## Project Report:

Experimental investigations into high-temperature creep of mineral aggregates have yielded valuable insights not easily discernible in natural settings. These include understanding the variations in rock strength under diverse geological conditions like stress, temperature, chemical compositions, and grain size. Additionally, these experiments shed light on the evolution of rock microstructure, including changes in crystallographic preferred orientation (CPO) during deformation. The conventional diffusion creep theory anticipates the migration of atomic mass happens across grain boundaries oriented perpendicular to the compressional (high) stress axis towards the boundaries oriented at low-stress direction. This deformation mechanism results in grains exhibiting anisotropic shapes, which frequently contributes to the formation of mineral lineations and foliations observed in highly deformed mantle rocks such as peridotites. Several experimental studies on fine-grained olivine aggregates have shown that selective grain boundary sliding (GBS) predominantly occurs along boundaries with low-index planes, facilitating grain rotation to align with the corresponding shear direction. This alignment leads to the development of CPO and shape-preferred orientation (SPO). It is widely recognized that the seismic anisotropy observed in the upper mantle is predominantly attributed to the CPO of olivine. The assumption that mantle anisotropy is a reflection of olivine CPO is due to the fact that olivine is the primary constituent anisotropic mineral found at this depth.

Pyroxene, on the other hand, is the second most abundant mineral in the lower crust and upper mantle, constituting approximately 20–30 modal percent, and understanding its CPO is equally crucial and challenging. Unfortunately, not much work have been done in this area. Here, at ERI, I took up this as my main research focus, as I believe that pyroxene CPO can play a critical role in bulk peridotite anisotropy, which in turn has important implications in mantle deformation and its flow dynamics. In polycrystalline materials, individual crystals are recognized to showcase diverse grain morphologies that are often influenced by the environmental conditions (e.g., presence of secondary phase) and the stages of grain growth. I conducted experiments on two phase rock aggregates of two different compositions, with Diopside ($CaMgSi_2O_6$) as the major pyroxene phase, combined with minor secondary phases of Anorthite ($CaAl_2Si_2O_8$) and Forsterite ($Mg_2SiO_4$), respectively. The highly dense, fine-grained (<1μm) samples was synthesized following standard procedures, using constituent nanosized powders of $Mg(OH)_2$, $SiO_2$, $CaCO_3$, $Ca(OH)_2$ and $Al(OH)_3$ in proportions as prescribed by previous workers. I synthesized fine grained highly dense samples of dimension ~4mm x 4mm x 8mm and conducted multiple high strain (~70% finite strain) experiments to supposedly reach the optimum deformation level required to study grain alignment and corresponding CPO. The samples were then cut and polished into all three coordinate axes (containing the 3 planes: XY, XZ, and YZ) to understand the grain growth and orientation in all three directions which revealed the ultimate 3D grain morphology. SEM studies showed that deformed DiAn aggregate depicts a much smaller grain size with strong anisotropy in the X direction, describing a pencil shaped morphology where X axis is highly elongated as compared to Y and Z axes. On the other hand, DiFo does not show such strong anisotropic character. Only EBSD measurements showed a faint CPO in the DiFo samples. Pole figure analysis based EBSD studies show a stark difference in the grain orientation (CPO) of the deformed DiAn with respect to DiFo samples. These primary results show that the secondary phase has a prominent effect on the deformation behaviour as well as the deformed grain morphology and CPO, implying a probable seismic anisotropy between the two phases. I believe, further high temperature high strain pure shear experiments and precise analysis will make us understand more about the anisotropic character of the upper mantle (containing Pyroxene) and the corresponding flow dynamics.