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Montoring the reversible low-to-high-quartz transition and irreversible elastic property changes in sandstone via temperature-dependent impulse excitation

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Temperature-dependent resonant frequency measurements via the impulse excitation technique (IET) can be used to characterize the temperature dependence of elastic properties and to determine the temperature of phase transitions during repeated heating and cooling cycles. In particular, the reversible and hysteresis-free displacive phase transition between the low- and high-temperature subpolymorphs of quartz (low-quartz and high-quartz) involves structural changes that are accompanied not only by changes of density, thermal properties and thermal expansion, but also of elastic properties. On the other hand, polycrystalline quartz-based materials like sandstone (which consists dominantly –but usually not exclusively –of quartz grains), can shift the transition temperature, can introduce a hysteresis of the transition temperature between heating and cooling and can also exhibit irreversible microstructural changes during heating and cooling, which may lead to irreversible changes of elastic properties. In this contribution we present recent results of temperature-dependent impulse excitation measurements obtained for sandstone samples from the Buntsandstein formation at Freudenstadt / Germany (with initial apparent porosities of 12.8 %) from room temperature to 800 ℃ and back (two complete heating-cooling cycles). Using bar-shaped samples it is shown that the low-to-high-quartz transition occurs at around 535 ℃ during heating and at around 560 ℃ during cooling (which is both significantly lower than the single-crystal value of 573 ℃ and clearly indicative of a hysteresis in the transition temperature of quartz in the polycrystalline sample) and that after cooling Young's modulus is significantly lower than before heating, which is a clear indication of damage accumulation (confirmed also by the higher porosity of 14.2 % after cooling). Using disc-shaped samples the temperature dependences of the Poisson ratio and shear modulus are determined in an attempt to answer the intriguing question whether sandstone becomes auxetic in the vicinity the low-to-high-quartz transition, as predicted for single-crystalline quartz [1].

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Participation

In-Person

References

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