Back-reaction between CO2 and CaO: Dependence of the CaO structure on the conversion rate

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CO_2 and SO_2/SO_3 have been considered to be released after asteroidal or cometary impacts on carbonates and sulfates, respectively (e.g., Lange and Ahrens, 1986; Yang and Ahrens, 1998). These gases are released in the atmospheres of the planets and affect the climates. For example, injection of large amount of CO_2 in the atmosphere makes the surface temperature of planets increase due to the greenhouse effect (e.g., O'Keefe and Ahrens, 1989). On the other hand, sulfate aerosols make the surface temperature decrease due to the sunlight block effect. These climatic changes may affect the mass extinction at 65 Ma Cretaceous/Tertiary boundary (e.g., Pierazzo et al., 2003).

Many studies have been made on the effects of such 'impact-induced degassing' on the climate of the planets. In these studies, all the gases once produced by shock were assumed to be injected in the atmosphere. However, there is a possibility that the gases produced by shock, such as CO_2 and SO_2/SO_3, react with residual solids, such as CaO and MgO (e.g., Kieffer and Simonds, 1980; Melosh, 1989). If such 'back-reaction' really occurs, the results of the previous studies will change significantly.

Agrinier et al. (2001) studied the back-reaction between CO_2 and CaO experimentally. They show that CO_2 reacts fast with CaO, which is produced by thermal decarbonation of $CaCO_3$, at 573-973K, and 40 to 80% of CaO back-reacts into $CaCO_3$. However, the structure of CaO produced by thermal decarbonation of $CaCO_3$ might be different from CaO produced by shock-induced decarbonation of $CaCO_3$. Different structures of CaO might show different reaction mechanisms, which results in different reaction rate and/or different conversion rate of CO_2 and CaO into $CaCO_3$. If it were the case, the results of Agrinier et al. (2001) will change.

In this study, we conduct back-reaction experiments of CO_2 and CaO to investigate the dependence of the CaO structure on the beck-reaction between CO_2 and CaO. Three types of CaO were prepared; (i) CaO produced by thermal decarbonation of $CaCO_3$, (ii) CaO produced by thermal dehydration of $Ca(OH)_2$, and (iii) chemically precipitated CaO, whose structures are different. Then, reaction rate and the conversion rate of CO_2 and CaO into $CaCO_3$ were measured. The results show that the conversion rate of CO_2 and CaO differs greatly depending on the types of CaO. In the case of CaO produced by thermal decarbonation of $CaCO_3$, about 55-70% of CaO back-reacts and was converted into $CaCO_3$ after 500 sec at 673-973K, while in the case of CaO produced by thermal dehydration of $Ca(OH)_2$, only about 25-65% of CaO back-reacts. In addition, the conversion rate of CaO decreases significantly, as the reaction temperature decrease. In the case of chemically precipitated CaO, the conversion rate of CaO is less, and stronger temperature dependency was observed. These suggest that the difference in structures of CaO affect the back-reaction between CO_2 and CaO. Thus, the results of this study indicate that the experiments on CaO produced not by thermal decarbonation but by shock-induced decarbonation are required to investigate whether or not the back-reaction occurs and to measure the conversion rate of CO_2 and CaO after impact-induced degassing.

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