



Experimental results of decomposition of Ca- and Mg- carbonates under conditions of interest to planetology

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Introduction

In the research on the origin of life on our Planet, the possibility of a contribution played by organic substances of extraterrestrial origin, which may have reached our planet through micro-fragments of planetary and cometary origin, is being taken into consideration more and more seriously (Flynn et al., 2003). These particles may also provide the necessary thermal protection for thermolabile, life-related molecules, to the high temperatures reached during the first stages of the atmospheric entry processes. Particularly interesting is the size of the order of a tenth of a millimeter, which corresponds to a peak in the distribution of the material entering the atmosphere.

Physical models of the entry process of such grains have been available in the literature for many years. When the composition of most promising mineral phase is considered, the most interesting candidates are carbonates (mostly of Mg, Ca, and Fe) which have been associated, in meteorites and in cometary grains, with organic molecules (McKay et al., 1996; Flynn et al., 2000; Pizzarello et al., 2006; Matrajt et al., 2012) for several reasons. Carbonates are very common in the Solar System. Outside the Earth, they have been identified on the surface of Mars (Ehlmann et al., 2008; Palomba et al., 2009; Wray et al., 2016), on Ceres (Rivkin et al., 2006; De Sanctis et al., 2016) and tentatively on other asteroids (Rivkin, 2009) as well as in cometary comas (Fomenkova et al., 1992; Lisse et al., 2006; Wirick et al., 2007). Since these astrophysical sites are thought to be the main sources of meteorites and micrometeorites, it is not surprising to find carbonates also in these small objects which reach our planet. In particular, Mg-, Ca-, and Fe/Mn-rich carbonate globules of putative biotic origin have been found in the Martian meteorite ALH84001 (McKay et al., 1996).

Carbonate decomposition

All the available studies of the atmospheric entry grains assume compositions corresponding to the bulk of meteorite bodies, i.e. silicates and metals. Only recently, carbonates have been taken in account as carriers in an astrobiological perspective (Bisceglia et al., 2017; Micca Longo & Longo, 2017; 2018). Carbonates are known to undergo decomposition in vacuum at temperatures of a few hundred °C (producing metal oxides and gaseous carbon dioxide) (L'vov, 1997; 2002). Therefore, during the atmospheric entry, the grains with carbonate composition are expected to be enriched in oxides and depleted of the initial carbonate amount. This process, being endothermic, can contribute

to the thermal protection of associated organic matter. However, the kinetics of the decomposition under such conditions is not well understood. The decomposition model developed in Micca Longo & Longo (2017 and 2018) is based on a well-mixed and ideal solid mixture, and it allows a first evaluation of grains behavior during their passage through the Earth's atmosphere. The Langmuir law allows to calculate the evaporation rate, per unit time and area, as stated in Bisceglia et al. (2017), in terms of the vapor pressure for the solid mixture carbonate/oxide.

Laboratory measurements

The kinetics of CO₂ diffusion within this kind of grains is still a subject of study. A first attempt was done in Micca Longo et al. (2019) where an important role for the evolution of the model was given to the interpretation of laboratory experiments emulating the conditions during the atmospheric entry processes.

In this work, we report the laboratory measurements on Ca and Mg carbonates done to follow the diffusion process of CO₂ within such materials. Powders were thermally processed under vacuum (10⁻⁴ and 10⁻⁵ mbar), for about 3.5 hours, at several temperatures by using a Carbolite furnace able to reach temperatures up to 1200°C. Infrared spectroscopy, gravimetry, Scanning Electron Microscopy, and Energy Dispersive X-ray analysis were involved to investigate spectral, morphological, and compositional modifications induced by thermal processing as done in Orfino et al. (2007), Blanco et al. (2011) and Micca Longo et al. (2019).

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