Effect of shearing by polishing on the crystallinity of graphite

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Carbon is distributed in various forms over a wide range from the earth surface to the inside, and it is one of the most important element in Earth Science. One of the forms of carbon present in rocks is “carbonaceous material (CM)”, which is universally included in sedimentary and metamorphic rocks. Beyssac et al. (2003) pointed out that the degree of crystallinity of CMs exposed on the surface is reduced by polishing, and the CMs on the sample surface is not suitable for temperature estimation. However, it may be difficult to find a CM that is completely buried in a thin section that contains only coarse CM grains, or CMs extracted from acid decomposition or fault mirror these are already exposed on the surface. It is not clear how much the crystallinity of CM on the surface is damaged by polishing. In this study, we carried out the confocal laser scanning microscopy and FIB-TEM analysis, and evaluate the depth of the effect of polishing. From these data, we point out the problem of temperature estimation by applying the Raman CM geothermometers to the CM exposed on the surface, and consider the effect on the CMs by shearing during the seismic slip similar to the polishing.

The measured sample is CMs contained in the garnet-biotite-sillmanite gneiss collected in the Mogok metamorphic belt, Myanmar. The peak metamorphic temperature of the analytical sample is estimated to be about 800 °C. Most of the CMs contained in the sample are coarse grain (>0.1 mm or more). Both the CMs exposed on the surface and buried in the thin section can be observed. The final polishing was carried out using a 0.5 μm diamond paste. As a result of Raman spectroscopic analysis, the CM buried under the transparent mineral is well-ordered graphite only with the G-band, whereas the CM exposed on the surface markedly shows D1-band, and the turbulence of the crystal structure by polishing was confirmed. In addition, the light and dark parts were observed within the CM grains exposed on the surface by reflection microscope. In the Raman spectrum of the dark part, a stronger D1-band was observed than that of the light part. This suggests that the crystal structure of graphite is more disturbed in the dark part than in the light part.

As a result of the surface shape analysis by the confocal laser microscope, it was confirmed that the light part was concave as a shape. The reason is not clear but the light part has little influence of polishing, and there is a possibility that it might appear brighter due to irregular reflection when observing with a reflection microscope.

As a result of FIB-TEM analysis, a large number of fractures considered to have been formed at the time of polishing were observed in the CMs exposed on the surface of the sample in the range of a depth of several μms from the surface. Such fractures were not observed in the CM buried in host minerals. Furthermore, it was revealed that the crystal orientation was different between the light and dark parts. In the dark part region, although the crystal orientation was partly bent by polishing, the entire orientation shows the same orientation, whereas the region corresponding to the light part region showed a random crystal orientation, and many fractures developed. In addition, such a region reached about several μms depth. It is conceivable that the characteristics of the crystal orientation of the region corresponding to such a light part may be formed by mechanical deformation during polishing.

From the above results, it was found that the CM exposed on the surface during the preparation of the thin section was affected by mechanical deformation by polishing, and it was inappropriate to estimate the peak metamorphic temperature using the Raman CM geothermometers. CMs in the fault rock is also affected to shearing during faulting similar to polishing, and it is necessary to consider the effect of mechanical deformation due to fault movement for the Raman spectroscopic analysis.

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