Supplementary Table 1.

Elemental abundances in reference materials as obtained using LA-ICP-TOF-MS mapping (LOD: limit of detection; n.d.: not determined; <LOD: below the LOD).

Samples	LOD	BHVO-2G		GOR128-G		Durango apatite (in-house)	
		This work (n=4)	Preferred values[1]	This work (n=4)	Preferred values[2]	This work (n=3)	Reference values[3,4]
(% m/m)							
Na	0.04	1.9 ± 0.2	1.8 ± 0.1	0.63 ± 0.09	0.426 ± 0.019		
Mg	0.01	4.1 ± 0.6	4.30 ± 0.01	14 ± 1	15.7 ± 0.2	<LOD	0.00622 ± 0.00025
Al	0.007	6.5 ± 0.6	7.20 ± 0.05	4.5 ± 0.7	5.24 ± 0.09		
Si	0.4	25 ± 1	23.0 ± 0.0	24 ± 2	21.5 ± 0.2	<LOD	0.219 ± 0.008
P	0.06	0.12 ± 0.01	0.13 ± 0.01	<LOD	0.011 ± 0.002	20 ± 1	18.7 ± 0.1
K	0.01	0.33 ± 0.09	0.42 ± 0.02	0.13 ± 0.04	0.030 ± 0.004		
Ca	0.8	6.8 ± 0.6	8.15 ± 0.07	3.7 ± 0.3	4.46 ± 0.09	34 ± 2	40.1 ± 0.3
Ti	0.003	1.5 ± 0.1	1.67 ± 0.01	0.15 ± 0.02	0.173 ± 0.007		
Cr	0.002	0.031 ± 0.008	0.0293 ± 0.0012	0.22 ± 0.03	0.227 ± 0.017		
Mn	0.0008	0.13 ± 0.01	0.13 ± 0.02	0.13 ± 0.01	0.136 ± 0.007	0.0074 ± 0.0006	0.00718 ± 0.00027
Fe	0.03	7.7 ± 0.5	8.78 ± 0.08	7.1 ± 0.3	7.63 ± 0.09	<LOD	0.0270 ± 0.0010
(µg/g)							
Sc	10	29 ± 3	33 ± 2	29 ± 4	32.1 ± 1.4		
V	1	320 ± 10	308 ± 19	180 ± 10	189 ± 13	29 ± 3	20.2 ± 0.7
Co	4	43 ± 5	116 ± 7	85 ± 6	92.4 ± 6.2		
Ni	15	120 ± 30	116 ± 7	1100 ± 100	1074 ± 61		
Cu	1	120 ± 10	127 ± 11	86 ± 24	63.8 ± 12.5		
Zn	2	97 ± 10	102 ± 6	120 ± 30	74.7 ± 6.7		
Rb	0.9	9.0 ± 1.6	9.2 ± 0.0	<2.0	0.406 ± 0.025	n.d.	0.04 ± 0.01
Sr	0.4	340 ± 30	396 ± 1	29 ± 5	30 ± 1	490 ± 60	516 ± 6
Y	0.4	18 ± 2	26 ± 2	8.7 ± 0.7	11.8 ± 0.5	1300 ± 100	1057 ± 6
Zr	0.8	160 ± 30	170 ± 7	12 ± 2	10.0 ± 0.5		
Nb	0.4	15 ± 1	18.3 ± 0.8	<LOD	0.099 ± 0.007		
Ba	2	120 ± 10	131 ± 2	8.6 ± 4.6	1.06 ± 0.03	n.d.	1.8 ± 0.2
La	0.5	12 ± 1	15.2 ± 0.2	<LOD	0.121 ± 0.004	5300 ± 300	4443 ± 22
Ce	0.4	33 ± 2	37.6 ± 0.2	1.4 ± 0.5	0.450 ± 0.016	7000 ± 500	6066 ± 31
Pr	0.2	4.0 ± 0.2	5.35 ± 0.22	<LOD	0.100 ± 0.004	580 ± 40	524 ± 3
Nd	0.4	19 ± 1	24.5 ± 0.2	0.70 ± 0.06	0.784 ± 0.047	2000 ± 100	1770 ± 12
Sm	0.2	4.6 ± 0.5	6.10 ± 0.03	0.46 ± 0.19	0.525 ± 0.02	290 ± 20	256 ± 3
Eu	0.2	1.4 ± 0.1	2.07 ± 0.01	0.27 ± 0.07	0.264 ± 0.008	24 ± 1	22.8 ± 0.4
Gd	0.3	4.2 ± 0.3	6.16 ± 0.05	0.81 ± 0.04	1.17 ± 0.04	270 ± 30	239 ± 2
Tb	0.06	0.61 ± 0.06	0.92 ± 0.04	0.21 ± 0.04	0.248 ± 0.012	36 ± 3	30.4 ± 0.2
Dy	0.3	3.7 ± 0.5	5.28 ± 0.05	1.5 ± 0.2	1.98 ± 0.07	210 ± 10	178 ± 2
Ho	0.03	0.64 ± 0.09	0.98 ± 0.04	0.36 ± 0.04	0.443 ± 0.019	42 ± 3	35.1 ± 0.4
Er	0.09	1.9 ± 0.4	2.56 ± 0.02	1.2 ± 0.2	1.40 ± 0.06	120 ± 10	99.2 ± 1.1
Tm	0.08	0.25 ± 0.05	0.34 ± 0.02	0.18 ± 0.02	0.204 ± 0.009	14 ± 1	12.2 ± 0.2
Yb	0.2	1.4 ± 0.1	2.01 ± 0.02	1.1 ± 0.4	1.41 ± 0.06	73 ± 5	63.2 ± 0.9
Lu	0.04	0.20 ± 0.01	0.279 ± 0.003	0.19 ± 0.05	0.206 ± 0.009	7.4 ± 0.4	6.44 ± 0.14
Hf	0.1	3.4 ± 0.4	4.32 ± 0.18	0.29 ± 0.03	0.349 ± 0.017	n.d.	0.04 ± 0.01
Ta	0.04	0.81 ± 0.09	1.15 ± 0.10	<LOD	0.019 ± 0.001		
Pb	0.3	2.4 ± 0.3	1.7 ± 0.2	2.0 ± 0.9	0.345 ± 0.043	n.d.	0.7 ± 0.1
Th	0.05	0.94 ± 0.17	1.22 ± 0.05	0.15 ± 0.07	0.008 ± 0.001	490 ± 20	412 ± 4
U	0.04	0.41 ± 0.04	0.403 ± 0.003	<LOD	0.0123 ± 0.0012	21 ± 1	17.8 ± 0.1

The uncertainties reported represent 1SD. LOD values for each analysis point are calculated from the blank intensities in the same analytical session based on the IUPAC approximation formula.[5] The reference values for Mg, Si, P, Ca, V, Mn, and Fe in in-house Durango apatite were obtained using ICP-AES, and those for Sr, Y, REEs, Th, and U were obtained using ICP-Q-MS combined with the isotope dilution method. The reference values for Rb, Ba, and Pb in in-house Durango apatite are from Marks *et al*. (2012),[3] and that for Hf is from Sha and Chappell (1999).[4]

Supplementary Table 2.

Elemental abundances (µg/g) in reference samples obtained using LA-ICP-SF-MS spot drilling analysis (LOD: limit of detection).

Samples	for phosphate analysis		for pyroxene analysis			for feldspar and olivine analysis			Preferred values[2]		
	LOD	ATHO-G This work (n=10)	LOD	GOR128-G This work (n=6)	GOR132-G This work (n=6)	LOD	GOR128-G This work (n=7)	GOR132-G This work (n=7)	ATHO-G	GOR128-G	GOR132-G
Sc			0.06	38 ± 2	43 ± 2					32.1 ± 1.4	36.5 ± 1.2
V	0.009	4.4 ± 0.8							3.91 ± 0.34	189 ± 13	214 ± 17
Zn			0.06	72 ± 7	67 ± 5	0.06	69 ± 9	68 ± 5		74.7 ± 6.7	76.8 ± 12.5
Mn	0.09	590 ± 40				0.03	1400 ± 100	1200 ± 100	821 ± 39	1363 ± 70	1193 ± 54
Rb	0.02	68 ± 5	0.007	0.35 ± 0.05	1.9 ± 0.1	0.005	0.42 ± 0.03	2.2 ± 0.2	65.3 ± 3	0.406 ± 0.025	2.10 ± 0.10
Sr	0.006	99 ± 8	0.002	31 ± 2	15 ± 1	0.002	33 ± 2	16 ± 1	94.1 ± 2.7	30.0 ± 1.0	15.3 ± 0.6
Y	0.002	100 ± 10	0.0009	15 ± 1	16 ± 1	0.001	15 ± 2	16 ± 2	94.5 ± 3.5	11.8 ± 0.5	12.9 ± 0.5
Ba	0.008	510 ± 60	0.002	1.0 ± 0.1	0.78 ± 0.14	0.002	1.1 ± 0.1	0.76 ± 0.08	547 ± 16	1.06 ± 0.03	0.815 ± 0.062
La	0.0007	62 ± 7	0.0002	0.13 ± 0.01	0.085 ± 0.012	0.0003	0.15 ± 0.03	0.091 ± 0.009	55.6 ± 1.5	0.121 ± 0.004	0.0842 ± 0.0029
Ce	0.0005	130 ± 10	0.0002	0.41 ± 0.04	0.31 ± 0.05	0.0003	0.46 ± 0.06	0.36 ± 0.02	121 ± 4	0.450 ± 0.016	0.393 ± 0.018
Pr	0.0006	16 ± 2	0.0002	0.10 ± 0.01	0.082 ± 0.012	0.0003	0.11 ± 0.01	0.091 ± 0.008	14.6 ± 0.4	0.100 ± 0.004	0.089 ± 0.004
Nd	0.003	71 ± 9	0.0007	0.77 ± 0.10	0.72 ± 0.08	0.0009	0.85 ± 0.05	0.74 ± 0.04	60.9 ± 2.0	0.784 ± 0.047	0.689 ± 0.017
Sm	0.007	16 ± 2	0.004	0.51 ± 0.10	0.50 ± 0.11	0.002	0.59 ± 0.06	0.58 ± 0.06	14.2 ± 0.4	0.525 ± 0.02	0.508 ± 0.015
Eu	0.001	3.0 ± 0.3	0.0006	0.26 ± 0.04	0.25 ± 0.03	0.0007	0.28 ± 0.02	0.26 ± 0.02	2.76 ± 0.1	0.264 ± 0.008	0.255 ± 0.007
Gd	0.006	18 ± 2	0.003	1.3 ± 0.2	1.3 ± 0.2	0.002	1.4 ± 0.1	1.4 ± 0.1	15.3 ± 0.7	1.17 ± 0.04	1.19 ± 0.04
Tb	0.001	2.9 ± 0.4	0.0005	0.28 ± 0.04	0.30 ± 0.04	0.0004	0.29 ± 0.02	0.30 ± 0.03	2.51 ± 0.08	0.248 ± 0.012	0.269 ± 0.011
Dy	0.01	18 ± 3	0.004	2.3 ± 0.4	2.5 ± 0.3	0.0009	2.4 ± 0.2	2.5 ± 0.3	16.2 ± 0.7	1.98 ± 0.07	2.15 ± 0.06
Ho	0.0009	3.9 ± 0.6	0.0004	0.55 ± 0.10	0.56 ± 0.08	0.0005	0.52 ± 0.04	0.57 ± 0.06	3.43 ± 0.11	0.443 ± 0.019	0.507 ± 0.019
Er	0.002	12 ± 2	0.0005	1.7 ± 0.2	1.8 ± 0.3	0.0009	1.7 ± 0.2	1.9 ± 0.2	10.3 ± 0.5	1.40 ± 0.06	1.56 ± 0.05
Tm	0.004	1.7 ± 0.2	0.002	0.23 ± 0.05	0.27 ± 0.05	0.001	0.22 ± 0.04	0.25 ± 0.05	1.52 ± 0.07	0.204 ± 0.009	0.234 ± 0.009
Yb	0.002	12 ± 2	0.0006	1.5 ± 0.3	1.8 ± 0.3	0.001	1.6 ± 0.1	1.8 ± 0.2	10.5 ± 0.4	1.41 ± 0.06	1.61 ± 0.04
Lu	0.0009	1.8 ± 0.3	0.0003	0.24 ± 0.04	0.26 ± 0.04	0.0004	0.24 ± 0.03	0.26 ± 0.03	1.54 ± 0.05	0.206 ± 0.009	0.237 ± 0.009
Hf	0.003	15 ± 1	0.0008	0.38 ± 0.08	0.38 ± 0.08	0.001	0.41 ± 0.04	0.42 ± 0.06	13.7 ± 0.5	0.349 ± 0.017	0.357 ± 0.018
Pb	0.0008	2.7 ± 0.5	0.002	0.25 ± 0.06	18 ± 2	0.002	0.27 ± 0.06	18 ± 3	5.67 ± 0.62	0.345 ± 0.043	19.5 ± 1.7
Th	0.0007	9.6 ± 1.0	0.0004	0.0060 ± 0.0020	0.005 ± 0.003	0.0005	0.0092 ± 0.0025	0.0080 ± 0.0070	7.4 ± 0.27	0.008 ± 0.001	0.009 ± 0.003
U	0.001	2.8 ± 0.5	0.0001	0.013 ± 0.003	0.031 ± 0.006	0.0002	0.011 ± 0.004	0.034 ± 0.013	2.37 ± 0.12	0.0123 ± 0.0012	0.048 ± 0.005

The uncertainties reported represent 1SD. LOD values are calculated from 3SD of the blank intensities in the same analytical session. Where the abundance of an element was below the LOD, the LOD value is substituted instead of the abundance for the average.

Supplementary Table 3.

Elemental abundances in whole areas as obtained using LA-ICP-TOF-MS mapping (<LOD: below the LOD).

Samples	A 09618 (H5)				Y-790960 (H7)				H chondrite mean[6,7]	
	Whole area		Bulk rock[6]		Whole area		Bulk rock[6]			
(% m/m)										
Na	0.65 ±	0.20	0.59 ±	0.02	0.57 ±	0.17	0.64 ±	0.03	0.638 ±	0.012
Mg	13 ±	4	13 ±	0	12 ±	4	15 ±	0	14.0 ±	0.1
Al	1.0 ±	0.3	0.88 ±	0.00	0.37 ±	0.11	1.0 ±	0.0	1.13 ±	0.03
Si	16 ±	5			17 ±	5			17.1 ±	0.26
P	0.091 ±	0.027	0.097 ±	0.001	0.33 ±	0.10	0.10 ±	0.00	0.118 ±	0.005
K	0.11 ±	0.03	0.068 ±	0.001	0.090 ±	0.027	0.071 ±	0.001	0.0747 ±	0.0033
Ca	1.3 ±	0.4	1.1 ±	0.0	0.92 ±	0.28	0.99 ±	0.01	1.24 ±	0.03
Ti	0.054 ±	0.016	0.057 ±	0.002	0.059 ±	0.018	0.058 ±	0.002	0.0719 ±	0.0024
Cr	0.17 ±	0.05	0.37 ±	0.00	0.20 ±	0.06	0.42 ±	0.00	0.356 ±	0.008
Mn	0.25 ±	0.07	0.23 ±	0.00	0.24 ±	0.07	0.24 ±	0.00	0.240 ±	0.006
Fe	29 ±	9	24 ±	0	29 ±	9	26 ±	0	27.5 ±	0.3
Ni	1.6 ±	0.5	1.5 ±	0.0	2.3 ±	0.7	1.7 ±	0.1	1.74 ±	0.04
(μg/g)										
Sc	<LOD				12 ±	3			7.9	
V	54 ±	16			53 ±	16			74	
Co	740 ±	200	750 ±	10	1100 ±	300	760 ±	0	810	
Cu	160 ±	50	79.0 ±	0.0	300 ±	90	84.5 ±	1.9	82	
Zn	130 ±	40	48.4 ±	0.1	110 ±	30	64.6 ±	1.1	47	
Rb	2.2 ±	0.7	1.94 ±	0.02	2.8 ±	0.9	2.61 ±	0.18	2.9	
Sr	7.5 ±	2.3	8.06 ±	0.02	5.5 ±	1.7	8.72 ±	0.15	10	
Y	1.2 ±	0.4	1.67 ±	0.02	1.2 ±	0.4	1.86 ±	0.04	2.20	
Zr	8.3 ±	2.5	4.42 ±	0.01	14 ±	4	4.63 ±	0.15	6.30	
Nb	0.53 ±	0.16	0.356 ±	0.003	0.87 ±	0.26	0.364 ±	0.017	0.360	
Ba	3.7 ±	1.1	2.90 ±	0.03	4.4 ±	1.3	3.07 ±	0.20	4.2	
(ng/g)										
La	1400 ±	400	278 ±	4	<LOD		307 ±	15	309 ±	26
Ce	2100 ±	600	707 ±	8	5500 ±	1700	777 ±	20	816 ±	68
Pr	240 ±	70	104 ±	2	<LOD		115 ±	10		
Nd	860 ±	260	537 ±	9	500 ±	150	558 ±	27	588 ±	37
Sm	<LOD		168 ±	5	<LOD		183 ±	20	189 ±	11
Eu	<LOD		67.6 ±	1.1	<LOD		67.3 ±	4.3	71.5 ±	2.4
Gd	<LOD		242 ±	8	<LOD		257 ±	6	255 ±	14
Tb	<LOD		43.9 ±	0.3	<LOD		46.7 ±	2.3		
Dy	<LOD		294 ±	8	<LOD		306 ±	5	320 ±	17
Ho	51 ±	15	66.2 ±	0.4	52 ±	16	66.9 ±	2.4		
Er	160 ±	50	200 ±	8	140 ±	40	208 ±	14	210 ±	11
Tm	<LOD		30.3 ±	0.2	<LOD		31.1 ±	1.1		
Yb	<LOD		197 ±	4	<LOD		205 ±	6	207 ±	11
Lu	<LOD		30.6 ±	0.7	<LOD		29.7 ±	0.6	32.0 ±	1.5
Hf	220 ±	70	136 ±	4	220 ±	70	135 ±	2	180	
Ta	<LOD		37.5 ±	13.6	<LOD		14.4 ±	1.4	22.0	
Pb	4300 ±	1300	97.3 ±	4.4	2400 ±	700	71.0 ±	13.4	240	
Th	61 ±	18	40.0 ±	3.5	56 ±	17	33.4 ±	1.0	41.5 ±	17.4
U	170 ±	50	13.0 ±	0.9	<LOD		8.47 ±	0.28	11.8 ±	6.1

The uncertainties reported represent 30% relative uncertainty for whole area. The bulk rock abundances of Ta and Pb in the meteorite samples were determined using the same aliquots and the same analytical procedure for ICP-Q-MS as those used in Maeda *et al*. (2021).[6] The abundances of Sc, V, Ta, and Pb for H chondrite mean are from Wasson and Kallemeyn (1988).[7]

Supplementary Table 4.

Elemental abundances in **merrillite** (TOF: abundances obtained based on LA-ICP-TOF-MS mapping; Spot: average abundances obtained based on EPMA in % m/m and LA-ICP-SF-MS spot analysis in µg/g; Min: the minimum abundances for Spot; Max: the maximum abundances for Spot; n: number of analyses and samples used for calculating the average in this study and literature values, respectively; <LOD: below the LOD).

Meteorite	A 09618 (H5)							Y-790960 (H7)							Literature values[8]		
	TOF	U	Spot	U	Min	Max	n	TOF	U	Spot	U	Min	Max	n	Mean	U	n
(% m/m)																	
F			<LOD		<LOD	<LOD	8			<LOD		<LOD	<LOD	12			
Na_2O	2.9 ±	0.6	2.74 ±	0.14	2.52	2.91	8			2.84 ±	0.15	2.62	3.09	12	2.76 ±	0.07	7
MgO	4.2 ±	0.8	3.14 ±	0.09	2.97	3.24	8	0.53 ±	0.11	3.17 ±	0.11	2.98	3.31	12	3.52 ±	0.07	7
Al_2O_3	0.62 ±	0.12													0.04 ±	0.01	7
SiO_2	3.6 ±	0.7	<LOD		<LOD	<LOD	8	4.3 ±	0.9	<LOD		<LOD	<LOD	12	0.17 ±	0.13	6
P_2O_5	36 ±	7	46.4 ±	1.2	44.2	48.3	8	45 ±	9	46.0 ±	0.7	45.1	46.8	12	46.4 ±	0.5	7
Cl			0.03 ±	0.02	<LOD	0.06	8			<LOD		<LOD	<LOD	12	0.06		2
K_2O	0.15 ±	0.03													0.06 ±	0.01	7
CaO	33 ±	7	47.3 ±	0.5	46.4	47.8	8	30 ±	6	47.7 ±	0.2	47.3	47.9	12	46.5 ±	0.5	7
TiO_2	0.0092 ±	0.0018													0.0292 ±	0.0128	6
Cr_2O_3	0.087 ±	0.017													0.0033 ±	0.0024	5
FeO	17 ±	3	0.69 ±	0.67	0.23	2.29	8	14 ±	3	0.52 ±	0.21	0.30	1.08	12	0.57 ±	0.15	7
NiO	1.5 ±	0.3															
Total	99.7 ±	10.5	100.3 ±	1.4				94.8 ±	11.3	100.2 ±	0.8				100.0 ±	0.7	
(µg/g)																	
Sc	<LOD														9.3 ±	3.0	7
V	7.8 ±	2	3.1 ±	0.9	2.0	4.4	5	68 ±	14	1.7 ±	0.0	1.7	1.7	2	3.5 ±	0.8	6
Mn	350 ±	70	215 ±	67	124	277	5	680 ±	140	112 ±	5	106	117	2	271 ±	84	6
Co	590 ±	120													17 ±	12	6
Cu	270 ±	50															
Zn	150 ±	30															
Rb	2.2 ±	0.4	1.3 ±	0.3	0.9	1.6	5			1.9 ±	0.3	1.6	2.2	2	1.2 ±	0.7	5
Sr	30 ±	6	33 ±	1	31	34	5	30 ±	6	32 ±	2	30	34	2	54 ±	21	7
Y	230 ±	50	322 ±	12	308	336	5	160 ±	30	378 ±	32	349	424	4	270 ±	142	7
Zr	2.4 ±	0.5													2.8 ±	3.3	5
Nb	<LOD														0.30 ±	0.18	6
Ba	7.3 ±	1.5	0.78 ±	0.06	0.71	0.87	5			0.24 ±	0.06	0.18	0.30	2	7.0 ±	10.3	5
La	60 ±	12	61 ±	3	58	66	5	29 ±	6	66 ±	5	64	73	4	56.8 ±	26.9	7
Ce	150 ±	30	174 ±	4	171	181	5	100 ±	20	189 ±	8	180	199	4	157 ±	74	7
Pr	19 ±	4	24 ±	0	24	25	5	11 ±	2	27 ±	1	26	28	4	22.4 ±	11.4	7
Nd	82 ±	16	119 ±	3	115	121	5	57 ±	11	135 ±	9	129	149	4	104 ±	55	7
Sm	25 ±	5	36 ±	1	34	37	5	17 ±	3	41 ±	4	38	47	4	31.5 ±	17.2	7
Eu	1.2 ±	0.2	1.6 ±	0.0	1.5	1.6	5	0.70 ±	0.14	1.6 ±	0.2	1.4	1.7	4	2.0 ±	0.4	7
Gd	30 ±	6	49 ±	2	46	50	5	23 ±	5	57 ±	6	53	65	4	39.7 ±	23.6	7
Tb	5.7 ±	1.1	8.2 ±	0.3	7.7	8.5	5	4.0 ±	0.8	9.8 ±	0.7	9.1	11	4	7.08 ±	3.98	7
Dy	37 ±	7	56 ±	2	52	58	5	29 ±	6	67 ±	5	63	75	4	46.1 ±	25.4	7
Ho	8.1 ±	1.6	12 ±	0	11	12	5	5.9 ±	1.2	14 ±	1	13	16	4	9.89 ±	5.40	7
Er	27 ±	5	35 ±	1	33	36	5	18 ±	4	42 ±	4	39	48	4	27.8 ±	14.7	7
Tm	3.2 ±	0.6	4.7 ±	0.1	4.5	4.9	5	2.5 ±	0.5	5.7 ±	0.5	5.2	6.4	4	3.75 ±	1.78	7
Yb	19 ±	4	29 ±	1	28	30	5	15 ±	3	34 ±	3	32	38	4	23.0 ±	10.2	7
Lu	2.9 ±	0.6	4.0 ±	0.1	3.8	4.1	5	2.1 ±	0.4	4.8 ±	0.3	4.4	5.1	4	3.20 ±	1.29	7
Hf	<LOD		0.005 ±	0.002	0.003	0.006	5			0.005 ±	0.002	<LOD	0.008	2	0.083 ±	0.101	5
Ta	0.059 ±	0.012													0.010 ±	0.008	5
Pb	34 ±	7	0.53 ±	0.08	0.42	0.65	5			0.72 ±	0.08	0.66	0.85	4	1.62 ±	0.89	4
Th	0.36 ±	0.07	3.6 ±	3.0	1.4	7.0	5	0.84 ±	0.17	2.8 ±	0.4	2.3	3.3	4	1.91 ±	1.43	7
U	0.049 ±	0.010	0.16 ±	0.07	0.09	0.27	5	0.084 ±	0.017	0.12 ±	0.09	0.02	0.23	4	0.27 ±	0.14	7

The uncertainties reported represent 20% relative uncertainty and 1SD for TOF and Spot, respectively. Where the number of analyses used for the average is two, the uncertainties reflect the range of the two values used for the average. Literature values and their uncertainties represent the mean values of merrillite in ordinary chondrites and the 95% confidence interval, respectively, calculated excluding anomalously high abundances.[8] Values with more than 100% relative uncertainty are shown in red. LOD values for EPMA are 3SD of the blank intensities in % m/m: 0.12 for F, 0.07 for Na_2O, 0.05 for MgO, 0.05 for SiO_2, 0.12 for P_2O_5, 0.02 for Cl, 0.02 for CaO, and 0.08 for FeO. Where the abundance of an element was below the LOD for Spot, the LOD value is substituted instead of the abundance for the average unless every analysis is below the LOD.

Supplementary Table 5.

Elemental abundances in **apatite** (TOF: abundances obtained based on LA-ICP-TOF-MS mapping; Spot: average abundances obtained based on EPMA in % m/m and LA-ICP-SF-MS spot analysis in µg/g; Min: the minimum abundances for Spot; Max: the maximum abundances for Spot; n: number of analyses and samples used for calculating the average in this study and literature values, respectively; <LOD: below the LOD).

Meteorite	A 09618 (H5)							Y-790960 (H7)							Literature values[8]		
	TOF	U	Spot	U	Min	Max	n	TOF	U	Spot	U	Min	Max	n	Mean	U	n
(% m/m)																	
F			0.62 ±	0.13	0.48	0.82	7			0.32 ±	0.14	<LOD	0.47	12	0.44 ±	0.19	6
Na_2O	0.78 ±	0.16	0.35 ±	0.06	0.28	0.45	7			0.35 ±	0.06	0.23	0.44	12	0.35 ±	0.09	6
MgO	0.51 ±	0.10	<LOD		<LOD	<LOD	7	0.21 ±	0.04	<LOD		<LOD	<LOD	12	0.06 ±	0.02	6
Al_2O_3	0.36 ±	0.07													0.04 ±	0.02	6
SiO_2	2.1 ±	0.4	0.09 ±	0.01	0.07	0.11	7	2.7 ±	0.5	0.09 ±	0.03	<LOD	0.14	12	0.15 ±	0.18	5
P_2O_5	36 ±	7	40.8 ±	1.3	38.3	41.9	7	40 ±	8	41.2 ±	0.9	39.9	42.7	12	41.1 ±	0.8	6
Cl			4.92 ±	0.38	4.25	5.30	7			5.74 ±	0.36	5.20	6.24	12	5.45 ±	0.42	6
K_2O	0.065 ±	0.013													0.03		6
CaO	41 ±	8	54.5 ±	0.8	53.3	55.4	7	39 ±	8	54.5 ±	0.7	52.9	55.6	12	53.1 ±	0.6	6
TiO_2	0.0095 ±	0.0019													0.0423 ±	0.0405	5
Cr_2O_3	0.0050 ±	0.0010													0.0241 ±	0.0256	6
FeO	18 ±	4	0.73 ±	0.57	0.27	1.84	7	13 ±	3	0.56 ±	0.54	0.20	1.94	12	0.46 ±	0.33	6
NiO	1.1 ±	0.2															
Total	99.8 ±	11.5	101.9 ±	1.7				94.9 ±	11.5	102.8 ±	1.3				101.2 ±	1.1	
X-site																	
X_F			0.17 ±	0.04	0.13	0.22	7			0.09 ±	0.04	0.03	0.12	11			
X_{Cl}			0.72 ±	0.06	0.61	0.80	7			0.84 ±	0.06	0.76	0.92	11			
X_{other}			0.11 ±	0.06	0.03	0.17	7			0.08 ±	0.04	0.03	0.18	11			
(µg/g)																	
Sc	<LOD														5.0 ±	2.4	6
V	1.5 ±	0.3	0.22 ±	0.03	0.22	0.22	1	33 ±	7	0.36 ±	0.48	0.05	0.92	3	16.1 ±	19.6	6
Mn	470 ±	90	138 ±	21	138	138	1	560 ±	110	160 ±	51	130	219	3	531 ±	518	6
Co	530 ±	100													11.0 ±	8.0	5
Cu	61 ±	12															
Zn	140 ±	30															
Rb	1.4 ±	0.3	0.12 ±	0.09	0.07	0.22	3			0.08 ±	0.08	0.03	0.17	3	0.8 ±	0.5	5
Sr	79 ±	16	94 ±	5	90	100	4	80 ±	16	107 ±	4	102	110	3	145 ±	87	5
Y	14 ±	3	21 ±	14	14	42	4	6.0 ±	1.2	18 ±	1	17	19	3	21 ±	11	6
Zr	4.5 ±	0.9													5.2 ±	2.6	5
Nb	<LOD														0.30 ±	0.43	5
Ba	4.3 ±	0.9	1.1 ±	0.4	0.8	1.6	3			0.73 ±	0.14	0.58	0.85	3	3.6 ±	4.9	5
La	16 ±	3	15 ±	5	12	22	4	4.6 ±	0.9	13 ±	1	12	14	3	15.0 ±	8.6	6
Ce	32 ±	6	29 ±	10	23	44	4	17 ±	3	24 ±	1	23	24	3	30.2 ±	14.6	6
Pr	2.9 ±	0.6	3.5 ±	1.3	2.7	5.3	4	1.1 ±	0.2	3.0 ±	0.1	2.9	3.1	3	3.59 ±	1.78	6
Nd	11 ±	2	14 ±	6	11	23	4	4.5 ±	0.9	13 ±	1	12	14	3	14.3 ±	7.5	6
Sm	1.5 ±	0.3	3.4 ±	1.6	2.5	5.7	4	1.1 ±	0.2	3.1 ±	0.3	2.9	3.5	3	3.31 ±	1.75	6
Eu	0.70 ±	0.14	0.93 ±	0.09	0.85	1.1	4	0.48 ±	0.10	1.1 ±	0.1	1.0	1.1	3	1.13 ±	0.42	6
Gd	2.8 ±	0.6	4.1 ±	2.1	2.8	7.1	4	1.2 ±	0.2	3.6 ±	0.2	3.3	3.7	3	3.75 ±	2.10	6
Tb	0.41 ±	0.08	0.63 ±	0.35	0.43	1.2	4	0.18 ±	0.04	0.55 ±	0.02	0.53	0.57	3	0.56 ±	0.33	6
Dy	2.2 ±	0.4	4.0 ±	2.3	2.5	7.4	4	1.1 ±	0.2	3.4 ±	0.1	3.4	3.5	3	3.56 ±	2.10	6
Ho	0.48 ±	0.10	0.79 ±	0.45	0.52	1.5	4	0.24 ±	0.05	0.73 ±	0.07	0.68	0.80	3	0.77 ±	0.41	6
Er	1.2 ±	0.2	2.4 ±	1.4	1.6	4.5	4	0.77 ±	0.15	2.1 ±	0.2	2.0	2.3	3	2.13 ±	1.13	6
Tm	0.14 ±	0.03	0.33 ±	0.21	0.21	0.64	4	0.11 ±	0.02	0.27 ±	0.00	0.26	0.27	3	0.28 ±	0.15	6
Yb	0.76 ±	0.15	2.1 ±	1.3	1.3	4.0	4	0.56 ±	0.11	1.7 ±	0.1	1.5	1.8	3	1.80 ±	0.86	6
Lu	0.19 ±	0.04	0.29 ±	0.15	0.20	0.51	4	0.079 ±	0.016	0.25 ±	0.04	0.21	0.29	3	0.24 ±	0.11	6
Hf	<LOD		0.025 ±	0.018	0.004	0.046	4			0.004 ±	0.001	<LOD	0.004	2	0.085 ±	0.050	5
Ta	<LOD														0.014 ±	0.019	5
Pb	38 ±	8	1.4 ±	0.7	0.9	2.4	4			1.3 ±	0.1	1.2	1.4	3	2.83 ±	2.25	4
Th	1.6 ±	0.3	2.7 ±	0.2	2.4	2.9	4	1.6 ±	0.3	5.7 ±	0.1	5.6	5.9	3	3.74 ±	3.20	6
U	3.8 ±	0.8	4.0 ±	0.2	3.7	4.2	4	2.6 ±	0.5	4.3 ±	0.1	4.1	4.4	3	2.93 ±	2.30	6

The uncertainties reported represent 20% relative uncertainty and 1SD for TOF and Spot, respectively. Where the number

of analyses used for the average is two or one, the uncertainties reflect the range of the two values used for the average or 15% relative uncertainty, respectively. Literature values and their uncertainties represent the mean values of apatite in ordinary chondrites and the 95% confidence interval, respectively, calculated excluding anomalously high abundances.[8] Values with more than 100% relative uncertainty are shown in red. LOD values for EPMA are 3SD of the blank intensities in % m/m: 0.12 for F, 0.07 for Na_2O, 0.05 for MgO, 0.05 for SiO_2, 0.12 for P_2O_5, 0.02 for Cl, 0.02 for CaO, and 0.08 for FeO. Where the abundance of an element was below the LOD for Spot, the LOD value is substituted instead of the abundance for the average unless every analysis is below the LOD.

Supplementary Table 6.

Elemental abundances in **Ca-rich pyroxene** (TOF: abundances obtained based on LA-ICP-TOF-MS mapping; Spot: average abundances obtained based on EPMA in % m/m and LA-ICP-SF-MS spot analysis in µg/g; Min: the minimum abundances for Spot; Max: the maximum abundances for Spot; n: number of analyses and samples used for calculating the average in this study and literature values, respectively; <LOD: below the LOD).

Meteorite	A 09618 (H5)							Y-790960 (H7)							Literature values[9-12]		
	TOF		Spot		Min	Max	n	TOF		Spot		Min	Max	n	Mean		n
(% m/m)																	
Na_2O	1.6 ±	0.5	0.53 ±	0.06	0.46	0.63	5	1.1 ±	0.3	0.56 ±	0.02	0.51	0.59	11	0.60 ±	0.17	3
MgO	16 ±	5	16.9 ±	0.0	16.9	17.0	5	17 ±	5	17.2 ±	0.2	16.7	17.6	11	16.7 ±	0.4	3
Al_2O_3	3.0 ±	0.9	0.65 ±	0.15	0.53	0.85	5	1.0 ±	0.3	0.58 ±	0.10	0.51	0.87	11	0.54 ±	0.15	3
SiO_2	51 ±	15	55.1 ±	0.5	54.7	55.9	5	54 ±	16	54.3 ±	0.6	53.4	55.2	11	54.1 ±	1.4	3
P_2O_5	0.18 ±	0.05	0.04 ±	0.01	<LOD	0.05	5	0.44 ±	0.13	0.04 ±	0.00	<LOD	0.05	11			
K_2O	0.18 ±	0.05						0.10 ±	0.03								
CaO	19 ±	6	22.2 ±	0.2	22.1	22.6	5	17 ±	5	22.1 ±	0.2	21.6	22.4	11	22.0 ±	0.3	3
TiO_2	0.33 ±	0.10	0.44 ±	0.03	0.40	0.47	5	0.26 ±	0.08	0.49 ±	0.01	0.47	0.51	11	0.43 ±	0.03	5
V_2O_5	0.040 ±	0.012	0.06 ±	0.02	0.05	0.10	5	0.033 ±	0.010	0.05 ±	0.01	<LOD	0.07	11	0.046 ±	0.058	3
Cr_2O_3	0.57 ±	0.17	0.75 ±	0.08	0.68	0.84	5	0.50 ±	0.15	0.84 ±	0.04	0.76	0.91	11	0.76 ±	0.15	6
MnO	0.24 ±	0.07	0.21 ±	0.01	0.19	0.22	5	0.27 ±	0.08	0.24 ±	0.02	0.21	0.27	11	0.24 ±	0.01	6
FeO	7.4 ±	2.2	3.71 ±	0.23	3.45	3.95	5	8.5 ±	2.6	4.40 ±	0.42	3.99	5.21	11	4.93 ±	0.37	3
NiO	0.34 ±	0.10	0.04 ±	0.01	<LOD	0.06	5	0.46 ±	0.14	0.05 ±	0.04	<LOD	0.16	11	0.0025 ±	0.0017	3
ZnO	0.0099 ±	0.0030	<LOD		<LOD	<LOD	5	0.0085 ±	0.0025	<LOD		<LOD	<LOD	11			
Total	100.0 ±	17.2	100.7 ±	0.6				100.1 ±	17.9	100.8 ±	0.8				100.4 ±	1.6	
Fs			0.06 ±	0.00	0.06	0.06	5			0.07 ±	0.01	0.06	0.08	11			
Es			0.48 ±	0.00	0.48	0.49	5			0.48 ±	0.00	0.48	0.49	11			
Wo			0.46 ±	0.00	0.45	0.46	5			0.45 ±	0.01	0.43	0.46	11			
(µg/g)																	
Sc	71 ±	21	112 ±	11	101	124	2	59 ±	18	132 ±	5	126	138	4	101 ±	65	4
Co	100 ±	30						180 ±	50						3 ±	1	3
Cu	49 ±	15						76 ±	23								
Zn	80 ±	24	21 ±	5	16	26	2	68 ±	20	23 ±	4	19	29	4	17 ±	6	4
Rb	3.7 ±	1.1	1.5 ±	0.2	1.5	1.5	1	2.8 ±	0.8	1.1 ±	0.1	1.0	1.2	4	0.5		2
Sr	14 ±	4	10 ±	2	10	10	1	7.1 ±	2.1	6.4 ±	0.7	5.6	7.0	4	17 ±	5	2
Y	4.5 ±	1.4	8.3 ±	0.9	7.5	9.2	2	4.6 ±	1.4	10 ±	1	9	12	4	5.1 ±	0.3	2
Zr	55 ±	16						57 ±	17						80 ±	30	2
Nb	1.0 ±	0.3						1.3 ±	0.4								
Ba	4.9 ±	1.5	2.3 ±	0.3	2.3	2.3	1	4.7 ±	1.4	0.89 ±	0.21	0.70	1.1	4	8 ±	2	2
La	0.61 ±	0.18	0.27 ±	0.02	0.26	0.29	2	0.54 ±	0.16	0.23 ±	0.03	0.22	0.27	4	0.35 ±	0.32	3
Ce	1.7 ±	0.5	0.93 ±	0.04	0.89	0.97	2	7.5 ±	2.2	0.89 ±	0.07	0.85	1.0	4	1.1 ±	0.4	3
Pr	0.22 ±	0.07	0.19 ±	0.01	0.18	0.20	2	0.26 ±	0.08	0.20 ±	0.01	0.19	0.21	4	0.3 ±	0.0	2
Nd	1.0 ±	0.3	1.2 ±	0.1	1.1	1.2	2	1.3 ±	0.4	1.1 ±	0.1	1.1	1.3	4	1.4 ±	0.2	2
Sm	0.38 ±	0.11	0.53 ±	0.00	0.53	0.53	2	0.40 ±	0.12	0.61 ±	0.07	0.55	0.68	4	0.62 ±	0.49	3
Eu	<LOD		0.091 ±	0.014	0.091	0.091	1	<LOD		0.051 ±	0.002	0.049	0.053	4	0.08 ±	0.11	3
Gd	0.54 ±	0.16	0.81 ±	0.05	0.76	0.87	2	0.74 ±	0.22	0.90 ±	0.14	0.79	1.11	4	1.30		1
Tb	0.11 ±	0.03	0.18 ±	0.02	0.16	0.20	2	0.10 ±	0.03	0.19 ±	0.02	0.17	0.21	4	0.23 ±	0.20	3
Dy	0.84 ±	0.25	1.4 ±	0.2	1.2	1.5	2	0.76 ±	0.23	1.5 ±	0.1	1.4	1.5	4			
Ho	0.18 ±	0.05	0.32 ±	0.03	0.28	0.35	2	0.16 ±	0.05	0.33 ±	0.05	0.29	0.40	4			
Er	0.60 ±	0.18	1.0 ±	0.1	0.9	1.1	2	0.44 ±	0.13	1.0 ±	0.1	1.0	1.2	4			
Tm	0.089 ±	0.027	0.16 ±	0.02	0.14	0.18	2	0.080 ±	0.024	0.16 ±	0.00	0.16	0.17	4	0.31 ±	0.02	1
Yb	0.66 ±	0.20	1.2 ±	0.1	1.1	1.3	2	0.52 ±	0.16	1.1 ±	0.1	0.9	1.2	4	0.98 ±	0.97	3
Lu	0.10 ±	0.03	0.19 ±	0.02	0.17	0.21	2	0.088 ±	0.026	0.17 ±	0.01	0.16	0.18	4	0.21 ±	0.07	3
Hf	1.5 ±	0.5	2.5 ±	0.2	2.2	2.7	2	1.4 ±	0.4	2.3 ±	0.1	2.1	2.4	4			
Ta	0.063 ±	0.019						0.050 ±	0.015								
Pb	2.5 ±	0.7	0.094 ±	0.014	0.094	0.094	1	3.2 ±	1.0	0.073 ±	0.056	0.036	0.16	4			
Th	0.090 ±	0.027	0.046 ±	0.005	0.042	0.051	2	0.11 ±	0.03	0.033 ±	0.019	0.020	0.061	4			
U	<LOD		0.0077 ±	0.0013	0.0065	0.0090	2	<LOD		0.0048 ±	0.0041	0.0023	0.011	4			

The uncertainties reported represent 30% relative uncertainty and 1SD for TOF and Spot, respectively. Where the number of analyses used for the average is two or one, the uncertainties reflect the range of the two values used for the average or 15% relative uncertainty, respectively. Literature values and their uncertainties represent the mean values of Ca-rich pyroxene in type 6 ordinary chondrites and the 95% confidence interval, respectively.[9-12] Where the number of analyses used for the literature value is two or one, the uncertainties reflect the range of the two values used for the average or 1SD of the value, respectively. Values with more than 100% relative uncertainty are shown in red. LOD values for EPMA are 3SD of the blank intensities in % m/m: 0.01 for Na_2O, 0.01 for MgO, 0.01 for Al_2O_3, 0.02 for SiO_2, 0.04 for P_2O_5, 0.01 for CaO, 0.03 for TiO_2, 0.03 for V_2O_5, 0.02 for Cr_2O_3, 0.02 for MnO, 0.02 for FeO, 0.03 for NiO, and 0.04 for ZnO. Where the abundance of an element was below the LOD for Spot, the LOD value is substituted instead of the abundance for the average unless every analysis is below the LOD.

Supplementary Table 7.

Elemental abundances in **feldspar** (TOF: abundances obtained based on LA-ICP-TOF-MS mapping; Spot: average abundances obtained based on EPMA in % m/m and LA-ICP-SF-MS spot analysis in µg/g or ng/g; Min: the minimum abundances for Spot; Max: the maximum abundances for Spot; n: number of analyses and samples used for calculating the average in this study and literature values, respectively; <LOD: below the LOD).

Meteorite	A 09618 (H5)							Y-790960 (H7)							Literature values[9-12]		
	TOF		Spot		Min	Max	n	TOF		Spot		Min	Max	n	Mean		n
(% m/m)																	
Na_2O	6.7 ±	2.0	9.53 ±	0.53	8.41	10.1	13	9.6 ±	2.9	9.63 ±	0.42	8.92	10.2	24	9.7 ±	1.0	3
MgO	7.4 ±	2.2	<LOD		<LOD	<LOD	13	4.6 ±	1.4	<LOD		<LOD	<LOD	24	0.1		1
Al_2O_3	13 ±	4	22.3 ±	0.9	21.6	24.3	13	8.3 ±	2.5	21.8 ±	0.4	20.9	22.5	24	21.0 ±	0.5	3
SiO_2	57 ±	17	64.7 ±	1.7	62.4	66.4	13	59 ±	18	65.7 ±	0.7	64.5	66.7	24	65.3 ±	0.4	2
P_2O_5	0.20 ±	0.06	0.07 ±	0.01	<LOD	0.09	13	0.29 ±	0.09	0.06 ±	0.00	<LOD	0.08	24			
K_2O	0.80 ±	0.24	0.83 ±	0.29	0.37	1.09	13	0.89 ±	0.27	0.96 ±	0.30	0.49	1.46	24	0.99 ±	0.20	
CaO	3.1 ±	0.9	2.69 ±	1.06	2.22	5.28	13	<LOD		2.53 ±	0.13	2.20	2.66	24	2.1 ±	0.0	3
TiO_2	0.15 ±	0.05	0.05 ±	0.02	<LOD	0.08	13	0.070 ±	0.021	0.05 ±	0.02	<LOD	0.10	24	0.0520		3
Cr_2O_3	0.59 ±	0.18	0.06 ±	0.03	<LOD	0.13	13	0.28 ±	0.09	<LOD		<LOD	<LOD	24	0.120		5
MnO	0.13 ±	0.04	0.05 ±	0.00	<LOD	0.06	13	0.10 ±	0.03	0.05 ±	0.00	<LOD	0.06	24	0.0		6
FeO	10 ±	3	0.68 ±	0.33	0.34	1.13	13	14 ±	4	0.39 ±	0.24	0.19	0.97	24	0.7 ±	0.2	2
NiO	1.1 ±	0.3						2.2 ±	0.7						0.0049		6
Total	99.9 ±	18.0	101.0 ±	2.3				99.7 ±	18.7	101.2 ±	1.0				99.7 ±	1.2	
An			0.11 ±	0.04	0.09	0.19	13			0.09 ±	0.01	0.06	0.11	24			
Ab			0.84 ±	0.03	0.79	0.86	13			0.85 ±	0.02	0.83	0.88	24			
Or			0.05 ±	0.02	0.02	0.06	13			0.06 ±	0.02	0.03	0.09	24			
(µg/g)																	
Sc	19 ±	6						18 ±	5						4.0 ±	2.3	4
V	110 ±	30						59 ±	18						22 ±	13	4
Mn	1000 ±	300	53 ±	8	53	53	1	790 ±	240	13 ±	6	8	19	2	262		6
Co	290 ±	90						710 ±	210						2.6 ±	2.5	6
Cu	90 ±	27						220 ±	70						5 ±	11	3
Zn	140 ±	40	4.1 ±	0.6	4.1	4.1	1	120 ±	40	5.4 ±	4.9	0.5	10	2	7 ±	6	6
Rb	16 ±	5	19 ±	3	19	19	1	36 ±	11	24 ±	1	23	26	2	25 ±	3	5
Sr	50 ±	15	104 ±	16	104	104	1	42 ±	13	91 ±	1	90	91	2	76 ±	9	3
Y	1.6 ±	0.5	0.11 ±	0.02	0.11	0.11	1	0.68 ±	0.20	0.47 ±	0.45	0.03	0.92	2	1		3
Zr	21 ±	6						24 ±	7						7 ±	4	3
Nb	1.0 ±	0.3						1.2 ±	0.4								
Ba	15 ±	5	38 ±	6	38	38	1	17 ±	5	29 ±	1	29	30	2	41 ±	3	3
(ng/g)																	
La	840 ±	250	100 ±	15	100	100	1	<LOD		170 ±	70	100	250	2	189 ±	38	2
Ce	1500 ±	500	130 ±	20	130	130	1	8100 ±	2400	290 ±	190	110	480	2	258 ±	26	2
Pr	<LOD		10 ±	2	10	10	1	<LOD		39 ±	29	9	68	2			
Nd	600 ±	180	42 ±	6	42	42	1	<LOD		210 ±	150	60	360	2	263 ±	32	2
Sm	<LOD		8 ±	1	8	8	1	<LOD		38 ±	35	14	73	2	100 ±	20	2
Eu	310 ±	90	740 ±	110	740	740	1	260 ±	80	630 ±	20	610	660	2	541 ±	87	3
Gd	<LOD		11 ±	2	11	11	1	<LOD		90 ±	80	10	170	2			
Tb	<LOD		2.2 ±	0.3	2.2	2.2	1	<LOD		14 ±	13	1	27	2	23 ±	11	2
Dy	300 ±	90	19 ±	3	19	19	1	<LOD		71 ±	68	3	140	2			
Ho	72 ±	22	2.1 ±	0.3	2.1	2.1	1	<LOD		16 ±	16	0	32	2			
Er	230 ±	70	14 ±	2	14	14	1	<LOD		56 ±	51	5	110	2			
Tm	<LOD		2 ±	0	2	2	1	<LOD		8 ±	6	2	14	2	14 ±	1	1
Yb	230 ±	70	22 ±	3	22	22	1	<LOD		41 ±	36	5	77	2	63 ±	13	2
Lu	46 ±	14	1.8 ±	0.3	1.8	1.8	1	<LOD		4.4 ±	3.0	1.4	7.5	2	13 ±	0	2
Hf	350 ±	110	18 ±	3	18	18	1	180 ±	50	11 ±	1	10	12	2			
Ta	80 ±	24						46 ±	14								
Pb	4400 ±	100	83 ±	12	83	83	1	5700 ±	1700	35 ±	2	33	37	2			
Th	73 ±	8	4.0 ±	0.6	4.0	4.0	1	110 ±	30	3.8 ±	2.1	1.8	5.9	2			
U	<LOD		2.4 ±	0.4	2.4	2.4	1	<LOD		1.8 ±	1.0	0.8	2.8	2			

The uncertainties reported represent 30% relative uncertainty and 1SD for TOF and Spot, respectively. Where the number

of analyses used for the average is two or one, the uncertainties reflect the range of the two values used for the average or 15% relative uncertainty, respectively. Literature values and their uncertainties represent the mean values of feldspar in type 6 ordinary chondrites and the 95% confidence interval, respectively, calculated excluding anomalously high or low abundances.[9-12] Where the number of analyses used for the literature value is two or one, the uncertainties reflect the range of the two values used for the average or 1SD of the value, respectively. Values with more than 100% relative uncertainty are shown in red. LOD values for EPMA analysis are 3SD of the blank intensities in % m/m: 0.03 for Na_2O, 0.02 for MgO, 0.02 for Al_2O_3, 0.03 for SiO2, 0.06 for P_2O_5, 0.01 for K_2O, 0.01 for CaO, 0.04 for TiO_2, 0.04 for Cr_2O_3, 0.05 for MnO, and 0.04 for FeO. Where the abundance of an element was below the LOD for Spot, the LOD value is substituted instead of the abundance for the average unless every analysis is below the LOD.

Supplementary Table 8.

Elemental abundances in **low-Ca pyroxene** (TOF: abundances obtained based on LA-ICP-TOF-MS mapping; Spot: average abundances obtained based on EPMA in % m/m and LA-ICP-SF-MS spot analysis in µg/g or ng/g; Min: the minimum abundances for Spot; Max: the maximum abundances for Spot; n number of analyses and samples used for calculating the average in this study and literature values, respectively; n.d.: not determined; <LOD: below the LOD).

Meteorite	A 09618 (H5)					Y-790960 (H7)					Literature values[9-12]	
	TOF	Spot	Min	Max	n	TOF	Spot	Min	Max	n	Mean	n
(% m/m)												
Na_2O	0.58 ± 0.17	0.01 ± 0.01	<LOD	0.02	7	0.26 ± 0.08	0.01 ± 0.00	<LOD	0.02	14	<0.04	3
MgO	27 ± 8	31.6 ± 0.2	31.2	31.8	7	25 ± 7	31.6 ± 0.1	31.3	31.8	14	29.3 ± 0.2	3
Al_2O_3	1.3 ± 0.4	0.15 ± 0.01	0.12	0.16	7	0.32 ± 0.10	0.18 ± 0.02	0.15	0.24	14	0.11 ± 0.09	3
SiO_2	56 ± 17	56.6 ± 0.3	56.0	56.8	7	60 ± 18	56.6 ± 0.2	56.3	56.9	14	55.6 ± 0.9	3
P_2O_5	<LOD	<LOD	<LOD	<LOD	7	0.12 ± 0.03	<LOD	<LOD	<LOD	14		
K_2O	0.11 ± 0.03					0.058 ± 0.017						
CaO	1.3 ± 0.4	0.53 ± 0.04	0.50	0.61	7	<LOD	0.68 ± 0.10	0.48	0.80	14	0.80 ± 0.22	3
TiO_2	0.17 ± 0.05	0.16 ± 0.02	0.13	0.18	7	0.14 ± 0.04	0.18 ± 0.02	0.16	0.23	14	0.17 ± 0.01	6
Cr_2O_3	0.22 ± 0.06	0.19 ± 0.16	0.08	0.43	7	0.15 ± 0.05	0.12 ± 0.01	0.10	0.15	14	0.17 ± 0.06	6
MnO	0.50 ± 0.15	0.40 ± 0.03	0.36	0.45	7	0.47 ± 0.14	0.39 ± 0.02	0.36	0.42	14	0.46 ± 0.05	6
FeO	12 ± 4	11.6 ± 0.0	11.5	11.6	7	13 ± 4	11.5 ± 0.1	11.3	11.8	14	13.9 ± 0.8	3
NiO	0.21 ± 0.06	0.04 ± 0.01	<LOD	0.05	7	0.29 ± 0.09	0.04 ± 0.01	<LOD	0.06	14	0.011 ± 0.009	6
ZnO	0.013 ± 0.004	<LOD	<LOD	<LOD	7	0.011 ± 0.003	0.04 ± 0.00	<LOD	0.04	14		
Total	99.9 ± 19.0	101.2 ± 0.4				99.4 ± 19.8	101.3 ± 0.3				100.5 ± 1.3	
Fs		0.17 ± 0.00	0.17	0.17	7		0.17 ± 0.00	0.16	0.17	14		
Es		0.82 ± 0.00	0.82	0.82	7		0.82 ± 0.00	0.82	0.82	14		
Wo		0.01 ± 0.00	0.01	0.01	7		0.01 ± 0.00	0.01	0.01	14		
(µg/g)												
Sc	12 ± 4	4.0 ± 0.3	3.7	4.4	2	18 ± 5	11 ± 2	11	11	1	10 ± 2	5
V	63 ± 19					54 ± 16					60 ± 29	5
Co	63 ± 19					120 ± 40					11 ± 5	6
Cu	35 ± 10					52 ± 16					10 ± 3	6
Zn	100 ± 30	16 ± 2	13	18	2	90 ± 27	99 ± 15	99	99	1	38 ± 26	6
Rb	1.6 ± 0.5	n.d.	n.d.	n.d.	2	0.99 ± 0.30	0.050 ± 0.008	0.050	0.050	1	0.09 ± 0.1	3
Sr	4.2 ± 1.3	n.d.	n.d.	n.d.	2	2.2 ± 0.7	0.053 ± 0.008	0.053	0.053	1	4.5 ± 0.5	2
Y	0.61 ± 0.18	0.23 ± 0.02	0.21	0.25	2	0.40 ± 0.12	0.36 ± 0.05	0.36	0.36	1	0.9 ± 0.1	2
Zr	8.4 ± 2.5					16 ± 5					5 ± 1	2
Nb	0.60 ± 0.18					0.60 ± 0.18						
Ba	2.6 ± 0.8	n.d.	n.d.	n.d.	2	3.4 ± 1.0	0.035 ± 0.005	0.035	0.035	1	2 ± 0	2
(ng/g)												
La	<LOD	14 ± 3	10	17	2	<LOD	6.3 ± 0.9	6.3	6.3	1	26 ± 3	2
Ce	560 ± 170	36 ± 7	29	43	2	6300 ± 1900	33 ± 5	33	33	1	99 ± 39	2
Pr	<LOD	5.3 ± 1.0	4.2	6.3	2	<LOD	1.1 ± 0.2	1.1	1.1	1		
Nd	<LOD	27 ± 3	24	30	2	<LOD	2.5 ± 0.4	2.5	2.5	1	30 ± 3	1
Sm	<LOD	13 ± 1	12	14	2	<LOD	12 ± 2	12	12	1	18 ± 4	2
Eu	<LOD	n.d.	n.d.	n.d.	2	<LOD	<LOD	<LOD	<LOD	1	3 ± 2	3
Gd	<LOD	17 ± 1	16	17	2	<LOD	10 ± 2	10	10	1		
Tb	<LOD	4.0 ± 0.3	3.7	4.3	2	<LOD	2.9 ± 0.4	2.9	2.9	1	6 ± 2	2
Dy	<LOD	33 ± 6	27	40	2	<LOD	44 ± 7	44	44	1		
Ho	<LOD	8.2 ± 0.6	7.6	8.7	2	<LOD	11 ± 2	11	11	1		
Er	93 ± 28	29 ± 3	26	31	2	<LOD	45 ± 7	45	45	1		
Tm	<LOD	6 ± 1	5	7	2	<LOD	12 ± 2	12	12	1	6 ± 0	1
Yb	<LOD	46 ± 8	38	53	2	<LOD	120 ± 20	120	120	1	93 ± 2	2
Lu	<LOD	8.5 ± 1.2	7.2	9.7	2	<LOD	19 ± 3	19	19	1	31 ± 7	5
Hf	170 ± 50	88 ± 12	77	100	2	270 ± 80	24 ± 4	24	24	1		
Ta	40 ± 12					<LOD						
Pb	2500 ± 800	59 ± 1	58	60	2	3500 ± 1100	34 ± 5	34	34	1		
Th	90 ± 27	82 ± 41	42	120	2	61 ± 18	7.1 ± 1.1	7.1	7.1	1		
U	<LOD	15 ± 8	7	23	2	<LOD	1.6 ± 0.2	1.6	1.6	1		

The uncertainties reported represent 30% relative uncertainty and 1SD for TOF and Spot, respectively. Where the number

of analyses used for the average is two or one, the uncertainties reflect the range of the two values used for the average or 15% relative uncertainty, respectively. Literature values and their uncertainties represent the mean values of low-Ca pyroxene in type 6 ordinary chondrites and the 95% confidence interval, respectively, calculated excluding anomalously high abundances.[9-12] Where the number of analyses used for the literature value is two or one, the uncertainties reflect the range of the two values used for the average or 1SD of the value, respectively. Values with more than 100% relative uncertainty are shown in red. LOD values for EPMA are 3SD of the blank intensities in % m/m: 0.01 for Na_2O, 0.01 for MgO, 0.01 for Al_2O_3, 0.02 for SiO_2, 0.04 for P_2O_5, 0.01 for CaO, 0.03 for TiO_2, 0.03 for V_2O_5, 0.02 for Cr_2O_3, 0.02 for MnO, 0.02 for FeO, 0.03 for NiO, and 0.04 for ZnO. Where the abundance of an element was below the LOD for Spot, the LOD value is substituted instead of the abundance for the average unless every analysis is below the LOD.

Supplementary Table 9.

Elemental abundances in **olivine** (TOF: abundances obtained based on LA-ICP-TOF-MS mapping; Spot: average abundances obtained based on EPMA in % m/m and LA-ICP-SF-MS spot analysis in µg/g or ng/g; Min: the minimum abundances for Spot; Max: the maximum abundances for Spot; n: number of analyses and samples used for calculating the average in this study and literature values, respectively; n.d.: not determined; <LOD: below the LOD).

Meteorite	A 09618 (H5)					Y-790960 (H7)					Literature values[9-12]	
	TOF	Spot	Min	Max	n	TOF	Spot	Min	Max	n	Mean	n
(% m/m)												
Na_2O	0.22 ± 0.07	0.01 ± 0.00	<LOD	0.02	9	0.15 ± 0.04	0.01 ± 0.00	<LOD	0.01	8	<0.03	3
MgO	40 ± 12	43.6 ± 0.5	42.7	44.2	9	38 ± 11	43.8 ± 0.2	43.5	44.1	8	39.5 ± 0.5	3
Al_2O_3	0.52 ± 0.16	0.04 ± 0.08	<LOD	0.25	9	0.12 ± 0.04	<LOD	<LOD	<LOD	8	<0.02	3
SiO_2	39 ± 12	39.3 ± 0.3	38.9	39.7	9	42 ± 13	39.6 ± 0.2	39.2	39.8	8	38.1 ± 0.5	3
P_2O_5	<LOD	0.05 ± 0.02	<LOD	0.09	9	<LOD	0.07 ± 0.06	<LOD	0.22	8		
K_2O	0.060 ± 0.018					0.038 ± 0.011						
CaO	0.36 ± 0.11	0.01 ± 0.00	<LOD	0.02	9	0.15 ± 0.04	0.02 ± 0.01	<LOD	0.05	8	<0.01	3
TiO_2	0.023 ± 0.007	0.05 ± 0.05	<LOD	0.15	9	0.011 ± 0.003	<LOD	<LOD	<LOD	8	0.023 ± 0.030	3
Cr_2O_3	0.074 ± 0.022	0.05 ± 0.02	<LOD	0.08	9	0.049 ± 0.015	<LOD	<LOD	<LOD	8	0.056 ± 0.022	6
MnO	0.49 ± 0.15	0.35 ± 0.03	0.32	0.40	9	0.47 ± 0.14	0.36 ± 0.04	0.28	0.41	8	0.46 ± 0.04	6
FeO	19 ± 6	18.4 ± 0.2	18.2	18.7	9	19 ± 6	18.5 ± 0.2	18.2	19.0	8	22.6 ± 1.2	3
NiO	0.18 ± 0.05	<LOD	<LOD	<LOD	9	0.26 ± 0.08	0.06 ± 0.06	<LOD	0.20	8	0.019 ± 0.013	6
ZnO	0.015 ± 0.005	<LOD	<LOD	<LOD	9	0.012 ± 0.004	<LOD	<LOD	<LOD	8		
Total	99.9 ± 17.7	101.9 ± 0.6				99.9 ± 17.8	102.5 ± 0.4				100.8 ± 1.4	
Fa		0.19 ± 0.00	0.19	0.20	9		0.19 ± 0.00	0.19	0.20	8		
Fo		0.81 ± 0.00	0.80	0.81	9		0.81 ± 0.00	0.80	0.81	8		
(µg/g)												
Sc	<LOD					10 ± 3					4 ± 3	6
V	12 ± 4					23 ± 7					16 ± 14	6
Mn	3800 ± 1100	3267 ± 338	2929	3605	2	3600 ± 1100	3849 ± 143	3694	3976	3	3563 ± 295	6
Co	61 ± 18					110 ± 30					19 ± 15	6
Cu	30 ± 9					26 ± 8					12 ± 9	3
Zn	120 ± 40	49 ± 2	48	51	2	99 ± 30	57 ± 3	55	61	3	40 ± 25	6
Rb	<LOD	0.25 ± 0.06	0.18	0.31	2	<LOD	0.20 ± 0.03	0.20	0.20	1	<0.05	3
Sr	1.9 ± 0.6	0.17 ± 0.10	0.07	0.26	2	1.5 ± 0.4	0.30 ± 0.05	0.30	0.30	1	0.7 ± 0.3	2
Y	<LOD	0.064 ± 0.021	0.043	0.084	2	<LOD	0.24 ± 0.11	0.13	0.35	2	<0.5	1
Zr	2.4 ± 0.7					11 ± 3					<4	2
Nb	0.40 ± 0.12					<LOD						
Ba	1.5 ± 0.5	0.078 ± 0.023	0.055	0.10	2	2.5 ± 0.7	0.14 ± 0.02	0.14	0.14	1	<0.8	3
(ng/g)												
La	<LOD	12 ± 0	12	13	2	<LOD	23 ± 3	20	25	2	11 ± 5	3
Ce	<LOD	59 ± 33	26	92	2	5400 ± 1600	59 ± 11	48	70	2	26 ± 21	3
Pr	<LOD	2.8 ± 0.1	2.7	2.8	2	<LOD	9.1 ± 3.8	5.3	13	2		
Nd	<LOD	11 ± 1	10	13	2	<LOD	46 ± 20	26	66	2	<31	2
Sm	<LOD	3 ± 0	3	4	2	<LOD	15 ± 5	10	20	2	5 ± 6	3
Eu	<LOD	1.0 ± 0.2	0.8	1.2	2	<LOD	11 ± 2	11	11	1	<1	3
Gd	<LOD	10 ± 2	7	12	2	<LOD	29 ± 15	14	43	2		
Tb	<LOD	1.6 ± 0.5	1.1	2.1	2	<LOD	6.0 ± 3.8	2.2	9.8	2	1 ± 1	3
Dy	<LOD	9.1 ± 1.8	7.3	11	2	<LOD	39 ± 19	20	57	2		
Ho	<LOD	3.0 ± 0.9	2.1	3.9	2	<LOD	8.4 ± 3.1	5.4	11	2		
Er	<LOD	10 ± 1	9	11	2	<LOD	31 ± 12	19	44	2		
Tm	<LOD	2 ± 1	2	3	2	<LOD	7 ± 3	4	9	3	1 ± 0	2
Yb	<LOD	19 ± 1	18	21	2	<LOD	46 ± 2	44	49	3	11 ± 9	3
Lu	<LOD	4.9 ± 1.2	3.7	6.1	2	<LOD	8.8 ± 1.6	7.8	11	3	4 ± 1	3
Hf	<LOD	55 ± 7	48	61	2	170 ± 50	5 ± 1	5	5	1		
Ta	<LOD					<LOD						
Pb	2000 ± 600	71 ± 11	71	71	1	3000 ± 900	36 ± 6	33	43	3		
Th	<LOD	5.2 ± 2.3	2.9	7.5	2	<LOD	6.3 ± 0.9	6.3	6.3	1		
U	<LOD	2.0 ± 0.5	1.6	2.5	2	<LOD	2.7 ± 0.3	2.4	3.1	2		

The uncertainties reported represent 30% relative uncertainty and 1SD for TOF and Spot, respectively. Where the number

of analyses used for the average is two or one, the uncertainties reflect the range of the two values used for the average or 15% relative uncertainty, respectively. Literature values and their uncertainties represent the mean values of olivine in type 6 ordinary chondrites and the 95% confidence interval, respectively, calculated excluding anomalously high abundances.[9-12] Where the number of analyses used for the literature value is two or one, the uncertainties reflect the range of the two values used for the average or 1SD of the value, respectively. Values with more than 100% relative uncertainty are shown in red. LOD values for EPMA are 3SD of the blank intensities in % m/m: 0.01 for Na_2O, 0.01 for MgO, 0.01 for Al_2O_3, 0.02 for SiO_2, 0.04 for P_2O_5, 0.01 for CaO, 0.03 for TiO_2, 0.03 for V_2O_5, 0.02 for Cr_2O_3, 0.02 for MnO, 0.02 for FeO, 0.03 for NiO, and 0.04 for ZnO. Where the abundance of an element was below the LOD for Spot, the LOD value is substituted instead of the abundance for the average unless every analysis is below the LOD.

Supplementary Table 10.

Elemental abundances in **oxides** (TOF: abundances obtained based on LA-ICP-TOF-MS mapping; Spot: average abundances obtained based on EPMA in % m/m; Min: the minimum abundances for Spot; Max: the maximum abundances for Spot; n: number of analyses and samples used for calculating the average in this study and literature values, respectively; n.d.: not determined; <LOD: below the LOD).

Mineral/	Chromite/A 09618 (H5)					Chromite/Y-790960 (H7)					Chromite/Literature values[9-12]		Ilmenite/Y-790960 (H7)				
Meteorite	TOF	Spot	Min	Max	n	TOF	Spot	Min	Max	n	Mean	n	TOF	Spot	Min	Max	n
(% m/m)																	
Na_2O	0.38 ± 0.11	0.01 ± 0.00	<LOD	0.02	9	0.22 ± 0.07	0.01 ± 0.00	<LOD	0.02	9	n.d.	3	<LOD	<LOD	<LOD	<LOD	3
MgO	4.3 ± 1.3	3.26 ± 0.18	3.09	3.52	9	3.6 ± 1.1	3.29 ± 0.13	3.05	3.45	9	2.50 ± 0.00	3	3.9 ± 1.2	5.04 ± 0.12	4.91	5.14	3
Al_2O_3	8.8 ± 2.7	6.63 ± 0.18	6.38	6.99	9	4.9 ± 1.5	6.73 ± 0.06	6.65	6.81	9	5.7 ± 0.5	3	0.056 ± 0.017	0.02 ± 0.01	<LOD	0.03	3
SiO_2	5.9 ± 1.8	0.03 ± 0.01	<LOD	0.04	9	6.4 ± 1.9	0.04 ± 0.03	<LOD	0.11	9	<0.11	3	2.2 ± 0.7	0.03 ± 0.00	0.03	0.04	3
P_2O_5	<LOD	<LOD	<LOD	<LOD	9	0.30 ± 0.09	<LOD	<LOD	<LOD	9			0.11 ± 0.03	<LOD	<LOD	<LOD	3
K_2O	0.086 ± 0.026					0.096 ± 0.029							0.032 ± 0.010				
CaO	<LOD	0.02 ± 0.01	<LOD	0.06	9	<LOD	0.02 ± 0.00	<LOD	0.03	9	n.d.	2	<LOD	0.01 ± 0.00	<LOD	0.02	3
TiO_2	1.7 ± 0.5	2.26 ± 0.16	1.88	2.41	9	1.3 ± 0.4	2.30 ± 0.04	2.23	2.35	9	2.8 ± 0.4	6	41 ± 12	55.6 ± 0.4	55.2	55.9	3
V_2O_5	0.62 ± 0.19					0.51 ± 0.15					0.50 ± 0.19	6	0.022 ± 0.007	<LOD	<LOD	<LOD	3
Cr_2O_3	38 ± 12	56.7 ± 0.5	56.0	57.3	9	47 ± 14	56.3 ± 0.3	55.8	56.8	9	55.1 ± 1.0	6	0.053 ± 0.016	0.07 ± 0.01	0.06	0.08	3
MnO	0.85 ± 0.26	0.72 ± 0.03	0.68	0.77	9	0.78 ± 0.23	0.66 ± 0.04	0.63	0.73	9	0.64 ± 0.08	6	2.1 ± 0.6	2.53 ± 0.12	2.40	2.64	3
FeO	37 ± 11	29.4 ± 0.3	29.0	29.8	9	34 ± 10	29.5 ± 0.2	29.3	29.9	9	31.0 ± 1.5	3	49 ± 15	39.2 ± 0.2	39.0	39.3	3
NiO	0.74 ± 0.22	<LOD	<LOD	<LOD	9	0.65 ± 0.19	0.04 ± 0.00	<LOD	0.04	9	0.038 ± 0.043 (red)	5	1.2 ± 0.4	<LOD	<LOD	<LOD	3
ZnO	0.19 ± 0.06	0.35 ± 0.04	0.32	0.43	9	0.43 ± 0.13	0.34 ± 0.04	0.29	0.41	9			0.0085 ± 0.0025	<LOD	<LOD	<LOD	3
Total	99.2 ± 16.4	99.5 ± 0.6				99.8 ± 17.5	99.3 ± 0.4				98.0 ± 1.9		99.9 ± 19.3	102.5 ± 0.5			
(µg/g)																	
Sc	<LOD					<LOD					3.4 ± 1.9	5	<LOD				
V	4200 ± 1300					3500 ± 1100					3417 ± 1260	6	150 ± 50				
Co	240 ± 70					270 ± 80					35 ± 9	5	890 ± 270				
Cu	73 ± 22					96 ± 29					227 ± 548 (red)	3	39 ± 12				
Zn	1500 ± 500					3400 ± 1000					2200 ± 994	3	68 ± 20				
Rb	<LOD					<LOD					<0.2	1	<LOD				
Sr	4.3 ± 1.3					3.2 ± 0.9					7 ± 3	3	4.3 ± 1.3				
Y	<LOD					<LOD					<0.5	2	<LOD				
Zr	5.9 ± 1.8					32 ± 10					3 ± 4 (red)	3	29 ± 9				
Nb	1.2 ± 0.4					1.1 ± 0.3							320 ± 100				
Ba	2.5 ± 0.7					5.7 ± 1.7					1.4 ± 0.6	2	7.0 ± 2.1				
Hf	0.11 ± 0.03					0.46 ± 0.14							1.0 ± 0.3				
Ta	0.042 ± 0.013					<LOD							13 ± 4				

The uncertainties reported represent 30% relative uncertainty and 1SD for TOF and Spot, respectively. Literature values and their uncertainties represent the mean values of chromite in type 6 ordinary chondrites and the 95% confidence interval, respectively, calculated excluding anomalously high or low abundances.[9-12] Where the number of analyses used for the literature value is two or one, the uncertainties reflect the range of the two values used for the average or 1SD of the value, respectively. Values with more than 100% relative uncertainty are shown in red. LOD values for EPMA are 3SD of the blank intensities in % m/m: 0.01 for Na_2O, 0.01 for MgO, 0.01 for Al_2O_3, 0.02 for SiO_2, 0.04 for P_2O_5, 0.01 for CaO, 0.03 for TiO_2, 0.03 for V_2O_5, 0.02 for Cr_2O_3, 0.02 for MnO, 0.02 for FeO, 0.03 for NiO, and 0.04 for ZnO. Where the abundance of an element was below the LOD for Spot, the LOD value is substituted instead of the abundance for the average unless every analysis is below the LOD.

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