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Wave propagation in the Earth's crust with discrete self-similarity

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Self-similarity of the Earth's crust is a well-discussed property prompted by both visual observations and the Guttenberg-Richter law. Self-similarity – the absence of a characteristic scale – is a very strong property, leading to the power law scale dependence of the corresponding variables. The next approximation is the so-called discrete self-similarity where a characteristic scale is present and the self-similarity and the power law dependencies are supported only at the scales that are multiples of the characteristic scale.

Mechanic of self-similar objects is based on the introduction of a set of equivalent continua each addressing its own scale. This set is a continuum for self-similar objects and discrete for the discrete self-similar ones. The most striking feature of self-similarity is the scaling of tensors, provided that the tensorial variable depends only upon the scale, as for instance the tensor of elastic moduli or compliances. We demonstrate that for both continuous and discrete self-similarity the components of the tensor either scale with the same exponent or independent of the scale. In the latter case the constant components are often equal to zero. In development of this paradigm we show that transversal isotropic Earth's crust (as for instance isotropic rock with one set of parallel fractures with dimensions ranging across the scales) would have all compliances independent of the scale. Opposite to this, the rock with three mutually orthogonal and equal sets of fractures has three Young's and three shear compliances (out of 9 independent compliances characteristic for orthotropic medium) have the same power (or discrete power) law dependence of the scale, while three other compliances are zero. Only p- and s- (dispersive) waves propagate with the velocities depending upon the propagation direction.

The developed theory can give the first approximation for upscaling elastic properties and wave velocities.