In this thesis, we present results of a numerical modelling study focused on the thermal evolution of the Earth and terrestrial planets. We focus particularly on two problems: I) constraining the internal structure of Venus and Mercury using their geoid and surface topography data and II) evaluating the effects of a rheologically distinct post-perovskite on the secular cooling of the Earth. In part I, we performed simulations in a broad group of models of the Venusian mantle, characterised by different rheological descriptions, and we compared spectra of their geoid and their surface topography with the observed quantities. Our analysis suggested that the geoid and the surface topography of Venus are consistent with a radially symmetric viscosity model with a strong 200 km thick lithosphere, without an asthenosphere and with a gradual viscosity increase in the underlying mantle. In the case of Mercury, none of our models was able to predict observed data, thus suggesting other than a dynamic origin of observed geoid and topography. In part II, we investigated style of Earth's mantle convection and its long-term evolution in the models that take into account a weak post-perovskite. We conclude that the presence of the weak post-perovskite enhances the core cooling. This effect is comparable in magnitude to the effect of a depth-dependent material parameters that, on the other hand, tends to delay the secular cooling.