Our studies of 36 diogenites collected recently from Northwest Africa, Oman, and the United Arab Emirates, from Northwest Africa, have revealed new compositional and textural features that were not previously represented in collections. The majority of the specimens resemble classic fall features (e.g., Sheikho and Jihzhark) and exhibit brecciated monomineral orthopyroxenites, comprising dominantly of orthopyroxene (Fs_{13.6}Wo_{0.7}, FeO/MgO = 25-35 g/g) with accessory chromite, troilite, and Ni-iron. Several specimens contain minor olivine (Fs_{23}), calcic plagioclase (An_{60-90}) and/or clinopyroxene. NWA 3229 contains minor merilitic and silica. Thin specimens are brecciated (e.g., there is no clear identification), although some monomineral and veining may be present, and primary textures are mostly intact. We have divided these into 4 orthopyroxenite subtypes based on diagnostic textures and mineralogy.

Protoproganular

This type is best exemplified by the medium-grained UAE 005 diogenite that has retained most of the original ordered to linear igneous grain boundaries (Figure 1). Protoproganular grains are also evident. Other diogenites in this category (below) have experienced various degrees of post-formational textural modifications. NWA 2037 is similar to UAE 005, but with a wider range in grain size and partial resorption at grain margins. NWA 1201 has very irregular grain boundaries (Figure 2).

Protoproganular (Mg-rich)

NWA 1481 is composed of mostly Fs_{13.6}Wo_{0.7} orthopyroxene, making it the most magnesium diogenite known (and its pyroxene has the lowest Wo content). This specimen attests to the existence of important vestian parent magmas, which also is inferred from the Vestan dunite NWA 2068 [1]. See Figure 3.

Medium to coarse-grained (without corona-like "necklace" around chromites)

NWA 044 has well-developed linear orientation of orthopyroxene and large, subhedral chromite crystals (< 2 mm) with offshoots into the surrounding matrix (Figure 4). Most chromite crystals are surrounded by a necklace-like array of very small subrounded grains of orthopyroxene (orthopyroxene) and olivine (Figure 5). In addition, chromite contains tiny inclinations of pigeonite, diopside, plagioclase, FeS, and metal. Small grains of FeS, metal, and clusters of olivine occur as inclusions in cumulate orthopyroxene. Overall characteristics are similar to those described in NWA 4218 [2], although NWA 044 lacks compositional zoning in pyroxene and chromite. NWA 2997 is similar to NWA 044 with the exception of having euhedral chromite inclusions. We found that the medium-grained Dhofar 700 diogenite (2) also has chromite necklaces and a complicated thermal history that includes sector exsolution of clinopyroxene in orthopyroxene, partial resorption of primary twinned orthopyroxene, and a combination of shock and resorption (Figure 6, 7, 8, 9). The necklaces in these specimens may have resulted from a reaction between early-formed crystals and trapped intercumulus melt.

Medium to coarse-grained (without corona-like "necklace" around chromites)

These specimens have simple mineralogy and contain > 85 vol % of orthopyroxene with sparse inclusion of large subhedral chromite and traces of FeS and metal. NWA 4054 (Figure 10). They are probably the most diogenites with a wider range in grain size and partial resorption at grain margins. NWA 2037 has very irregular grain boundaries (Figure 2).

Conclusions

From our preliminary observations, we conclude that crystallization of the various diogenite orthopyroxenites resulted from a range of differentiation mechanisms that include fractional crystallization (undetected in most diogenites), replenishment (resorption textures, e.g., NWA 3229 and Dhofar 700), magnetic mixing and/or assimilation (enriched clusters in Dhofar 700), and possibly filter pressing (e.g., NWA 044 and NWA 2997). In time, it may turn out that the geological processes that acted on 4Vesta, at least from early effects, are more complicated and advanced than we ever imagined. It will be most interesting to learn how the lithologies on 4Vesta identified by the Dawn mission compare not only with diogenites and olivine diogenites, but also with other meteorites including eucrites and mesosiderites, which share some mineralogical and isotopic characteristics with the specimens described here.

References