European Mineralogical Conference
Vol. 1, EMC2012-307-1, 2012
European Mineralogical Conference 2012
© Author(s) 2012

Mechanical spectra of rocks and minerals: Q^{-1} from lab to planet (Schlumberger medal 2012, Mineralogical Society)

S.A.T. Redfern
Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge, CB2 3EQ, UK (satr@cam.ac.uk)

Mechanical spectroscopy developed as a tool for investigating the damping properties of metals and alloys in the mid 20th century. Techniques typically involve either probing responses at the resonant frequency of a sample, or of materials subjected to off-resonant forced dynamic stress. Methods such as dynamic mechanical analysis or forced torsional oscillation have also been applied to the study of ceramics, minerals, natural glasses and rocks more recently. Such experiments can reveal dynamic responses of solids and molten systems as a function of varying frequency, typically overlapping with the key time scales of seismic properties, ranging from mHz to Hz. Recent studies have demonstrated that the mechanical properties and elastic moduli of minerals may display significant dispersion as a function of the time scale or frequency of observation/stress application. Structural defects, be they planar defects such as twin walls and grain boundaries, line defects such as dislocations, or point defects may all, under the correct conditions, display a strain response to applied stress at a characteristic relaxation time. Such relaxations are revealed in mechanical spectra as peaks in energy dissipation (loss, internal friction, or [equivalently] inverse quality factor) with dynamic characteristics determined by the details of the defect mobility.

We have measured dynamic loss in perovskites, spinels and in systems approaching their melting point and find, in each case, characteristic loss processes that, in some cases, can be attributed to clearly identified changes in microstructure, defect mobility, or mineral transformation. Recent results will be presented to show the importance of anelastic loss in controlling the mechanical properties of $MgAl_2O_4$ spinel, and of the utility of the method in understanding the mechanical changes displayed in basaltic crystal-melt composites as they cool through the glass transition temperature. Finally, the role of anelastic loss in determining the properties of the inner core will be discussed.