The Earth’s surface and core-mantle boundary (CMB) heat fluxes are controlled by mantle convection and have important influences on Earth’s thermal evolution and geodynamo processes in the core. However, the long-term variations of the surface and CMB heat fluxes remain poorly understood, particularly in response to supercontinent Pangea. In this study, we reconstruct temporal evolution of the surface and CMB heat fluxes since the Paleozoic by formulating three-dimensional spherical models of mantle convection with plate motion history for the last 450 Ma that includes the assembly and break-up of supercontinent Pangea. Our models reproduce well present-day observations of the surface heat flux and seafloor age distribution. Our models show that the present-day CMB heat flux is low below the central Pacific and Africa but high elsewhere with subducted slabs, particularly when chemically dense piles are present above the CMB. We show that while the surface heat flux may not change significantly in response to Pangea assembly, it increases by ~16% from 200 to 120 Ma ago as a result of Pangea breakup and then decreases for the last 120 Ma to approximately the pre-200 Ma value. As consequences of the assembly and breakup of Pangea, equatorial CMB heat flux reaches minimum at ~270 Ma and again at ~100 Ma ago, while global CMB heat flux is at maximum at ~100 Ma ago. These extrema in CMB heat fluxes coincide with the Kaiman (316-262 Ma) and Cretaceous (118-83 Ma) Superchrons, respectively, and may be responsible for the Superchrons.