

## High $P$ - $T$ single-crystal elasticity of zircon by Brillouin spectroscopy

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### ABSTRACT

Understanding the natural petrologic and tectonic processes, such as slab subduction, requires accurate determination of the metamorphic pressure ( $P$ ) and temperature ( $T$ ) conditions of the exhumed rocks. Recent development of elastic thermobarometry based on the difference between the thermoelastic properties of mineral inclusions and their hosts allows constraining the formation  $P$ - $T$  conditions of the inclusion/host system without assuming thermodynamic equilibrium. However, the reliability of elastic thermobarometry heavily depends on the accurate determination of the high  $P$ - $T$  single-crystal elastic properties of relevant minerals. In this study, we performed the first high  $P$ - $T$  single-crystal elasticity measurements of zircon, which is one of the most common inclusion/host minerals in metamorphic rocks, using Brillouin spectroscopy at pressures up to 7 GPa and temperatures up to 700 K. The single-crystal elastic properties of zircon at ambient conditions were determined as:  $\rho_0 = 4.6674(4)$  g/cm<sup>3</sup>;  $K_S = 231(3)$  GPa;  $G = 108(11)$  GPa;  $C_{11} = 428(2)$  GPa;  $C_{33} = 484(3)$  GPa;  $C_{44} = 113.5(8)$  GPa;  $C_{66} = 46.9(8)$  GPa;  $C_{12} = 75(2)$  GPa; and  $C_{13} = 151(1)$  GPa. We also obtained the  $P$  and  $T$  derivatives of the elastic moduli as  $\partial K_{S0}/\partial P = 5.0(2)$ ,  $\partial K_{S0}/\partial T = -0.019(2)$  GPa/K,  $\partial G_0/\partial P = 0.73(6)$ , and  $\partial G_0/\partial T = -0.011(1)$  GPa/K. Compared with other common rock-forming minerals (e.g., quartz, pyroxene, olivine), zircon is extremely incompressible (high  $K_S$ ) and its stiffness ( $K_S$ ) has relatively small  $T$  dependence, making it an ideal mineral for the application of elastic thermobarometry. Finally, we utilized the high  $P$ - $T$  single-crystal elasticity data of zircon and garnet to evaluate the potential applications of zircon-in-garnet in elastic thermobarometry via elastic modeling.

**Keywords:** Zircon, elasticity, Brillouin spectroscopy, thermobarometry