ORIGIN OF "WHITE DRUSE" SALTS IN THE EETA79001 METEORITE

James L. Gooding[1] and Susan J. Wentworth[2] [1]SN21/Planetary Science Branch, NASA/Johnson Space Center, Houston, TX 77058 USA [2]C23/Lockheed Engineering and Sciences Co., Houston, TX 77058 USA.

Introduction. During clean-room sawing of the Elephant Moraine, Antarctica A79001 (EETA79001) shergottite in 1986, millimeter-sized spots of a white coating were discovered in association with a vuggy pocket of black glass near the geometric center of the meteorite [1]. After preliminary work revealed that the drusy white material was principally calcium carbonate [2], a small consortium investigation organized by one of us (JLG) published results for mineralogical and stable-isotope ($^{13}C/^{12}C$ and $^{18}O/^{16}O$) compositions of the carbonate [3-5]. Although paucity of sample material prevented a definitive oxygen three-isotope analysis, the summation of petrological and geochemical evidence favored pre-terrestrial origin of the white druse. In 1990, further curatorial subdivision of EETA79001 revealed new occurrences of the white druse [6]. Given the interest generated by the original work [3-5], other investigators proposed a variety of new analyses on the druse, including trace-element geochemistry, ^{14}C and ^{10}Be measurements, and organic geochemistry. Here we confirm that the 1990 druse is essentially the same material discovered in 1986 and we review our hypothesis for its origin and history.

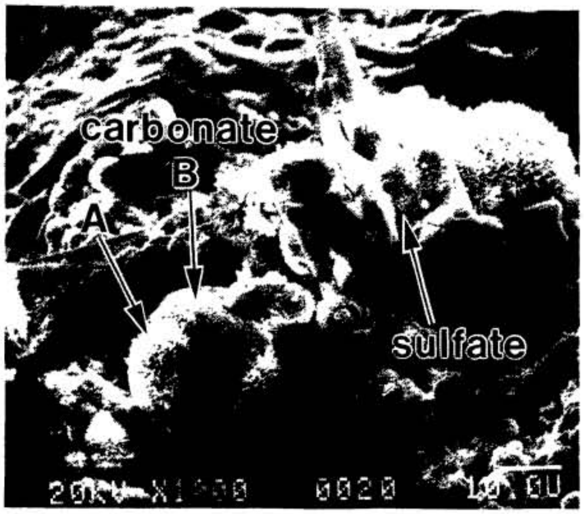
Samples and Methods. Untreated rock chips were studied by scanning electron microscopy (SEM) and energy-dispersive X-ray spectrometry (EDS) using previously established procedures [1,2], including direct EDS for carbon and oxygen. As before, carbon X-ray peaks intrinsic to mineral grains were unambiguously distinguished from those originating from vacuum-evaporated conductive coatings. Sample EETA79001,335 comprised a drusy seam along a glass vein in igneous Lithology A whereas sample EETA79001,325 consisted of druse associated with a millimeter-sized inclusion of vesicular black glass (Lithology C).

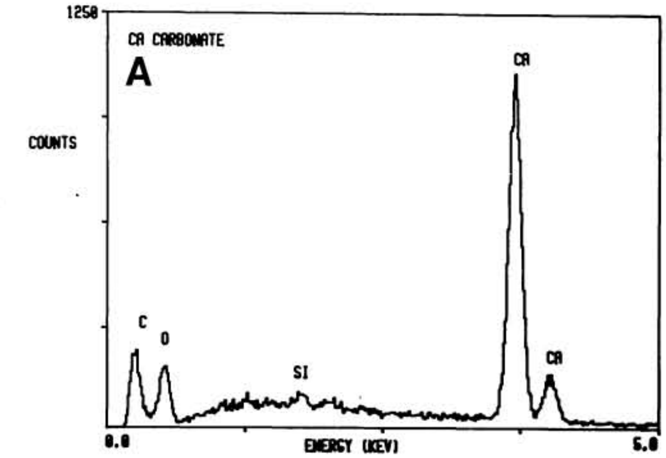
Results. The mineral composition of the white druse in the 1990 samples was essentially the same as previously reported for the 1986 discovery [3] although a few additional textural relationships were observed in the new samples. The mineral assemblage is dominated by subequal proportions of nearly pure Ca-carbonate and Mg-phosphate and with lesser amounts of Ca-sulfate, silica, and possibly a second variety of Mg-bearing Ca-carbonate (Figs. 1-2); ferric "rust", which would be expected from oxidation of mafic minerals, is rare to absent. In at least one occurrence, radiating-acicular Ca-carbonate is superposed on mamillary, Mg-bearing Ca-carbonate (possibly magnesian calcite) and blocky-prismatic Ca-sulfate (possibly gypsum) (Fig. 1). In other localities, radiating-acicular Ca-carbonate is superposed on massive to bladed Mg-phosphate (possibly collinsite or holtedahlite [3]); botryoidal silica is either intergrown with, or superposed on, the phosphate (Fig. 2). These observations suggest the following precipitation sequence:

Mg-phosphate; silica --> Mg,Ca-carbonate; Ca-sulfate --> Ca-carbonate

Transmission electron microscopy (TEM; in progress) will be used for microstructural mineral identifications.

Origin of the Druse. *EVIDENCE AGAINST TERRESTRIAL FORMATION.* All occurrences of the white druse have been in association with either glass veins or pockets of vesicular black glass in the interior of the meteorite; no druse has been observed on external surfaces. Although evaporites of terrestrial origin have been noted in many Antarctic meteorites [7], Ca-carbonate and Mg-phosphate have never been found among them; evaporites in and on Antarctic meteorites are predominantly Mg-carbonates and Mg-sulfates with minor Ca-sulfate [7,8]. Terrestrial weathering products on the exteriors of EETA79001 and other Antarctic stony meteorites [9] are substantially different from the white druse. As originally pointed out by Gooding et al. [3], textural evidence for pre-terrestrial origin of the druse minerals occurs separately as isolated grains of Ca-carbonate and Ca-sulfate that are physically trapped as inclusions in quench-textured pyroxene and glass. This virtually incontrovertible microstratigraphic evidence is independent of other arguments based on geochemical or isotopic measurements. *FORMATION ON THE SNC PARENT BODY.* We postulate that the white druse originally precipitated from water-based solutions on the shergottite-nakhlite-chassignite (SNC) parent planet although it is not clear whether the igneous parent rock was invaded by deuteric fluids or was subjected to surface weathering. In either case, the precipitates filled fractures and voids in the rock, producing a texture resembling that of an amygdaloidal basalt. A subsequent transient heating event (probably shock wave from a meteorite impact) selectively melted the veins and pockets to form the black glass now observed as Lithology C. Because the heating event was short-lived, however, disequilibrium prevailed and the more refractory constituents of the druse were incompletely decrepitated, leaving the relics that are now found in and around the black glass. To explain the bulk composition of the black glass (similar to Lith A), we postulate that the original amygdaloidal fillings also included (now melted) clay-like, secondary ferromagnesian aluminosilicates and oxides. We suggest that, with respect to textures of secondary minerals, the parent rock of EETA79001 originally resembled that of Nakhla which contains rusty (possibly smectite-bearing) silicate veins with intergrown carbonates and sulfates [10, 11]. Whereas the complete vein assemblages are preserved in relatively unshocked Nakhla, they have been differentially melted in highly shocked EETA79001.





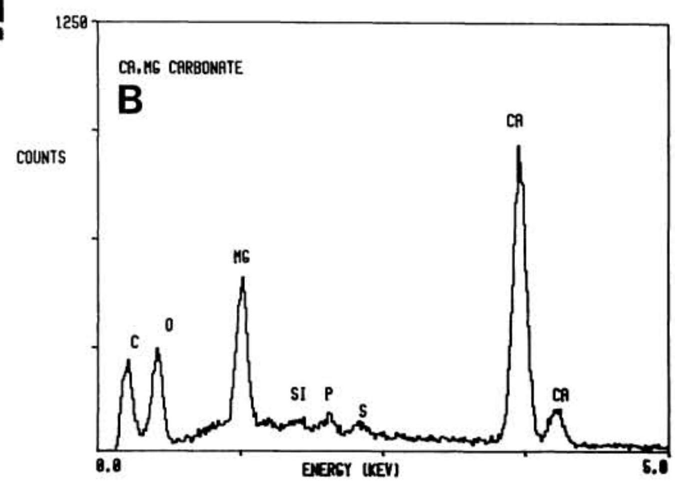


Figure 1 (Above and right). SEM image (10 μm scale bar) and EDS spectra for Ca-carbonate (A) and Ca,Mg-carbonate (B) intergrown with Ca-sulfate in white druse in EETA79001,325.

References: [1] Martinez R. and Gooding J. L. (1986) Antarctic Meteorite Newsletter, 9(1), Johnson Space Center, Houston, 23-29. [2] Wentworth S. J. and Gooding J. L. (1986) Meteoritics, 21, 536-537. [3] Gooding J. L. et al. (1988) Geochim. Cosmochim. Acta, 52, 909-915. [4] Wright I. P. et al. (1988) Geochim. Cosmochim. Acta, 52, 917-924. [5] Clayton R. N. and Mayeda T. K. (1988) Geochim. Cosmochim. Acta, 52, 925-927. [6] Gooding J. L. (1990) Antarctic Meteorite Newsletter, 13(2), Johnson Space Center, Houston, 4. [7] Velbel M. A. (1988) Meteoritics, 23, 151-159. [8] Miyamoto M. (1990) In Koeberl C. and Cassidy W. A. (Eds.), LPI Tech Rept. 90-01, Lunar and Planetary Institute, Houston, 68-71. [9] Gooding J. L. (1986) Geochim. Cosmochim. Acta, 50, 2215-2223. [10] Wentworth S. J. and Gooding J. L. (1989) Lunar Planet. Sci. XX, Lunar and Planetary Institute, Houston, 1193-1194. [11] Wentworth S. J. and Gooding J. L. (1990) Lunar Planet. Sci. XXI, Lunar and Planetary Institute, Houston, 1321-1322.

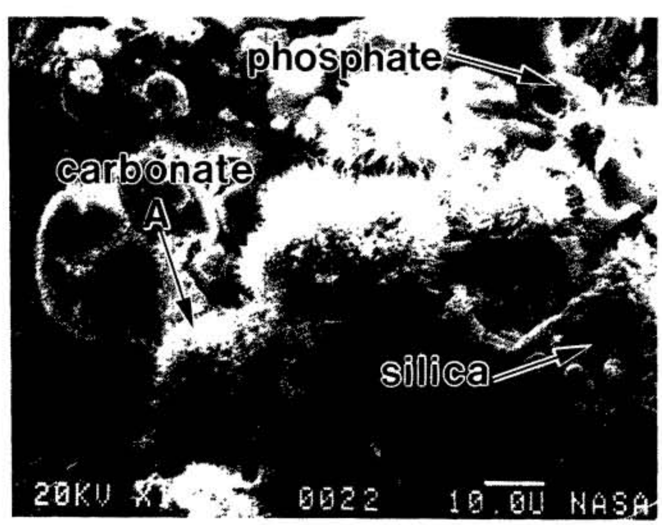


Figure 2 (Right). SEM image (10 μm scale bar) of white druse (separate from that in Fig. 1) in EETA79001,325. Phases were identified by EDS (spectra not shown). Carbonate A is the same composition as that in Fig. 1.