On the contemporary Earth, distinct plate tectonic settings exhibit contrasts in heat flow that are registered in metamorphic rocks as differences in apparent thermal gradients ($T/P$ at the metamorphic peak). We have compiled $T$, $P$ and $T/P$, and ages of metamorphism (timing of the metamorphic peak) for 456 localities from the Cenozoic to Eoarchean Eras to test the null hypothesis that $T/P$ through time did not vary outside of the range expected for each distinct plate tectonic setting. Using $T/P$, metamorphic rocks are classified into three natural groups: high $dT/dP$ (>775 °C/GPa), intermediate $dT/dP$ (775–375 °C/GPa) and low $dT/dP$ (<375 °C/GPa). Plots of $T$, $P$ and $T/P$ against age demonstrate the widespread occurrence of two contrasting types of metamorphism—high $dT/dP$ and intermediate $dT/dP$—in the rock record since the Neoarchean, the widespread occurrence of low $dT/dP$ metamorphism in the rock record since the end of the Neoproterozoic, and a thermal maximum for high $dT/dP$ metamorphism during the period 2.3 to 0.85 Ga. These observations falsify the null hypothesis, but are consistent with the alternative hypothesis that changes in thermal gradients evident in the metamorphic record were related to changes in geodynamic regime. Based on the observed variations, Earth has evolved through three geodynamic cycles since the Mesoarchean and just entered a fourth.