Report:

Mobility of the fragmented lithosphere (or plates) over a weaker asthenosphere and subduction (destruction of plates) in our planet earth is somewhat unique in the solar system. Consumption of plates in the subduction zone is counteracted by the generation of the new lithosphere at mid-oceanic ridge settings, where divergent plate motion leads to mantle melting and subsequent formation of new oceanic crust by crystallization of magma. However, the magma outcome is not equally distributed throughout the Earth instead it is believed to be intrinsically linked with the rate of plate spreading. The making of a self-sustaining divergent plate boundary usually traces back from the continental rifting (due to lithospheric thinning and/or uprising mantle plume) and is considered a fundamental step in the Wilson cycle. Usually, continental rifting under influence of mantle plumes causes enormous magmatic outpour in spite of significant investigation spanned through the last few decades it is still unknown how such excess volcanism took place in a surprisingly short duration and the major controlling geodynamic factors behind it. According to the Wilson cycle disassembly and assembly of the supercontinents starts with initial pre-drift extension followed by rift-to-drift phase, the initial opening of an oceanic basin, seafloor spreading, widening of the basin, subduction of oceanic lithosphere, closure of the basin, and finally continent-continent collision. A classic example of continental extension, breakup, and formation of new mid-oceanic spreading centres can be found in the Atlantic ocean. The North Atlantic Igneous Province eruptions started around 61-62 Ma and formed the northern Atlantic passive margins to the present state. It is still poorly unresolved that, what is the key mechanism behind the excess amount of magmatism in a surprisingly short duration causes the breakup of the northeast Atlantic.

The main drive of the IODP Expedition 396 in August and September 2021, was to understand the relationship between rifting, enormous magmatism, and paleoclimate, and to resolve the relative contribution from plume upwelling, small-scale convection, and mantle heterogeneity and their relation to the formation of volcanic rifted margins during the northeast Atlantic continental breakup. Departing from Iceland, JOIDES Resolution sailed northeastward and drilled thick sequence of seaward dipping volcanics on the Mid-Norwegian continental margin on the western edge of the Vøring Basin. A total of 21 boreholes were drilled during Expedition 396 and successfully acquired cores of marine volcanic sediments and hard rock basement from nine boreholes along-strike and one cross-strike margin transect. The total drilling depth was 3950 with high recovery (overall about 57%), more than 500 m of basement rocks, and more than 2000 m of Paleogene sediment were drilled. A combination of RCB, XCB and APC drill bits were used during this expedition. The key paleoclimate interval the Paleocene-Eocene Thermal Maximum (PETM) in the Modgunn and Mimir transect; and the basalt stratigraphic intervals across the volcanic rifted margin, including both subaerial and deep marine sheet flows with inter-lava sediments were successfully recovered.

Over the past few years, extensive research efforts have been dedicated to investigating the structure of the lithosphere, the depth of the lithosphere-asthenosphere boundary, and the seismological and material science characteristics throughout a vast expanse of the Pacific Ocean. In the 67 days of the short-term program in the Earthquake Research Institute expanding our understanding of the aforesaid research topic. It's crucial to note the striking scarcity of information or constraints pertaining to the structural intricacies near ocean ridges, which serve as pivotal locations for the genesis of tectonic plates. The Lithosphere-asthenosphere boundary (LAB) marks the transition between stronger and weaker mantle, but the specifics of how, where, and why this transition occurs are mysterious. The classical thermal definition suggests a gradual shift from the cooling lithosphere to the convective asthenosphere. However, various geophysical observations challenge this age-dependent thickening, proposing alternative factors like the presence of melt, anelasticity, or water content to explain the asthenosphere's behavior and LAB definition. This evidence points to a strong link between mantle conditions, basalt geochemistry, and lithospheric thickness. Though some correlations have been inferred, an integrated petrological-geophysical study to firmly establish this connection in the unique rifting to spreading stage remains lacking. In the Mid-Norwegian Continental Margin, stretching to the matured Mid-Atlantic Ridge near Iceland, we have identified an ideal tectonic setting for studying the evolution of the Lithosphere-Asthenosphere Boundary. The approach combines a comprehensive petrological analysis with robust geophysical constraints. The primary petrological focus is to synthesize the basaltic geochemistry data from the North Atlantic Igneous Province (NAIP). While prior research has mainly concentrated on the western parts and the Mid-Atlantic Ridge axis, this study aims to complete the puzzle using samples collected during the IODP Expedition 396 in the NE Atlantic margin in 2021. This research will augment existing data with traditional geochemical analysis, including in situ mineral phase analysis, whole-rock major and trace element analysis, and isotopic ratios of Sr-Nd-Pb, creating an unbiased geochemical dataset for the NAIP region. Specifically, we estimate the temperature and pressure conditions for formation based on thermodynamic phase equilibrium analysis and the independent magma analysis based on unsupervised machine learning approaches with multivariate statistical analyses using the major component-trace element composition, and isotope ratio composition of lava.