

INVESTIGATION OF THE VOLCANIC ROCKS ON MARBLEHEAD NECK THROUGH PETROGRAPHIC, GEOCHEMICAL, AND FIELD ANALYSES

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INTRODUCTION

The North Shore of Massachusetts, north of Boston, lies within the Proterozoic Avalon terrane, a peri-Gondwanan terrane purported to have accreted to Laurentia during the Late Silurian-Middle Devonian Acadian Orogeny. The rifting of Avalon and its later accretion to Laurentia resulted in the formation of three distinct Late Proterozoic to Siluro-Devonian volcanic deposits, including Middlesex Fells, Lynn Mattapan Volcanics, Cape Ann Plutonic Complex, and the Newbury Volcanics.

Marblehead Neck lies off the coast of the North Shore and is shown on the 1983 Bedrock Map of Massachusetts to be underlain by Ediacarian Dedham Granodiorite and Lynn Volcanics. Despite this, the age and origin of the plutonic and volcanic rocks on Marblehead Neck have not been determined and remains controversial.

- Dennen (1991) and Clapp (1921) believed them to be extrusive equivalents of the Cape Ann Granite
- Emerson (1917) believed them to be related to the Newbury Volcanics
- Smith (1985) and Hepburn et al. (1993) believe the Lynn and the Dedham are comagmatic based on identical geochemical analysis and field relations.
- A weighted mean $^{206}\text{Pb}/^{238}\text{U}$ concordant dates of 596 ± 3 and 595.81 ± 0.42 Ma (CA-TIMS) (Thompson et al, 2010) from exposures within the Melrose subblock and suggest an ~10 Ma unconformity between the Lynn-Mattapan Complex and the Dedham Granite.

This relationship is not reflected in field relations north of Boston.

METHODS

To resolve this controversy, the following studies were initiated to the bedrock on Marblehead Neck:

- Field Mapping
- Petrographic analysis and facies analysis
- Review of previous geochemical analysis

The data collected was compared to that of each volcanic complexes mapped at these location, primarily in the areas of Boston, Saugus, and Newburyport.

PURPOSE

This study attempts to identify the volcanics on Marblehead Neck by correlating them to the local (North Shore) volcanic complexes:

- Newbury Volcanics
- Lynn Mattapan Volcanics
- Cape Ann Plutonic Complex Extrusives
- Middlesex Fells

FIELD MAPPING RESULTS: BEDROCK GEOLOGY OF MARBLEHEAD NECK, NORTH SHORE, MA

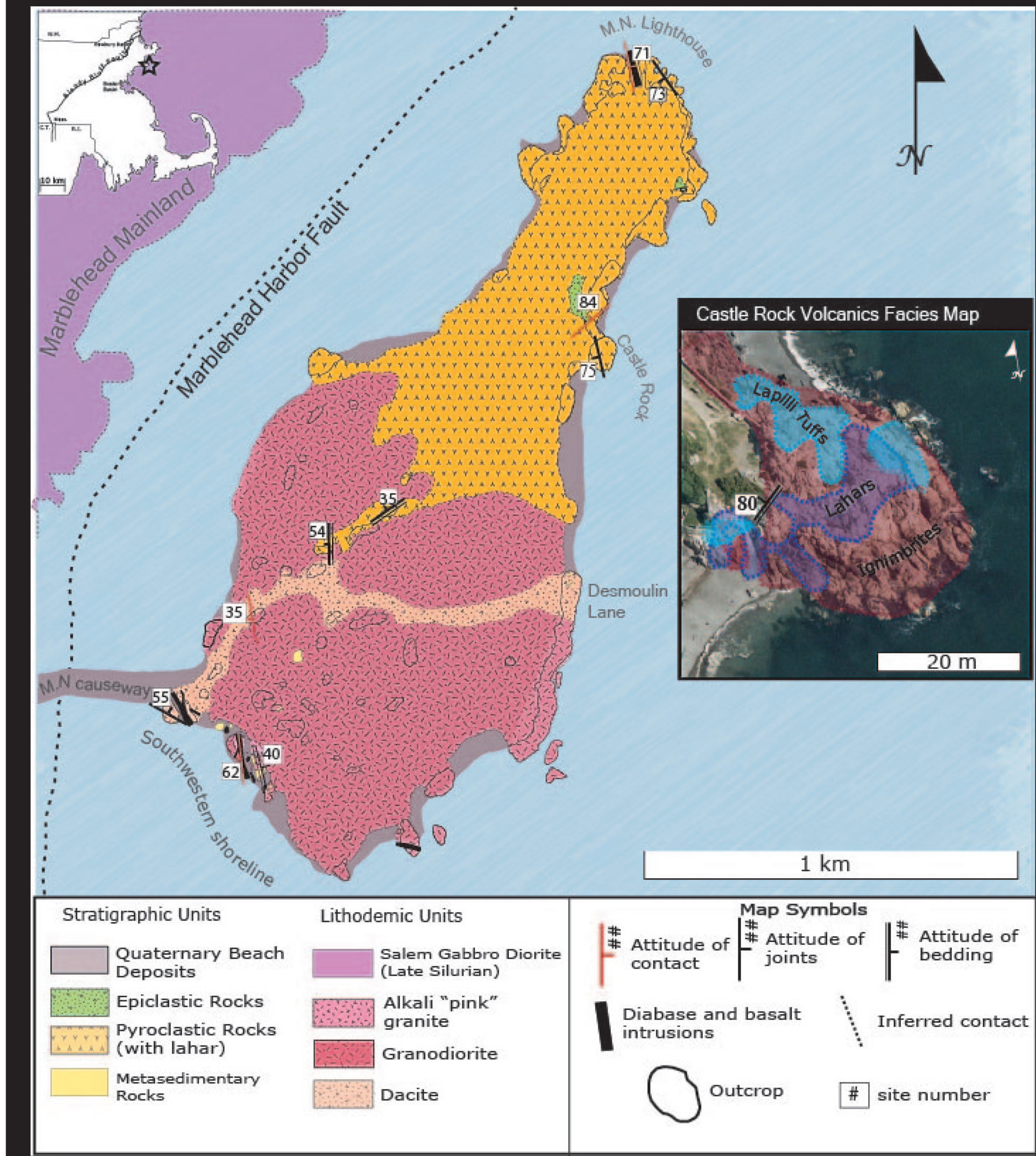


Figure 1: Reconnaissance field mapping result: Bedrock Map of Marblehead Neck of North Shore Massachusetts. Locus map in upper left hand corner indicates study area location by a star icon. Sample MT95-6 (Thompson, unpublished) is mapped in proximity sample location. Letters on the map reference in situ photos taken that are represented on the right hand side. Bedding of lapilli tuff were taken: 180° 54° W and 233° 35° NW. Facies map of Castle Rock on Marblehead Neck. Attitude of steeply dipping flamme was taken: range of 218-225° and 75° NW-90°.

RESULTS

Table 1: Lithologies present on Marblehead Neck, produced by petrographical and field analysis. Note Metasedimentary unit is missing from table

	Stratigraphic Units		Lithodemic Units		
	Epiclastic	Volcanics: Pyroclastics	Alkali "pink" granite(?)	Granodiorite	Dacite
Texture	Clastic, med.-fine grained, poorly sorted, angular & subangular clasts.	Porphyritic-aphanitic Phenocrysts: 15% Groundmass: 85%	Phaneritic Anhedra & subhedral crystal habit	Phaneritic Anhedra & subhedral crystal habit	Porphyritic-aphanitic Phenocrysts: 30% Groundmass: 70%
Modal Composition (%)					
Notes	Clasts: dark grey ignimbrites, flow banded vitrophyre, felsic pink rock, and minor amounts of quartzite and schist.	Dark aphanitic groundmass, broken phenocrysts of plagioclase, possible lithic fragments of quartzite and schist.	Poikilitic texture: orthoclase phenocrysts with hornblende XX growing. Qtz with microcline inclusions. Perthite ortho.	Plagioclase crystals are zoned, altered, and/or perthitic. Hydrothermal alteration to chlorite.	Deformation of phenocrysts. Poikilitic texture to orthoclase from hornblende XX. G.M. felsic: plag & ortho.
Contact Relations	Underlain by ignimbrites	Volcanics underlay Epiclastic unit. Inclusions of pyroclastics within granodiorite.	A diffusive contact with Dedham Granite. Potential residual melt of Dedham. Does not contain metasedimentary inclusions	Granite intrudes Dacite and Volcanics	Granite displays a chill margin at contact with Dacite. Contains inclusions of metasedimentary rocks.

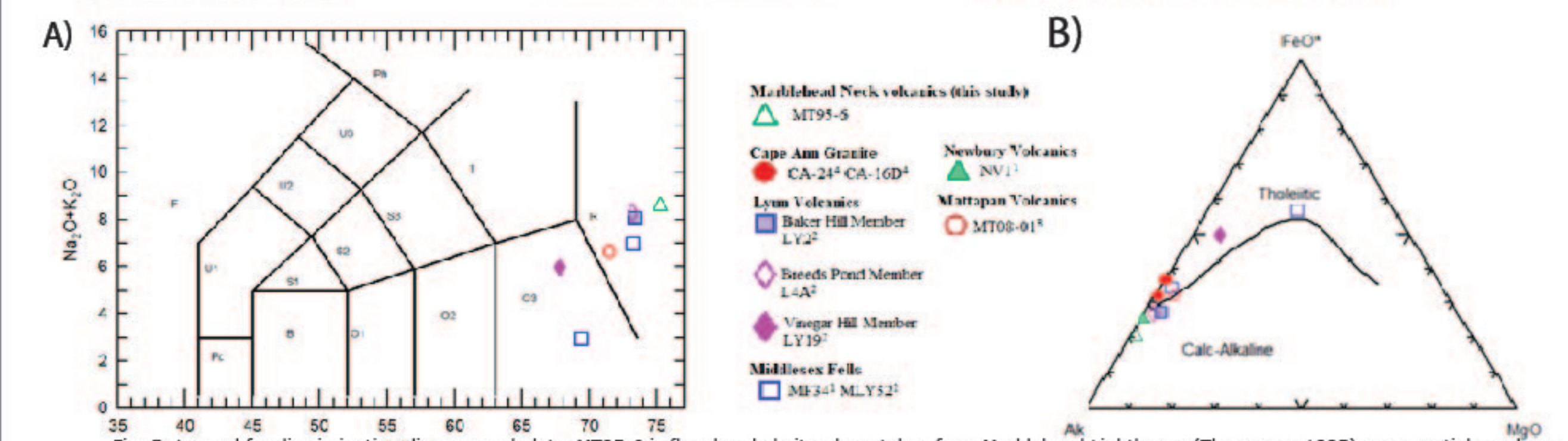
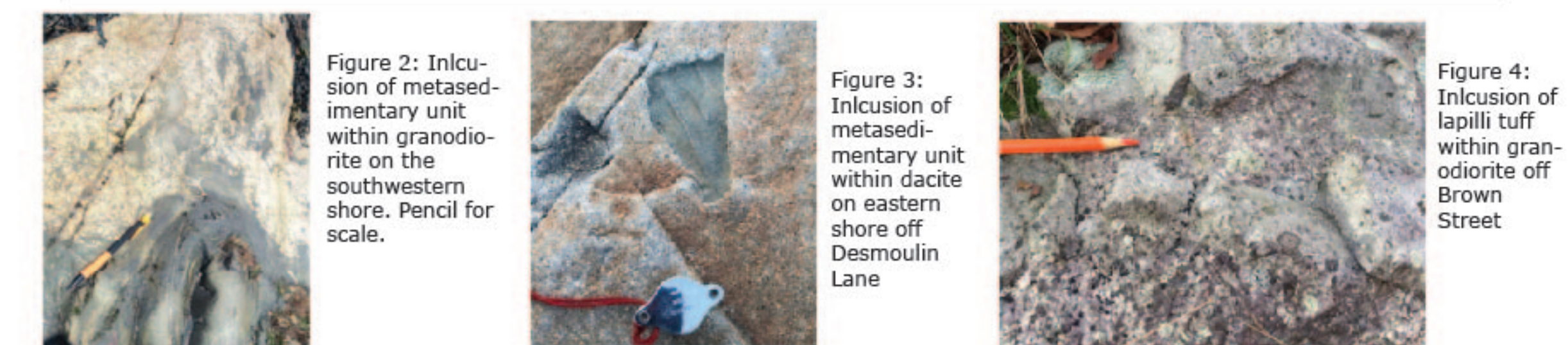


Fig. 5: Legend for discrimination diagram and plots. MT95-6 is flow-banded vitrophyre taken from Marblehead Lighthouse (Thompson, 1995). exponential numbers indicate source: (Zarrow, 1978) 1, (Smith, 1985) 2, (Thompson et al., 2014) 3, and (Hon, Page, and Loftens, 1993) 4. All major and trace elements data was obtained through XRF. (A) TAS diagram for volcanic rocks. Note sample MT95-6 (hollow green triangle) and most samples plot as rhyolite while Vinegar Hill Member of Lynn Volcanics and one of the Middlesex Fells plots as dacite. (B) Irvin and Baragar (1971) AFM diagram in weight percent oxide. Alk= Na₂O+K₂O, FeO* is total iron as FeO.

DISCUSSION AND CONCLUSION

- Metasedimentary = Westboro Formation
- Granodiorite = Dedham Granite

Identity of volcanics on Marblehead Neck	
Requires further investigation	Absolutely Not
<ul style="list-style-type: none"> • Middlesex Fells • Lynn-Mattapan Volcanic Complex 	<ul style="list-style-type: none"> • Newbury Volcanics • Extrusive of the Cape Ann Plutonic Complex

The volcanics on Marblehead Neck CANNOT be related to the Newbury Volcanics or extrusives of the Cape Ann Plutonic Complex because:

- Granite displays a chill margin at contact with volcanics
- Xenoliths of the volcanic facies present in the Granite
- Xenoliths of turbidites and quartzite are within Dacite Volcanics on east, coastal side.

Further study and dating efforts of the subvolcanic and volcanic rocks, and their relation to the Dedham Granite, is essential to fully understand the geologic history of Marblehead Neck and New England.

ACKNOWLEDGMENTS & REFERENCES

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