The boundary between the Lithosphere and Asthenosphere (lithosphere-asthenosphere boundary or LAB) denotes the shift from a stronger to a weaker mantle, yet the exact mechanisms governing this transition remain enigmatic. While the classical thermal definition proposes a gradual transition of the cooling lithosphere (as well as getting older and thicker away from the ridge) to the convective asthenosphere, alternative factors such as melt, anelasticity, or water content challenge this age-dependent thickening of the lithosphere. Recent studies demonstrated some strong correlations between evolving geochemical signatures of basalt with the geophysically constrained lithospheric thickness, suggesting a crucial link between mantle conditions, basalt geochemistry, and lithospheric thickness. Despite such inferred correlations, an integrated petrological-geophysical study is lacking to characterize the origin and evolution of LAB during the rifting to spreading stage. Conventional geochemical methods have been implemented to understand processes like melting and element fractionation. However, by adopting unsupervised machine learning algorithms (specifically K-means cluster analysis and Independent component analysis) to analyse entire regional datasets objectively, we reveal the novel aspects within the broader data structure, thereby complementing previous geochemical interpretations.

The Mid-Norwegian Continental Margin, extending to the matured Mid-Atlantic Ridge near Iceland, provides an ideal tectonic setting for investigating the evolution of the Lithosphere-Asthenosphere Boundary. The present study will provide a comprehensive petrological analysis with robust geochemical constraints, synthesizing basaltic geochemistry data from the North Atlantic Igneous Province (NAIP) and forming a framework for comparing mantle plume ridge interaction signatures from the dataset. Unlike previous studies focusing on the western parts of the NAIP and the Mid-Atlantic Ridge axis, this research, utilizing samples from the IODP Expedition 396 in the NE Atlantic margin in 2021, aims to complete the puzzle. The research in ERI we adopted the implementation of sophisticated unsupervised machine learning approaches for a large regional geochemical dataset from the North Atlantic Igneous Province to identify the underlying tectonic processes and their implications for LAB and plume-rift interaction. The aim is to evaluate (the combined?) effects of mantle plume and spreading in the North-East Atlantic Ocean crust formation and that will enhance existing data with conventional geochemical analysis, estimating temperature and pressure conditions for formation through thermodynamic phase equilibrium analysis (in future studies) and independent component analysis based on multivariate statistical analysis, incorporating major component-trace element composition, and isotope ratio composition of lava.