NORTHWEST AFRICA 8418: A CV4 CHONDRITE, WITH NEW INSIGHTS INTO SECONDARY PROCESSES ON THE CV PARENT BODY. L. Mallozzi[1], G. J. MacPherson[2,] C. M. Corrigan[2]., A. J. Irving[3], and D. Pitt. [1]Stony Brook University, Stony Brook, NY, 11794, USA. [2]Department of Mineral Sciences, Smithsonian Institution, National Museum of Natural History, Washington, D.C., 20560 USA. [3]Univ. Washington, Seattle, WA 98195, USA. Email: lucia.mallozzi@stonybrook.edu .

Introduction: CV chondrites are characterized by abundant and typically large (~ 1 cm) calcium-aluminum-rich inclusions (CAIs) and amoeboid olivine aggregates (AOAs), distinctive barrel-shaped matrix olivine crystals with an average composition of ~ Fa_{50} [1, 2], and abundant large (commonly mm-sized) chondrules. So far, all CV chondrites have been designated as petrologic Type 3, indicating a limited range of parent body thermal and metasomatic [1, 2, 3]. However, a newly discovered [1] carbonaceous chondrite, Northwest Africa (NWA) 8418, has unique characteristics that, although similar to those of CV3 chondrites, indicate this rock underwent substantially higher levels of secondary processing than CV3s. Our new results presented here warrant classification of this meteorite as CV4.

Methods: A large (1" × 1 ¾") rectangular polished thin section of NWA 8418 was studied using optical microscopy and with a FEI Nova NanoSEM 600 scanning electron microscope at the Smithsonian Institution. The latter instrument is equipped with a Thermo-Noran silicon-drift, energy-dispersive X-ray detector that we operated at 15 keV accelerating voltage. All full-spectrum images and mineral analyses were processed using Noran System-6 software.

Results: Ironically, CAIs are excellent recorders of parent body metamorphism and metasomatism because their high-temperature phases are unstable at lower temperature. The CAIs in NWA 8418 are particularly informative in this regard. The single section we studied contained several CAIs, all larger than 1 mm in size and one of which exceeds 1 cm in maximum dimension. An elemental area map of this latter object, shown in Fig. 1, shows a texture that superficially resembles that of a typical Type B CAI: coarse anorthite and abundant Al-Ti-rich pyroxene both poikilitically enclose abundant smaller spinel crystals. However, there is no trace of any remaining melilite. Areas that occupy the textural regions expected for melilite are instead filled with a fine-grained intergrowth of aluminous augite (~ 3-5 wt. % FeO), ferroan olivine (Fa_{30-40}), abundant troilite, and fine-grained secondary calcic plagioclase (~ 2 wt. % Na_2O). Secondary nepheline and sodalite are minor in abundance and concentrated mainly in the outer regions of the CAI. Spinel throughout this and the other CAIs in the meteorite is uniformly enriched in iron (21-22 wt. % FeO). Figure 1 also shows another unique feature of this meteorite: the presence of abundant chlorapatite [2], mainly as thick discontinuous mantles on the margins of the CAIs but elsewhere as well. Chondrules in NWA 8418 range up to more than 1 mm in diameter, and include porphyritic and barred varieties. Most chondrule olivine has been replaced by ferroan olivine, typically Fa_{30-40}. Porphyritic chondrules do, however, preserve relict forsteritic olivine (Fa_{0-5}) in crystal cores. Monoclinic low-Ca pyroxene also is preserved, as are complex microcrystalline groundmass textures. No true isotropic glass was found. The porous matrix of NWA 8418 bears some similarities to CV3 matrices but with some interesting differences. The olivine grains (Fig. 3) are variable in size up to 10-20 μm in length, are mostly blocky in shape but some barrel-shaped crystals do occur, and the composition range is Fa_{35-50} but mostly around Fa_{38} (Fig. 4). This is distinctly less ferroan than typical CV3 matrix olivines (Fig. 4).

Discussion: The evidence points to NWA 8418 being an oxidized CV chondrite of some petrologic type. The large CAI and chondrule sizes alone are very suggestive, as are the porous matrix textures and the rimming of original forsteritic olivine in chondrules by highly ferroan olivine. The preservation of forsteritic olivine cores in porphyritic chondrules, monoclinic low-Ca pyroxene, and delicate microcrystalline textures in chondrule groundmass all point to petrologic Type < 5. Four features stand out as separating NWA 8418 from being a CV3 chondrite: the uniformly more magnesium-rich matrix olivine compositions, the abundance everywhere of chlorapatite, the complete replacement of CAI melilite by a fine-grained intergrowth of pyroxene+Na-bearing-plagioclase+olivine+troilite, and the uniform iron-enrichment in all CAI spinels. In Allende and other CV3 (oxidized) chondrites, chlorapatite is absent. Its abundance in NWA 8418 indicates widespread scavenging of P (presumably from metal) by circulating fluids and its re-precipitation as chlorapatite wherever calcium was abundant, such as around and near CAIs where the melilite had broken down. Also in Allende and other CV3 (oxidized) chondrites, melilite is only partially replaced by the very different assemblage monticellite+grossular±wollastonite. This latter assemblage was estimated by [3] to have formed at a peak metamorphic temperature of ~668 ºC. The different assemblage in NWA 8418 suggests different metamorphic conditions, likely at a higher temperature and in an environment of more pervasive fluid flow than in CV3 chondrites. On balance we conclude that NWA 8414 is best characterized as a CV4 chondrite of

the oxidized sub-type, which makes it the first of this type.

References: [1] Bouvier A. et al. (2017) *MAPS* **52**: 2411; [2] Kuehner S. M. et al. (2015) Ann. Mtg. Met. Soc., abst. #5244; [3] Hutcheon I. D. and Newton R. C. (1981) *LPSC XII*, abst. #1171.

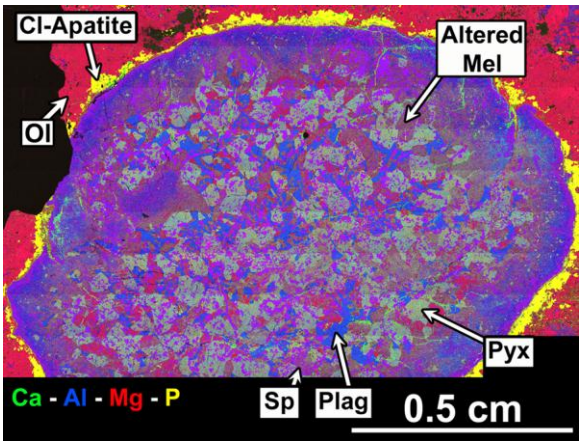

Figure 1. Element map of a large CAI in NWA 8418. Anorthite (blue; Plag) and pyroxene (grey; Pyx) enclose abundant spinel (magenta; Sp). Former melilite (dull red; Mel) is replaced by a fine grained secondary assemblage (see text). Chlorapatite (yellow) rims the CAI.

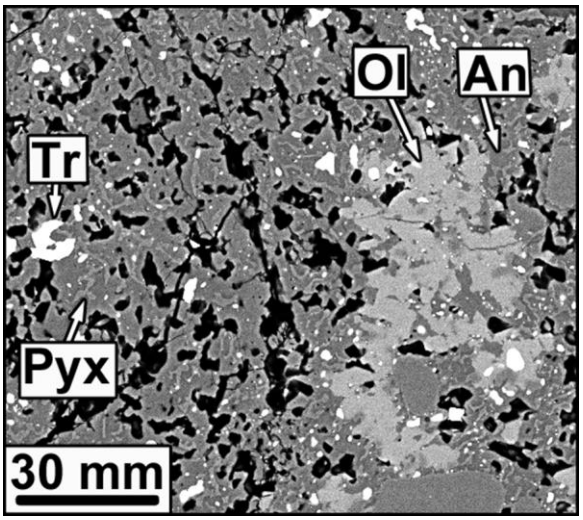

Figure 2. Backscattered electron image of the secondary assemblage replacing melilite in a CAI in NWA 8418. Tr – troilite; Ol – olivine. An – calcic plagioclase.

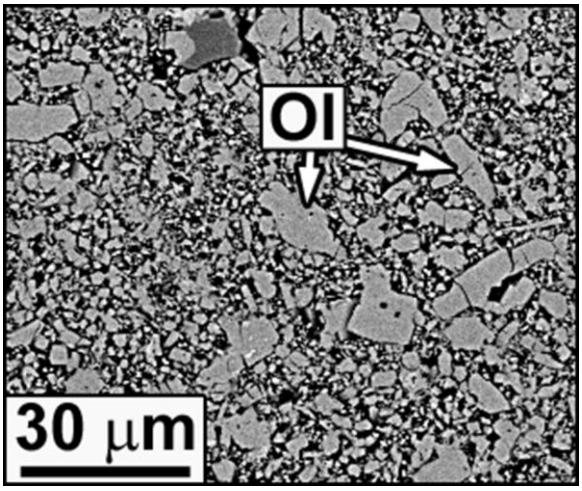

Figure 3. Backscattered electron image of the matrix in NWA 8418. Note that although many of the olivine grains are blocky in shape, some have the characteristic "barrel shape) of typical CV3 matrix olivines.

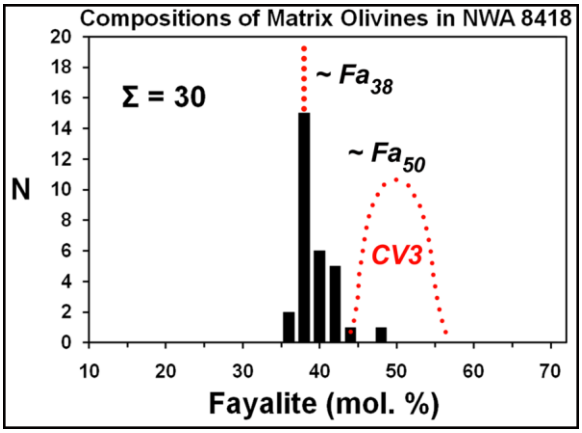

Figure 4. Histogram of matrix olivine compositions in NWA 8418. There is little overlap between the olivine compositions in NWA 8418 and those in the matrices of CV3 chondrites