Constraining the 3.3~4.1 Ga Impacts on Vesta from Impact Glass Compositions

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Impact glass provides clues on the chemistry of the impactor as well as the target rock. Recents studies demonstrated that howardits contain low-K and high-K impact glasses (e.g., Barrat *et al*, 2009; Singerling *et al*, 2013). The high-K glasses are uncommon, and are proposed to be derived by melting a K-rich lithology (indigenous rock), which has not been sampled by metoerites, nor observed by the DAWN mission. On the other hand, the low-K impact glasses in howardites display ^{40}Ar-^{39}Ar ages of 4.1 to 3.3 Ga, starting from the late heavy bombardment era (Cohen, 2013 and references there in). These ages were used to argure an episode with higher (>10 km/s) than normal (~5 km/s) impact velocity at Vesta, in order to generate the melt and reset the ^{40}Ar-^{39}Ar clock. This episode may be induced by the cometary flux of the Nice model or from the Main Belt itself (Cohen, 2013; Marchi *et al*, 2013). To constrain this, I examined the data in the literature on impact glasses (Barrat *et al*, 2009; Warren *et al*, 2009; Singerling *et al*, 2013).

Low-K glasses reported in the literature define a trend in Ni – Co space parallel to the chondirtic one. The Ni and Co abundances in low-K glasses are 184 – 1200 ppm and 42 – 300 ppm, respectively, much higher than those in eucrites andn diogenites (Ni <155 ppm; Co <40 ppm). The Co/Ni correlation in low-K glasses also differs from those in pristine metals in HED, which was suggested to contain more Co at a similar Ni content (Hewins, 1979).

The high-K glasses also define a trend in Ni/Co space parallel to chondirtic one, but contain much lower Ni and Co contents of 12 – 175 ppm and 2 – 31, resepctively. The Ni abundances are comparable to diogenites, but higher than eucrites. The Co contents range from those similar to diogenites to the lowest Co in an igneous eucrite, Nuevo Laredo.

These observations corroborate with the suggetion of Barrat *et al* (2009), that high-K impact glasses are mainly derived from K-rich indigenous rocks. The data of low-K glasses suggest they contain large chondritic inputs. Together with the age data, these observations suggest that the proposed high-velocity episode at 4.1-3.3 Ga was likely caused by chondritic impactors from the leftover planetesmals.