Temperature Dependence of Young's Modulus and Damping of Natural Basalt Rock and Melt Cast Basalt Products Determined via the Impulse Excitation Technique (IET)

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Melt cast basalt is a useful material for floor tiles and similar abrasion-resistant products obtained by melting natural basalt rock and casting into molds. It is a possible candidate for thermal energy storage. For this application the high-temperature properties, including elastic moduli and damping, have to be known in great detail. The impulse excitation technique (IET) is ideally suited for this task. In this work the temperature dependence of Young's modulus and damping of natural basalt rock and melt cast basalt are compared during two complete heating-cooling cycles with a maximum temperature of 800 °C. It is shown that during the first heating the Young modulus of basalt rock from the Czech-German border decreases from approximately 105 ± 2 GPa at room temperature to 83 ± 3 GPa at 400 °C but remains almost constant from 400 to 800 °C. During the first cooling, the temperature dependence has a completely different, arc-shaped character and ends at approximately 64 ± 1 GPa at room temperature. The second heating has a completely different character, increasing via an inverted arc from 61 ± 2 GPa at room temperature to 82 ± 2 GPa, thus forming, together with the second cooling branch, a closed hysteresis loop. This behavior is accompanied by high-scatter damping with inverse quality factors in the range 0.003–0.023. On the other hand, the temperature dependence of Young's modulus and damping of melt cast basalt with exactly the same chemical composition has a completely different behavior, viz., a monotonic decrease from 107 GPa at room temperature to 93 GPa at 800 °C, with a negligible hysteresis between heating and cooling. The damping exhibits low scatter and increases from values of 0.001 at room temperature through a flat local maximum of 0.0025 at around 150 °C (where the temperature dependence of Young's modulus exhibits a weak inflexion point) and a shallow local minimum of 0.002 at around 400 °C to values of around 0.02 at 800 °C, with the onset of the steep damping increase located at around 550 °C (where the temperature dependence of Young's exhibits a relatively steep decrease). The differences between the behavior of natural basalt rock and the melt cast basalt products of identical chemical composition are explained in terms of phase composition and microstructure.