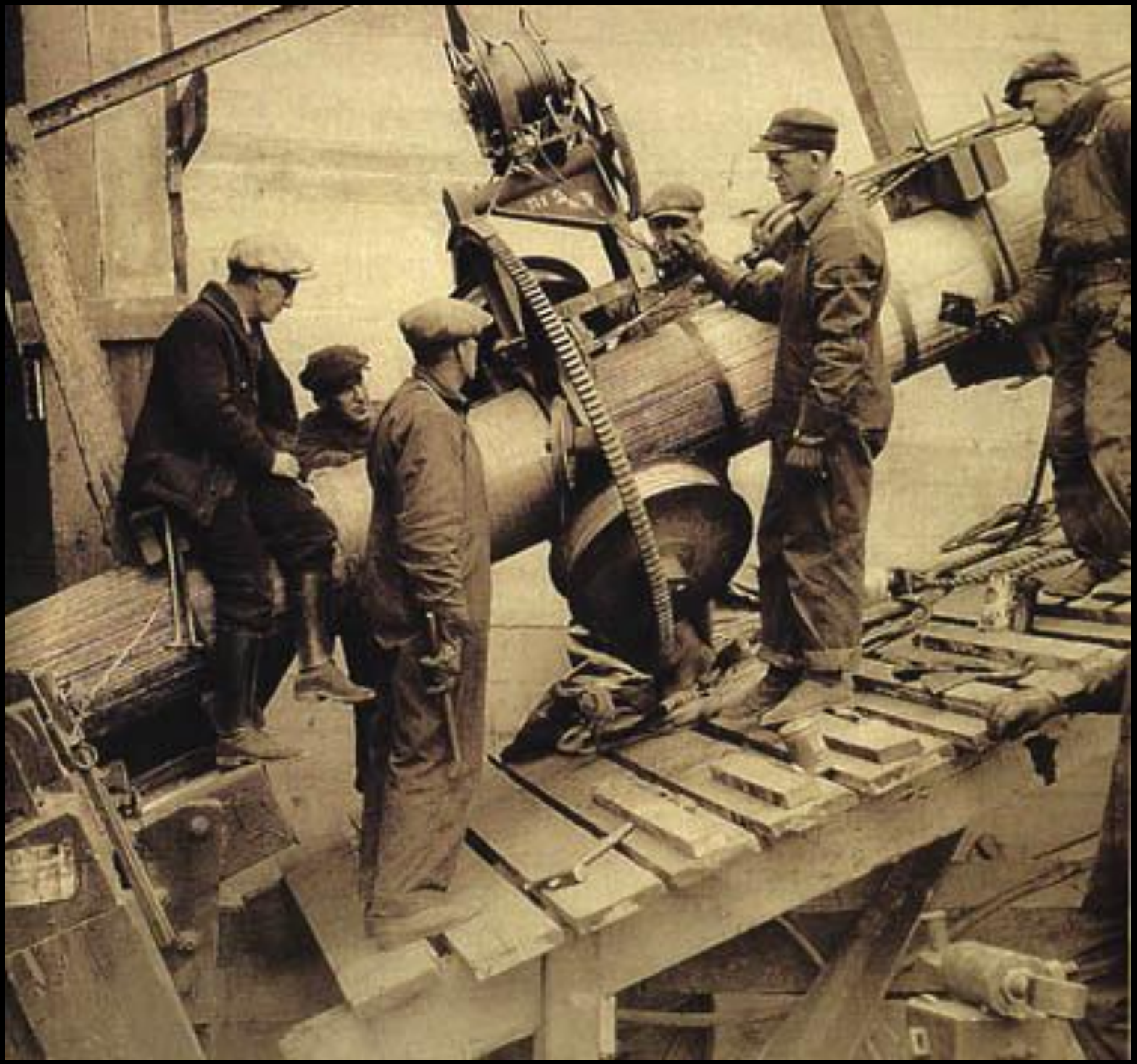
Anthony's Nose

14 Apr 1924

East Highway

April 1924






ROEBLING


South Anchorage - East Shore

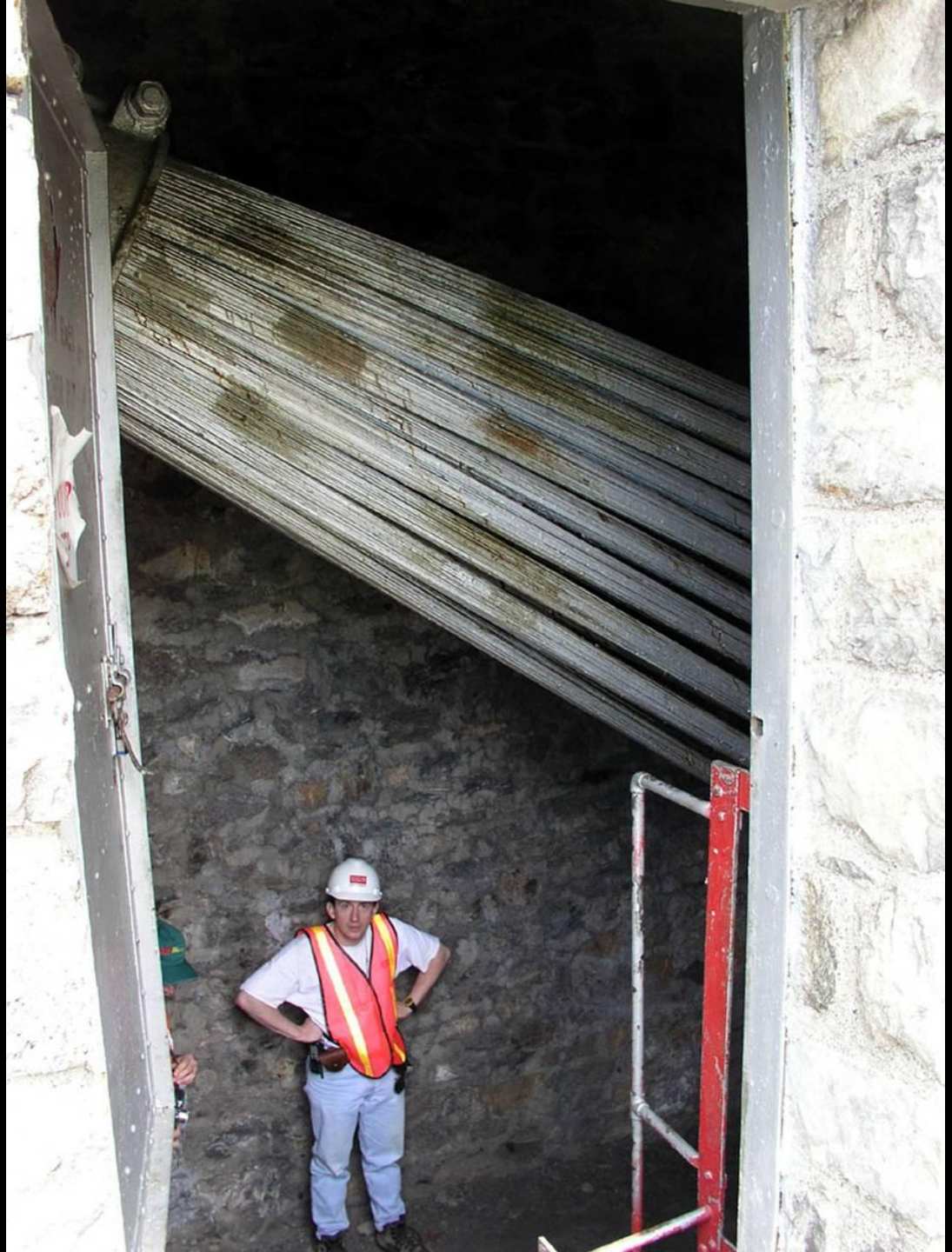

Concreting South Pr
West Anchorage
Sept. 4-1924

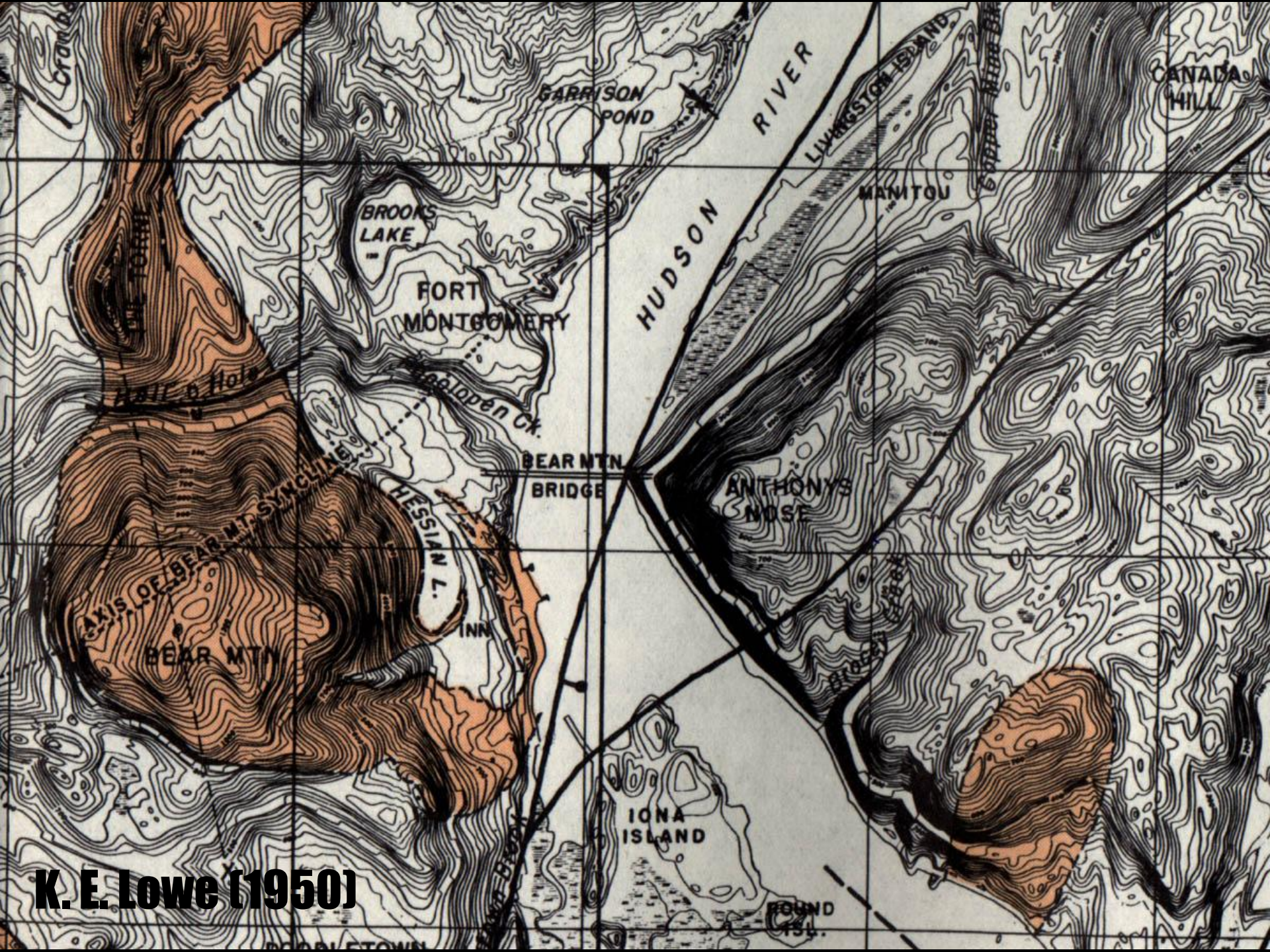

Bridge Open
27 November 1924


PEEKSKILL 5
BEAR MTN 1

East Anchorage

East Anchorage




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

K. E. Lowe (1950)


BMB West QTVR
E-ZPass

NW Anchorage


Corroding Cables
and
Shifting Anchorage
SW Anchorage


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

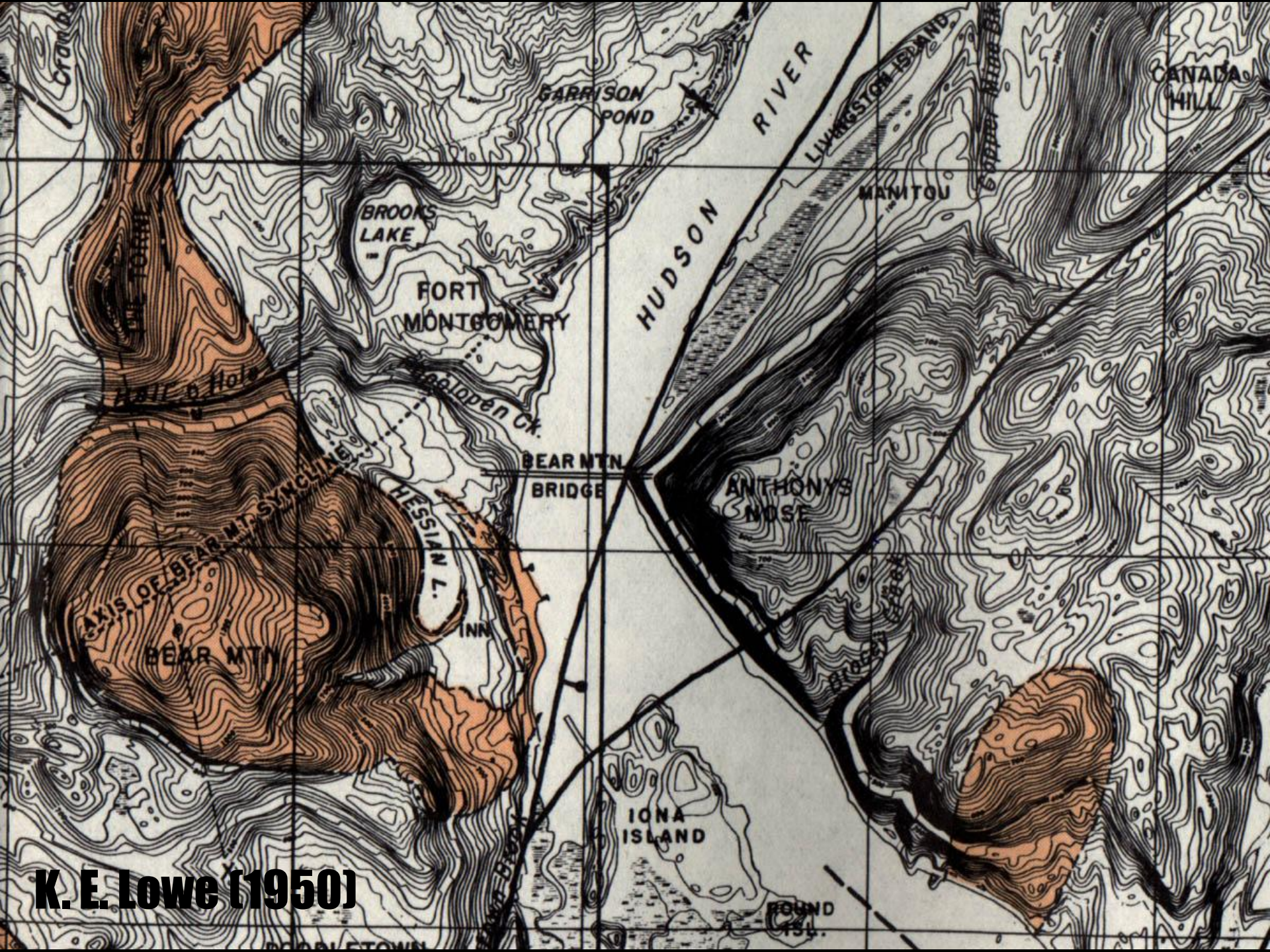
Zig-Zag Course of the Hudson River

Results from Emphatic Structural Control and Glacial Erosion

Gary Agranat Photo

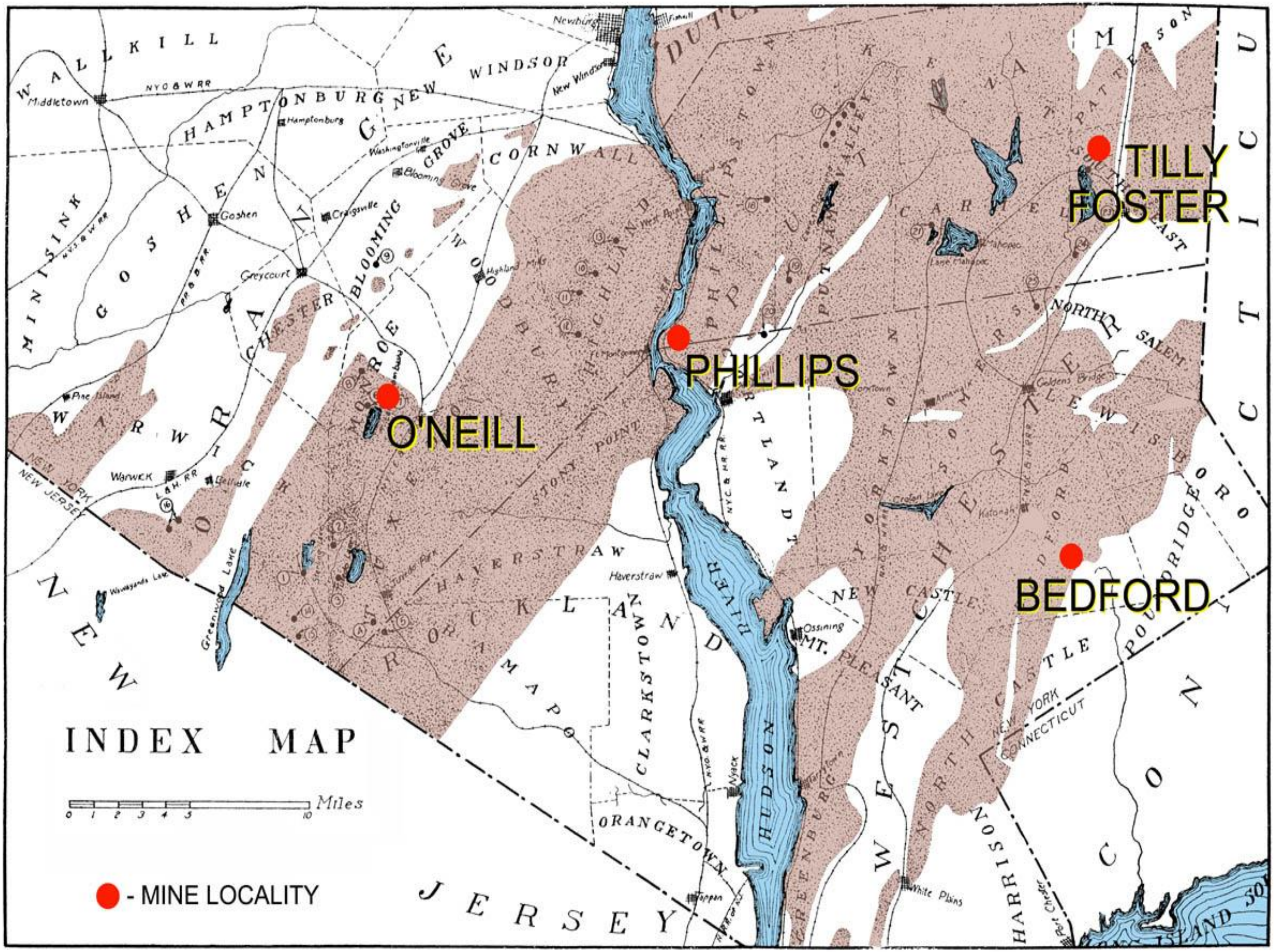
Gary Agranat Photo

Camp Smith
9W
9
Camp Smith
9

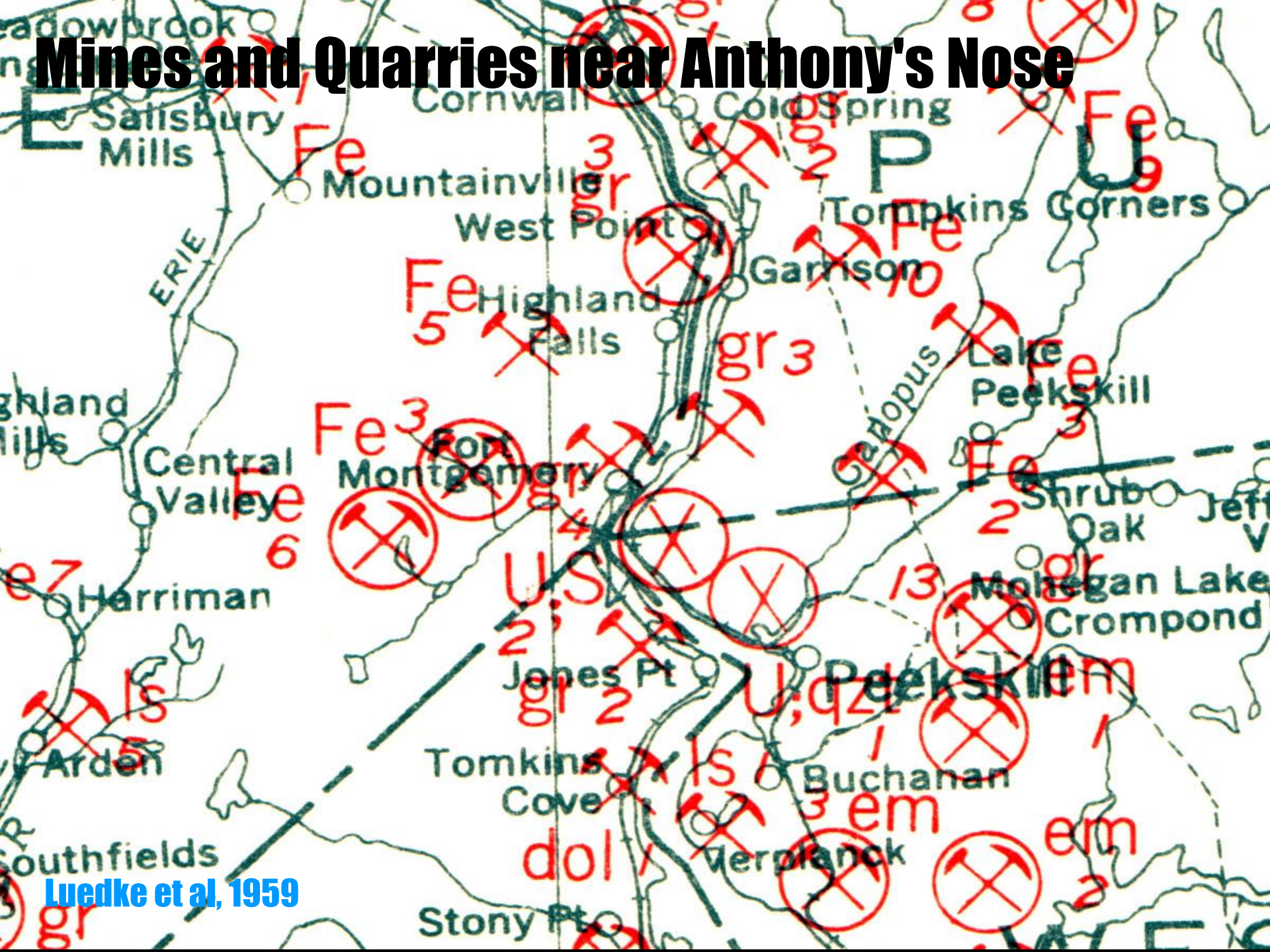

GARRISON POND
HUDSON RIVER
LIVINGSTON ISLAND
CANADA HILL
MANITOU
BROOKS LAKE
FORT MONTGOMERY
Hall o Hole
Dolopen Ck.
BEAR MTN BRIDGE
ANTHONYS NOSE
AXIS OF BEAR MT. SYNCLINE
HESSIAN L.
INN
BEAR MTN
IONA ISLAND
FOUND GRAVEL

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
WALLKILL
MINISINK
GOSHEN
HAMPTONBURG
NEW WINDSOR
CORNWALL
BLOOMING GROVE
CHESTER
MONROE
WARWICK
WOODBURY
HIGHLAND
STONY POINT
HAVERSTRAW
ROCKLAND
RAMAPO
CLARKSTOWN
ORANGETOWN
HUDSON RIVER
PHILIPSTOWN
PUTNAM VALLEY
KENT
CARMEL
PATTERSON
SOUTHEAST
NORTH SALEM
LEWISBORO
POUND RIDGE
BEDFORD
NEW CASTLE
NORTH CASTLE
MT. PLEASANT
YORKTOWN
SOMERS
GREENBURG
HARRISON
NEW JERSEY
NEW YORK
CONNECTICUT
Middletown
Goshen
Newburgh
Haverstraw
Ossining
White Plains
Greenwood Lake
NYO & WRR

Mines and Quarries near Anthony's Nose



Luedke et al, 1959

Lewis C. Beck, M.D.

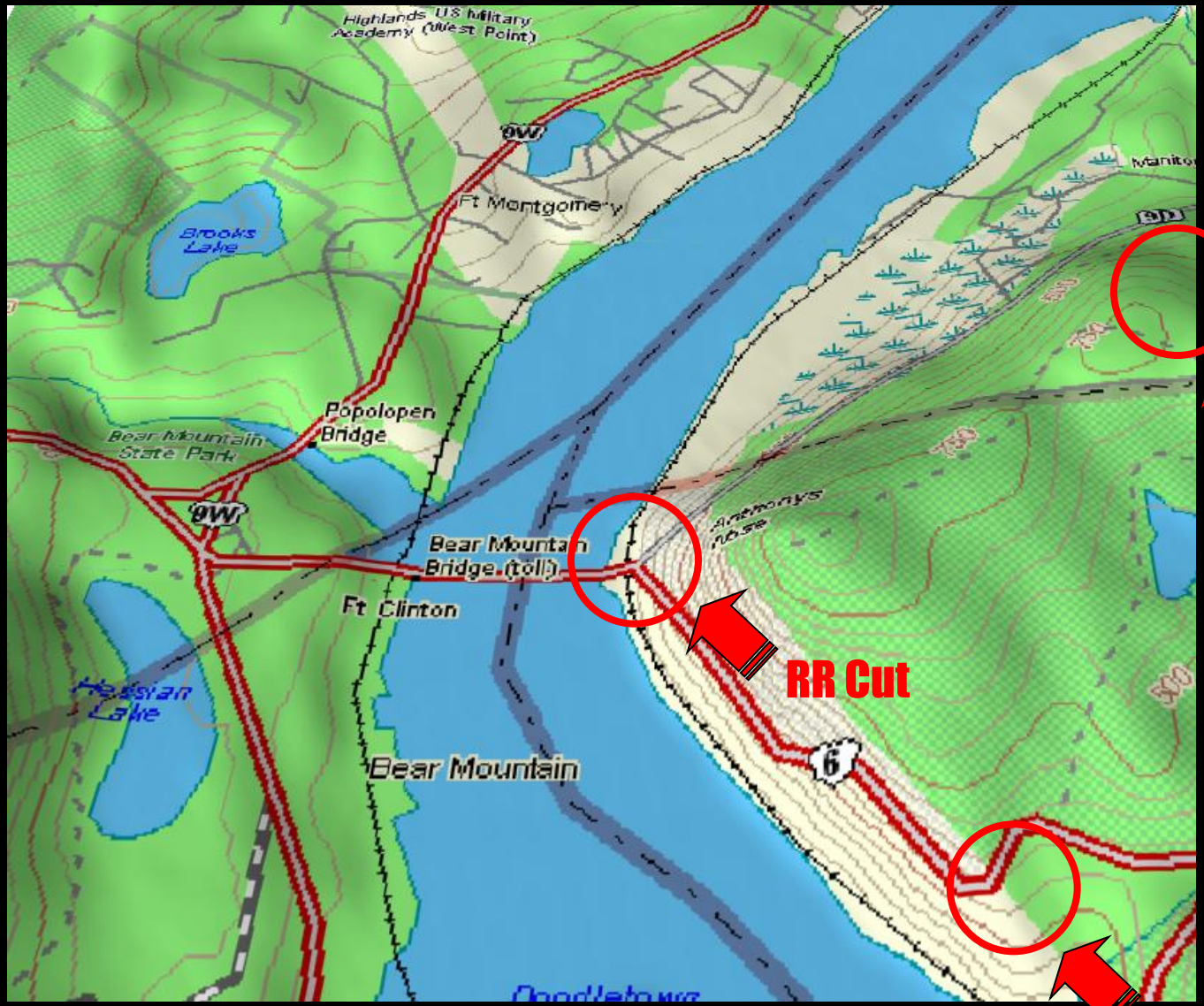
Professor of Chemistry and Natural History, Rutgers University

New York State Geological Survey

Wrote **Mineralogy of New York** (1842) and two addenda (1849, 1850)

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

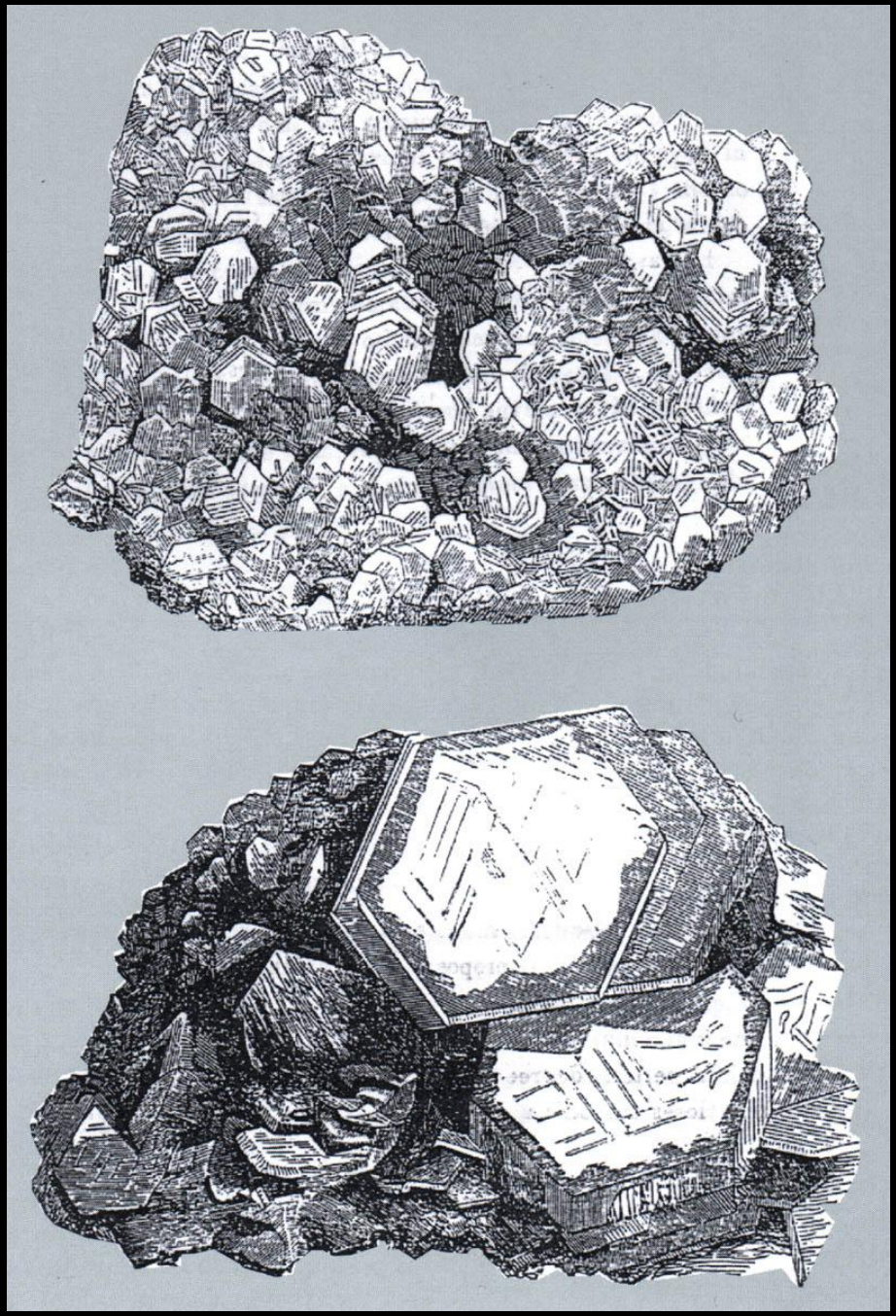
Anthony's Nose Area, NY



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

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

The lower specimen, donated by John E. Henry, is now at the New York State Museum



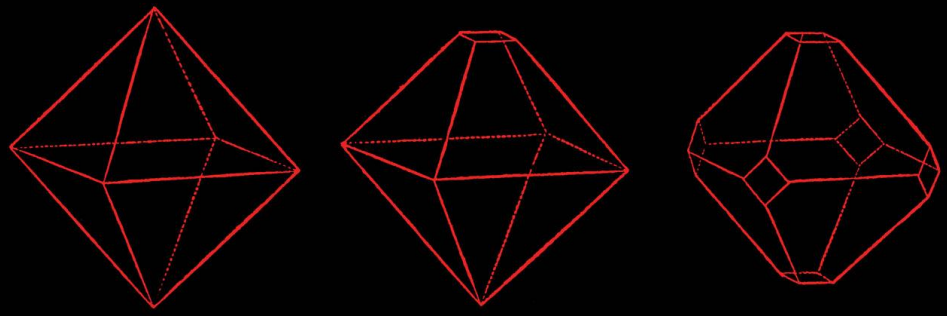
Calcite - 1848 RR Tunnel, Anthony's Nose, Westchester Co., NY


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

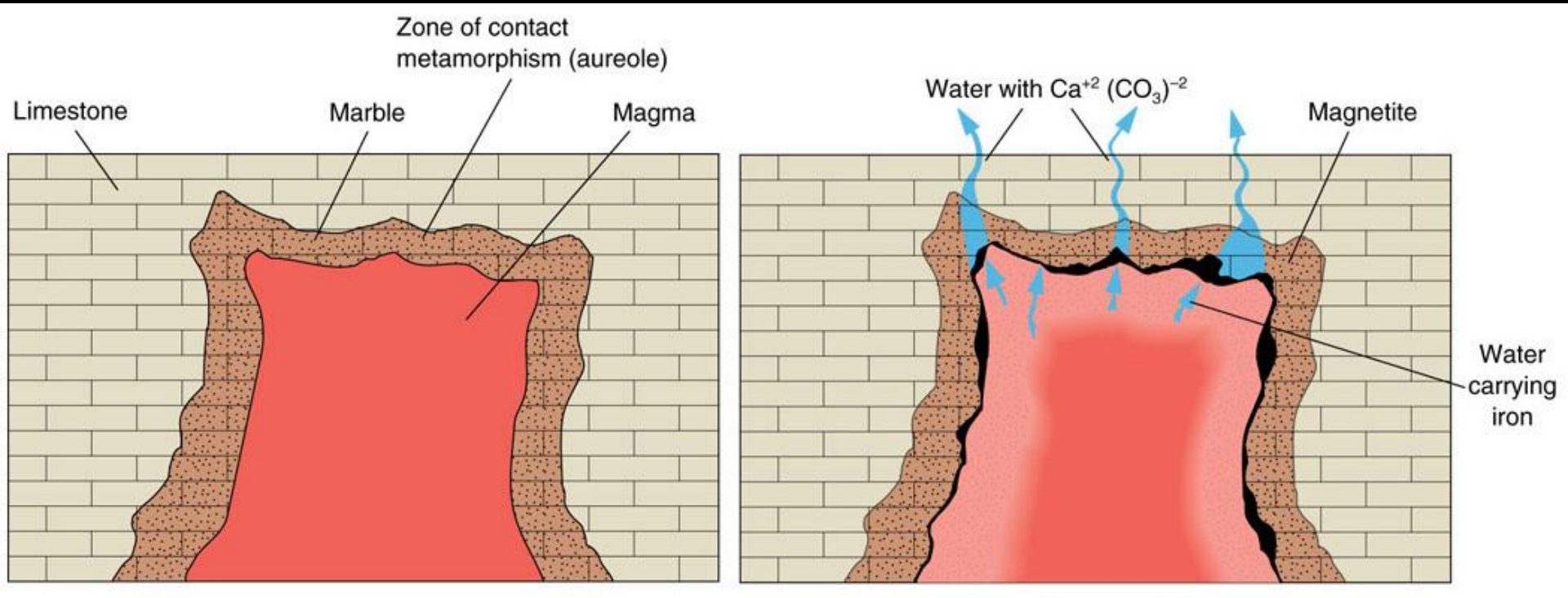


- Metamorphic minerals include garnet, coccolite (diopside), pyroxene, spinel, hornblende, amianthus (asbestos), glaucophane, epidote, serpentine, calcite, and aragonite

- Highlands orebodies are strataform, internally layered and consist of finely recrystallized magnetite and gangue minerals

- Highlands orebodies are all associated with intrusives and/or faults in their Grenville host rocks

Highlands Iron Mines



Phillips Mine
Anthony's Nose

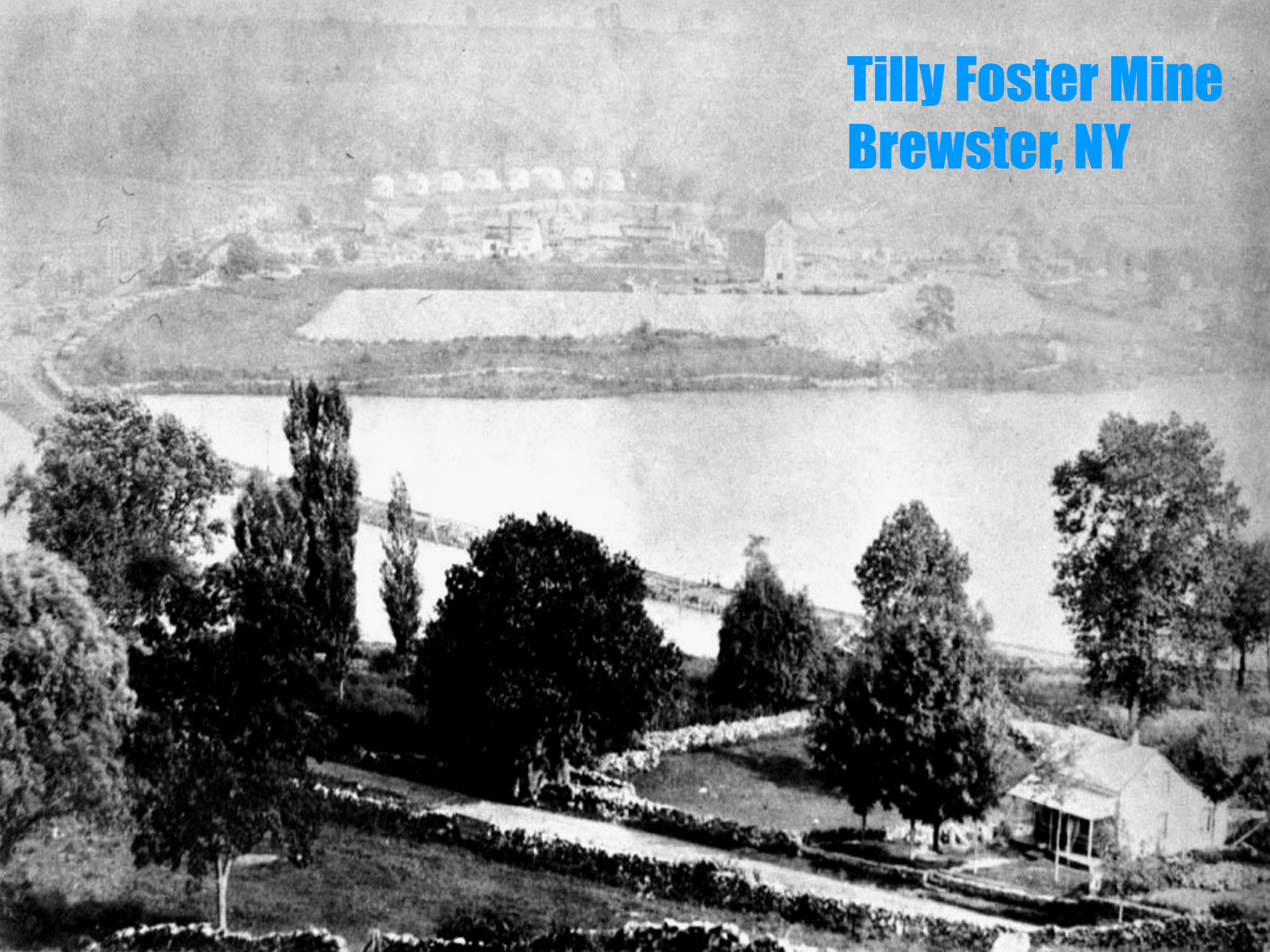
Phillips Mine, Winter 1907

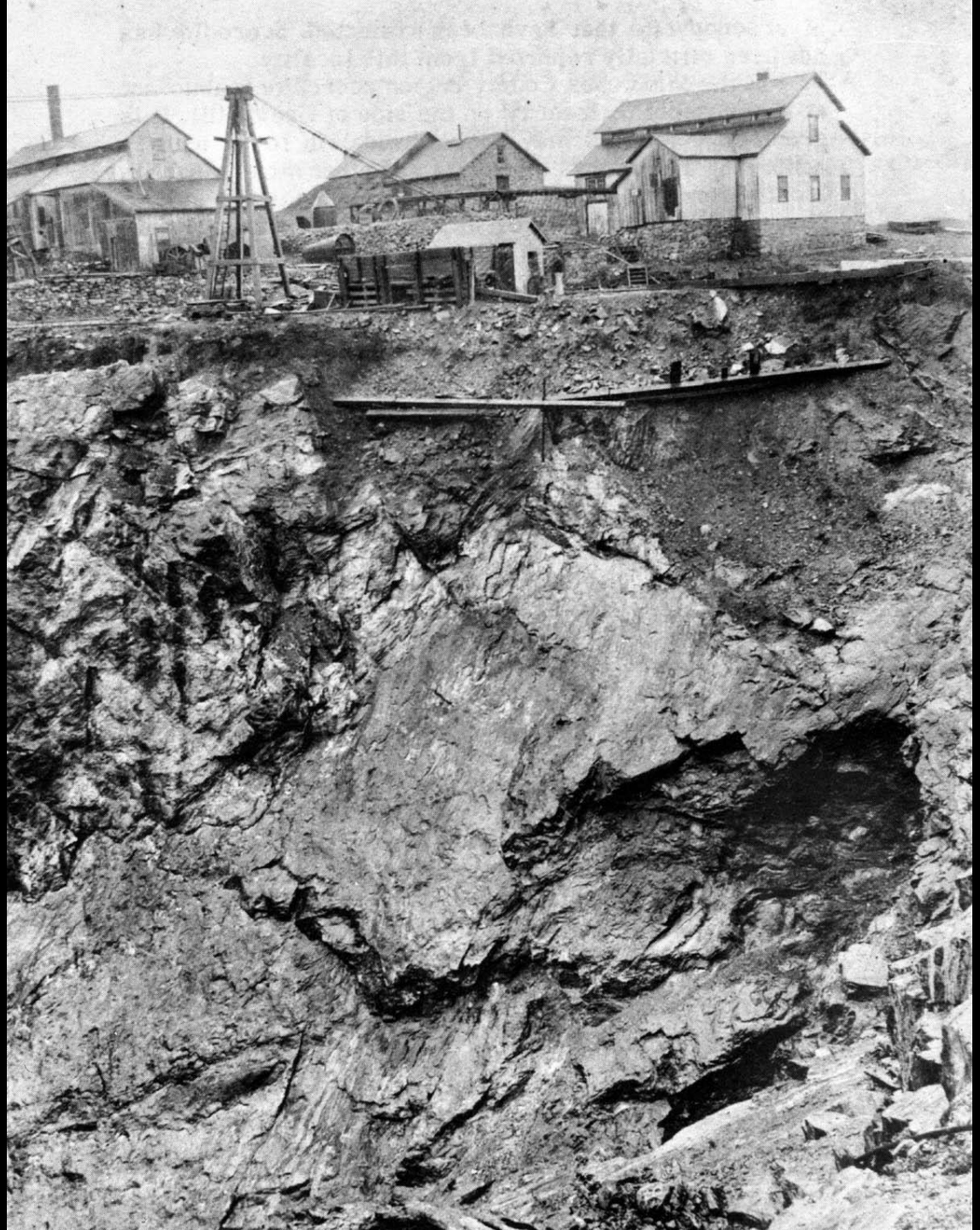
Phillips Mine
Anthony's Nose, Putnam Co.

- The oldest mining location in the Anthony's Nose district
- Beck (1842) describes iron mine as "long ceased operation". Mine dump is still accessible
- Renowned for pyrite, pyrrhotite, and fine apatite crystals – 26 species listed by Betts (1997)
- Mined first for iron ore but high sulfide content made ore less desirable than local magnetite mines
- Renewed interest in 1950s for uraninite mining

Mine Hill
Granite (Quartz Diorite)
Contact?
Granite (Pyroxene Diorite)
Ore Body
Hornblende Dike
Pyroxene Diorite
Dark Hornblende Gneiss (Monzonite Gneiss)
Upper Tunnel (Elev. 704.2)
Albite Porphyry
Pyroxene Diorite
Dark Hornblende Gneiss (Monzonite Gneiss)
Fault
Granite
Lower Tunnel Elev. = 640.2
Datum = 600 Feet
Cross-Section Through Tunnels
Scale
0
100
200 Ft.

Betts (1997)


Tilly Foster Mine
Brewster, NY



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
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 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

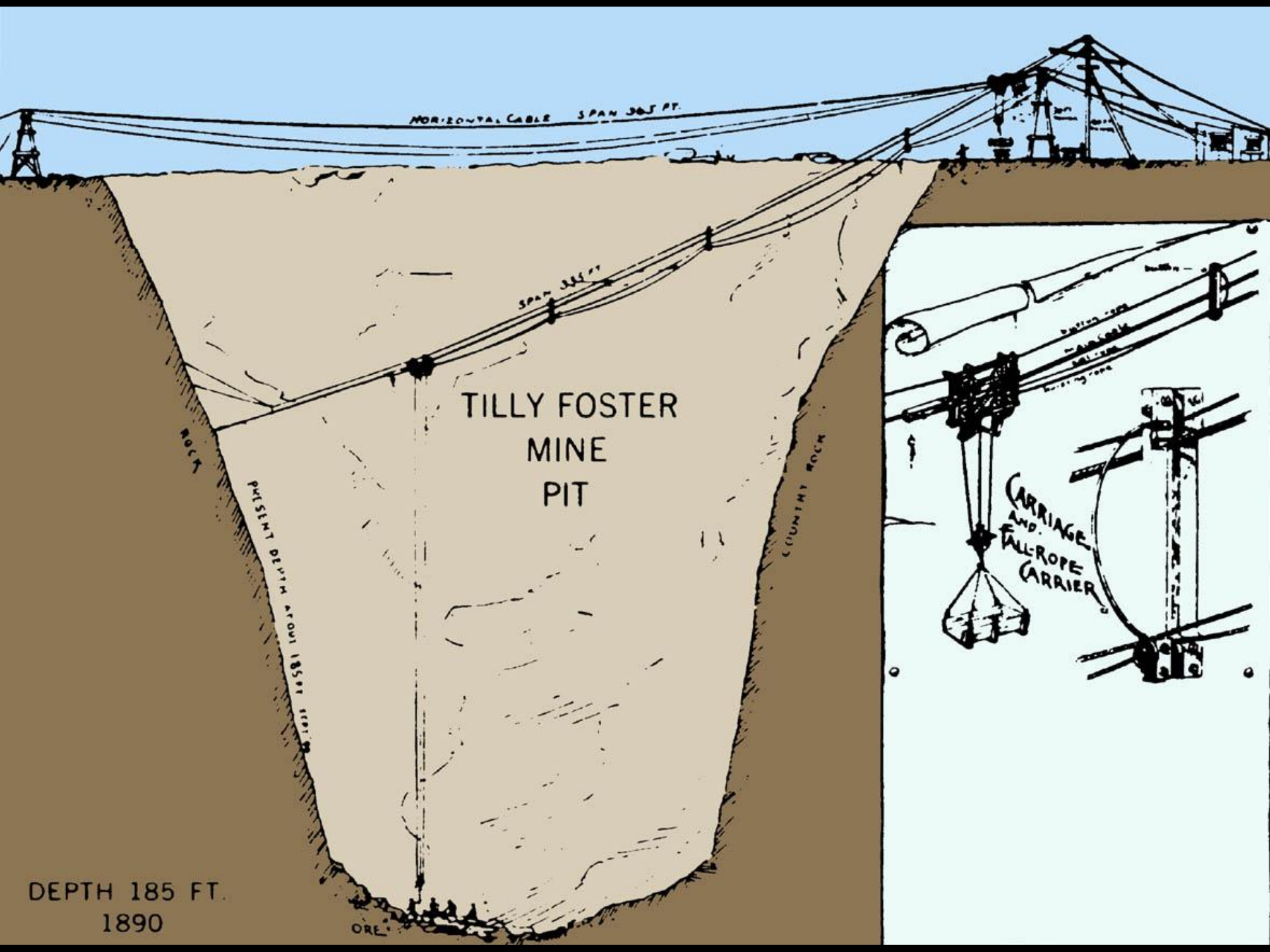
- Turned over to John Cheever in 1864 under the corporate name Tilly Foster Mine

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

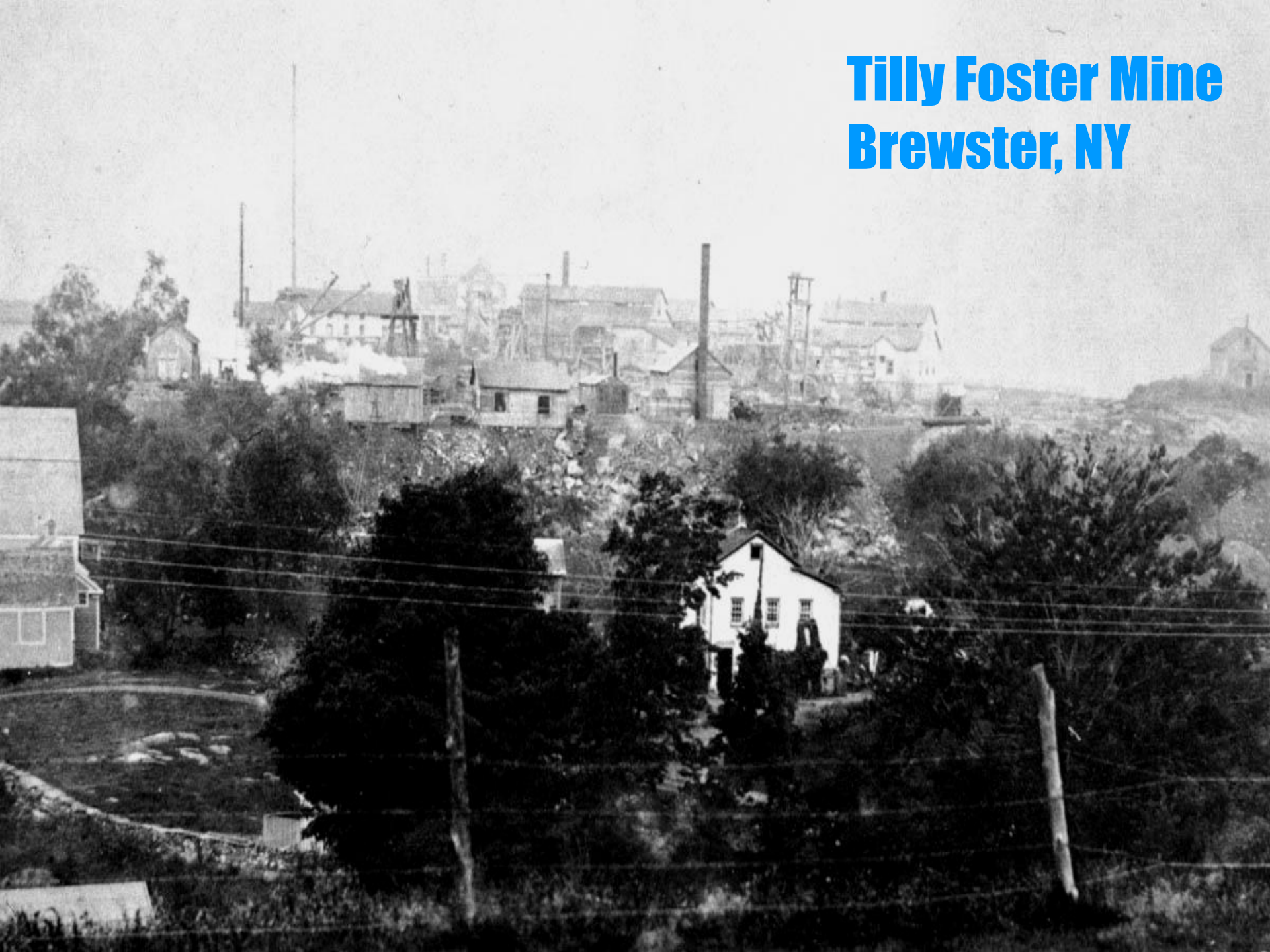
- Over 100 species are recognized known from this locale including many interesting pseudomorphs


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

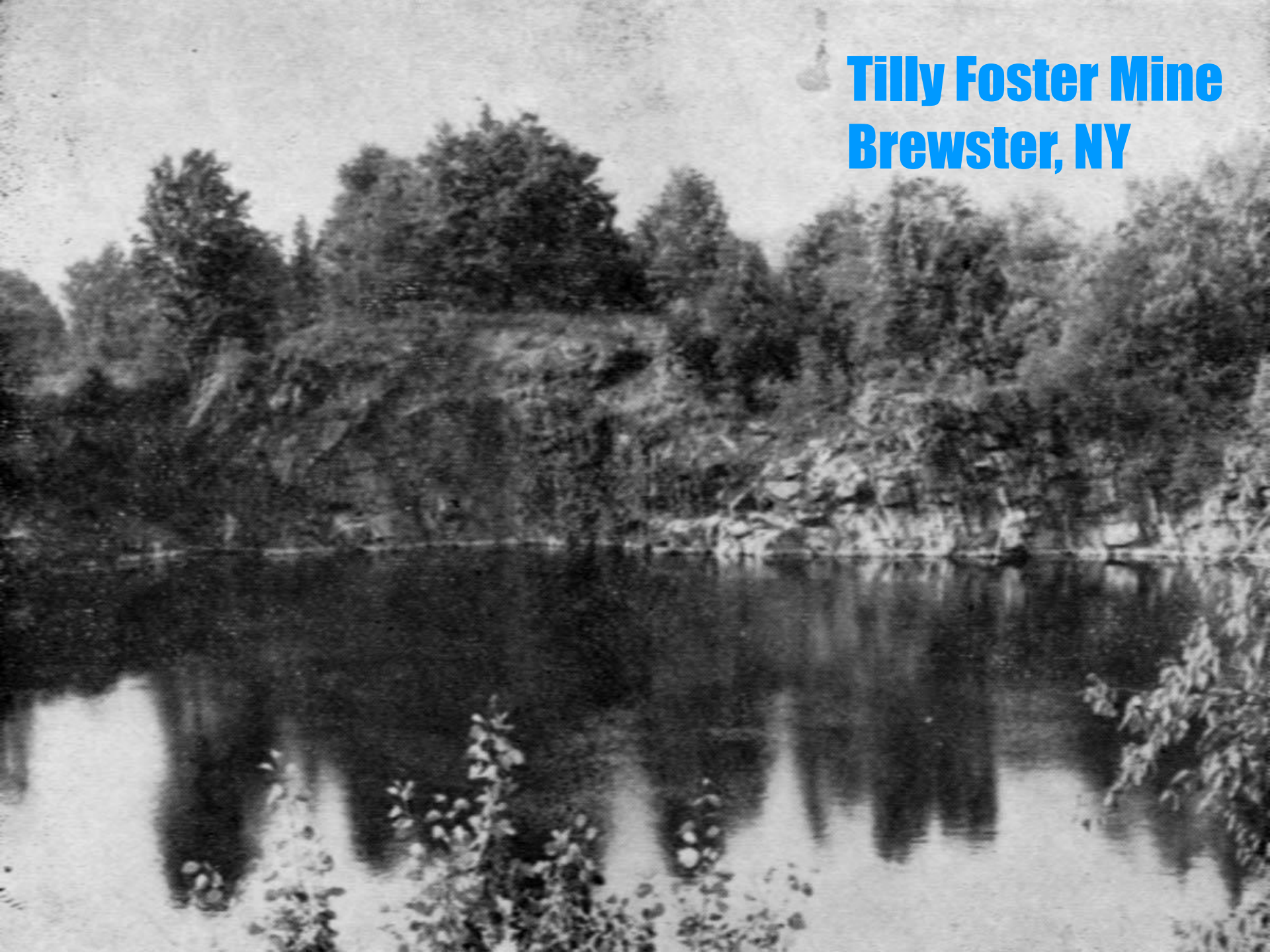
Tilly Foster Mine

Dumps renowned by mineral collectors for the following:

Magnetite
Chondrodite
Clinochlore
Titanite
Pyrrhotite


Tilly Foster Mine
Brewster, NY


Tilly Foster Mine
Brewster, NY


Tilly Foster Mine
Brewster, NY

Magnetite - Tilly Foster Mine, Brewster, NY

Chondrodite - Tilly Foster Mine, Brewster, NY

Clinochlore and Chondrodite - Tilly Foster Mine, Brewster, NY

Clinochlore - Tilly Foster Mine, Brewster, NY

Titanite - Tilly Foster Mine, Brewster, NY

Pyrrhotite - Tilly Foster Mine, Brewster, NY

The Bedford Pegmatite Quarries
Bedford, Westchester Co., NY

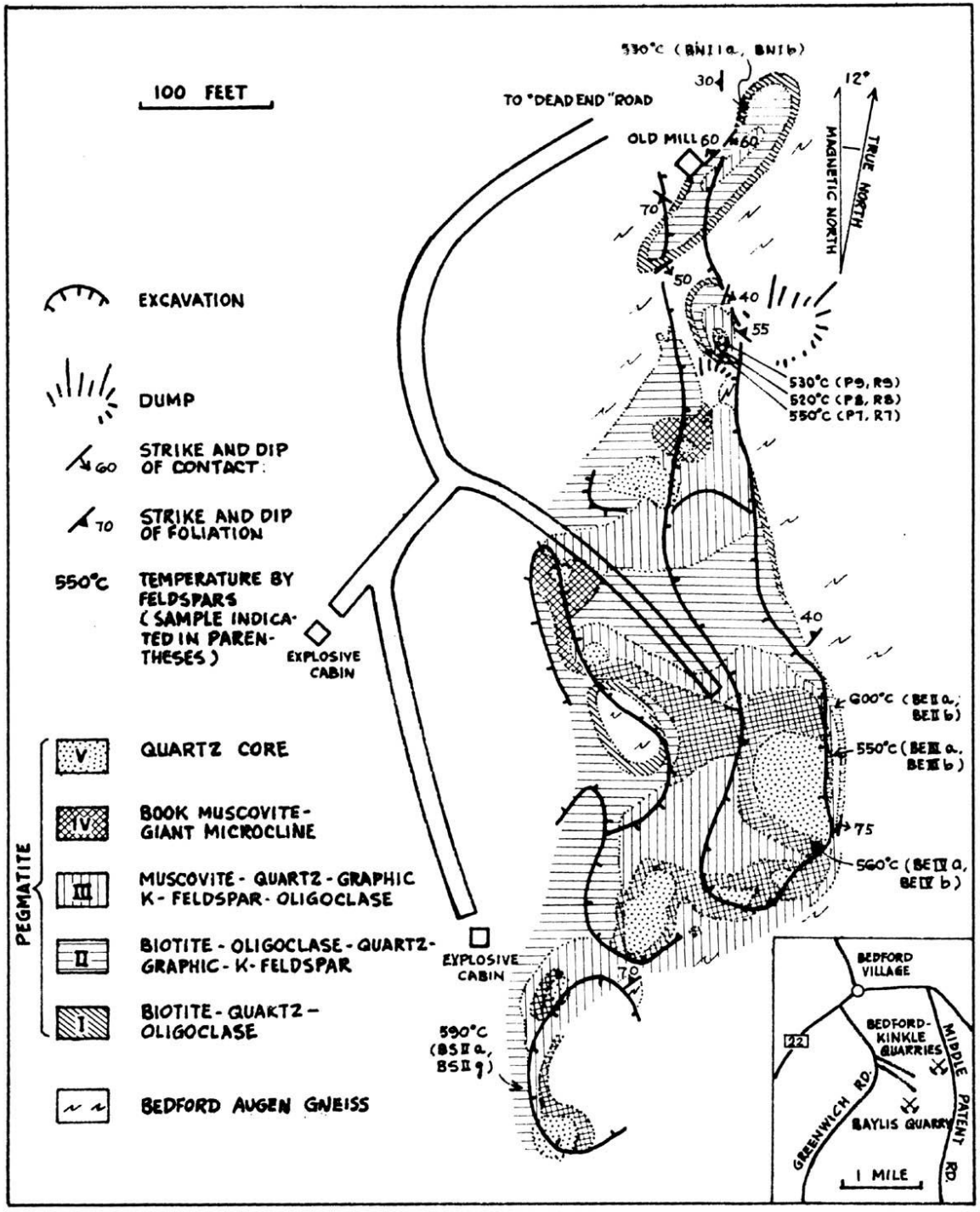
The eight Bedford quarries, opened in 1878, are found within a 2 mile radius of Bedford Village

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 was several thousand tons/year
- Roughly a ton of Beryl also mined

The Bedford Pegmatites

- **Feldspar** was an important resource in the late 1800s
- Large quarries in the Adirondacks and near Bedford Village in New York were established
- **Potash feldspar** (a perthititc microcline), suitable for ceramics was found in crystals up to 5 feet long and the **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

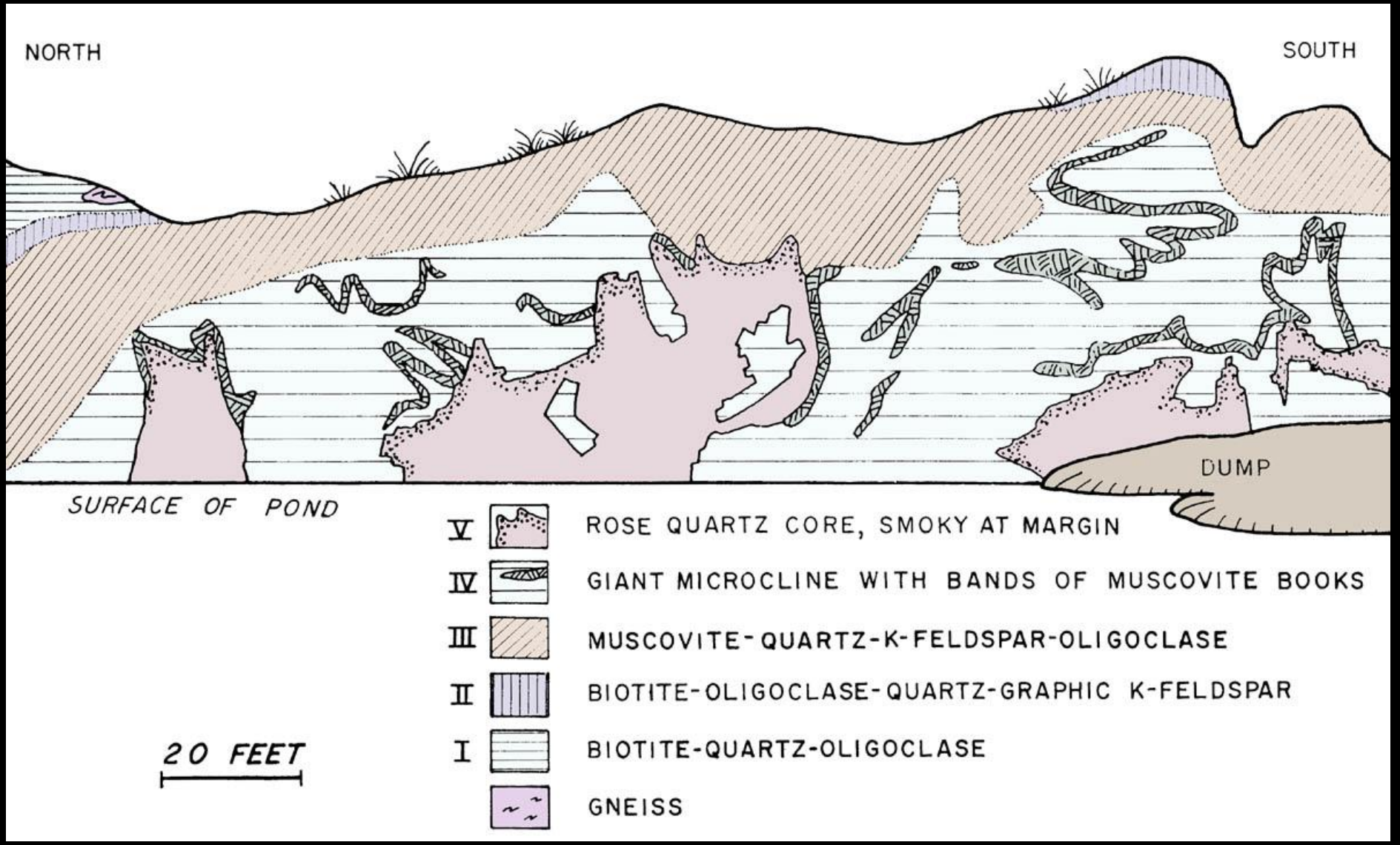


Baylis Quarry

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

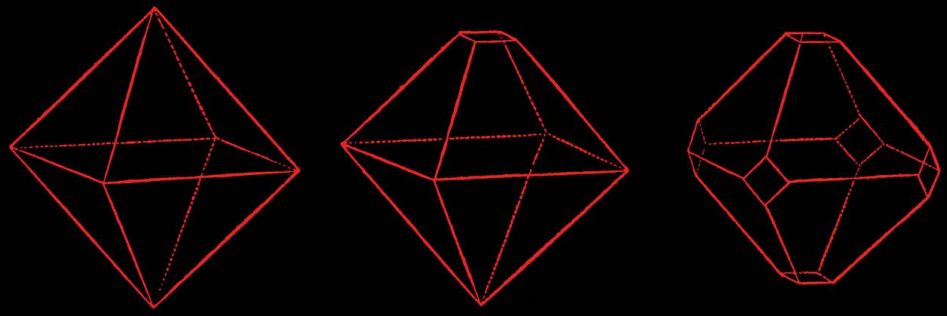
Microcline - Bedford, Westchester Co., NY

Manchester
Specimen

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)

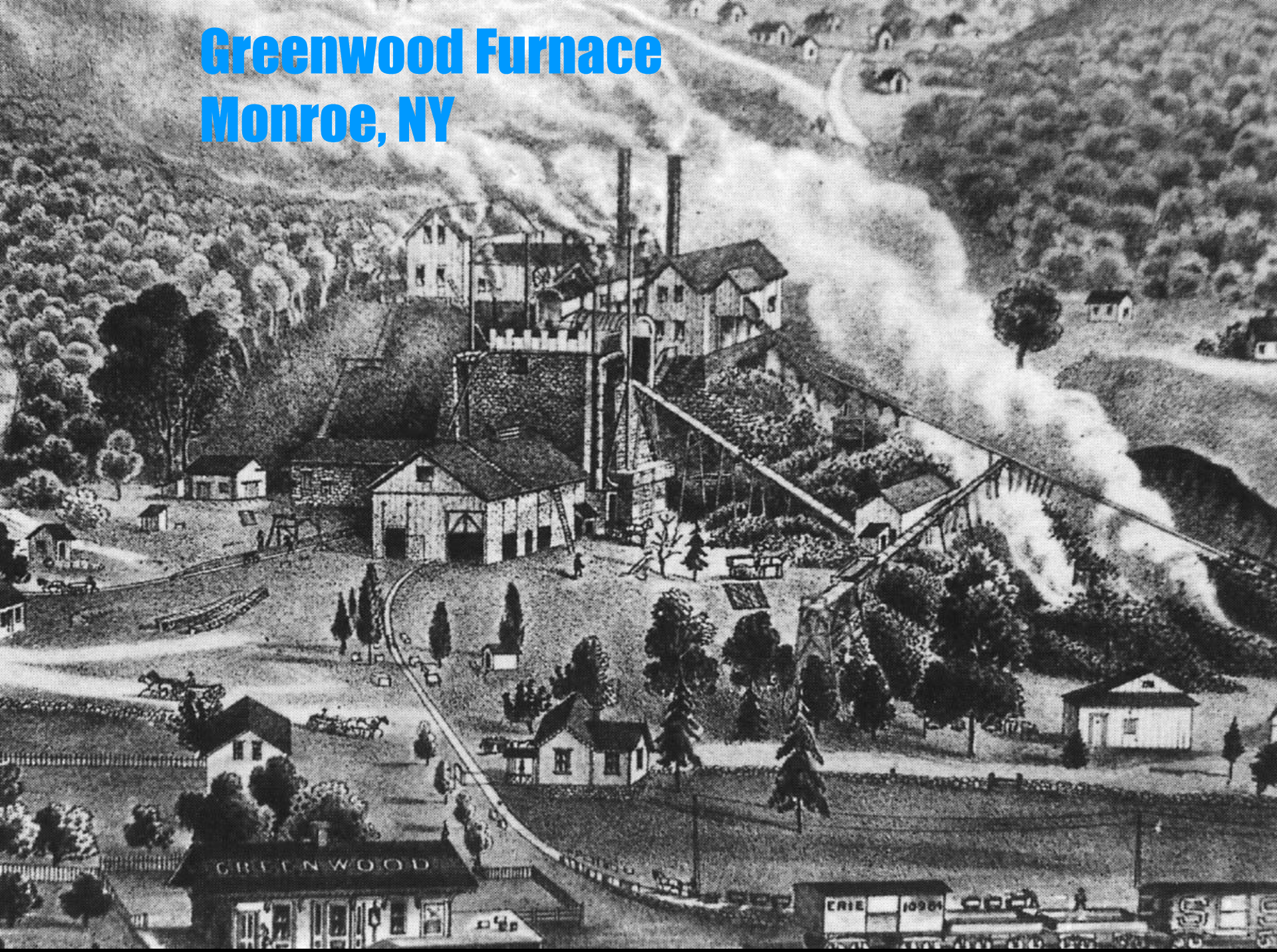
- Described as a "vast bed of the magnetic oxide of iron" that was extensively worked and contained iron pyrites

- Associated minerals include 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

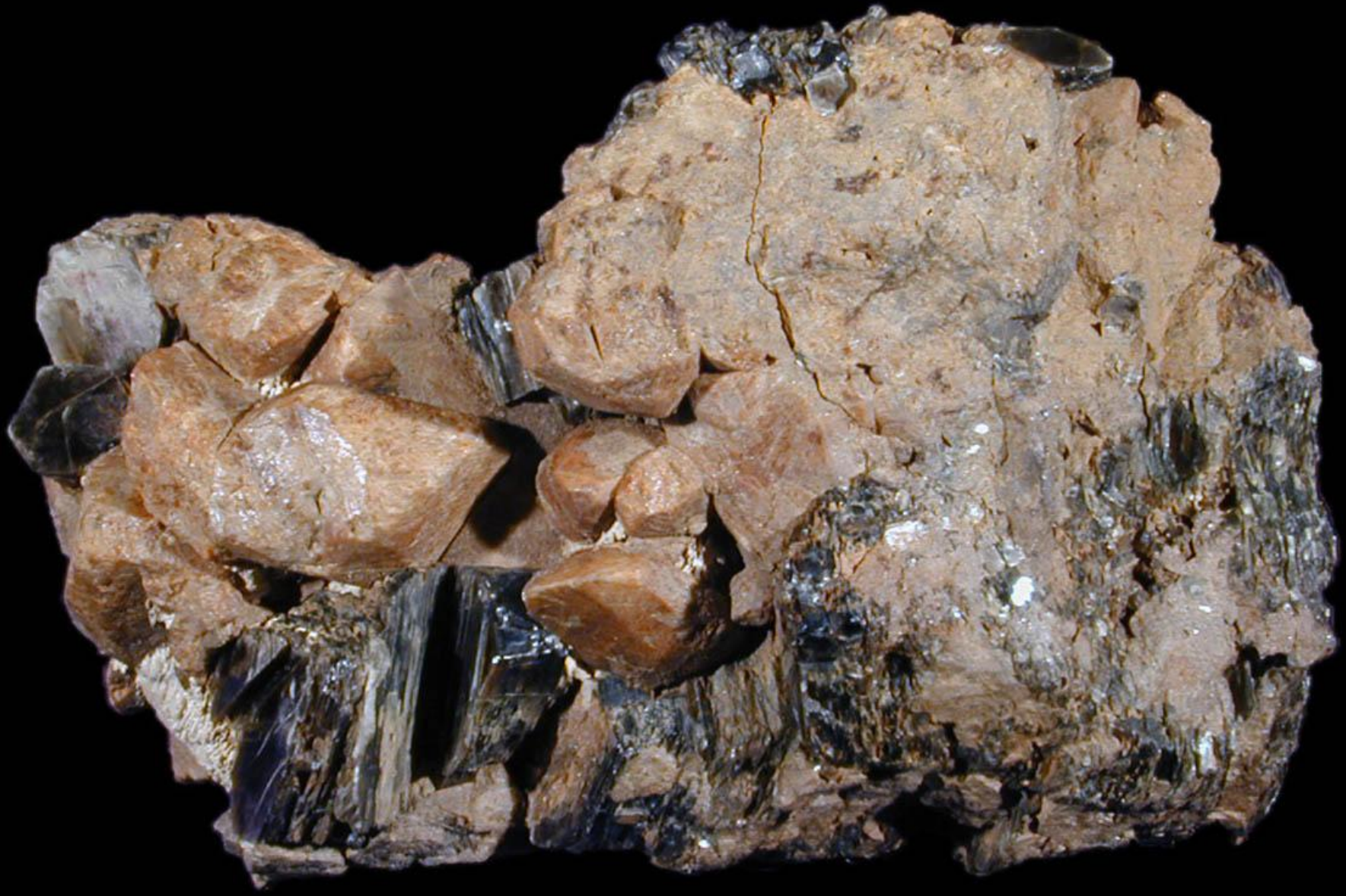
Greenwood Furnace
Monroe, NY




Greenwood Furnace #2
Clove Furnace, Monroe, NY
1860

Edenville District
Orange Co., NY

Fluorapatite - Edenville, Orange Co., NY



Chondrodite - Edenville, Orange Co., NY

Allanite - Edenville, Orange Co., NY

Fluorpargasite on Diopside - Edenville, Orange Co., NY

Spinel - Monroe, NY

Cold Spring
Tompkins Corners
Garrison
Lake Peekskill
Central Valley
Fort Montgomery
Shrub Oak
Harriman
Mohegan Lake
Crompond
Jones Pt
Peekskill
Arden
Tomkins Cove
Buchanan
Verplanck
Stony Pt


Erases