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Origin of paired Antarctic achondrites GRAs

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Introduction:
The paired Antarctic achondrites Graves Nunatak 06128 and 06129 (hereafter we call them GRAs) represent unique asteroidal magmatic processes; they are interpreted to originate from a low-degree partial melt from a volatile-rich oxidized asteroid [1,2]. Owing to the curiousity, they are still under many comprehensive geochemical and petrologic studies to reveal their origin and evolutional history: e.g., spectroscopic properties, melting condition, metamorphism condition, and magnetic proparties [2 and refer-ences therein]. Among them, especially, analysis of isotopic systems give some constraints to the thermal evolution of GRAs and their parent body. Thus, in this study, we try to constrain the physical condition and thermal evolution of GRAs' parent body by carring out numerical simulations with wide variety of conditions.

Constraints on the thermal evolution of GRAs:
We employ the following physical and chronological parameters as boundary conditions for our numerical simulations, although these parameters are still in debate. First of all, a parent melt of GRAs represent a low-degree melt of chondritic material (~10-15 %) [e.g., 2]. Melting experiments of chondrite compositions suggest that the melting temperature should not exceed ~1 300 degree-C to keep degree of melting lower than 30% [3, 4]. Secondly, abundance of siderophile elements suggest GRAs experienced only limited silicate-metal separation [1], that means significant vertical mass movement did not take place in the GRAs' parent body. Thirdly, the melting occurred 1.3+/-0.3 myr and ceased 3.23 myr after CAI formation [2]. Fourth, the temperature fell below 500 degree-C by the time of 50+/-60 myr after CAI formation [1]. Successful numerical results that account for the thermal evolution of GRAs must satisfy all of these constraints.

Conclusion:
Numerical simulations on the thermal evolution of the possible GRAs' parent body with wide variety of parameters are carried out. We could seek out numerical grids that satisfy all of the constraints given from analytical study of GRAs: the parent body should have formed 0.7 to 1.2 myr after CAI formation, the mass of their parent body shoud be $5x10^{16}$to $5x10^{18}$kg, and the depth of GRAs' birth place should be 4 to 13 km depending on the size of parent body. Since the maximum temperature also depends on the size of parent body, if the maximum temperature can be constrain by comprehensive partial melting experiments [e.g., 5], the size of GRAs' parent body would be better constrained.

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