UNUSUALLY ABUNDANT REFRACTORY INCLUSIONS AND IRON OXIDE-RICH SILICATES IN AN EH3 CHONDRITE, SAHARA 97159.

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Introduction: Enstatite (E) chondrites formed under highly reducing conditions, and they rarely contain refractory inclusions, compared with ordinary (O) and carbonaceous (C) chondrites. However, recent discoveries of several refractory inclusions [1-3] and FeO-rich silicates [e.g., 4,5], hint the complicated histories of the E chondrites.

Here we report the first discovery of unusually abundant refractory inclusions and FeO-rich silicates from an EH3, Sahara 97159. This chondrite is paired with Sahara 97096 that was studied in detail by Weisberg and Prinz [4].

Petrography and Mineralogy: We studied two thin sections of the Sahara 97159 (total area, 6.2 cm^2), and found 56 refractory inclusions and 10 spinel isolated grains. This is a huge number in comparison with 14–24 inclusions so far reported from 5-15 sections of other E chondrites [3,6]. These inclusions are small in size (10–120 µm), similar to those reported in other E chondrites. Spinels (almost $MgAl_2O_4$) are the most common mineral, associated with hibonite, corundum, perovskite, Ca-rich pyroxene, anorthite, nepheline, sodalite and troilite. We also found rare olivine ($<Fa_{0.5}$), TiO_2 phase, Ti-nitride, oldhamite, Ti,V-sulfide and altered Na-Cr-sulfide. No any secondary FeO-bearing phases are encountered. However, most of the inclusions contain the secondary nepheline and sodalite surrounding corroded or irregular spinel and anorthite. In several inclusions, albite also seems to be a secondary phase [6].

Most of the spinels contain <0.64% Cr_2O_3, whereas those in an inclusion and three isolated grains are Cr_2O_3-rich (3.28–17.37%). Ca-rich pyroxenes are enriched in TiO_2 (1.50–4.71%) and Al_2O_3 (7.11–26.08%). Troilites in the inclusions contain higher Ti (2.78–7.57%) and lower Cr (0.64–1.20%) than the other occurrences (0.14–0.26% Ti and 0.66–3.64% Cr).These inclusions contain lower bulk concentrations of CaO (0.2–11.9%, mostly <4%), but higher Na_2O (0.4–9.2%, mostly <2%), in comparison with those in C chondrites. This is consistent with the high degree of the secondary alteration.

FeO-rich silicates in chondrules and as isolated grains (10–150µm) are abundant in the Sahara 97159. Most of them are low-Ca pyroxene with $Fs_{7.4–29.7}$. Albite and silica mineral were often encountered in the FeO-rich silicate-bearing chondrules. Peripheral parts of these pyroxenes are often more magnesian (e.g., Fs_{13}) than the cores (Fs_{21}).

Implications: One of the characteristic features of the refractory inclusions in the Sahara 97159 is low abundance of Ca-rich phases, and high abundance of secondary feldspathoids. The altered parts of several inclusions contain albite. Ti-rich troilites seem to have replaced some primary Ti-phases. Therefore, the alteration reaction took place under reducing and SiO_2-rich conditions, in comparison with those in C and O chondrites.

Our observations give the first discovery of refractory inclusion-rich E chondrite. Although it is not yet evident why the inclusions are abundant in the Sahara 97159, some H3 chondrites also contain a large number of refractory inclusions [7]. The distribution of the inclusions may be highly heterogeneous in chondrites than reported before.

Measurements of O-isotopic compositions of the FeO-rich pyroxenes and selected inclusions are in progress, which will shed light on origins of these objects and the E chondrite hosts.

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