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The chemical compositions of Antarctic iron meteorites and their classification*

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Abstract The concentrations of 13 elements in the metal of 52 Antarctic irons have been reported and these irons have been classified based on the structures and their Ga, Ge, Ni, Ir and other trace elemental contents. The 52 iron meteorites assigned to chemical group consist of 16 of IAB, 12 of IIAB, 1 of IIE, 3 of IIIAB, 1 of IIICD, 1 of IVA and 18 of ungrouped irons. The IAB, IIICD and IIE iron meteorite groups are considered to be of nonmagmatic origin. Nonmagmatic IAB, IIICD and IIE irons formed as individual pools of a chondritic body. The other groups, IIAB, IIIAB and IVA show the evidences of having originated by fractional crystallization of a metallic magma. The slopes on element-Ni trends in the magmatic are generally higher than in the nonmagmatic groups. Most interestings are the high abundance of ungrouped and IAB (47.2% and 27.8%, respectively) and low abundance of IIIAB (5.8%). Antarctic irons of the group abundances can be distinguished from non-Antarctic irons, which provide the information about previously unsampled parent planets, mass, shock and collision, as well as nebula regions.
Key words Antarctica, Antarctic meteorites, iron meteorites, classification of iron meteorites.

1 Introduction

Most of iron meteorites are classified into 13 chemical groups on the basis of their structures and the contents of Ga, Ge, Ni as well as other trace elements (Table 1, Wang *et al.*, 1982, 1983; Malvin *et al.*, 1984; Wasson, 1985). Of 13 groups of irons, 10 groups (IC, IIAB, IIC, IID, IIF, IIIAB, IIIE, IIIF, IVA and IVB) seem to have formed by the fractional crystallization of large metallic magmas on separate parent bodies (Wasson *et al.*, 1980; Wasson and Wang, 1986). The remaining 3 groups (IAB, IIE and IIICD) may have formed as individual pools of shock melt (Scott, 1972; Wasson *et al.*, 1980; Wasson and Wang, 1986). Their origin may be non-magmatic. In addition, 96 of 598 irons examined and classified are called "ungrouped", which account for 16.1% (Wasson *et al.*, 1989). But 18 of 52 examined Antarctic irons are classified as

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"ungrouped", which make up about 34.6%. If the paired irons are taken as a single falling event in Antarctica, of 36 irons in study 17 "ungrouped" ones account for about 47%. Their abundance is much higher than that of irons from the other parts of the world. It seems that these new and "ungrouped" irons may provide some information of the planet bodies and nebular region where the samples have not been collected, and it suggests that there may be some metallic Fe-Ni cores from meteorite parent bodies and small planets which have not been collected as yet. According to our data of chemical composition and classification of 12 Antarctic irons and the data published in recent years, we discuss their composition characteristics and origin. The experimental procedures (INAA and RNAA) were described in detail by Wang *et al.* (1983) and Malvin *et al.* (1984).

Table 1. Properties of 13 iron-meteorite and two other metal-rich groups

Group	Freq. (%)	Bandwidth (mm)	Sturcture	Ni (mg/g)	Ga (μg/g)	Ge (μg/g)	Ir (μg/g)	Ge-Ni Corre.
IA	17.0	1.0~3	Om-Ogg	64~87	55~100	190~520	0.6~5.5	negative
IB	1.7	0.01~1.0	D-Om	87~250	11~55	25~190	0.3~2.0	negative
IC	2.1	<3	Anom,Og	61~68	49~55	212~247	0.07~2.1	negative
IIA	8.1	>50	H	53~57	57~62	170~185	2~60	positive?
IIB	2.7	5~15	Ogg	57~64	46~59	107~183	0.01~0.9	negative
IIC	1.4	0.06~0.07	Opl	93~115	37~39	88~114	4~11	positive
IID	2.7	0.4~0.8	Of-Om	96~113	70~83	82~98	3.5~18	positive
IIE	2.5	0.7~2	Anom	75~97	21~28	62~75	1~8	absent
IIF	1.0	0.05~0.21	D-Of	106~140	9~12	99~193	0.8~23	positive
MES	—	~1	Anom	61~101	8.9~16	37~56	2.2~6.2	absent
PAL	—	~0.9	Om	79~129	14~27	29~71	0.01~2	negative?
IIIA	24.8	0.9~1.3	Om	71~93	17~23	32~47	0.15~20	positive
IIIB	7.5	0.6~1.3	Om	84~105	16~21	27~46	0.01~0.15	negative
IIIC	1.4	0.2~3	Off-Ogg	62~130	11~92	8~380	0.07~2.1	negative
IIID	1.0	0.01~0.05	D-Off	160~230	1.5~5.2	1.4~4.0	0.02~0.07	negative
IIIE	1.7	1.3~1.6	Og	82~90	17~19	34~37	0.05~6	absent
IIIF	1.0	0.5~1.5	Om-Og	68~85	6.3~7.2	0.7~1.1	0.006~7.9	negative
IVA	8.3	0.25~0.45	Of	74~94	1.6~2.4	0.09~0.14	0.4~4	positive
IVB	2.3	0.006~0.03	D	160~180	0.17~0.27	0.03~0.07	13~38	positive

Mes: mesosiderite; Pal: pallasite; Freq.: frequency; Corre.: correlation; H: hexahedrite; Ogg, Og, Om, Off, Opl: coarsest, coarse, median, fine, finest, plessite octahedrite respectively; D: ataxite; Anom: anomalous.

2 Composition and classification of Antarctic iron meteorites

52 Antarctic irons were classified (Table 2) based on the contents of Ga, Ge, Ni, Ir and other trace elements (Co, Cu, Au, As, W etc.) and the structural characteristics. These irons consist of 16 of IAB, 12 of IIAB, 1 of IIE, 3 of IIIAB, 1 of IIICD, 1 of IVA and 18 of ungrouped ones. As compared with the chemical groups of the examined 598 irons, the abundances of IAB and "ungrouped" irons from Antarctica are very high (Table 3), but those of IIIAB and IVA are relatively low. Besides, some mesosiderites (ALHA77219, ALHA81059, ALHA81098, ALHA81208, EET87500, EET87501, EET92001, LEW86210, LEW87006, MAC88102, QUE86900, RKPA79015, RKPA80229, RKPA80246, RKPA80258, KPA80263), pallasites (PCA91004, PCA91004, PCA91388) and some metal-rich fragments (LEW88677, LEW88698)

Table 2. Chemical composition of Antarctic iron meteorites and their classification

Meteorite	Group	Structure*	Bandwidth mm	Cr μg/g	Co mg/g	Ni mg/g	Cu μg/g	Ga μg/g	Ge μg/g	As μg/g	Sb ng/g	W ng/g	Re ng/g	Ir μg/g	Pt μg/g	Au μg/g	Ref.	Paired	Silicate	Fa mol%	Fs mol%
EET87516	☆☆	Off	0.03	340	4.84	93.0	176	1.76	2.7	6.28	<50	840	700	6.40	9.6	0.92	(4)				
EET83230	☆☆	D		13	4.48	164	492	1.34	0.075	13.4	9.3	220	<220	0.105		2.72	(4)				
LEW88023#	☆☆	O?				67.8		11.9	58.9					0.0068			(4)		yes		
LEW88631	☆☆					60.2		47.4						2.18			(4)				
LEW88055	☆☆																(4)		yes		0
LEW87109	☆☆					63.2		53.9						2.96			(4)				
LEW86498	☆☆	Anom															(4)	LEW86211	yes		
LEW86211	☆☆	Anom				69.7		28.4	240					23.4			(4)		yes, FeS	2	1~5
LEW85369	☆☆	Anom		186	3.33	74.1	318	46.8	100	13.4	420	570	350	3.49	6.3	1.49	(4)				
HOW88403¥	☆☆	D				762		19.1	45.4					4.33			(4)				
Y-791076	☆☆	Opl		15	5.94	139	402	32.0	264	24.5	1140	1190	<200	0.393	6.3	2.28	(4)				
Y-790517	☆☆	Anom		36	5.44	70.7	118	19.8	47.0	8.02	55	690	60	0.523		0.924	(4)				
ALH84233	☆☆	Anom	>5	12	5.39	64.6	168	14.0	63.2	14.4	260	985	<30	<0.003	<0.7	1.07	(4)		yes	20	17
ALHA81014	☆☆	Of	0.22	69	5.40	108	84	7.53	1.52	6.05	10	1260	400	3.64		1.11	(1)				
ALHA80104	☆☆	D		8	6.81	162.7	299	6.03	10.2	26.1	570	410	<30	0.083		2.66	(4)				
ALHA77255	☆☆	D		363	5.66	124.2	10	0.083	0.058	0.29	2	1230	1010	10		0.070	(1)				
ILD83500	☆☆	D		24	9.46	175	338	19.3	47.9	11.4	122	710	520	7.15		1.61	(4)				
Lazaev	☆☆	Om	1.3	76	6.93	94.6	226	15.1	24.0	8.94	81	900	390	3.94	10.5	1.02	(4)				
ALHA76002	IA	Og				70.0		92.4	423					2.4			(2)				
ALHA77250	IA	Og		28	4.5	69	150	93	410	11	300	1800	290	2.5		1.5	(1)	ALHA76002			
ALHA77263	IA	Og		29	4.5	67	140	98		12		1500	320	2.5		1.6	(1)	ALHA76002			
ALHA77289	IA	Og		37	4.4	69	160	92		11		1600	280	2.5		1.5	(1)	ALHA76002			
ALHA77290	IA	Og			4.4	69	160	92		11	685	1600	300	2.5		1.5	(1)	ALHA76002			
ALHA77283	IA	Og	1.8	21	4.81	74.7	146	77.2	320	15.4	400	1080	245	2.0		1.72	(1)				
PGPA77006	IA	Og	1.8	28	4.68	74.0	142	77.2	284	14.2	430	1000	263	2.1		1.65	(1)				
RKPA80226	IA-an	Anom	1.2	23	4.88	84.0	173	68.4	255	17.1	450	900	222	2.1		1.74	(1)				
EET83333	IAB	Om	1.0	20	4.88	80.6	184	74.8	226	16.4	460	800	280	2.88	6.8	1.75	(4)		yes	5	7
EET84300	IAB	Off	0.05	80	5.10	102.2	192	41.3	92.3	14.4	360	330	180	1.82	2.9	1.29	(4)		yes	1	6
Y-791694	IAB	D		8	5.67	342	1943	12.9	36.9	34.2	4000			0.238		1.86	(4)				

Table 2 continued

Meteorite	Group	Structure*	Bandwidth mm	Cr μg/g	Co mg/g	Ni mg/g	Cu μg/g	Ga μg/g	Ge μg/g	As μg/g	Sb ng/g	W ng/g	Re ng/g	Ir μg/g	Pt μg/g	Au μg/g	Ref.	Paired	Silicate	Fa mol%	Fs mol%
EET87506	IAB-an	Anom		34	5.37	205	921	22.1		28.6	2760	350	279	3.05	5.7	1.96	(4)		yes	3	6
EET87505	IAB-an	Anom															(4)	EET87506	yes	3	6
EET87504	IAB-an	Anom															(4)	EET87506	yes	3	6
PCA91003	IAB	Og?				171		82.5						3.61			(4)				
TIL91725	IAB					79.3		73.6						3.67			(4)	yes		5	7
ALHA78100	IIA	H		37	4.38	54.4	136	59.0	181	4.08	52	4030	2680	27		0.544	(1)				
ALHA81013	IIAB	H		73	4.45	54.8	147	58.2	192	3.86	39	3740	2760	30.8		0.532	(1)	ALHA78100			
EET83245	IIAB	Anom		22	4.79	60.4	118	54.8	157	9.70	89	740	<100	0.026		1.07	(4)				
DRPA78009	IIB	Ogg	5	29	4.62	65.4	117	55.1	135	9.55	100	660	<60	0.014		1.2	(4)	9 paired			
DRPA78001-						59.9-												irons			
78008	IIB	Ogg				66.4											(3)				
EET83390	IIE	Anom	1.4	20	4.45	83.1	228	27.8	68.2	11.7	191	1150	420	3.86	9.6	1.17	(4)				
ALHA84165	IIIAB	Om	0.9	118	5.03	80.6	178	20.0	40	4.20	20	1090	300	3.49	12.9	0.646	(4)				
Y−790724	IIIAB	Om	1.1	124	4.97	79.9	192	20.4	35.9	3.66	31	1310	1100	9.25		0.556	(4)				
GRO85201	IIIAB	Om	1.1	18	5.15	84.7	146	20.0	42.3	7.41	<50	570	<30	0.360	6.2	1.01	(4)				
LEW86540	IIICD	Off	0.035	12	5.93	187.1	459	4.31		29.6	730	<80	<30	0.044	<1.3	1.81	(4)				
ALHA78252	IVA	Of	0.4	100	4.04	96=−3	154	2.44	0.138	13.3	6	460	<100	0.37		2.54	(1)				

*: see Table 1; #: similar to Hose Creek, the metal contains Si; ¥: FeS-rich(15%); Ref.: reference; ☆☆: ungrouped.

DRP-Derrick Peak (80°04′S, 156°23′E); GRO-Grosvenor Mountains(85°40′S, 175°00′E); EET-Elephant Moraine(76°11′S, 157°10′E); LEW-Lewis Cliff(84°17′S, 161°05′E); HOW-Mount Howe(87°22′S, 149°30′E); ALH-Allan Hills(76°43′S, 159°40′E); ILD-Inland Forts(77°38′S, 161°00′E); Lazaev(71°57′S, 11°30′E); Y-Yamato(71°30′S, 35°40′E); PGP-Purgatory Peak(77°20′S, 162°18′E); RKP-Reckling Peak (76°16′S, 159°15′E); PCA-Pecora Escapment(85°38′S, 68°42′E); TIL-Thiel Mountains(85°15′S, 91°00′E).

Reference: (1) Wang *et al.*, 1982, 1983; Malvin *et al.*, 1984. (2) Kracher *et al.*, 1980. (3) Jarosewich, 1990. (4) Wasson *et al.*, 1989; Wasson, 1990; Grossman, 1994.

have been collected. Among them, the chemical composition of an anomalous mesosiderite, RKPA91005, has been determined, it has 150 mg/g Cr, 4.73 mg/g Co, 100 mg/g Ni, 201 μg/g Cu, 12.9 μg/g Ga, 42.9 μg/g Ge, 12.3 μg/g As, 500 ng/g Sb, 790 ng/g W, <90 ng/g Re, 0.51 μg/g Ir and 1.48 μg/g Au. This is a metal-rich mesosiderite, but the contents of Ni, Ga and Ge are higher and that of Ir is lower by a factor of about 5~10 than the mesosiderites ever studied, so that it was classified as an anomalous mesosiderite. A metal- rich fragment LEW88432 contains about 6.9% Ni in metal and 19% Fa in olivine and 17% Fs in low-Ca pyroxene respectively, which is similar to H-chondritic metal.

Table 3. Distribution of chemical groups of 598 iron meteorites compared to that of 52 Antarctic iron meteorites

Group	Meteorites*		Antarctic irons		Deducted pailed meteorites
	Number	Freq. (%)	Number	Freq. (%)	
IAB	105	17.6	16	30.8	10 (27.8%)
IC	13	2.2	0	0	
IIAB	66	11	12	23.1	3 (8.3%)
IIC	7	1.2	0	0	
IID	16	2.7	0	0	
IIE	13	2.2	1	1.9	1 (2.7%)
IIF	5	0.8	0	0	
IIIAB	87	31.3	3	5.8	3 (8.3%)
IIICD	19	3.2	1	1.9	1 (2.7%)
IIIE	11	1.8	0	0	
IIIF	6	1.0	0	0	
IVA	43	7.2	1	1.9	1 (2.7%)
IVB	11	1.8	0	0	
Ungrouped	96	16.1	18	34.6	17 (47.2%)
Total	598		52		36

* : Data from Wasson *et al.*, 1989.

Low Ni and high Ge contents are characteristics of the most of IAB iron meteorites. But Yamato79164 (71g) has high Ni content (342 mg/g), it is the second IAB iron with the highest Ni content (Okitibbeha County is the first IAB member with the highest Ni content). In general, the masses of all IAB irons with high Ni contents are relatively small, which have been thought that these irons formed as very low-degree melts produced by impacts onto a chondritic regolith (Wasson *et al.*, 1989). The Au content of EET84300 iron is slightly lower (about 1.2) than that of normal IAB members. Silicate assemblages have been recognized in the EET83333 iron. They consist of olivine (Fa 5), orthopyroxene (Fs 7) and plagioclase (An 9). In the EET84300 they are abundant (about 5% of total area) and consist of olivine (Fa 0.8), orthopyroxene (Fs 6) and plagioclase (An 12). As suggested in earlier papers, IAB iron meteorites contain chondritic mineral assemblages. Allan Hillis A77283 contains diamonds and lonsdaleite of shock origin, their structures are also identical to those in Canyon Diablo iron meteorite. If Canyon Diablo diamonds were produced by impact with the Earth, it is possible that Allan Hillis A77283 was ejected to Antarctica from the Arizona Meteor Crater. On the basis of element abundance, Allan Hillis A77283 has about 7% Ni, 24% As and 11.7% Au higher than Canyon Diablo, but 5.6% Ga and 16. 7% Ir lower than the latter, indicating that they are not paired. In comparison with IAB iron meteorites, IIICD iron LEW86540 is characterized by lower Ga, Ge and Ir and higher As. The EET83390 (IIE) falls within all IIE element-Ni fields but silicates were not observed in its section.

ALHA78100 (IIAB) is a normal hexahedrite with abundant rhabdite inclusions. ALHA81013 is a hexahedrite having a structure of a low-Ni, high-Ir IIAB iron. Its Ir content indicates that ALHA81013 is paired with ALHA78100. DRPA78009 is a coarsest octahedrite of group IIB and is one of 9 paired IIAB irons in study. EET83245 iron shows evidence of severe heat alteration with selective melting that obscured the original texture, so it was classified as a IIAB-an member. ALHA78252 is a normal IVA group iron meteorite with very low Ga and Ge contents, and relatively low Co content.

Among the ungrouped irons, Yamato791076 has the highest Ge (264 μg/g) and it is paired with Yamato75031 (Clake, 1986). ILD83500 iron is closely similar in composition and (ataxitic) structure to other two high-Ni irons, i. e. Babb's Mill (Troost's) and South Byron (Wasson *et al.*, 1989). Lazarev is also an ungrouped iron (Zaslavskaya and Kolesov, 1980). New data (Wasson *et al.*, 1989) agree with literature data (Zaslavskaya and Kolesov, 1980) within the error of about 10%, except Co (6. 93 vs. 6. 0 mg/g), Ge (24. 0 vs. 47 μg/g), Ir (3. 94 vs. 2. 6 μg/g) and Pt (10. 5 vs. 7 μg/g). It has the highest terrestrial age in known irons, ~5 Ma (Nishiizumi *et al.*, 1987), and ILD83500 iron has the second highest terrestrial age, ~3 Ma. Both were found on Antarctic ice-free areas. The EET83230 ataxite seems in composition to be similar with Shingle Springs (169 mg/g Ni, 0. 206 μg/g Ga and 0. 13 μg/g Ge, Wasson *et al.*, 1989), but it has a Cu content 20 times lower than that in EET83230, 6 times lower Ga and 1. 7 times higher Ge content, ruling out a close genetic relationship between Shingle Springs and EET83230. The ALHA84233, EET87516, LEW85369 and LEW86211 irons differ in numerous ways from those observed in groups having the most similar Ga and Ni contents (Wasson, 1990). As compared to mesosiderite having a similar Ni content, Ir in ALHA84233 is low by a factor of 100, and Co, As, and Au are about 1. 2 times as high. The EET87516 has a structure and Ga content similar to those of group IVA iron meteorites, but its Ir content is too high by a factor of 10, its Co content is high by a factor of 1. 2, and its Ga content is low by a factor of 1. 2 for an iron meteorite with a Ni content of 92 mg/g. The meteorite LEW85369 contains Si dissolved in the Fe-Ni metal and the LEW86211 contains ~ 62% FeS by volume, after Soroti the second highest percentage in an iron meteorite. It is compositionally most similar to the low-Ni extreme of group IIE (Wasson, 1990), but its Ir and W are 34 and 1. 5 times as high. The LEW88055 iron contains mm-sized aubritic silicate inclusions, but its kamacite is Si-free. It is clearly different from the another meteorite which has aubritic silicates mixed with metallic Fe-Ni, Mt. Egerton. The LEW88055 iron has abundant distorted Neumann bands in the metal and distorted clinoenstatite twinning in the aubritic inclusions, and some small taenite area contain martensitic plessite and are associated with schreibersite along grain boundaries. So it belongs to ungrouped iron (Prinz *et al.*, 1991). It is possible that this meteorite formed in different portion of the solar system and presumably came together by severe impact collision.

3 Discussion

The chondritic body with metal and silicates differentiated completely to metal core by melting process. If the iron meteorite body with core results from this mechanism, it would form by homogenous agglomeration and accretion of solar nebular condensates. Therefore, the magmatic irons are defined to mean "formed in molten regions having dimensions >100 m, and probably >1 km with all meteorites in each group forming from a single magma". Nonmagmatic irons mean "formed in small (10 cm~50 cm) pools of molten matter; in many cases one meteorite formed in one pool" (Wasson and Wang, 1986). They formed by partial melting, and originated as individual pools of impact-produced melt in the near-surface region of a chondritic parent body. The original metallic masses were similar in size to recovered iron meteorites, and they were embedded in a silicate matrix like raisins in raisin bread (Urey, 1959). In addition to 13 chemical groups of irons, a considerable number of irons can not be classified by their structure and chemical composition and are so called "ungrouped" irons.

The principal parameters to classify irons are based on their structure and composition. The key diagrams are log element (Co, Cu, Ga, Ge, As, Sb, W, Re, Ir, Ru, Os, Pt and Au)-logNi for different chemical groups of irons. Besides, some parameters are also important. For example, the composition and diffusion coefficient of equilibrated phase, cosmic ray exposure age and the component and abundance of minerals, including troilite (FeS), schreibersite [$(Fe,Ni)_3P$], haxonite [$(Fe, Ni)_{23}C_6$], daubreelite ($FeCr_2S_4$), cohenite(Fe_3C), graphite (C), carlsbergite (CrN), chromite ($FeCr_2O_4$), sphalerite (ZnS) and so on (but excluding kamacite and taenite). These minerals show the abundances of minor elements such as C, P, N, Cr, S and Zn. The differences between magmatic and nonmagmatic irons are: (1) magmatic iron meteorites are essentially silicate free or were only observed in the core-mantle interface of some samples; the primitive rare gases are free or very low; the I-Xe formation interval age (since I^{129} was composed) is larger than that of chondritic meteorites; The largest taenite grain can exceed 50 cm, which formed by fractional crystallization of melting core; Large systematic fractionation of Ir (and Re and Os) can be observed in the largest magmatic group, for example, Ir concentrations span a range of ~6000 in group IIAB and a range of ~2000 in group IIIAB. Systematic fractionations are observed among other siderophiles in these groups; Linear arrays are observed on all log siderophile-log Ni diagrams. The correlations with Ni are positive if the k_x value, the solid/liquid partition ratio, is less than unity, and negative if the k_x value is greater than unity (Wasson and Wang, 1986); The fractionation model of the solar nebula was never observed. (2) nonmagmatic irons contain massive silicates having chondritic compositions and planetary rare gases; the I-Xe formation interval age is similar to that of chondritic meteorite; Most elements show systematic fractionations, but the slopes on log element-log Ni diagrams are generally much smaller; the silicates contain albitic plagioclase, demonstrating that these silicates have spent little time at temperature above the albite melting point, ~1500 K; The fractionation model of the solar nebula has been observed. In addition, oxygen isotope compositions ($\delta^{17}O$-$\delta^{18}O$ diagram) of the differentiated silicates in IIE iron, Colomera, fall or close to the region of H chondrites, and it has a high Rb-Sr age, 4.51±0.04Ga (Sanz *et* *al.* , 1970). This age is essentially the same as the age of the solar system. The Colomera $^{87}Sr/^{86}Sr$ initial ratio implies its formation ~ 59 Ma later than the Allende CV-chondritic inclusion.

High abundance of ungrouped iron meteorites in Antarctica was ever noted. According to Wasson's statistics (1990) , ungrouped non-Antarctic irons are 15 percent of all iron meteorites collected in the world, but 12 ungrouped of 31 Antarctic irons occupy ~ 39 %. Our recent statistics shows that ungrouped Antarctic irons amount to 34. 6 %. Not counting paired meteorites, the ungrouped Antarctic irons account for about 47. 2 %, which is much higher than the abundance of non-Antarctic irons. The differences between the Antarctic irons and those found in the rest of the world are: (1) the median terrestrial age of Antarctic irons may be older, which of that found on the ice is roughly 100 ka. Three Antarctic irons found on ice-free surfaces have terrestrial ages of 1 to 5 Ma. The median terrestrial age of non-Antarctic irons is 20 ka. (2) the median size of Antarctic irons is smaller. The median mass of 50 Antarctic irons under study is 6. 6 kg, among them, that of 15 ungrouped irons is 500 g (Grossman, 1994), whereas that of non-Antarctic irons is about 30 kg(Buchwald, 1975). Thus, there is almost two orders of magnitude difference in the median mass of the two populations. Wasson *et al.* (1989) suggested that the percentage of ungrouped Antarctic irons was determined by their mass, which was generally small. During cratering, the ejection velocity of small mass iron is much greater than that of large mass iron, the range of orbits is also much greater, and easily escaped from asteroid belt and their perihelion was reduced so that it was captured by the Earth. Whether this explanation is correct or not, it requires to be detailedly studied. Except the ungrouped irons, Antarctic irons evidently have high abundances of IAB, low IIIAB groups (Table 3) and most ungrouped irons have silicate inclusions (Table 2), which are apparently of shock origin. It seems that nonmagmatic irons are enriched and magmatic irons are depleted in Antarctica, which is related with formation regions of the parent bodies in addition to the orbital ejection angle. It is possible that the nonmagmatic irons formed in the interior side of asteroid belt or closer to the Sun. As compared with magmatic irons, the nonmagmatic irons have smaller primitive parent bodies and suffer from collision more frequently.

It should be pointed out that the ungrouped irons in Antarctica have a relatively high ratio, except some new chondritic classes(CK, CR, R chondrites, lunar meteorites and martial meteorites), indicating that some new groups of iron meteorites and their formation and evolution processes are not understood. The existing taxonomy parameters need to be revised and supplemented, and the study on ungrouped irons should be enhanced in the future.

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