Investigating the Effect of Water on the Modulus and Yield Strength of Quartz via Nanoindentation

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Introduction
- Hydrolytic weakening of quartz has been shown to occur at temperatures of ~400°C, but has not been shown to occur in the Low Temperature Plasticity (LTP) regime.
- Understanding of the yield strength of earth materials in this regime has important implications for interpreting the strength of the lithosphere.
- As part of the RORD REU, we explore the influence of water content on the elastic modulus and hardness of quartz at room temperature.

Methods
- Synthetic single crystal of quartz with water contents (H/Si):
  - ~2480 ppm
  - ~1280 ppm
  - ~160 ppm
- Nanomechanics Nanoindenter fitted with a Berkovich tip (Figure 1 and Figure 5).
- Samples indented // to c-axis, loaded to 600 mN with a maximum depth of 5000 nm.
- Additional tests on rotated samples (relative to the fixed tip orientation) to test for anisotropic modulus and hardness (Figure 4).

Main Result: No influence of water content on hardness of quartz at room temperature.

Discussion
- Our results show:
  - Hardness values of ~14 +/- 0.5 GPa (Figure 2)
  - Modulus values of ~113 +/- 5 GPa (Figure 3)
- This indicates that there is no effect of water content on the hardness of quartz at room temperature.
- The lack of an effect on water is consistent with other work done on hydrolytic weakening in the LTP regime.
- There appears to be a systematic increase in modulus with increasing water content in our samples, however this variation falls into the range of variation due to orientation effects (Figure 4).

Future Research
- Test additional samples with water content between 1280 & 160 ppm (H/Si).
- Test at a range of temperatures to determine specific temperature where hydrolytic weakening is initiated.

References