THERMAL AND IMPACT HISTORY OF VESTA: ESTIMATE FROM IN-SITU U-PB DATING OF PHOSPHATE MINERALS IN BASALTIC EUCRITES.

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Introduction:

Elucidation of planet formation process is a long-standing issue. Scarcity of surviving ancient small bodies (i.e. protoplanets; sizes of 100s – 1000 km) makes it difficult to reveal the early planetary history. Meteorites from ancient protoplanets provide important knowledge. Eucrites, the largest group of HEDs (howardite–eucrite–diogenite), are basaltic crustal samples from a differentiated protoplanet, possibly, asteroid 4–Vesta. NASA's DAWN mission investigated Vesta's physical and mineralogical propertes, which support the link between HEDs and this asteroid (e.g. [1]–[3]). Detailed mineralogical, geochemical and chronological studies of eucrites have helped to reveal the ancient accretion and evolution history of Veta and other Vesta-like protoplanets (e.g. [4]–[9]).

U-Pb chronologies of zircons in various basaltic eucrites were investigated previously [5]–[7]. They indicate high-temperature (≥ 900 °C) crustal metamorphism on Vesta at 4554 Ma. Meanwhile, K-Ar systems in eucrites recorded much recent events around 4.5 – 3 Ga, due to the low temperature thermal process and/or impact reheating. U-Pb systems in phosphate minerals, such as apatite, provide moderately robust thermo-chronometer with typical closure temperatures of 450 – 600°C [10]. To reveal severely complicated history of eucrites perant body (i.e. Vesta), it is useful to combine various chronological systems among various meteorites. In this study, we conducted *in-situ* U-Pb dating of phosphate minerals in several basaltic eucrites. Based on chronological information, we dicussed the thermal and/or impact history of Vesta and other ancient asteroids.

Samples and Methods:

We have analyzed phosphates (apatite and/or merrillite) in four basaltic eucrites: Juvinas, Camel Donga, Stannern and Agoult, and an anomalous basaltic achondrite: Ibitira. Three of the five (Juvinas, Camel Donga, Stannern) were severely brecciated during impacts, whereas the others (Agoult, Ibitira) are unbrecciated. All samples are observed SEM and EPMA before dating to identify the phosphates locations. In-situ U-Pb dating are conducted using NanoSIMS 50 at AORI, UTokyo, with previously extablished analytical and calibration protocols [11]–[13].

Results and Discussion:

The U-Pb systems in the analyzed phosphates represent significantly different events between the brecciated eucrites and the unbrecciated ones. Several aptite grains in Agoult, the unbrecciated eucrite, difines a concordant U-Pb age with ^{207}Pb–^{206}Pb isochron at 4522 ± 11 Ma. This value is younger than the eucrites igneous age at 4.56 Ga, suggesting the moderate reheating and/or slow cooling to ~600°C at 4.52 Ga in the Vesta's crust.

U-Pb in phosphates in the brecciated eucrites, in contrast, recorded much younger events. In both Juvinas and Stannern, several phosphate grains revealed the U-Pb reset event at ca. 4.15 Ga, possibly due to the impact reheating (+ partial remelting). Combined with literature, our study reveals that at least several eucrites simultaneously suffered the impact reheating(s) at 4.2–4.1 Ga [9]. This timing is somewhat earlier than peak of the K-Ar chronologies (ca. 4.0–3.5 Ga) [8]. There might be possibility that Vesta has suffered an intense bombardment at (or until) 4.2–4.1 Ga. Furhter investigations of other meteorites will help to uncover the ancient bombardment history of protoplanets.

References:

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