Geophysical Research Abstracts,
Vol. 10, EGU2008-A-04101, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-04101
EGU General Assembly 2008

Phonon thermal conductivity of silicate minerals: Relations to adiabatic incompressibility

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Two variants of a semi-empirical relationship between the phonon thermal conductivity at room temperature, ko, and adiabatic incompressibility, Ks, for silicate materials (related to the Earth's mantle and crust) are presented. Considerations are based on the Debye's theory of crystalline lattice vibrations (with only the acoustic modes taken into account). The mean velocity of phonons is approximated by a hydrodynamical speed of sound. In particular case, the Anderson-Jordan seismic equation of state was also used. Thermodynamical and elastic laboratory data used in our calculations are for polycrystalline aggregates of minerals. The first variant is of the form: log ko = (5/6)logF - 0.7422, where the seismic parameter F = Ks/d (symbol "d" denotes the density). It is assumed that the average free path of acoustic phonons is about 0.65 nm (mean dimensions of the [SiO4]-tetrahedron). The second variant is of the following form: ko = (18.4/3)(Ks/<A>)<to>, where <to> is the mean lifetime of phonons (in picoseconds), and <A> is the mean atomic weight (in g/mol). Other variables, as ko, F, Ks, d, are expressed in W/mK, (km/s)ˆ2, GPa, and g/cc, respectively.