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Origin of D'Orbigny glass: Towards the understanding of the angrite parent body

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D'Orbigny is an unusual angrite in its presence of abundant glasses (Kurat et al., 2001). So, it is very important to reveal the origin of the glasses for understanding of the formation process of D'Orbigny and internal properties of the angrite parent body. Varela et al. (2003) and Kurat et al. (2004) argued that the D'Orbigny glass is a nebular condensate that later suffered from alteration by a metasomatic event. However, this idea contradicts the more popular arguments of igneous origin for D'Orbigny (e.g. Mittlefehldt et al., 2002; McCoy et al., 2006) in that they also regard the constituent minerals as nebular condensates. We have investigated the origin of the glasses by observation with optical microscope and FE-SEM and by chemical analyses of glasses and minerals with EPMA and EDS to resolve the confusion about the origin of D'Orbigny and to extract more reliable information on the D'Orbigny parent body.

The 0.1mm-thick black glossy glass in the sample covers D'Orbigny minerals. The glass surface is covered by numerous vesicules as Varela et al. (2003) called foamy glass. This glass is further covered by aggregates of terrestrial minerals with average grain size less than 10 microns, such as K-feldspar, quartz and orthopyroxene, which are not derived from the angrites. Along the contact between the D'Orbigny glass and the aggregate, a thin layer of silica-rich glass, different from the D'Orbigny glass in including K, is present. The internal parts of D'Orbigny show partial melting texture and decomposition texture of FeS only within 0.5 mm from the glass.

The average chemical composition of D'Orbigny glass is almost identical to that of the bulk rock, which is consistent with Varela et al. (2003). The chemical composition varies within the area defined by connecting main mineral compositions on the oxide plots. There exists flow structure exhibited by the compositional variation as reported by Varela et al. (2004). Olivine in contact with the glass is zoned and has an Mg-rich inner zone with thickness of max 5 micron and a Fe-rich outer zone with thickness of max 2 micron towards the contact. In addition, both Mg and Fe in glass decrease towards the olivine.

The average composition of D'Orbigny glass almost identical to that of the bulk rock excludes the idea that glass is a melt come from an external source (Varela et al., 2003). It is impossible to solidify glass with the bulk rock composition and the holocrystalline lithology with the max size of 1mm in one event, because they require very different cooling rate. We argue that the melting occurred on Earth because the terrestrial aggregate covers the D'Orbigny glass with the thin silica rich glass sandwiched inbetween. The chemical heterogeneity in contacting glass and olivine suggests that the olivine once melted and then grew rapidly. It is concluded that D'Orbigny melted during falling in the atmosphere by fictional heating, which produced abundant melt. The porous nature of D'Orbigny facilitates migration of frictional melt inside the meteorite through voids or druses. This idea is consistent with the noble gas analyses, which show that the D'Orbigny glass has the solar gas component, while the bulk rock has spallogenic component (Busemann et al., 2006).

The D'Orbigny glass represents quenched melt formed by frictional heating during falling though the atmosphere. The crystalline part of D'Orbigny is an igneous rock because of its texture and systematic sequence of minerals and chemical zoning toward interstices (Mittlefehldt et al., 2002; Suzuki et al., 2012). These results allow us to distinguish the information relevant to the parental body of D'Orbigny from that attributed to the frictional melting on the Earth. Internal processes of the angrite parental body can be examined based on the essential information from D'Orbigny by eliminating terrestrial phenomena.