Comprehensive geological history of asteroid Vesta

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In this paper, we present a time-stratigraphic scheme and geologic time scale for the asteroid Vesta, based on global geologic mapping and other analyses of NASA Dawn spacecraft data, supplemented with insights gained from laboratory studies of howardite-eucrite-diogenite (HED) meteorites and geophysical modeling. We identify four geologic time periods for Vesta, associated with the formation of major impacts: Pre-Veneneian, Veneneian, Rheasilvian, and Marcian.

The Pre-Veneneian period covers the time from the formation of Vesta (a few Myr after the formation of the first solids in the proto-solar disk that took place at ~ 4.57 Gyr ago) up to the Veneneia impact event. The Veneneian period covers the time between the Veneneia and Rheasilvia impact events. The Rheasilvian period covers the time between the formation of Rheasilvia and Marcia craters, and the Marcian period covers the time between the formation of Marcia crater until the present. Absolute ages for the boundaries of these periods have been derived by applying two crater chronologies, one based on the current understanding on asteroidal impact rate at Vesta and its evolution over time; the other is based on an extrapolated version of the lunar crater chronology. While the ages and durations of the various periods change considerably depending on which chronology is applied, the relative age of the Veneneia and Rheasilvia impacts is unambiguously determined by superposition relationships, while the formation of the Marcia crater clearly represents the youngest major geologic event on Vesta.

Absolute model ages allow us to relate Vesta geologic time periods to key features of the main asteroid belt, such as the formation of the large vestan dynamical family. The formation ages of the Vesta's family can be assessed with independent means, such as by measuring the spreading of the family members in orbital space, and therefore provide a benchmark for both theoretical models of asteroid family evolution and crater chronology. Absolute ages also provide an important framework to interpret impact-generated radiometric ages of HEDs.

Our proposed four-period geologic time scale for Vesta is consistent with those developed for other terrestrial bodies, such as the Moon, Mars, Earth, and Mercury, and allow us to place Vesta in the context of major phases of the evolution of the solar system, such as the Late Heavy Bombardment, a period of intense bombardment in the inner solar system triggered by the migration of the giant planets.