MICROCHONDRULE-BEARING, IRON-RICH CHONDRULE RIMS IN NORTHWEST AFRICA 5717. J. N. Bigolski[1, 2, 3], M. K. Weisberg[1, 2, 3], H. C. Connolly, Jr.[1, 2, 3, 4], D. S. Ebel[2, 3]. [1]Dept. Phys. Sci., Kingsborough Community CUNY, Brooklyn, NY 11235, USA. Email: jbigol@gmail.com. [2]Earth and Env. Sci., Graduate Center, CUNY, New York, NY 10016, USA. [3]Dept. Earth Planet. Sci., American Museum Natural History, New York, NY 10024, USA. [4]University of Arizona, Lunar and Planetary Laboratory, Tucson, AZ 85721, USA.

Introduction: Chondrule rims, especially unmelted ones, are important chondrite components that can reveal information on the abundance and nature of dust in chondrule-forming environments. Measurements of rim thicknesses have been applied to model accretion processes in the nebula [1], linking petrologic observations to astrophysical modeling. Recognized since [2], chondrule rim origins, their components, and their relationship to chondrules and matrix remain enigmatic.

The ungrouped chondrite Northwest Africa 5717 (NWA 5717) provides an opportunity to explore the nature of chondrule rims. NWA 5717 is a highly unequilibrated (type 3.05) ordinary chondrite described as having unusual petrology [3]. In a previous study we showed that many chondrules in NWA 5717 have remarkable sulfide-rich rims containing up to 200 µm-sized microchondrules [4]. Here we present a detailed petrologic study of chondrule rims in NWA 5717. Our goals are to document the characteristics of the rims, understand their origin, and determine the relationship of the rims to their host chondrule and to the matrix.

Analytical Techniques: We studied 46 chondrules and their rims in detail using the JSM-6390 LV/LGS scanning electron microscope (SEM) with a Quantax 200 Energy Dispersive X-ray spectrometer at Kingsborough Community College and the Hitachi S4700 field emission SEM and Cameca SX100 electron microprobe at the AMNH.

Results and Discussion: A high percentage (>75%) of the chondrules in NWA 5717 are rimmed, as shown in the composite X-ray map of the studied section (Fig. 1) The rims show up in sharp contrast to their host chondrule and to the matrix in backscatter electron (BSE) images due to their high abundance of Fe-sulfide (Fig. 2) or the higher FeO content of their silicates compared to the surrounding chondrite matrix (Fig. 3). Rims occur around chondrules that show a variety of textures, including barred olivine (BO), radial pyroxene (RP), cryptocrystalline (CC), porphyritic (P) and glass-rich. Both type-I and -II chondrules have similar rims. Two major types of rims can be recognized (sulfide-rich and sulfide-poor). Rim apparent thickness is up to 120 µm with an average of ~ 40 µm.

The rims have highly unequilibrated mineral assemblages that include olivine and pyroxene mineral fragments, lithic clasts, microchondrules, sulfide nodules with rare Cr-rich phases, and minor Fe/Ni metal grains. Olivine and pyroxene show a wide range of compositions even within the same rim. These grains are all surrounded by a Fe-sulfide-rich material in the case of the sulfide-rich rims (Fig. 2) or a fluffy FeO-rich silicate material in the case of sulfide-poor rims (Fig. 3). The FeO-rich silicate has a composition that resembles olivine but typically shows low electron probe totals either due to porosity or the presence of hydrous minerals. Such Fe-enrichments as those in sulfide-poor rims are not observed in the interchondrule matrix.

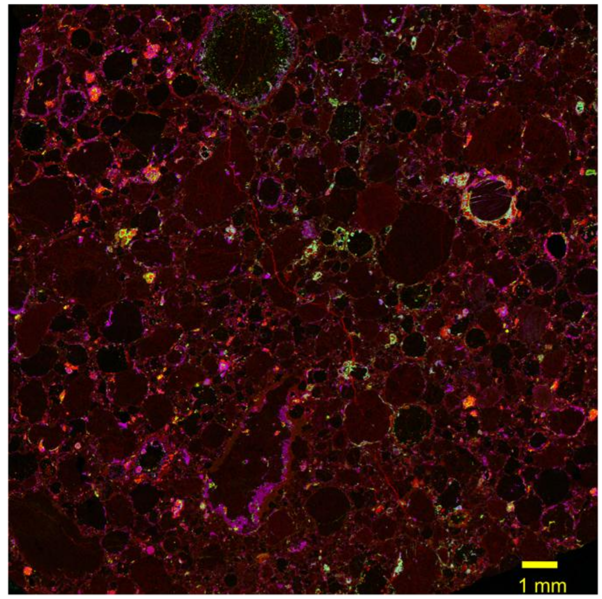

Fig. 1. Fe-Ni-S (red-green-blue) composite x-ray map showing a high concentration of chondrules hosting sulfide-bearing rims.

Many of the chondrules show what appear to be embayments commonly filled with rim material (Fig. 4). In some cases, the embayments appear to be the result of alteration of metal nodules on the edge of type-I chondrules. In other cases, the embayments appear to be due to plastic deformation of the chondrule. Irregular surfaces on chondrule edges have also been interpreted to indicate re-melting of rim material [5].

Mineral fragments: Rims contain olivine, low-Ca pyroxene ($Wo_{2.8}Fs_{11}$), Ca-rich pyroxene ($Wo_{36}Fs_{5.3}$) and rare Ca-rich plagioclase grains. In addition a glassy silica-rich phase is present in some rims. Olivine shows a wide range in composition (Fa_{6-30}) with FeO-rich olivine up to Fa_{80}. Some olivine fragments are zoned, with FeO concentrations increasing towards outer portions of grains. Although mineral fragments have a

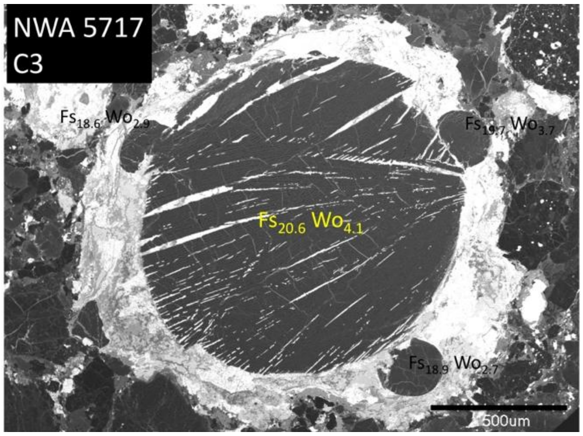

Fig. 2. BSE image of sulfide-rich rim containing three small chondrules of similar composition as the RP host chondrule.

wide range of compositions, some are compositionally similar to minerals in the host chondrule.

Microchondrules and lithic fragments: Most of the rims we studied contain microchondrules. Microchondrules range from 1–200 µm in size. Most are <20 µm with cryptocrystalline textures. Microchondrules with microporphyritic textures are also present, containing olivine phenocrysts less than 1µm in size. In many cases, the microchondrules contain sharply bound FeO-rich rinds (Fig. 4). These rinds are generally not completely concentric, and often occupy a crescent-shaped portion of the microchondrule. In some cases, the microchondrules have similar compositions and texture to the host chondrule (e.g., Fig. 2). These microchondrules clearly crystallized from molten droplets compositionally similar to the host chondrule and most likely experienced the same igneous history and formed contemporaneously with their host chondrules.

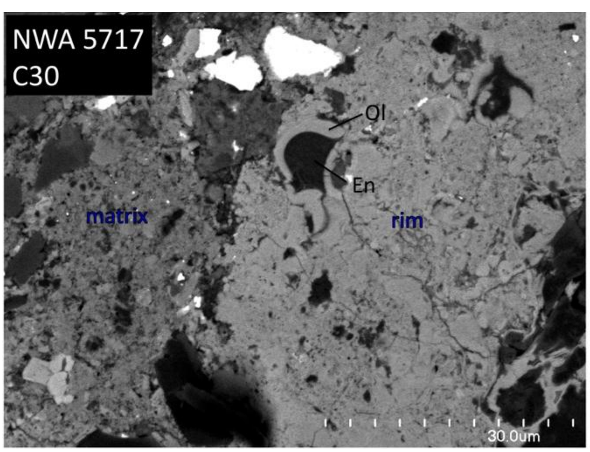

Fig. 3 BSE image showing a sulfide-poor chondrule rim in contact with the matrix. The rim is more FeO-rich than the adjacent matrix material and it contains an enstatite mineral fragment with a rind of FeO-rich olivine.

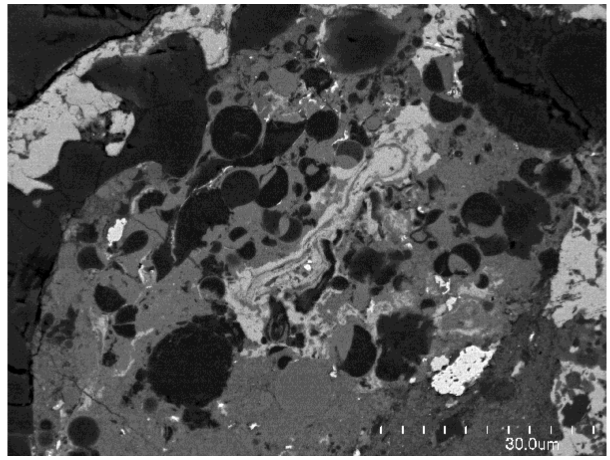

Fig. 4. BSE images of a sulfide-poor rim and crescent microchondrules filling an embayment in a type I chondrule.

Implications: Some rim components – mineral and lithic fragments and microchondrules – are hypothesized to have originated from the host chondrule due to textural and compositional affinities. They may have formed by melting of the host chondrule surface or from dust ball accumulating around the host chondrule during formation in the nebula [5]. Melting of chondrule/rim boundaries is supported by Fe-rich fine-grained infill within scalloped edges of the host chondrule's surface (Fig. 4), a possibly localized source region for microchondrules. However, this cannot explain the mineral fragments that show a wide range of mineral compositions. Do such fragments pre-date the formation of host chondrules? Additionally, the fine-grained FeO-rich component may represent earlier free-floating pre-accretionary dust within the disk.

The sulfide-rich rims (Fig. 1, 2) may have formed by a sulfide-rich liquid coating the chondrule surface. The stability of such a melt and its consequences upon the thermal history of associated host chondrules is not currently known. Sulfide-rich rims could have also formed through the reaction of the dusty FeO-rich rims with a sulfur-rich vapor. Further work on determining the $f(S_2)$ of the ambient gas the host chondrules formed in would help clarify whether, following their formation, rims and chondrule surfaces experienced alteration, either from heat generated during accretion, or in the presence of hot nebular gas.

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