

Relationship between Raman spectral pattern and crystal orientation of cordierite

ABE, Miyako^{1*} ; MADHUSOODHAN, Satish-kumar¹ ; KAGI, Hiroyuki²

¹Niigata University, ²Tokyo University

In the crystal structure of cordierite, six-membered rings of (Al, Si) O₄ are stacked along the *c*-axis and form a channel structure. This channel structure can trap volatiles such as H₂O and CO₂, and makes cordierite an important mineral for preserving the information of past fluid conditions during metamorphism. Earlier studies have shown that the intensity of CO₂ Raman band represents the contents of CO₂ inside the channel (e.g. Kaindl et al., 2006). Carbon dioxide is aligned linearly along the *a*-axis in the channel (Aines and Rossman, 1984), and therefore the peak intensity of CO₂ at 1383cm⁻¹ in the Raman spectra varies considerably depending on the crystal orientation of cordierite (Kolesov and Geiger, 2000). Thus, it is necessary to correct the effect of crystal orientation for the determination of true contents of CO₂ in randomly oriented cordierite grains in metamorphic rocks. As a first step to accurately quantify the CO₂ content in cordierite using Raman spectroscopy, we analyzed euhedral crystals of cordierite for revealing the relationship between Raman spectral patterns and crystal orientation.

In this study, euhedral cordierite crystals collected from the volcanic ash deposit in the Takiga swamp, Gunma Prefecture, Japan were examined in detail using micro-Raman spectroscopy. Raman spectra were observed with different conditions for each analytical point to check the effect of polarization and crystal orientation. Mineral chemical analyses of cordierite crystals indicate homogeneity in its composition ($X_{Mg} = 0.735 \pm 0.14$). However, different Raman spectral patterns were obtained for (001) plane and (100) plane; the (001) plane show only one pattern, but the (100) plane showed three different patterns. Peak splitting between 554 and 575 cm⁻¹, the peaks of 970 cm⁻¹ and 1180 cm⁻¹ changed its intensity drastically, whereas the peak at 670 cm⁻¹ remained constant. We selected five Raman peaks at 554 cm⁻¹, 575 cm⁻¹, 670 cm⁻¹, 970 cm⁻¹, and 1180 cm⁻¹ attributable to the cordierite (Al, Si)O₄ structure and analyzed the intensity ratio of these five peaks in different orientations. A parameter of Δ intensity was defined, where the intensity ratios of (001) plane were concentrated around 0, and those of (100) plane deviates from 0. This parameter can be used to identify the crystal orientation of cordierite. The spectral variations observed in cordierite and its relationship with crystal orientation are interpreted based on the stretching and/or bending vibrations of cordierite unit cell structure

Keywords: Cordierite, Raman spectroscopy, Crystal orientation

References

Aines, R. D. and Rossman, G. R. (1984) The high temperature behavior of water and carbon dioxide in cordierite and beryl. *American Mineralogist*, 69, 319-327

Kaindl, R., Tropper, P. and Deibl, I. (2006) A semi-quantitative technique for determination of CO₂ in cordierite by Raman spectroscopy in thin sections. *European Journal of Mineralogy*, 18, 331-335

Kolesov, B. A. and Geiger, C. A. (2000) Cordierite II: The role of CO₂ and H₂O. *American Mineralogist*, 85, 1265-1274

Keywords: Cordierite, Raman spectroscopy, Crystal orientation