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WINONAITES: A PRIMITIVE ACHONDRITIC GROUP RELATED TO SILICATE INCLUSIONS IN IAB IRONS. M. Prinz[1], D.G. Waggoner[2] and P.J. Hamilton[3]. 1. Dept. Mineral Sci., Am. Mus. Nat. Hist., New York, NY 10024. 2. Grad. Sch. Oceanography, Univ. Rhode Island, Kingston, R. I. 02881 3. Univ. Cambridge, Cambridge, U. K.

The meteorites Winona and Mt. Morris have been considered anomalous (1), forsterite chondrite (2), "approximately" chondritic (3), or not classified (4). Bild (3) has made the strongest argument for their chondritic nature and similarity to silicate inclusions in IAB irons. Winona has been looked at somewhat more carefully than Mt. Morris, but neither meteorite has been extensively studied, and this report includes a detailed Min-Pet study of both meteorites, combined with the first reported REE data. The strongly fractionated REE patterns, and comparison with data from related meteorites has led us to conclude that they are part of a primitive achondritc group which we propose to call WINONAITES, which is correlated with silicate inclusions in IAB irons.

The winonaite group includes the following meteorites: Winona, Mt. Morris, Pontlyfni (2), ALHA 77081 (5), Acapulco (6) and Tierra Blanca (7). This group does not include Kakangari which is truly chondritic (8, 9), nor the chondritic clast in Cumberland Falls, for the same reason. Graham et al. (2) described Pontlyfni and Davis et al. (9) called it igneous and not chondritic. Personal study of ALHA 77081, combined with information available on Acapulco and Tierra Blanca indicate that these meteorites have strong similarities to the others. When more complete data are available for this group they will provide important information on early planetary development because they are closer to chondritic than are most achondrites.

Two samples of Winona and one of Mt. Morris (all from the AMNH) were studied. All three are weathered and have equigranular textures, of varying grain size. Winona 3768 is coarse-grained, Winona 4158 is fine-grained, and Mt. Morris 4099 is variable, mostly fine-grained, with abrupt changes to medium-grained, and a small area which is coarse-grained, in the section studied. The textures yield no clues as to previous history of these meteorites and indicate uniform conditions of crystallization or recrystallization.

Silicate modes, determined by automated probe techniques, are given in Table 1. They are all similar, being mainly olivine-pyroxene rocks (79-82%) with plag (14-20%); that is, feldspathic lherzolite in igneous terminology, a possible mantle material. Coarse-grained Winona (3768) has notable higher phosphate (1.1%) and metal + troilite (~ 55%) as compared to fine-grained Winona (4158). Mineral compositions are similar to those reported earlier, but with significant additions. Results are summarized in Table 2. Winona 3768 is slightly more MG-rich than Winona 4158, indicative of fractionation within samples from the same meteorite; this is confirmed by REE data (below). This is also true of some silicate inclusions in IAB irons (e.g. Campo del Cielo) (10), as well as in IIE irons (e.g. Weekeroo Station) (11). Pontlyfni is the most Mg-rich winonaite (Fo 98.1) and ALHA 77081 and Acapulco the least Mg-rich (Fo 89) from data available to date (2,5,6). Winona and Mt. Morris have the zincian chromites characteristic of this group, but large chromites are found to be more Cr-rich than finer matrix chromites; all are remarkably high in Cr, with only minor Al. Daubreelite is found as exsolution lamellae in troilite, but some are Zn-rich (Winona, 6.1%; Mt. Morris, 4.0%) and some contain nearly none. Alabandite was found as exsolution lamellae in troilite in Mt. Morris (Mn 59.5%; Fe 4.1%), as was an unknown sulfide (or fine mixture) with Fe 22.8%; Mn 15.15%; Zn 25.2%; and S 36.2%. Chlorapatite was the only phosphate found, in both. Graphite is present as gray plates, often associated with olivine, but also in metal and matrix; this phase is common in

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silicates in IAB irons. Metal (mostly kamacite, 6.7% Ni) and schreibersite were found in both meteorites.

Modal and mineral compositions are similar to those in silicate inclusions in IAB irons (unpublished data) so that bulk compositions are similar. However, REE elements have not previously been determined for Winona and Mt. Morris and were made by isotope dilution techniques. Results are presented in Table 3 and Fig. 1A. These data show strongly fractionated patterns indicative of igneous processes. Coarse-grained Winona (3768) has a large negative Eu anomaly whereas fine-grained Winona (4158) has a large positive Eu anomaly and U-shaped pattern, and Mt. Morris is similar and intermediate. Winona 3768 has high phosphate (Table 1) and the other two meteorites have patterns that may reflect phosphate depletion. These patterns are compared with REE data from Pontlyfni (9) and silicates in IAB irons Woodbine (3,12), Campo del Cielo (3,12), Linwood (12), Copiapo (3), Four Corners (10), and Landes (3) (Fig. 1B). The entire group of patterns, combined with Winona and Mt. Morris, represent a complex pattern of igneous fractionation processes that establish this as an achondritic group, as contrasted to the chondritic interpretation of others (2,3,6,12), and in agreement with Davis et al.(9).

Nevertheless, there are compelling arguments that these meteorites have some near-chondritic characteristics. These include the phase assemblage and compositions (especially the plagioclase), the Mg/Si ratio (2), REE patterns that sometimes are near-flat and near-chondritic, non-volatile and siderophile element patterns that sometimes do not vary as widely from chondritic as do many other achondrites (3). Most studies have wavered between chondritic and achondritic interpretations because this material does not appear to be as highly fractionatated other achondrites. However, we suggest that enough evidence has now accumulated to establish that these meteorites are primitive achondrites. To call them chondrites and then make interpretations about nebular condensation process is unwarranted. Their value lies in their primitive characteristics.

Clayton and Mayeda (13) show that winonaites and silicate inclusions in IAB irons have come from a similar oxygen isotope reservoir, further substantiating the correlation of these groups. They do not coincide with any known chondritic group. Similarly, silicate inclusions in IIE irons come from a coherent, but different oxygen isotope reservoir. These inclusions have not as yet been found or recognized in any non-iron meteorites, but they too represent an achondritic group (11) which has not as yet been clearly enough recognized. As compared to silicate inclusions in IAB irons, they are younger (4.3-3.8 Gy), more fractionated (less primitive) rock types, with complex histories, except for Netschaëvo which is chondritic.

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	Winona 4158	Winona 3768	Mt. Morris 4099
Opx	54.4	45.8	46.1
Cpx	0.4	1.7	2.8
Plag	14.3	19.6	20.0
Ol	27.2	31.8	31.0
Phos	0.4	1.1	0.1
Cm	0.1	-	-
% Metal + Troilite	~25	~55	~20
Area (mm²)	49.6	18.6	35.3

Table 1. Metal-troilite-free modes of silicates in Winona and Mt. Morris.

	Ol (Fo)	Opx (En)	Cpx Wo	Cpx En	Cpx Fs	Plag An	Plag Or
Winona 4158	94.9	91.5	45.3	53.2	1.5	15.9	3.4
Winona 3768	96.1	91.8 (93.8)[1]	44.6	52.7	2.7	15.4 (8.5)[2]	3.5 (5.3)[2]
Mt. Morris 4099	96.8	95.0	45.5	52.8	1.7	21.3	2.6

1. One grain included in olivine.
2. Grains in dark matrix.

Table 2. Mineral compositions in Winona and Mt. Morris.

	La	Ce	Nd	Sm	Eu	Gd	Dy	Er	Yb
Winona 4158	0.177	0.260	0.118	0.0369	0.0795	0.0604	0.124	0.143	0.191
Winona 3768	-	0.910	0.801	0.279	0.0477	0.398	0.455	0.283	0.276
Mt. Morris 4059	0.310	0.491	0.246	0.0482	0.0400	0.0813	0.148	0.148	0.187

Table 3. REE data for Winona and Mt. Morris.

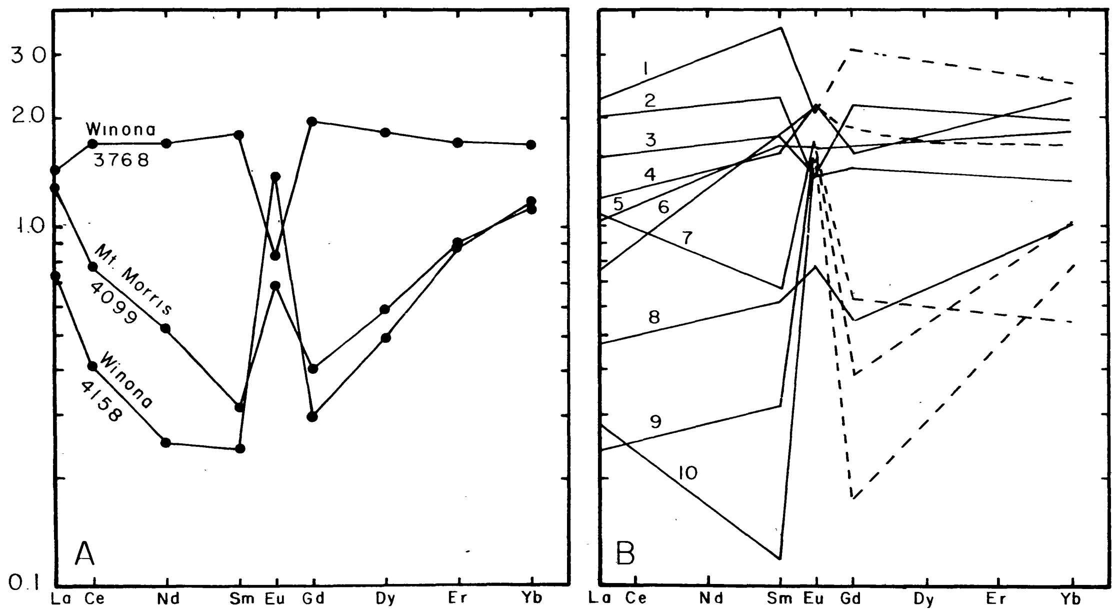

Fig. 1. REE patterns for Winona, Mt. Morris and related meteorites. A. Winona and Mt. Morris. B. 1. Woodbine (3). 2. Linwood (12). 3. Woodbine (12). 4. Four Corners (12). 5. Copiapo (3). 6. Landes (3). 7. Pontlyfni (9). 8. Campo del Cielo (12). 9, 10. Campo del Cielo (3).

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