

Introduction

This project investigates the petrological and geochemical signature of the magmatic intrusions known as mafic dikes that intrude the Salem Gabbro-Diorite (SGD) in Salem Willows Park and Winter Island, as well as the tectonic relationship to other previously studied dikes within the greater Boston area. The Salem Gabbro-Diorite is a member of the Avalon terrane, an exotic terrane thought to have originated from West Africa that drifted away from Gondwana approximately 489 Ma (Thompson, 2007). During its drift, it is speculated that the Avalon terrane was intruded by the Cape Ann Complex, a plutonic suite including the SGD, before eventually docking on to North America (Hanson, 2013). Several mafic dike swarm events have been distinguished within the Cape Ann Complex occurring throughout the Paleozoic and the Mesozoic eras (Ross, 1990). Four dikes were studied using petrological analysis and major and trace/rare-earth element geochemistry to be compared with previously-published data. Mapped in Figure 1, sampled mafic dikes range in width from 10cm to 60cm and generally trend NNE. They are predominantly fine-grained, yet most contain plagioclase phenocrysts.

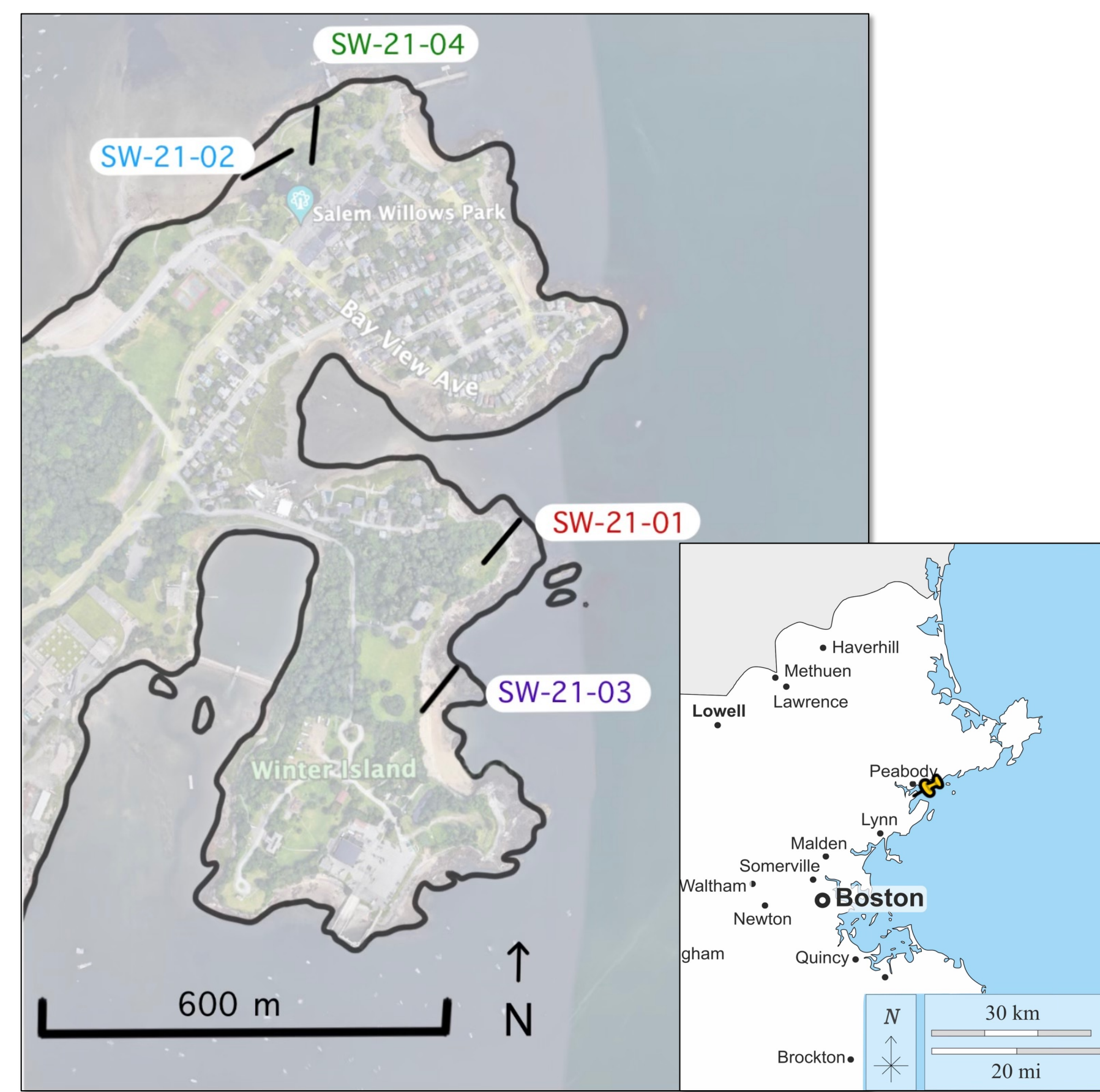


Figure 1. Location map of the Salem Willows, MA. The inset shows the study area in the greater Boston area. The length and width of the dikes are exaggerated to emphasize their NE orientation.

Methodology

- Petrological analysis of hand samples collected from the dikes
- Major element geochemistry (XRF, Hamilton Analytical Labs)
- Trace and rare-earth element geochemistry (LA-ICP-MS, Hamilton Analytical Labs)

Petrological Analysis

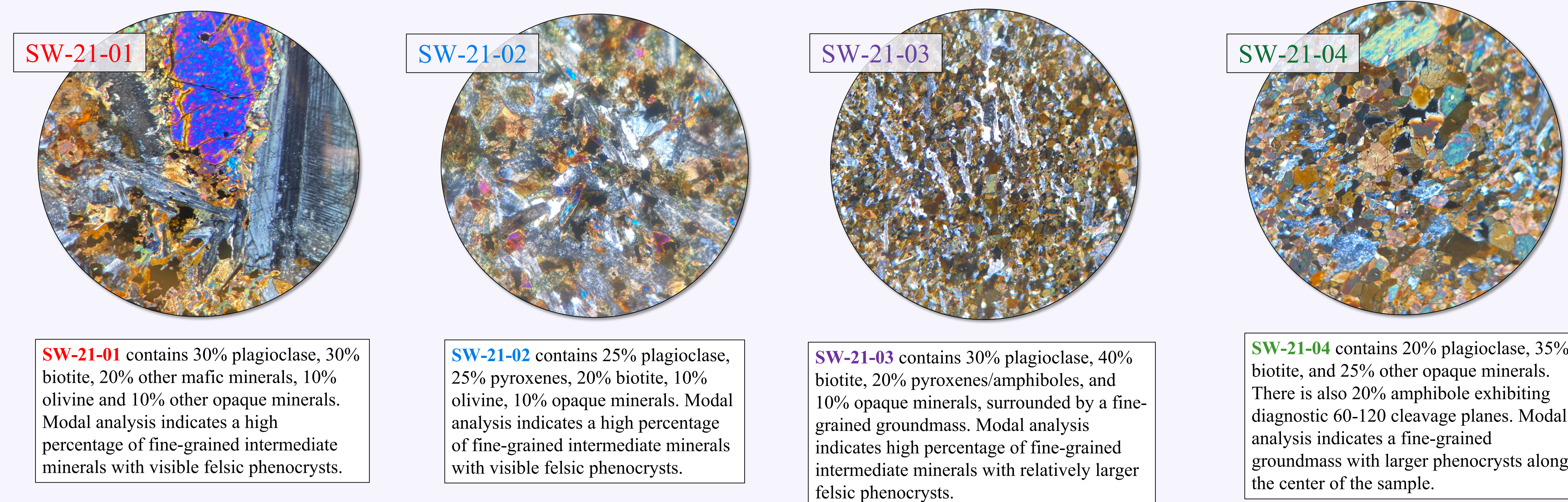


Figure 2. Modal and textural information were gathered through petrologic analysis of each sample using thin sections and hand samples. Field view is 2mm wide for all. Thin sections, shown here in XPL, include similar assemblages of feldspathoids, biotite, amphiboles, olivine, and other opaque minerals. Hand samples demonstrate a fine-grained groundmass with 0.5-1cm long and randomly-oriented plagioclase phenocrysts.

Field Images

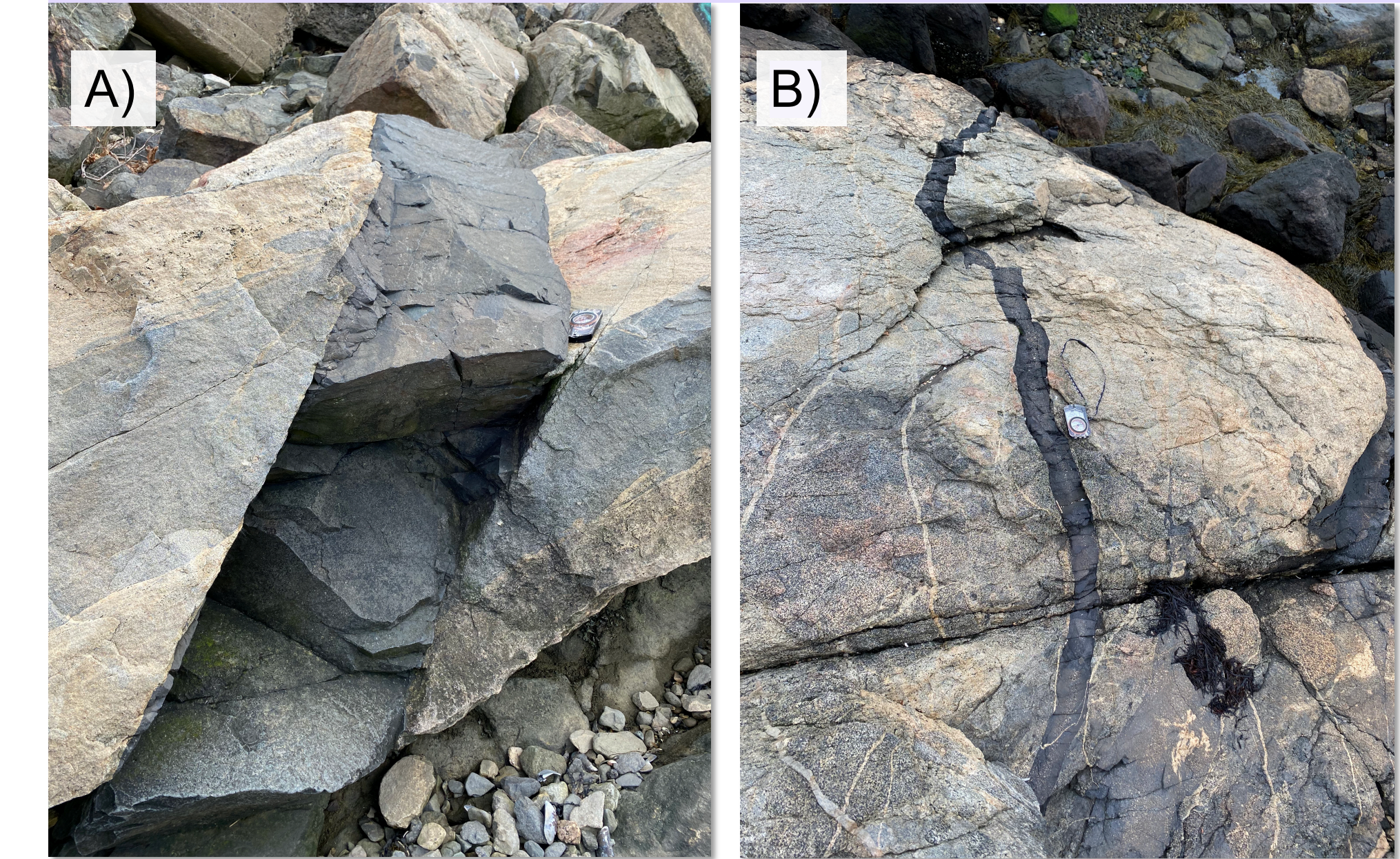


Figure 4. Field photographs of the sampled dikes. A) Sample SW-21-02 is 45cm thick NE trending (240). Its contact with the Salem Gabbro-Diorite is sharp and has randomly-oriented plagioclase phenocrysts embedded in the groundmass. B) Sample SW-21-04 is 10cm thick N trending (185). Its margin in the Salem Gabbro-Diorite is distinct and has phenocrysts along the center of the dike.

Results

- Field mapping reveals the mafic dikes are NE oriented with distinct margins in the Salem Gabbro-Diorite
- Major element geochemistry indicates dikes are silica-undersaturated and lean tholeiitic, suggestive of a within-plate tectonic setting
- Trace and rare-earth elements show the dikes plot between enriched mid-ocean ridge basalts and ocean island basalts
- The spider diagrams display a diagnostic pattern of ocean-island basalts, and an enrichment of incompatible trace elements such as Ba and Rb, which suggest an enriched magma source for these dikes

Geochemical Analysis

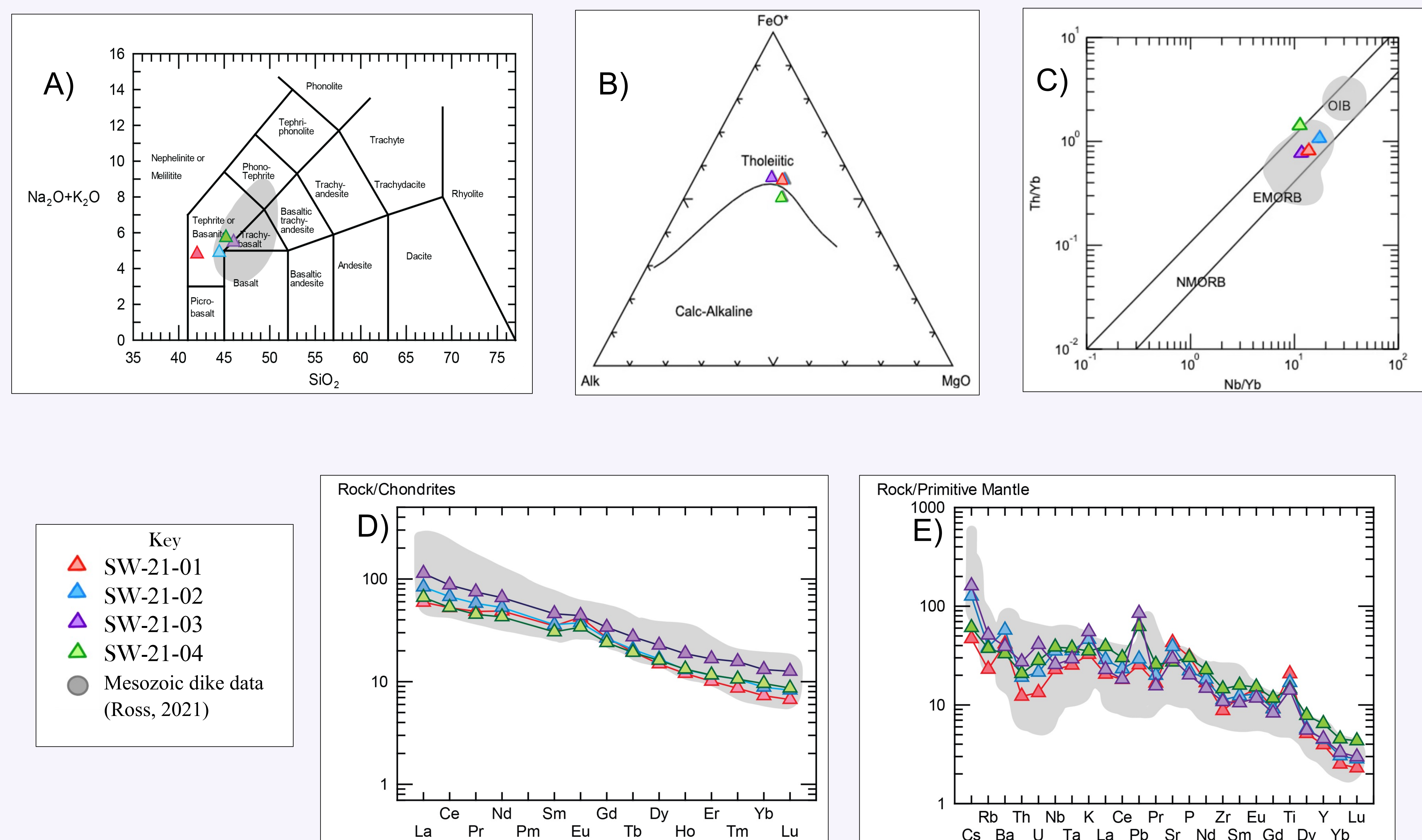


Figure 3. Geochemistry of mafic dikes. Our samples are shown in colored triangles. Several plots display compositional data of Mesozoic silica-undersaturated dikes in Cape Ann Complex (Ross, 2021) as shaded underlying background. A) TAS diagram (LeBas et al., 1986). B) AFM diagram showing oxide composition and calc-alkaline tholeiitic boundary after Irvine and Baragar (1971). C) Nb/Yb vs Th/Yb tectonic discriminant diagram after Pearce (2008). D) REE and trace-element composition of samples normalized to chondrite values after Sun and McDonough (1995). E) Spider diagram showing primitive mantle normalized values after Sun and McDonough (1995).

Discussion and Conclusion

- The silica-undersaturated and NE-trending magmatic intrusions within the Avalon terrane at the Salem Willows corroborate best with the Mesozoic dike swarm of coastal Massachusetts as described in Ross (2020) using orientation, textural characteristics, and geochemical analysis
- The tectonic discrimination results of the Salem Willows dikes are agreeable with the projected tectonic model for the Mesozoic swarm formation via a deep mantle plume linked to the emerging breakup of Pangaea in Ross (2020)
- These dikes may be related to what is known as the Central Atlantic Magmatic Province (CAMP) (Dorais, 2005), a Mesozoic-age flood basalt province which extends down coastal Canada and New England
- Future K-Ar dating could be performed in order to conclusively determine a precise age for these dikes

References

Ross, Martin. (2021). Mafic Dikes of the Boston Metropolitan Area, Massachusetts. 10.13140/RG.2.2.29116.16909; Ross, Martin. (2020). THE DIKE COMPLEX OF CAPE ANN, MASSACHUSETTS. 10.13140/RG.2.2.35438.69921; Martin E. Ross, 1990. "Mafic dikes of the Avalon terrane, Massachusetts", *Geology of the Composite Avalon Terrane of Southern New England*, Anthony D. Succi, James W. Slichter, Geoffrey W. Smiley, Hanson, L.S. and McFadden, R. 2014. *Rocks and landforms of the Lynn Woods and Breakheart Reservations: What they reveal about the local geologic history and what still needs to be explored*; in Thompson, Margaret D., *Guidebook to Field Trips in Southeastern New England (MA-NH-RI)*, 100th Annual NEIGC, Wellesley College, C21-24; Thompson, M.D., Gunnow, A.M., and Ramezani, J., 2007. Late Neoproterozoic paleogeography of the Southeastern New England Avalon Zone: Insights from U-Pb geochronology and paleomagnetism. *Geological Society of America Bulletin*, v. 119, p. 681-696, doi: 10.1130/B26014.1.