ductive fluid layer is analyzed to determine the critical Rayleigh number for convection. If the amplitude of an initial perturbation grows with time, the fluid layer can convect. If the amplitude decays and the layer returns to a conductive equilibrium, the fluid layer cannot convect.

The gravitational restoring forces that retard plume growth depend on the viscosity of the fluid, so the critical Rayleigh number is a function of the rheology of the fluid in addition to the thermal and physical properties of the fluid layer. For a fluid with a viscosity dependent on temperature only, the critical Rayleigh number is a function of how sharply the viscosity varies with temperature near the melting point. In a fluid with a non-Newtonian rheology, the restoring force depends on the thermal stress generated by the initial convecting plume. As a result, the critical Rayleigh number for convection in a non-Newtonian fluid depends on the initial temperature perturbation in the fluid, in addition to the rheological and physical parameters.

1.6.2 Non-Newtonian Rheologies

Numerical studies regarding the onset of convection in non-Newtonian, basally heated fluids define the critical Rayleigh number as the minimum value of Rayleigh number where convection cannot occur regardless of initial conditions (*Solomatov*, 1995). This definition of critical Rayleigh number is directly relevant to terrestrial planets because it can be used to address the conditions under which convection in a planetary mantle will cease as the radiogenic heating that drives convection in terrestrial planets decays with time.

However, the critical Rayleigh number for the onset of convection in a non-Newtonian fluid cannot be determined using linear stability analysis (*Tien et al.*, 1969; *Solomatov*, 1995). The viscosity of a non-Newtonian fluid depends on both temperature and strain rate, so the viscosity in the perturbed layer of fluid depends on the amplitude of the initial perturbation and becomes infinite as the amplitude becomes