LOW-FeO ORDINARY CHONDRITES: A NEBULAR ORIGIN AND NEW CHONDRITE PARENT BODY.

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ABSTRACT - We have studied five meteorites [Wray (a), Cerro los Calvos, Willaroy, Moorabie and Suwahib (Buwah)] which differ from other chondritic meteorites and appear to form a new group. They are closely related to ordinary chondrites, but have lower FeO in the mafic silicates than H chondrites. Furthermore, their oxygen isotopic compositions are intermediate between E and H chondrites; they have highly variable metal contents, low Co concentrations in kamacite, and high troilite contents. The differences between low-FeO and H, L and LL chondrites appear to have been established in the solar nebula, not through parent body processes. Low-FeO chondrites did not originate on the H chondrite or IIE iron parent bodies, but probably represent a new ordinary chondrite parent body.

PROPERTIES - The low-FeO contents of Cerro los Calvos, Willaroy, Moorabie and Suwahib (Buwah) have been noted by several authors [e.g.,1,2] and these meteorites have been examined in detail [2]. We recently recognized the low-FeO nature of Wray (a) [3] and here report on our comparative studies.

Classification - Low-FeO chondrites are weakly metamorphosed and exhibit wide ranges of shock and weathering. Classification of petrologic types, shock stages [4] and weathering [5] are as follows: Wray (a): 4, S4, W1; Cerro los Calvos: 4, S2, W3; Willaroy: 3.8, S2, W4; Moorabie: 3.9, S4, W1; and Suwahib (Buwah): 3.8, S5, W1.

Mafic Silicate Compositions - Fa concentrations in low-FeO chondrites ($Fa_{12.8-15.3}$) are below those of H chondrites ($Fa_{16.9-20.4}$). Low-Ca pyroxene compositions are intermediate between H and E chondrites.

Metal and Troilite Abundances - Fe,Ni metal abundances in low-FeO chondrites are highly variable (11.2-19.4 wt.%, weathering corrected) and overlap with H and L chondrites. Troilite contents in the mildly weathered Moorabie (9.1 wt.%) and Suwahib (Buwah) (8.6 wt.%) are higher than found in any ordinary chondrite [6], although analyses of these meteorites by [7] suggest normal OC abundances of troilite. Sampling heterogeneity may be responsible.

Cobalt in Kamacite - The Co concentrations in kamacite of low-FeO chondrites (0.30-0.45 wt.% [2, this work]) are near or lower than those in H chondrites (0.44-0.51 wt.% [8]).

Chondrule Sizes - Low-FeO chondrites have mean chondrule diameters around 400 μm [Wray (a), Cerro los Calvos, Willaroy] and 600 μm [Moorabie, Suwahib (Buwah)]. These values are close to H (~300 μm) and L (~600-800 μm) chondrites [9]. The poorly constrained ranges of chondrule sizes in H, L and LL chondrites and large standard deviations for chondrule sizes in low-FeO chondrites suggest that this parameter is unreliable for establishing group membership.

Oxygen Isotopes - The $\Delta^{17}O$ values for low-FeO chondrites (0.32-0.87‰ [10,11]) are less than or equal to H chondrites (0.73±0.09‰,[10]). Moorabie and Suwahib (Buwah), which have slightly larger chondrules, also have higher $\Delta^{17}O$. Figure 1 plots the compositions of low-FeO chondrites, along with the fields for H, L, LL and E chondrites.

NEBULAR OR PARENT BODY ORIGIN FOR MINERALOGIC AND ISOTOPIC COMPOSITIONS?

WASSON *et al.* [2] suggested that Willaroy & Cerro los Calvos and Suwahib (Buwah) & Moorabie are H and L chondrites, respectively, that were incorporated into, and partially equilibrated with, aubritic material, primarily because their study of Cumberland Falls chondritic inclusions indicated formation by this mechanism. Low-FeO chondrites also lack the high siderophile abundances of Netschaëvo, which [12] called "HH" chondritic material based on extrapolation of H-L-LL trends. Because of the lack of definitive evidence for reduction (e.g., Fs>Fa) or a reducing host, high troilite contents, and short diffusion distances for oxygen in type 5 ordinary chondrites [10], we suggest nebular processes produced the low-FeO concentrations.

In fact, there is no reason to invoke parent body processes to produce the unusual compositions observed in low-FeO chondrites. Some properties of low-FeO chondrites do not fall on extrapolations of H-L-LL trends, owing to large variability within low-FeO chondrites. In fact, significant variability is also observed within other chondrite groups, particularly among type 3 chondrites. This variability causes overlap for some features between groups of ordinary chondrites (e.g., $\Delta^{17}O$ in L and LL chondrites). Variability of metal and troilite abundances comparable to those in low-FeO chondrites are observed in EH (17.5-23.8 wt.% Fe,Ni; 5.8-9.8 wt.% FeS; [13]) and, particularly, EL chondrites (1.6-28.0 wt.% Fe,Ni; 4.7-16.7 wt.% FeS; [13]). The variability of these properties reflects incorporation of different proportions of nebular components (e.g., matrix, type IA and II chondrules, metal), rather than parent body processes.

WHICH PARENT BODY SUPPLIED THE LOW-FEO CHONDRITES?

H Parent Body - Low-FeO chondrites have some properties identical to those in H chondrites and might have come from the H parent body. However, studies of H chondrite breccias [14,15] have not identified low-FeO chondritic clasts. A clast intermediate in chemical composition between H and E chondrites was identified [16], but this clast may have formed by shock melting. The absence of low-FeO clasts in H breccias suggests that these groups originated on different parent bodies.

Chondritic Material from the IIE Iron Parent Body - The low-FeO chondrites share many properties with highly metamorphosed, chondritic clasts in the IIE iron Netschaëvo. These clasts contain relict chondrules [17,18], have mafic silicate compositions ($Fa_{14.1}$,$Fs_{13.6}$,[17]) below H chondrites, contain abundant Fe,Ni metal (23.2 wt.%, this work) with 0.45 wt.% Co in kamacite [8] and have an oxygen isotopic composition intermediate between H and E chondrites ($\Delta^{17}O$=0.37,[19]). The major objection to a common parent body for low-FeO chondrites and IIE irons is the low petrologic types of the low-FeO chondrites. The IIE iron parent body was heated to high temperatures, as reflected by the formation of a core or metal pools, the highly metamorphosed silicates in Netschaëvo and differentiated silicates in Colomera. We question whether unequilibrated chondritic material could survive on this parent body and, thus, do not favor a common parent body for these two groups.

Another Ordinary Chondrite Parent Body - The most plausible scenario for the origin of the low-FeO chondrites is that they are samples of a separate parent body. The similarities between low-FeO and ordinary chondrites suggests that this is a new ordinary chondrite parent body, joining the H, L and LL parent bodies.

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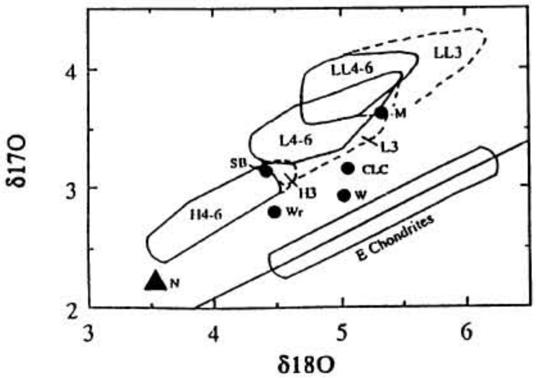

FIGURE 1. Oxygen isotopic compositions of low-FeO chondrites Wray (a) (Wr), Cerro los Calvos (CLC), Willaroy (W), Moorabie (M) and Suwahib (Buwah) (SB), as well as chondritic clasts in Netschaëvo (N), ranges for E chondrites, equilibrated H, L and LL chondrite falls (fields with solid lines) and unequilibrated H, L and LL falls and acid-washed finds (dashed fields).