Hydrogen Uptake in Hydrothermally Annealed Quartz: Implications for Hydrolytic Weakening

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The uptake of hydrogen in quartz has been studied by hydrothermally annealing nominally dry, Brazilian quartz crystals at T = 800°C and P_{H_2O} = 8.9-15.7 kb for times of up to 2 days and examining the infrared absorptions due to O-H stretching modes at wavelengths near 3 μm. Annealed specimens, taken from the same crystal used in the classic hydrolytic weakening experiments of Griggs and Blacic (1965), exhibit a progressive increase in sharp dichroic absorptions at wavenumbers of 3464, 3428, 3364, and 3303 cm^{-1} (as measured at 77 K) and lack any detectable broad-band absorptions. The principal absorptions at 3428 and 3364 cm^{-1} correspond to those identified by Kats (1962) with hydrogen interstitials charge compensating for aluminum substitutions for silicon. In addition, the equilibrium H concentration of 83 ± 10 ppm appears to depend upon the initial Al concentration of 91 ± 1 ppm. The observed increase in H uptake with time has been used to determine an H diffusivity of (2 ± 1.6) x 10^{-7} cm^2s^{-1} at T = 800°C and P_{H_2O} = 8.9 kb, comparable with the rate of ^1H-^2H exchange in quartz (D = 1.4 x $10^{-8}cm^2s^{-1}$) determined by Kats et al. (1962) at much lower pressures (P_{H_2O} = 25 bars). Although the sharp dichroic absorptions observed in this study are common in other natural quartz crystals, these absorptions are not known to be associated with hydrolytic weakening. The absence of any detectable broad-band absorptions therefore calls into question whether hydrogen incorporation as molecular water may be taken up in significant concentrations and affect the strength of natural quartz crystals at our experimental conditions.