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Analyses of deformation stages and paleostress in the Kamuikotan metamorphic rocks, west of the Asahikawa-city, Hokkaido

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The Kamuikotan belt, distributed in the central Hokkaido, is a representative high-P/T type metamorphic belt that developed on the convergent boundary between the Eurasian Continent and the oceanic plate subducting beneath the edge of the Asian continent in the Cretaceous. In the metamorphic rocks cropping out in the Kamuikotan gorge area in the western part of Asahikawa city, structures such as foliations and folds have been developed well, and many quartz veins intruded. We measured the orientations of these, and found the existence of three deformation stages Okamoto (2011, graduation thesis) has suggested, from analyses of orientations of foliations. The D1 is defined as the stage at which principal foliations in this area (S1) were formed. S1 was folded to form closed east-vergent folds with axes which trend N-S?NNE-SSW and plunge south at low angles (D2). Furthermore, S1 locally formed open folds with axes that are almost vertical and fold axial surface oriented in E-W. These folds overprinted D2 folds (D3). Poles of quartz veins in the outcrop where D2 folds are dominant were distributed symmetrically with respect to the D2 fold axial surface. This indicates that quartz veins intruded in a stress field that formed D2 folds. We also sampled a quartz vein with dominant D3 crenulation folds that was intruded parallel to foliations, and analyzed microstructures of quartz using three methods explained below to infer the paleostress field. We first define the sample coordinates, the X-Y-Z axes, where X trends E-W and plunge east at 15 degrees, Y trends north and plunges horizontally, and Z trends E-W and plunges east and upward at 75 degrees, respectively. Poles of deformation lamellae in quartz grains are relatively rotated towards sigma 3 direction from the direction of c-axis. Estimation of the paleo-sigma 1 and 3 directions can be possible from the distribution of arrows which connect the c-axis and lamellae pole (arrow head) orientations in grains. Arrows converged in the direction that plunge the -X axis at 20-60 degrees in the XZ plane. Kink bands tend to be formed in grains where the c-axes are oriented between the sigma 1 and 3 axes (i.e. orientations of highest resolved shear stress on slip plane), and not to be formed in grains where the c-axes are oriented to the directions of principal stress axes. Based on these facts, we can estimate the directions of principal stress axes from distributions of c-axes orientations in grains containing and not containing kink bands. The c-axes in grains with kink bands showed a girdle distribution with the angular radius of 45 degrees whose center is Y axis, and those in grains without kink bands were concentrated in the direction that plunges -X direction at 20-30 degrees in the XZ plane. Sigma 3-direction can also be estimated from distribution of poles of healed microcracks formed in quartz grains because they are ideally formed perpendicularly to the sigma 3-axis. The highest concentrated area of poles of microcracks plunges -X direction at 40 degrees in the XZ plane. Combining all these results, we could estimate that the paleostress field during the D3 period is such that the sigma 1, 2, and 3 axes trends N-S with no plunge, vertical, E-W with no plunge, respectively. From the measurement of homogenization temperature of fluid inclusions in quartz grains constituting a vein which probably formed during the D3 period, we obtained the values of temperature of 142-176 degrees. We could estimate that the pressure was 1.6-2.1 kbar when fluid inclusions were trapped, using the slope of isochore of pure water (76 degrees/kbar). This pressure value during D3 period is significantly lower than that estimated from fluid inclusions trapped during D2 period by Okamoto (2011, graduation thesis) (about 2.5 kbar). These facts indicate that an uplift of 0.5-1.0 kbar (1.5-3 km) occurred from the D2 period to the D3 period.

Keywords: Kamuikotan metamorphic rocks, deformation stage analyses, paleostress analyses, deformation microstructures in quartz, healed microcrack, fluid inclusion