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Mineralogical and Geochemical Analysis of Howardite DaG 779: understanding geological evolution of asteroid (4) Vesta

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The HED meteorites, a clan of stony achondrites, are believed to originate from asteroid (4) Vesta (e.g. Mittlefehldt et al. (2015)). Recent evolution models (e.g. Toplis et al. (2013)) and observations from Dawn spacecraft data (e.g., Prettyman et al. (2013)) indicate that diogenites form the lower crust and uppermost mantle of (4) Vesta. Deep seated material excavated by large impacts such as the Rheasilvia- and Veneneiaforming event should be present in howardites.

We analysed a slice of howardite DaG 779 which had been recovered from the Libyan Desert in 1999 and was briefly described by Grossmann (2000). The data presented here include electron microprobe, bulk-rock XRD and XRF as well as trace element analysis by ICP-MS and INA. The petrographic results confirm earlier observations that DaG 779 is polymict and mainly contains diogenite and eucrite clasts. Mass balance calculations using bulk-rock and microprobe major element data reveal a modal mineralogy of 77% orthopyroxene, 8% plagioclase, 7% clinopyroxene and 2% spinels, the rest being olivine, SiO_2-phases, sulphides, and native Fe(Ni). When compared with the element compilation recently reported by Mittlefehldt (2015) the 39 trace element analysed here (including REE and PGE) confirm that this howardite is clearly dominated by diogenite.

Beside the modal petrographic information, a number of more detailed observations obtained from microprobe investigations reveal fresh and recrystallized glasses, troilite-orthopyroxene symplectites from a mixed silicate-sulphide melt giving rise to graphic intergrowths as well as vermicular and reticular FeS in highly disrupted clasts. While the origin of the FeS in these clasts is not clear yet, its particular shape and distribution indicates that this mineral has been (partially) molten and recrystallized from a sulphide melt. The silicate minerals around these FeS occurrences are recrystallized but there is no indication for a partial silicate melt.

Further metasomatic reactions were observed between clinopyroxene (pigeonite) and a sulphide-bearing agent, according to the principal reaction **Pigeonite (Fe-rich) + S_2 ↔ FeS + Augit (Mg-rich) + SiO_2**. This type of metasomatism (Zhang et al. (2013)) is not well understood yet.

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