The use of porphyroblast inclusion trail asymmetries to reconstruct deformation history in metamorphic rocks: insights from the Barrovian sequence of the Kaghan-Naran valley, north Pakistan

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Multiply deformed and metamorphosed rocks commonly preserve a record of lengthy periods of deformation and associated several phases of porphyroblast growth. This is evident from several sets of foliations and lineations reported from a number of orogenic terrains around the globe. However, when it comes to the interpretation of foliations and associated lineations, controversies arise in terms of their tectonic control and kinematic models. To resolve the tectonic origin of foliations and lineations, sophisticated structural techniques have been devised and their refinements over the years allow the users to track the tectonic history of a given orogenic terrain as accurately as possible.

The purpose of this research is to reconstruct 'original' geometrical orientation of foliations and lineations that are preserved in porphyroblasts in the form of inclusion trails from the multiply deformed and metamorphosed sequences of the Kaghan-Naran valley, north Pakistan. No such studies have been carried out to date in the proposed region. Yet, the metamorphic rocks of the Kagahn-Naran valley are crucial in many ways not only to decode the sequential two-phase exhumation tectonics of this important region within the Himalaya, but also to understand the synchronous collision-extension history of this world-class orogenic system. Inclusion trail geometries in porphyroblasts can help us to thoroughly investigate fine-scale processes involved in crustal-scale mechanics, where synorogenic two-phase collision and exhumation have been proposed.

Two conflicting hypothesis have been postulated for the asymmetric inclusion trail geometries: porphyroblast rotation and non-rotation. Porphyroblast non-rotation assumes that porphyroblast preserve successive sets of foliations with respect to fixed geographic coordinates during progressive deformation in case not obliterated internally. Hence, multiple deformation phases can be deduced and correlated from sample to sample and from one region to other. Rotation model postulates that during simple shear, porphyroblasts synchronously grow and trap single foliation during progressive shearing. In this study, not only the two models are tested but the inclusion trail geometries preserved in porphyroblasts are also measured and an attempt is made to reconstruct the deformation and associated metamorphic sequences of the Kaghan-Naran valley.

Two main FIA sets are obtained through 'asymmetry switch' method. The first FIA is E-W trending mostly obtained from garnet porphyroblasts, and corresponding to the N-S bulk shortening of the Indian Plate with Kohistan-Island Arc. The second FIA set is N-S trending and obtained from both garnet and staurolite porphyroblasts and formed as a result of E-W bulk shortening. The two distinct shortening directions match well with the FIA data obtained from the Swat area.