
The Moore County meteorite is a cumulate eucrite which is thought to be located at the lower part in a eucritic crust on a diogenitic crust in the HED parent body (e.g., 1). Therefore, the burial depth of Moore County gives a rough estimate of the thickness of the eucritic crust. On the other hand, the complex exsolution texture of Moore County pyroxene has been reported (1,2). It consists mainly of coarse (001) augite lamellae (100 μm in width) and fine (001) augite lamellae (100 nm) in the host pigeonite, and blebby augite in the orthopyroxene inverted from pigeonite. The coexistence of two generations of exsolution lamellae with very different thickness has been a source of its puzzling cooling histories. We calculated cooling rate and burial depth of Moore County on the basis of chemical gradients and the width of lamella in pyroxene by numerically solving the diffusion equation. A reheating history of the Moore County eucrite has been proposed from our diffusional calculations.

The method is analogous to that developed by (3). The cooling rate was obtained by fitting both the calculated width of augite lamella and compositional gradients at the interface between augite and host pigeonite by assuming the solvus function (4) to the observed ones. We used the Ca diffusion coefficient in pyroxene parallel to the c direction which is experimentally determined by (5). Measurements of compositional profiles by an electron microprobe were made parallel to the c direction for an oriented crystal prepared by Dr. H. Mori.

Mg# (=100xMg/(Mg+Fe)) of augite is 62 and Mg# of host pigeonite is 51. We assume that an initial profile is uniform at bulk Ca composition of 10 mol% of pigeonite. Pigeonite begins to exsolve at 990 °C when the bulk Ca composition meets the solvus function, and cools down to 730 °C at a rate of 0.00016 °C/yr to form a coarse (001) augite lamella of 100 μm in width (Fig. 1). This cooling rate corresponds to a burial depth of ca. 8 km by assuming a rock-like thermal diffusivity (0.004 cm²/s). These results are consistent with those previously obtained by us (6). We note that the calculated chemical gradients in augite and pigeonite near the interface are slightly different from the observed profile as seen in Fig. 1.

To fit the chemical gradients near the interface, we had to assume a reheating event. After a cooling which formed the coarse (001) augite lamellae, a sudden temperature rise probably due to an impact took place up to ca. 930 °C, then it cools down again to 770 °C at a rate of 0.3 °C/yr. This cooling should stop at ca. 770 °C by another impact. Fig. 2 shows the calculated profile after a reheating event. A closer agreement between the observed and calculated profiles near the interface is obtained. During the reheating event, the host pigeonite which has bulk Ca composition of ca. 5 mol% exsolves at ca. 820 °C to form fine (001) augite lamellae in the pigeonite host between the thick lamellae, whose width (100 nm) is consistent with the second rapid cooling rate if Ca diffusion controls the formation of the lamellae.

A reheating process is essential to Moore County (Fig. 3) and this cooling scenario including a reheating gives an explanation of the puzzling exsolution texture of the Moore County pyroxene (2). The excavation of the original mass should be done by moving very large block since no impact effect has been recorded in Moore County except for its fragile pyroxenes.
TWO-STAGE COOLING OF MOORE COUNTY: Miyamoto M. and Takeda H.


Fig. 1. Ca compositional profiles for augite and pigeonite of the Moore County eucrite. Open circles show an observed profile at the interval of 1 micrometer. The origin is the center of augite lamella. Solid line shows the calculated profile by a cooling from 990 to 730 °C. Arrows indicate places of disagreement.

Fig. 2. Ca compositional profiles. The format is the same as Fig. 1. Solid line shows the calculated profile for an additional reheating from 930 to 770 °C after the cooling shown in Fig. 1. Note that a closer agreement between the calculated and observed profiles near the aug-pig interface than those in Fig. 1 is seen after a reheating.

Fig. 3. A schematic diagram of two-stage cooling history of the Moore County eucrite.