stress level. The transition stress between any pair of flow laws, for example, GBS and dislocation creep, is

$$\sigma_T = \left(\frac{A_{GBS}}{A_{disl}} \frac{d^{p_{disl}}}{d^{p_{GBS}}} \exp\left(\frac{(Q^*_{disl} - Q^*_{GBS})}{RT} \right) \right)^{\frac{1}{n_{disl} - n_{GBS}}} . \qquad (1.6)$$

The expressions for the transition stresses between the various deformation mechanisms can be used to construct deformation maps showing the boundaries of regimes of dominance for each constituent creep mechanism. Deformation maps for ice with grain sizes 0.1 mm, 1.0 mm, 1.0 cm, and 10 cm are shown in Figure 3.1. If the high-temperature creep enhancement is not included in the rheology, deformation in ice is accommodated by the Newtonian deformation mechanism of volume diffusion when the temperature of the ice is close to the melting point, or the grain size is small, ($d < 1$ mm). In this regime of behavior, the viscosity of ice depends strongly on temperature only. At lower temperatures and/or for grain sizes larger than 1.0 cm, deformation in ice is accommodated by dislocation creep, and the viscosity of ice depends strongly on temperature and stress. For intermediate grain sizes, deformation occurs due to GSS creep, and the viscosity of the ice is strongly temperature-dependent, but only weakly stress-dependent.

1.5 Convection in Ice I

Over millions of years, the behavior of ice can be described as flow of a highly viscous fluid, analogous to flow within the Earth's mantle. The outer ice I shells of large icy satellites are heated from beneath by decay of radioactive elements in the satellites' rocky interiors, and potentially from within by tidal dissipation. Similar to rock, ice expands when it is heated, so a basally heated or internally heated ice shell will be gravitationally unstable, and when perturbed, warm ice will rise from the base of the shell. Likewise, cold pockets of ice near the surface will sink. When this process is self-sustaining over a geologically long time scale, it is referred to as solid-state convection.