

Formation of amorphous forsterite particles by levitating Mg_2SiO_4 melt droplets

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To simulate the evolution of amorphous Mg_2SiO_4 (forsterite) to the forsterite crystals, we need amorphous particles in the experiment as the starting materials. Although amorphous forsterite has been synthesized from vapor phase [1], these particles are too small ($\phi < 1\mu\text{m}$) to be investigated by optical method. Therefore, we have applied a gas jet levitator method to solve this problem. A gas jet levitator method is useful to avoid heterogeneous nucleation during cooling process and thus melt droplets were very stable at large supercooling ($> 1000\text{ K}$) [2].

The starting materials were synthesized forsterite spherules ($\sim 2\text{ mm}$), which was set at the top of the nozzle (1 mm in diameter) of the gas jet levitator and then levitated by introducing Ar gas. The spherule was melted by CO_2 laser (100 W) irradiation. The melt temperature was measured with a pyrometer. The crystallization and vitrification process from the supercooled melt were observed with a CCD camera.

The experimental results show that amorphous formation of forsterite took place at $\sim 1000\text{ K}$ with a larger cooling rate than 300 K/s (fig. 1), which was much smaller cooling rate as obtained by Tangeman *et al.* (2001), 700 K/s [3]. While, enstatite melts with higher SiO_2 content formed only amorphous material at any conditions.

The value of 300 K/s is not led only by heat radiation but by additional gas flow during cooling. If forsterite melt droplets were cooled only by radiation in space, melt droplets with less $10\mu\text{m}$ in diameter, could become amorphous particles rather than crystalline particles. Presence of amorphous forsterite particles around AGB stars might be due to this reason.

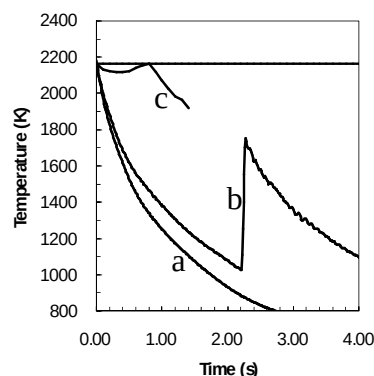


Fig. 1 Cooling curves during formation of (a) amorphous forsterite and (b) forsterite crystal in levitation. (c) The sample was set on a graphite rod.

Reaction kinetics of shallow water marine carbonates: Successes and failures in bringing laboratory experiments and the ocean together

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A wide range of geochemical observations have been made of the composition and behavior of marine carbonates in shallow water carbonate-rich sediments generally found in tropical to sub-tropical waters typified by environments such as atolls and lagoons, carbonate banks and platforms, and coral reefs. The carbonates found in these environments are often a complex mixture of aragonite, high and low magnesian calcites, and, rarely, (proto) dolomite. They may have both biotic and abiotic origins, and can undergo both formation and dissolution during early diagenesis. Because they will play a significant role in the response of the ocean to its “acidification” due to rising atmospheric $p\text{CO}_2$, there has been renewed interest in understanding the reaction kinetics of their formation and dissolution.

A major question that has often been hotly debated and continues to be a major source of concern is how well laboratory measurements of factors influencing their precipitation and dissolution kinetics, and pseudo-solubility behavior are representative of their behavior in the “real world”. These concerns center around several basic factors. Perhaps foremost amongst these are the clear and potential differences between natural biogenic material and abiotic carbonate minerals. Numerous studies of the behavior of magnesian calcites, which typically comprise about 24% of shallow water marine carbonates, stand as all too clear examples of the limitations and failures that can be encountered. However, in situations where abiotic marine carbonate formation occurs, such as aragonite needles in “whittings” on the Great Bahama Bank, experimental and observed reaction rates can be brought into close agreement, but, even in these types of situations surprises can be found—e.g. the “kinetic” solubility is about twice that of aragonite.

After over half a century of trying to understand the behavior of natural marine carbonates in marine sediments from laboratory kinetic experiments there is clearly still much to be learned.

References

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