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2012 ASTRO Summer Report

During my summer work experience, I researched the effects of strain in Earth and Planetary materials. Two different studies have been started:

Tectonic and Shock Strain Deformation: Optical Strain Patterns and their Correlating X-Ray Diffraction Patterns

When a mineral undergoes strain from either tectonic or shock metamorphism, it may deform through inhomogeneous, i.e. plastic, bending. Different strain environments cause minerals to deform in various ways, which can be seen in both light microscopy (e.g. different extinction patterns and subgrain formation), and in micro X-ray diffraction, ⌈XRD, (e.g. greater streak length in the chi dimension, and slight line broadening/ thickening in 2θ dimension). This study correlates the various types of strain environments for the minerals quartz, SiO_2, and olivine, $(Mg,Fe)_2SiO_4$, to their corresponding extinction and XRD patterns. Thin sections from four different strain environments were used: (1) Concord Granite, (2) Kimberlite from the Diavik Diamond mine, (3) granite from Vredefort impact site, and (4) Nakhla meteorite. Grains from each sample that exhibited varying amounts of deformation were examined optically and through ⌈XRD techniques and were found to have distinct features depending on the way in which it was strained. This research shows that it is possible to gain information about deformation history and strain environment based on mineral extinction and/or XRD patterns.

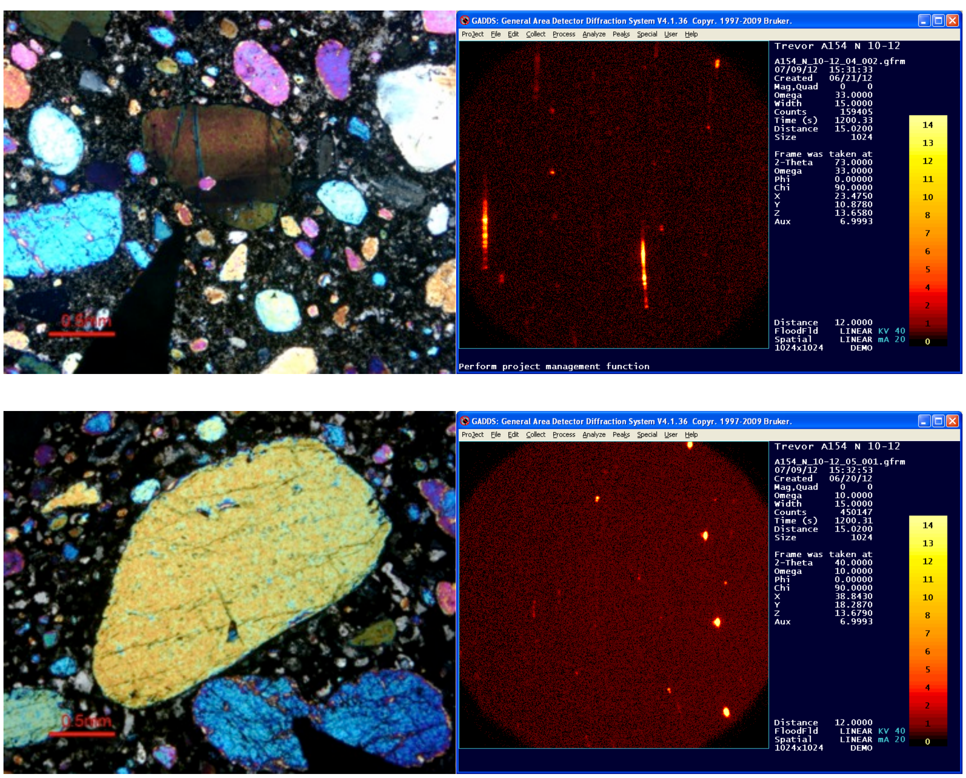


Fig. 1: XRD Patterns of strained Olivine grain (undulose extinction) versus an unstrained Olivine Grain (no undulose extinction)

Observation and Calibration of Strain in Minerals of Earth and Planetary Materials

After being subjected to stress, such as tectonic forces during regional metamorphism, or shock such as during asteroid impact, minerals exhibit deformation by inhomogeneous or plastic strain (or bending). Inhomogeneous or plastic strain can produce two effects: (1) increasing mosaic spread as seen by streaking in the chi dimension, and (2) inherent strain, as seen by line broadening of the X-ray diffraction peak in the 2θ dimension. Strain induced deformation of Earth and planetary minerals was calibrated by placing large (1.0 – 1.5 cm) single crystals of a variety of minerals in a strain jig and applying a controlled amount of strain (measured using a strain gauge). This strain was then correlated to the mineral's mosaicity (i.e. streak length along chi) using a Bruker D8 Discover micro-XRD and general area diffraction detector system. Increasing the applied strain to the mineral forced the mineral to sustain more deformation, which resulted in a greater streak length in chi (higher FWHM value). Plotting values of FWHM against strain showed a positive linear correlation and allowed for calibration of strain in certain minerals. Micro-XRD analysis may be applied to gain information about the amount of strain minerals have undergone in various environments.

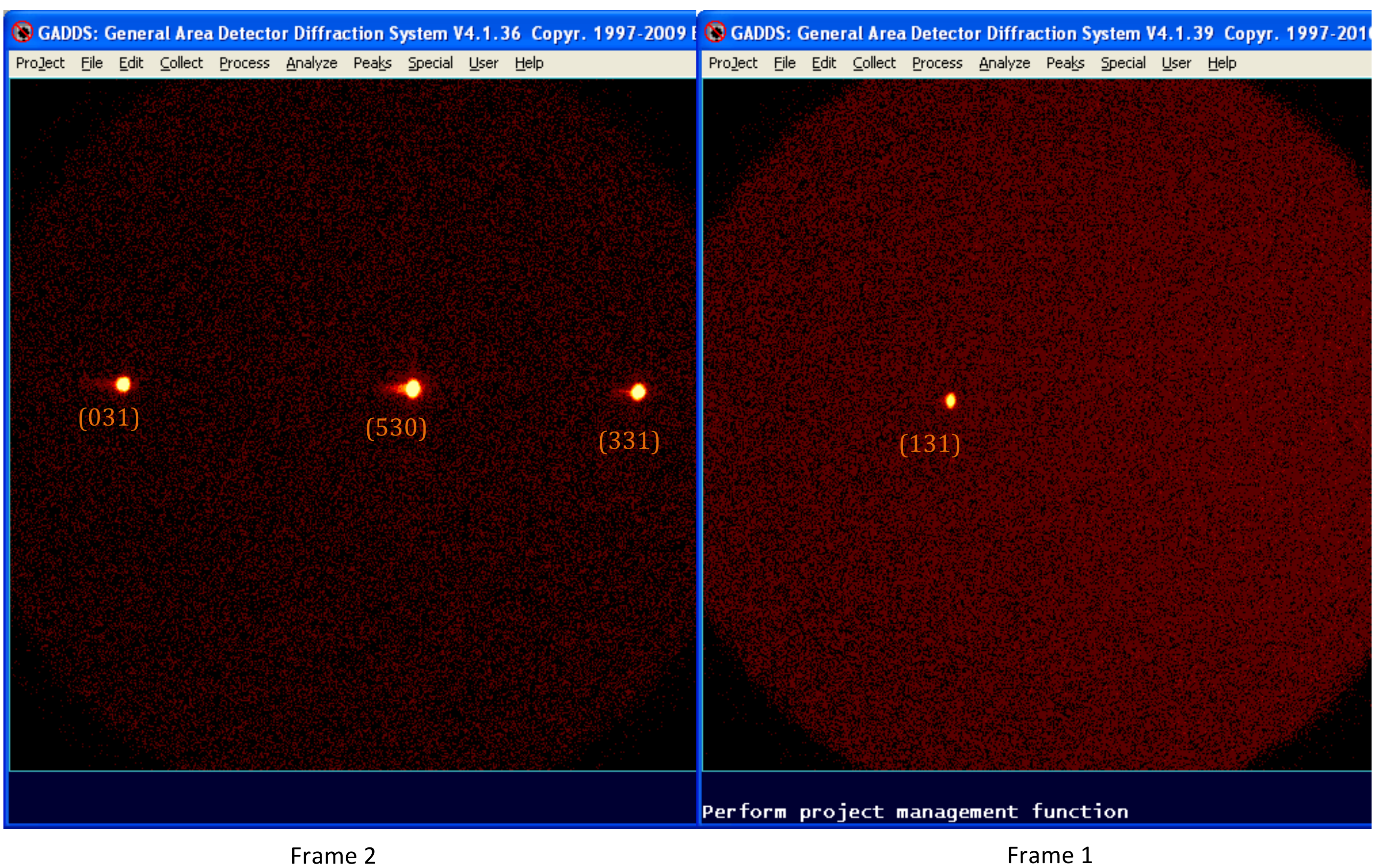


Fig 2: X-Ray Diffraction Pattern of unstrained Diopside crystal

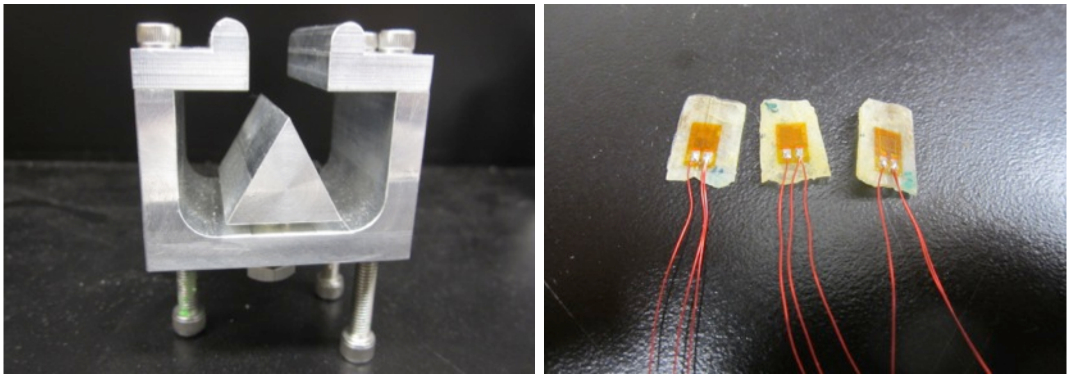
(a)  (b)

Fig 3: (a) 3-Point Strain Jig (b) Diopside Slabs with strain Gauges attached