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Determination of Olivine Orientation Dependence Through Raman Spectroscopy

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ABSTRACT

Raman spectra were taken of olivine for analysis of vibrational energy intensity ratios. This allowed for determination of its crystal orientation. Garnet inclusions in peridotite were mapped and Raman spectra were taken for these as well. The inclusions could not be identified, and data from the Raman spectra proved inconclusive due to difficulty in removing background signal.

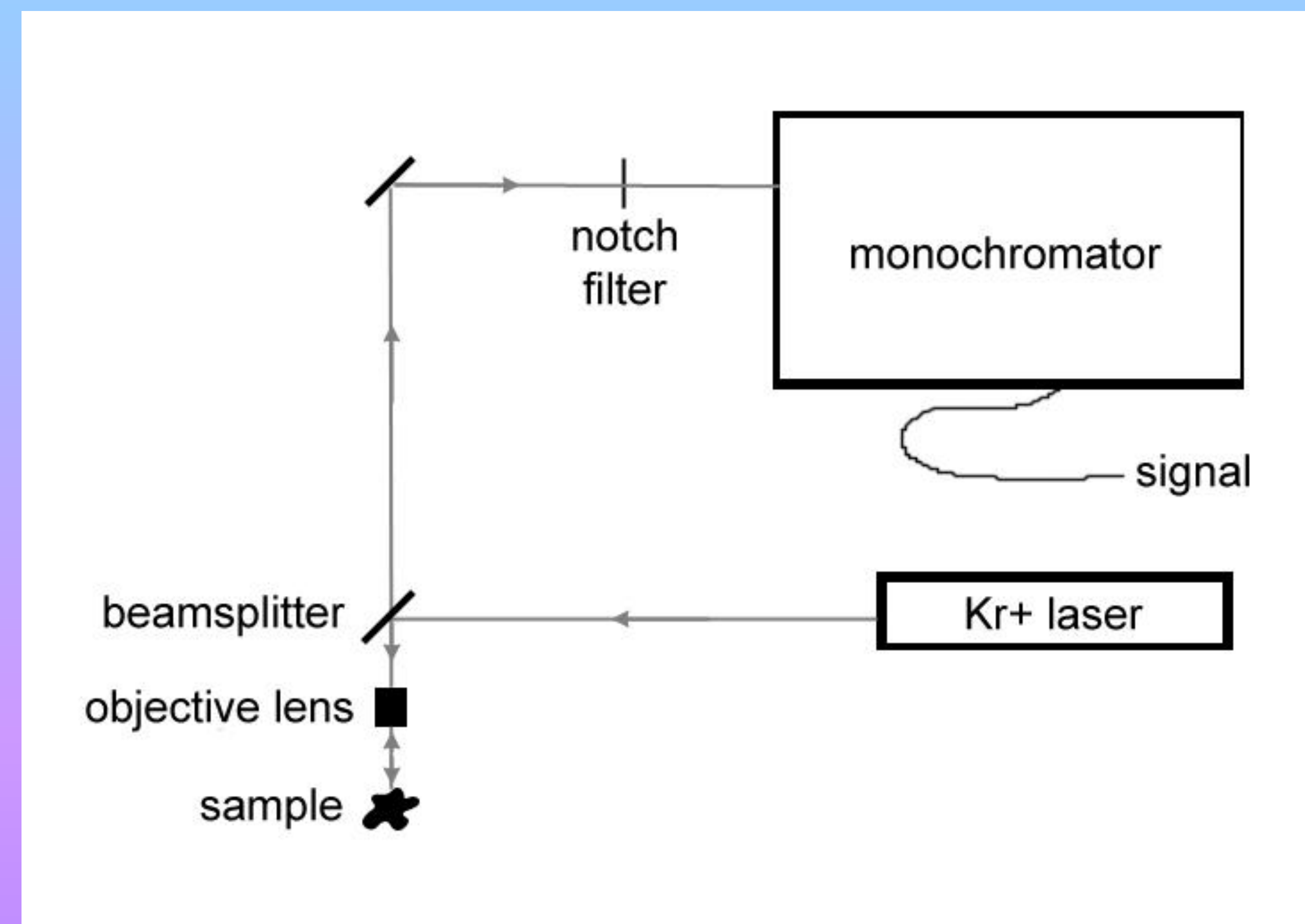
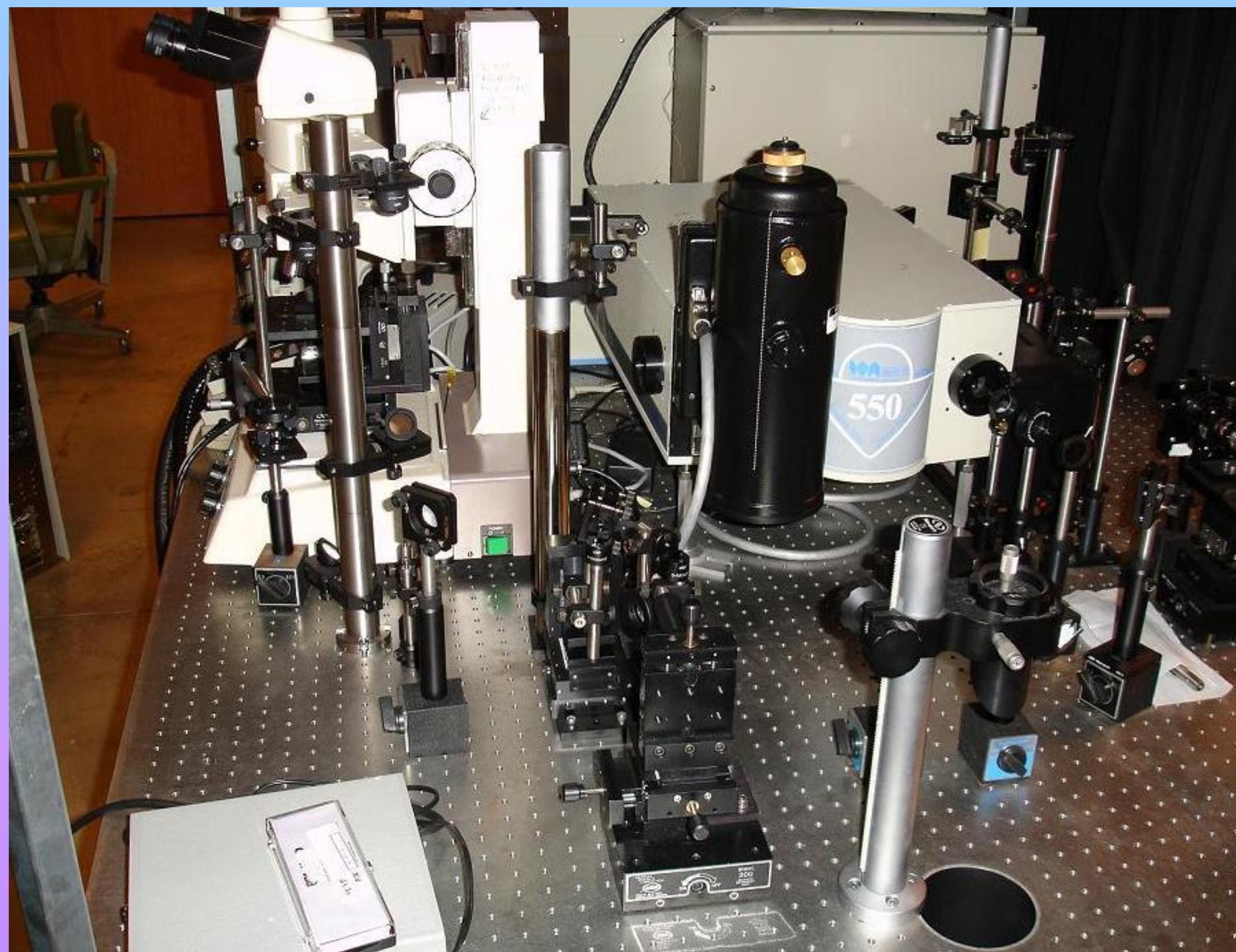


Figure 1a. Raman setup

Figure 1b. Raman diagram.

BACKGROUND

Kimberlite is a volcanic rock that carries various xenoliths from the upper mantle to the earth's surface. We investigated one such xenolith, a garnet-peridotite, which is composed primarily of the minerals olivine and garnet. Raman spectroscopy of olivine allows for examining crystal orientation and, thus, it provides information on visco-elastical flow of the peridotite when it resided in the mantle. Raman spectroscopy on inclusions in garnet may provide information on conditions of formation - pressure, temperature, and depth. X-ray diffraction (XRD) is commonly used for examining crystal orientation, but Raman spectroscopy is much faster.

EXPERIMENTAL DETAILS

Samples of single domain olivine were mounted onto slides with epoxy and polished prior to use in the Raman setup displayed in Figure 1. A rotating platform was mounted on the microscope so that for each sample spot, spectra could be taken at 15° increments; Raman shift was observed. Intensity ratios of the changing vibrational energies were extrapolated from the data collected by integrating spectra peaks such as those shown in Figure 2. The ratios were normalized to the largest peak and plotted against the angles of rotation. A sinusoidal curve was fit to the data as shown in Figure 3.

Peridotite samples were likewise mounted and polished. These thin sections were analyzed using a polarized microscope to locate potential inclusions. Snapshots were taken of each inclusion at varying degrees of magnification with and without the polarizer. With the polarizer, inclusions appear white on the black garnet backdrop, whereas in the absence of the polarizer, the entire garnet is in shades of bronze, and the inclusions are barely distinguishable by their greenish tint. Change in vibrational energy was also studied by taking Raman spectra for every 15° rotation of the inclusions.

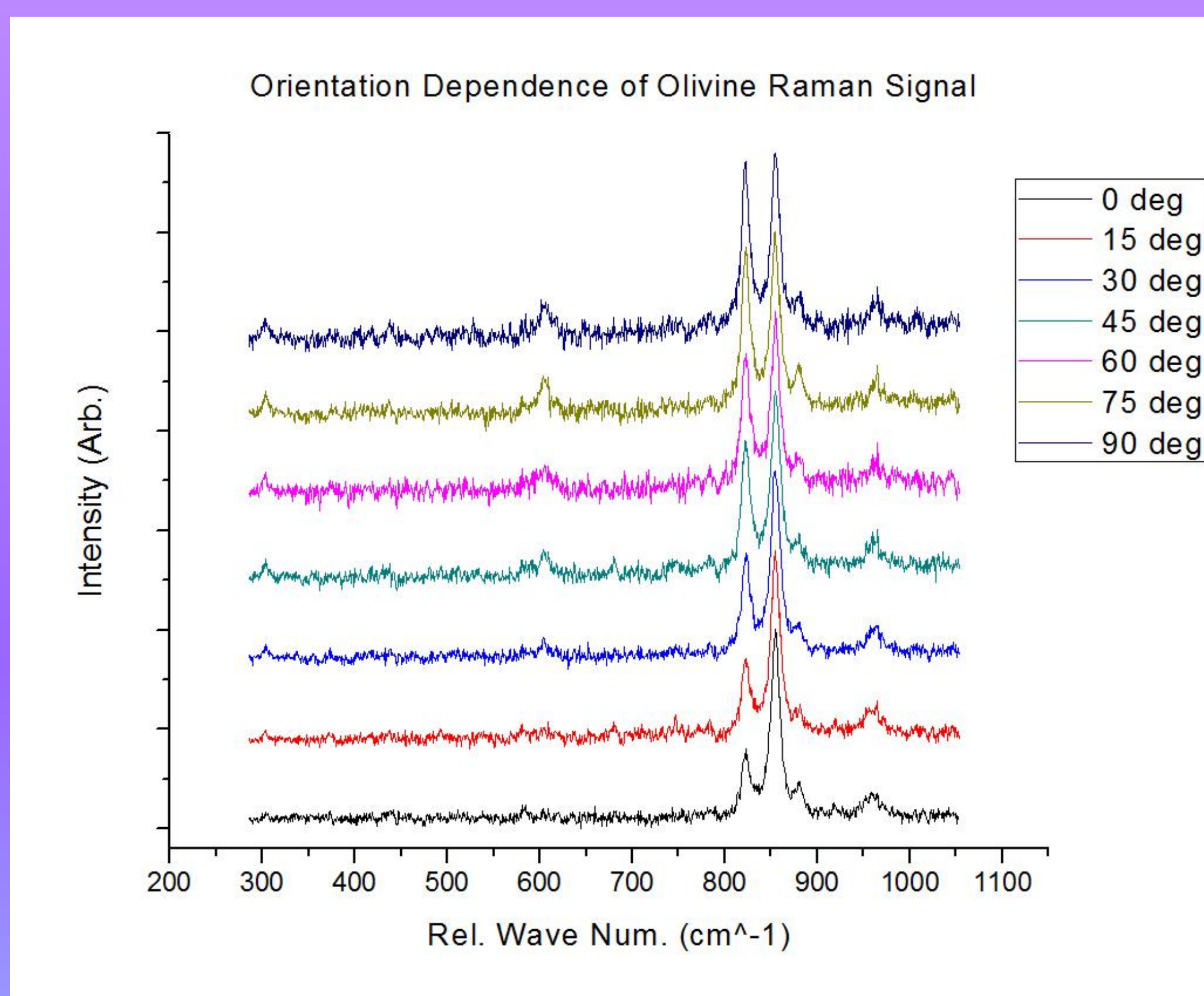


Figure 2.

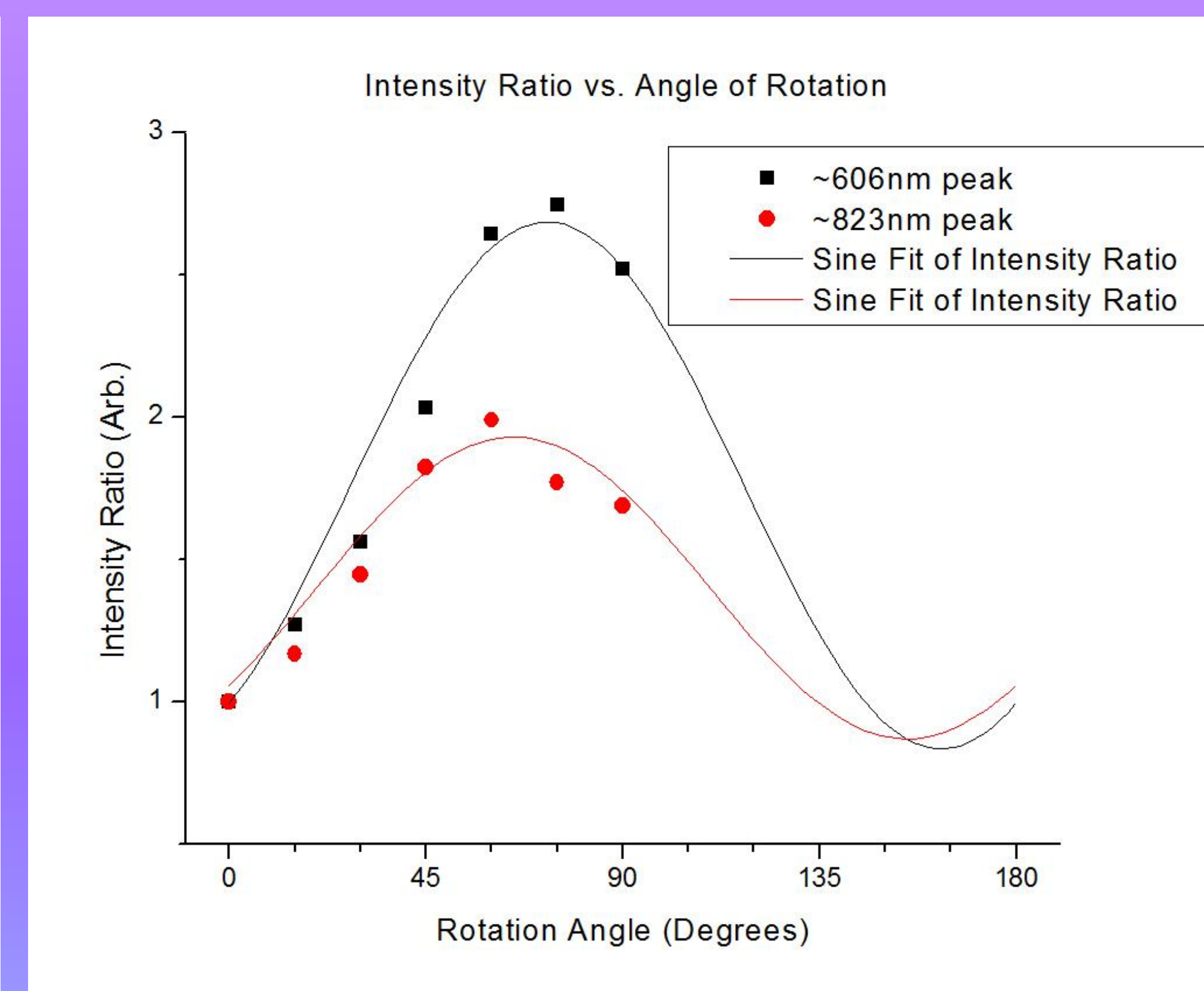


Figure 3.

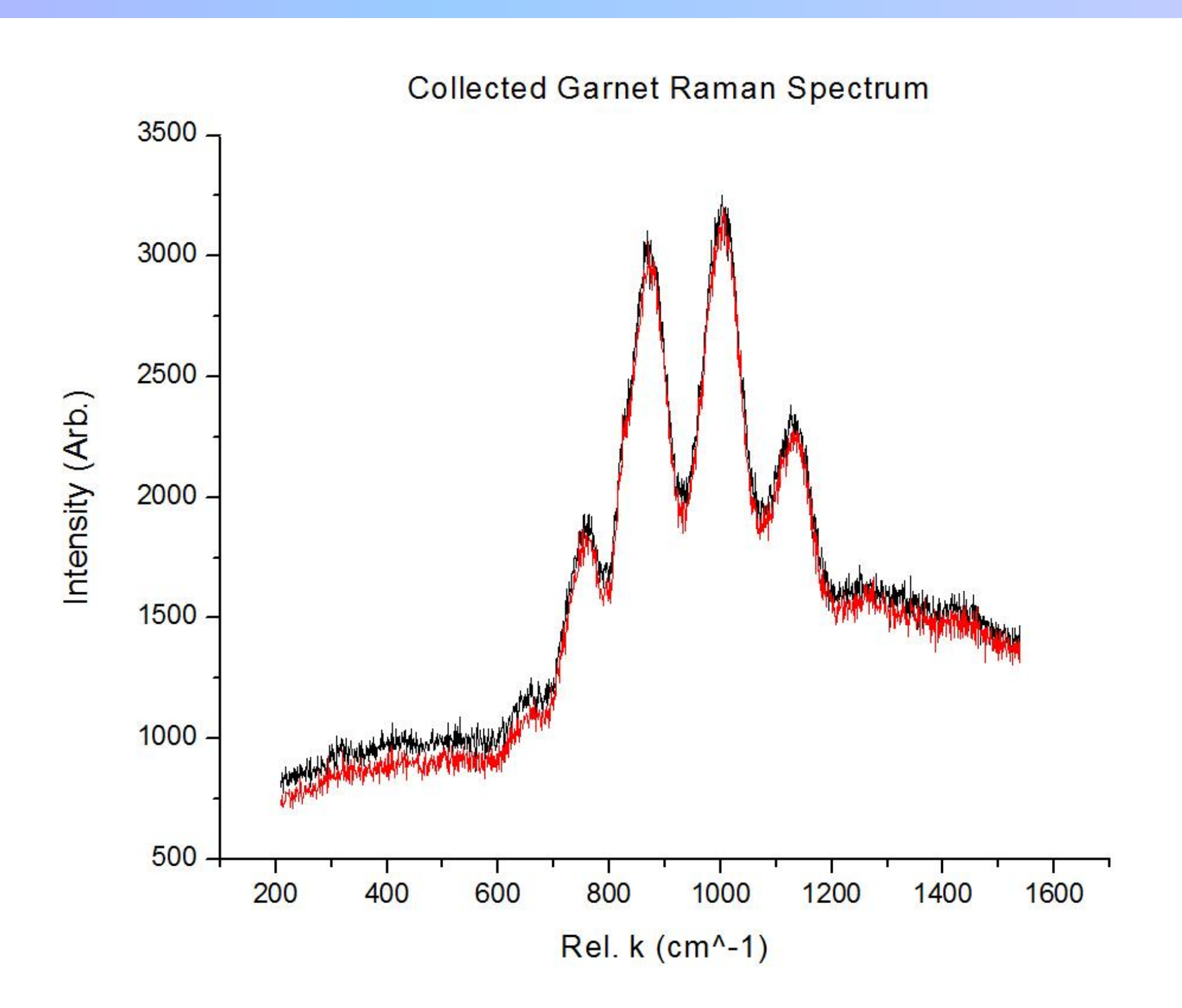
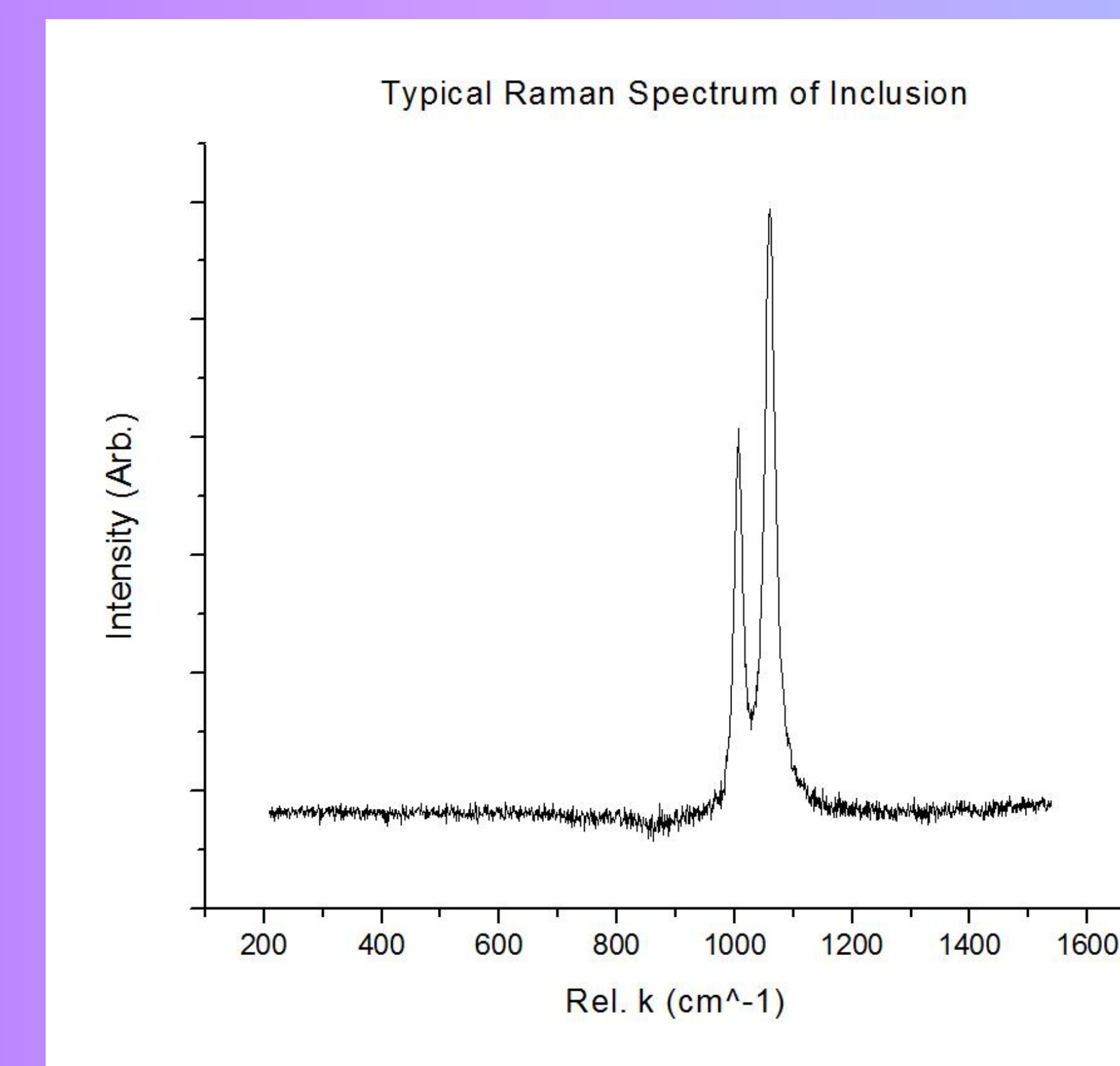


Figure 4. Top left: Raman spectrum of inclusion within garnet; Top right: Raman spectrum of garnet, away from inclusion; Bottom right: Difference of previous spectra with varying angle of rotation

CONCLUSION

Results indicate the existence of periodicity in the Raman signal of olivine. Smaller angular increments and a larger range would increase the precision of the sinusoidal fit. In comparing the relative orientation determined by the Raman spectra and absolute orientation known from EBSD, full understanding of crystal orientation can be attained through Raman analysis. However, EBSD was not procured for the samples used, so further studies are necessary. Lack of attaining a clean spectrum of the inclusions in garnets prevented identification. This was likely a result of excitation of glass underneath the sample and the presence of resin. A possible future solution involves using thicker, non-embedded samples.

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