A primitive chondrite, NWA 8613 chondrite, CV3.1-3.2

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Carbonaceous chondrites are primitive meteorites, and they give important information about the early processes in the solar system. Especially one of them, CV chondrites are characterized by the occurrence of large refractory inclusions and chondrules. They are classified into three subgroups: two oxidized groups, CV_{oxA} and CV_{oxB}, and a reduced group, CV_{red} [1]. Oxidized CVs were subjected to the secondary metasomatic reactions and partly aqueous alteration. On the other hand, CV_{red} chondrites preserve their primitive nature, although most of them partly experienced the secondary reactions [2]. Here we present our petrographic results on a new CV chondrite.

We studied NWA 8613. This is a newly classified CV chondrite. The shock stage is S1, and the weathering grade is W3. It consists of large chondrules (0.84 mm on average diameter, and 38 vol.% in modal composition), refractory inclusions (13 vol.%), and matrix (41 vol.%). Magnetite and phyllosilicate are not encountered, but kamacite is abundant. All these features indicate that the NWA 8613 is classified as CV_{red}.

Chondrules in NWA 8613 do not show preferred orientation, and are mostly porphyritic olivine and olivine-pyroxene type (89%). Mesostasis phases are mainly anorthitic plagioclase often with diopside. Olivine phenocrysts are mostly magnesian ($Fa_{2.1}$ on average). The width of ferroan rims of olivine gains is below 1 μm in general. Low-Ca pyroxenes are also magnesian ($Fs_{1.7}$). Chondrules contain kamacite and troilite.

Type A CAI and AOA are most common refractory inclusions. Melilite is the most abundant mineral, and gehlenitic (Geh_{72-93}). Magnesian spinel (mostly <0.3 wt.% FeO) is abundant in many inclusions. A few CAIs contain ultrarefractory metal nuggets. Olivines in AOAs hardly show chemical zoning, and the width of ferroan rims is smaller than 1 μm. Matrix comprises fine-grained minerals, mainly ferroan olivine with spinel, metal and sulfides. Matrix contains Ni-rich metal, troilite, and pentlandite.

Kimura and Ikeda [2] showed that even chondrules in CV_{red} chondrites experienced the secondary reactions, such as replacement of low-Ca pyroxene by ferroan olivine, secondary zoning of olivine, and exchange of Ca-Na to produce nepheline and sodalite. Chondrules in NWA 8613 hardly show the evidence for all these reactions. Only very thin nepheline lamellae (<0.5μm in width) and narrow ferroan rims of olivine grains are noticed in chondrules.

Metamorphic degree (petrologic subtype) can be estimated for CO and partly CV chondrites by several methods. One of them is the grain size of matrix olivine [3]. That of NWA 8613 is <0.9 μm on average. The width of ferroan olivine rims in AOAs is also a key for the classification [4], and is <1 μm in NWA 8613. Although Fe-Ni metals in chondrules do not show typical plessitic texture in Semarkona (type 3.01) [5], tiny Ni-rich metals are encountered within host kamacite. All these features indicate that NWA 8613 is classified as type 3.1-3.2.

We conclude that NWA 8613 hardly experienced shock metamorphism, thermal metamorphism, and metasomatism. This is one of the most primitive CV chondrites so far. Therefore, NWA 8613 is a significant sample to classify CV chondrites, and to clarify the processes in the early solar system.

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