HOKKAIDO UNIVERSITY

Title	Tectono-metamorphic evolution of the Himalayan metamorphic rocks : Insights from the Mandakini and Madhmaheswar Ganga river valley, Northwestern India [an abstract of entire text]
Author(s)	Shivaji, Saha
Citation	北海道大学. 博士(理学) 甲第14201号
Issue Date	2020-09-25
Doc URL	http://hdl.handle.net/2115/79566
Type	theses (doctoral - abstract of entire text)
Note	この博士論文全文の閲覧方法については、以下のサイトをご参照ください。
Note(URL)	https://www.lib.hokudai.ac.jp/dissertations/copy-guides/
File Information	Shivaji_Saha_summary.pdf

Instructions for use

Hokkaido University Collection of Scholarly and Academic Papers : HUSCAP

Summary of Doctoral Dissertation

Degree requested: Doctor of Science Applicant's name: Shivaji Saha

Title of Doctoral Dissertation

Tectono-metamorphic evolution of the Himalayan metamorphic rocks: Insights from the Mandakini and Madhmaheswar Ganga river valley, Northwestern India

（ヒマラヤ変成岩の造構－変成発展史：北西インドの Mandakini および Madhmaheswar Ganga 川峡谷地域からの考察）

Evolutionary signatures of active mountain building tectonic process as a consequence of collision between Indian plate and Tibetan plate are well preserved in the Himalayan metamorphic rocks. The ductile deformation of the crust caused by the Main Central Thrust which in turn, resulted from southward extrusion of high grade metamorphic rocks (amphibolite to granulite facies) of Greater Himalayan Sequence (GHS) over low grade (greenschist facies) Lesser Himalayan Sequence (LHS) creating an inverted metamorphic field gradient across the MCT. The study area in NW Himalaya along Madhmaheswar Ganga valley, Rudraprayag district, Uttarakhand, India is comprised of Munsiari formation and Vaikrita group of rocks (lower GHS). Garnet-kyanite bearing migmatitic gneiss of lower GHS (~ 3 km thickness) was juxtaposed over orthogneiss and garnet bearing metapellites of Munsiari formation (~ 7 km thickness) by north-easterly dipping MCT. Intercalations of metabasic rocks are persistent throughout Munsiari formation. The study area is characterized by the presence of an inverted Barrovian sequence from biotite zone through garnet zone upto kyanite zone where kyanite-in isograd lies immediately above the MCT.

In order to understand the inverted metamorphism along with the deformation condition in the study area, it is important to examine the tectonic behavior of the rocks with increasing structural level across the MCT by means of microstructural observations and metamorphic P-T conditions of equilibrium mineral assemblages. Therefore, detailed microstructural analysis is necessary to define the extent of a shear zone and therefore, monomineralic rocks has been extensively studied in this regard. Thus, this study aims at investigating polymineralic rock such as mylonitic granite to understand the deformational behavior of quartz grains in different domains by means of understanding the kinematics of MCT shear zone.

Microstructural observations are essentially focused on the quartzo-feldspathic gneiss of the Munsiari formation and L-GHS. Quartz microstructures from lower part of the Munsiari formation are generally characterized by subgrain rotation recrystallization (SGR). Some domains of polygonal quartz grains with triple point junction indicate SGR followed by static grain growth. Whereas, lobate boundaries of quartz grains with sweeping extinction and deformation lamellae has been documented from upper Munsiari formation indicating high temperature grain boundary migration (GBM) overprinted by late stage low temperature deformation. Quartz grains in the L-GHS rocks are coarser than that of the Munsiari rocks and highly irregular in shape. High temperature deformation is evidenced by the presence of elongated subgrains and chessboard pattern extinction of quartz.

To carry out further microstructural studies, 14 samples were selected for EBSD analysis. Monomineralic quartz-rich and polyphase domains has been subjected to the investigation by means of understanding the development of quartz LPO fabric across the MCT. Quartz *c*-axis fabric from quartz-rich domains of the Munsiari formation rocks shows a series of type-*II* crossed girdle fabrics with *Y*-maximum. Here, the quartz *c*-axes are aligned parallel to intermediate finite strain axis *Y*, revealing the intracrystalline deformation by active prism {10-10} <a> slip system. In contrast, c-axis orientations obtained from thin monomineralic quartz layers (thickness 72-163 μm) records girdles ranging from small circle girdles to type-*I* crossed girdle fabric with r-maxima. In this case, the rhombohedral plane of quartz is aligned parallel to the foliation plane (*XY*), which indicate basal (0001) <a> slip and rhomb {10-11} <a> slip system activity. Thus, there is an effect of thickness of monophase layers on fabric development and, perhaps the role of other phases has a strong impact on the fabric development for the case of thin monomineralic layers.

On the other hand, polyphase domains are characterized by the quartz grains totally surrounded by other phases. The size of recrystallized quartz grains within polyphase domain increases from ~64.4 μm in Munsiari to ~109 μm in L-GHS. C-axes orientations are random for the Munsiari samples. Whereas, C-axis fabric with point maxima is observed for the L-GHS samples. However, those fabric patterns are strengthened with increasing modal abundance of quartz.

The strength of the quartz *c*-axis fabric is quantified as a function of eigenvectors (λ_1 = maximum; λ_2 = intermediate; λ_3 = minimum) from *c*-axes orientation distribution. Following Vollmer (1990), three end member fabric types are determined from these eigenvectors; those are point (*P*), girdle (*G*) and random (*R*). Then, by introducing cylindricity index (*B*) of Vollmer (1990), the variation in fabric strength of quartz LPO is shown as a function of strain localization throughout the Munsiari formation. Progressive increase in fabric intensity for both thin and quartz rich layers indicate an increase in strain towards the MCT.

The Geochemical studies are consisted of Garnet line profile analysis, X-ray elemental mapping for major elements such as Ca, Fe, Mn, Mg and the Point analysis of matrix minerals by an electron probe microanalyzer (EPMA). Garnets from the MCTZ and lowermost GHS are characterized by growth zoning with consistently decreasing X_{Mn} content from core to rim suggesting the grain growth during burial with increasing *P* and *T*. On the other hand, most of the garnet porphyroblasts in the L-GHS exhibit flat profile of X_{Mn} with little increase at rim. The diffusional zoning profile of the L-GHS garnets is a result of higher rate of diffusion of major elements at higher elevated temperature than that of growth zoning causing homogeneous distribution of these elements. Rim with higher X_{Mn} content signify retrograde reaction during exhumation and cooling of the lower GHS rocks. The results obtained from conventional thermobarometers is showing a peak *P*-*T* condition of 535 ± 25 °C and 5.8 ± 1.2 kbar from the assemblage of garnet + quartz + chlorite + chloritoid + plagioclase + biotite + muscovite ± ilmenite in the lowermost MCTZ. Whereas, the upper MCTZ rocks have experienced peak *P*-*T* condition of 632 ± 25 °C and 8.5 ± 1.2 kbar. In contrast, lowermost GHS experienced peak *P*-*T* condition of 683 ± 25 °C and 11 ± 1.2 kbar attained by the equilibrium assemblage of garnet + quartz + plagioclase + muscovite + biotite ± kyanite ± ilmenite ± rutile. a steep inverted pressure gradient of 16.4 ± 1.3 kbar km^{-1} persist between uppermost MCTZ sample and lowermost GHS sample which could suggest extreme post-metamorphic thinning of rock strata due to thrusting along the MCT.