Appendix

1. Methods

Preparation of clean Se fractions from rocks and minerals for isotope analysis via chemical purification is very challenging. Generally, the complex chemical properties of Se due to the different oxidation states (-II, 0, +II, +IV, +VI) together with the high volatility of compounds produced by reactions with HCl (e.g., Se_2Cl_2, 127 °C boiling point) must be considered during all steps from dissolution of the sample to the final retrieval of the pure Se needed for mass spectrometric analysis. Consequently, the temperature of any step involving the evaporation in HCl must be kept below 80 °C to minimize loss of Se. Since Se in meteorites is chalcophile under reducing conditions and low temperatures it is almost exclusively concentrated in sulphides (Dreibus et al., 1995). Therefore, the leaching method described below is applicable to chondrite samples to reduce the amount of matrix for chromatographic column chemistry.

1.1. ^{77}Se-^{74}Se double spike preparation

A ^{77}Se-^{74}Se double spike (DS) solution was prepared from two commercially available Se elemental powders enriched in ^{74}Se and ^{77}Se, respectively, obtained from Isoflex, Russia. The materials were provided with a certified isotope composition (Table A1). The two powders were dissolved in 14 M HNO_3 in a PFA beaker and left closed for one week at 80 °C to achieve complete dissolution. The two solutions were then mixed gravimetrically according to the recommendations of Rudge et al. (2009) to achieve a ^{77}Se/^{74}Se ratio of about 0.6. The ^{77}Se-^{74}Se DS solution was calibrated against the National Institute of Standards and Technology (NIST) SRM 3149 standard by measuring DS to standard ratios between 0.4 and 1.5. The ^{77}Se/^{74}Se, ^{78}Se/^{74}Se, and ^{82}Se/^{74}Se ratios were iteratively modified using the Microsoft Excel® solver add-in

function to achieve a $\delta^{82/78}$Se of 0‰ for all mixes. The calibrated Se double spike isotope composition is given in Table A2. The Se isotope variations, expressed as $\delta^{82/78}$Se relative to the SRM 3149 standard distributed by NIST are calculated via:

$$\delta^{82/78}Se = \left(\frac{\left({}^{82}Se / {}^{78}Se \right)_{sample}}{\left({}^{82}Se / {}^{78}Se \right)_{SRM\,3149}} - 1 \right) * 1000$$

1.2. Sample preparation

Samples consisting of cm-sized pieces of rocks were sawed and crushed to mm-sized fragments. The troilites samples were physically separated from the iron meteorite samples with a small gouge that was cleaned with ethanol. Only fragments that showed no weathering or fusion crusts as well as no sawing surfaces were picked with tweezers under the microscope. About 10 to 200 mg of sample material, depending on the Se concentration and representing about 430 ng of Se, was then either ground for 20 min. in an agate ball mill for samples with weight larger than about 150 mg or with an agate mortar and pestle for lower sample weights and subsequently transferred into a PFA beaker. During the transfer from and to the ball mill beaker as well as the grinding itself between 7 and 30 mg of material was lost, representing 1 % to 17 % of the total sample mass. Considering a particular loss of the metal fraction due to their smearing on the ball mill walls, a maximum material loss of 17% with a 3 times higher metal content (free of any Se due to the high sulphide-metal partition coefficient (Brenan, 2015)) would lead to an overestimate of the bulk Se concentration of <4%, which is still within the analytical uncertainty. The water-moistened sample was reacted with 4 ml 14 M HNO_3 for 3 h at 100 °C and then placed in a Parr® Bomb into an oven at 165 °C overnight. The sample was transferred into a polypropylene test tube, the PFA beaker washed with 2 ml H_2O (ultrapure 18.2 MΩ was used

44 throughout the entire sample preparation) which was added to the test tube and centrifuged for
45 20 min at 3000 rotations per minute (rpm). The supernatant was pipetted into a PFA beaker and
46 the centrifugate was reacted with 4 ml 6.4 M HCl for 24 hours at room temperature to dissolve
47 any oxidised Se-bearing compounds, like $CaSeO_3$, which could have formed by the reaction with
48 HNO_3. The HCl solution was then centrifuged for 20 min at 3000 rpm and the supernatant was
49 added to the HNO_3 extract. The remaining centrifugate did not contain any detectable Se as
50 tested by a complete dissolution with HF-HNO_3 of this fraction on several samples. The leachate
51 solution was then filtered through a 0.45 µm syringe filter. For the determination of the Se
52 concentrations, a small aliquot was taken and mixed with a ^{77}Se-^{74}Se DS and treated in the same
53 way as the aliquot used for the Se isotope composition described below. This allows spiking the
54 samples to a similar Se_{spike}/Se_{sample}, thereby reducing possible effects of memory and an
55 imperfect DS calibration, and to process and measure a similar amount of Se_{sample}. The reported
56 data on Se abundances (Table 3) is from the "isotope aliquot". The samples and DS were mixed
57 to a ratio of Se_{spike}/Se_{sample} = 0.63 and dried to incipient dryness at 80 °C on a hot plate.

58 To convert all Se to the +IV oxidation state, 1.6 ml 6.4 M HCl was added and subsequently
59 heated in a closed beaker in a water bath for 60 min at 70 °C (Pettersson and Olin, 1991).
60 Afterwards 8.4 ml H_2O was added to obtain 10 ml of a 1 M HCl solution.

61 **1.3. Chromatographic column separation**

62 Thiol cellulose powder (TCP) used for Se enrichment was prepared based on the procedure
63 described by Xiao-Quan and Kai-Jing (1985) and later modifications (Elwaer and Hintelmann,
64 2008b; Marin et al., 2001; Pogge von Strandmann et al., 2014; Rouxel et al., 2002; Yu et al.,
65 2001; Zhu et al., 2008). Specifically, 21 ml thioglycollic acid, 14 ml acetic anhydride, 7 ml acetic
66 acid, and 60 µl H_2SO_4 were placed in a PFA beaker and 4 g acid-washed cellulose powder

67 (Sigma Aldrich, grain size: >250 µm: <10 %; 74-250 µm: >40 %) and a Teflon® coated magnetic
68 stirrer were introduced. The beaker was closed and left for 4 days in a water bath at 40 °C while
69 continuously being stirred. Afterwards the TCP was filtered and washed with about 1 l H_2O
70 using a funnel with a sintered-glass frit (16-40 µm nominal maximum pore size). The TCP was
71 dried in the clean laboratory at room temperature, ground in a mortar, and stored in brown glass.
72 The stability of the TCP was not systematically checked, but a significant decrease in Se yields
73 was observed after three months. Therefore, the TCP was used no longer than for 1 month after
74 preparation.

75 Selenium separation by chromatographic column separation was performed based on the
76 procedure described by Elwaer and Hintelmann (2008b). Specifically, 0.15 g TCP was weighed
77 into a 7.5 ml polypropylene column with a 0.45 µm frit mesh size (Rockbourne Scientific,
78 Hampshire, UK). The TCP was washed with 2 x 4 ml H_2O, 4 ml 5 M HCL, and 4 ml 1 M HCl.
79 The sample was loaded on the TCP column, which was then consecutively washed with 4 ml
80 H_2O, 4 ml 5 M HCl, and 4 ml 1 M HCl. The average flow rate was about 1 ml in 5 min. The TCP
81 was transferred to a test tube with about 8 ml H_2O, centrifuged for 20 min at 3000 rpm, and the
82 supernatant was discarded. To desorb the Se from the TCP the Se-binding sites on the TCP were
83 destroyed by adding 800 µl 7 M HNO_3 and 200 µl 30 % H_2O_2 (Suprapur, Sigma Aldrich) and
84 heating in a boiling water bath for 20 min. Then 2 ml H_2O was added and the sample was
85 centrifuged for 20 min at 3000 rpm. The supernatant containing the desorbed Se was transferred
86 to a PFA beaker. The desorption procedure was repeated one more time for the remaining TCP
87 and the second extract was added to the first one. To remove most of the remaining cellulose
88 powder in the extract, the sample was filtered through a 0.45 µm syringe filter. The sample was
89 then dried to a volume of about 100 µl. It was observed that a complete drying of the sample

90 resulted in a significant Se loss, especially when the samples were not filtered before. To oxidise
91 any remaining cellulose, 800 µl 7 M HNO_3 and 200 µl 30 % H_2O_2 were added and heated for at
92 least 5 h at 80 °C in a closed beaker, and afterwards dried to 100 µl at 80 °C. The oxidising step
93 was repeated until the remaining liquid was colourless.

94 For the MC-ICP-MS measurements, the Se was converted to the +IV oxidation state by adding
95 1.6 ml 6.4 M HCl and subsequently heating in a closed beaker in a water bath for 60 min at 70
96 °C. Afterwards 8.4 ml H_2O was added to obtain 10 ml of a 1 M HCl solution with a Se
97 concentration that was typically 70 ng/l.

98 **1.4. MC-ICP-MS measurement procedure**

99 Selenium isotope measurements were carried out at the Institute of Geological Sciences in Bern,
100 Switzerland, using a Nu Plasma MC-ICP-MS (Nu Instruments, Wrexham, UK). Measurements
101 were done using a 7.5 kV acceleration voltage and 10^{11} Ω resistors for the Faraday cups.
102 Standard design nickel cones were used.

103 The samples were introduced using a multimode sample introduction system (MSIS) (Marathon
104 Scientific, Niagara Falls, Canada) used in hydride generation mode which was already used and
105 described in another study by Elwaer and Hintelmann (2008a). The MSIS chamber is designed to
106 provide a continuous flow, with the sample flowing down the inner cone and forming a thin film.
107 The reducing agent solution (0.2 M $NaBH_4$ in 0.05 M NaOH) also flows down the same cone,
108 interacts, and produces volatile hydrides, which are transported to the torch by an Ar gas flow of
109 about 0.9 l/min. The solutions were pumped to the hydride generator by a multi-channel
110 peristaltic pump (Gilson, Inc., Middleton, USA) using an uptake rate of about 800 µl/min. A 700
111 ng/ml Se standard solution typically gave an ^{82}Se intensity of 5 pA, which is the lowest Se

isotope signal investigated. The intensity is about 4 times lower compared to other studies due to a lower signal intensity of the 16-year old MC-ICP-MS. For a precision similar to or slightly better than recent MC-ICP-MS studies, about 430 ng sample Se is required. Selenium isotope measurements on MC-ICP-MS systems suffer from isobaric interferences of Ar_2, ArCl, Ge, NiO, or hydrides formed with Ar_2, As, Ge, and Se (Table A3), which precludes the precise measurement of ^{80}Se and ^{76}Se signals due to large interferences from Ar_2 dimers. However, Se isotope measurements on state-of-the-art TIMS instruments, which do not suffer from these interferences, are affected by memory problems that prohibit a precision on $\delta^{80/78}Se$ of better than 1 ‰ (Vollstaedt et al., 2016).

All measurements were performed in static mode with the cup configuration shown in table A3. Due to the large number of possible interferences, on-peak zero measurements were performed using 1 M HCl prior to the measurement of every sample and this background signal was subtracted from the measured sample signal. Typical on-peak zero signals measured at the beginning of each measurement session are given in table A3 and are about factors 5-10 lower when compared to previous studies on a different MC-ICP-MS and introduction system (Zhu et al., 2008). The Se on-peak zero signals may increase by a factor of about 7 during the measurements and could be decreased by washing the MSIS chamber in about 0.5 M HCl at 60°C between the measurement sessions. Further, an Ar_2 interference correction was applied to correct for sample/carrier gas variations during the measurement (Stueken et al., 2013; Wen and Carignan, 2011). Doing so, it was assumed that the variations in the mass bias corrected $^{80}Se/^{74}Se$ ratios over the measurement only result from variations in the $^{40}Ar^{40}Ar$ interference. The calculated $\Delta^{40}Ar^{40}Ar$ (relative to the first block) were then used to correct for Ar_2 interferences on masses 76 and 78 assuming a natural Ar isotope composition. For the studied

chondrites no Ge interference correction was made for two reasons. First, monitoring Ge on masses 73 and 72 requires a dynamic mode cup configuration, which results in larger uncertainties for the measured Se isotope ratios and requires higher sample amounts. Second, Ge was never detected in the Se fractions of samples that underwent Se separation using TCP. Therefore, about 10 cycles were routinely integrated on mass 72 (28% natural Ge occurrence) before Se isotope measurements to verify that the Se fractions of the samples did not contain Ge.

At the beginning of each session three spiked SRM 3149 standards and a Se standard solution (Certipur, Merck Millipore) were measured to ensure reproducibility and accuracy. After every 3-4 samples a spiked SRM 3149 standard was measured. For each sample and on-peak zero measurement 10 blocks, each with 10 cycles of 3 s integration time were measured, giving a total integration time of 300 s. After every sample a washout using 1M HCl was performed.

It was observed that washout times of 40 min. were necessary to achieve low and constant memory Se signals over a time period of about 13 min. in the on-peak zero measurements. Long washout times of several tens of minutes were also observed in another study by Pogge von Strandmann et al. (2014), using a Cetac HGX 200 hydride generator.

The reproducibility of the method used in this study is demonstrated by repeated analyses of the SGR-1 shale (obtained from the U.S. Geological Survey). The Se concentration of this reference material was measured to be 3.5±0.2 µg/g and the $\delta^{82/78}$Se to be 0.04±0.37 ‰ (2 s.d., n=8; if not otherwise indicated, uncertainties are always given as 2 times the standard deviation) which is in the range of published values, ranging from -0.13 ‰ to 0.31 ‰ (Layton-Matthews et al., 2013; Mitchell et al., 2012; Pogge von Strandmann et al., 2014; Rouxel et al., 2002; Schilling et al., 2011; Stueken et al., 2013). The reproducibility of ±0.37‰ on the $\delta^{82/78}$Se value is taken as

representative for the whole analytical procedure and is comparable to previously reported reproducibilities ranging from 0.1 ‰ to 0.85 ‰ for $\delta^{82/76}$Se values (Layton-Matthews et al., 2013; Mitchell et al., 2012; Pogge von Strandmann et al., 2014; Rouxel et al., 2002; Schilling et al., 2011; Stueken et al., 2013). The mean and uncertainty of the SGR-1 refers to 0.02±0.39‰ and -0.44±0.85‰ without applying the ArAr and on-peak zero correction method, respectively. The Merck Se standard solution gave a $\delta^{82/78}$Se of -1.21±0.21‰ (n=18). The $\delta^{82/78}$Se of the interlaboratory Se standard MH495 was measured to -1.89±0.20‰ (n=4) which is well within the range of most of the published values for this material ranging from -2.29 ‰ to -1.85 ‰ (converted from $\delta^{82/76}$Se; (Carignan and Wen, 2007; Layton-Matthews et al., 2013; Rouxel et al., 2002; Zhu et al., 2008)). Existing discrepancies in published Se isotope values for reference materials, as observed for the SGR-1, that are significantly larger than the claimed analytical uncertainties might be due to differences in the applied interference corrections (Vollstaedt et al., 2016). The procedure analytical blank is 0.8±0.6 ng Se (n=4), representing about 0.2±0.1 % of the sample Se, which does not have an effect on the measured $\delta^{82/78}$Se outside the given analytical uncertainty.

2. Supplementary figures

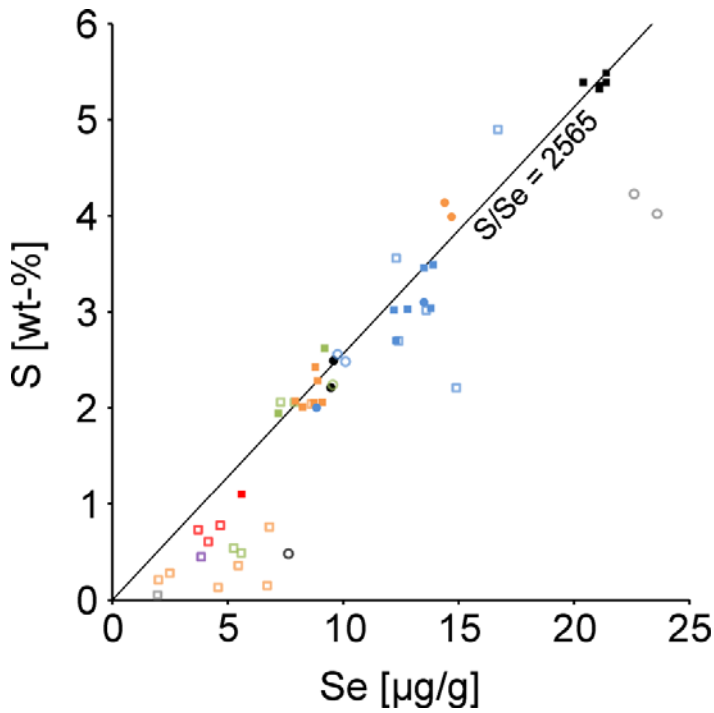

Figure A1 – Sulfur and Se concentrations in chondrites. Closed and open symbols represent falls and finds, respectively. Black squares = CI, blue squares = CM, green squares = CO, orange squares = CV, grey squares = CK, red squares = CR, violet squares = CH, black circles = H, blue circles = L, green circles = LL, orange circles = R, grey circles = EH. Straight grey line is the average S/Se ratio of 2565 of all carbonaceous chondrite falls (except CR). Data is from Table A4.

3. Supplementary tables

Table A1 - Original isotope composition of the two Isoflex Se elemental powder isotope enrichment materials

Material	^{74}*Se*	^{76}*Se*	^{77}*Se*	^{78}*Se*	^{80}*Se*	^{82}*Se*
^{74}Se single spike	99.96	0.02	<0.005	<0.005	<0.005	<0.005
^{77}Se single spike	<0.02	0.1	99.2	0.3	0.2	0.2

Table A2 – Calibrated isotopic composition of the Se double spike

^{77}Se/^{74}Se	^{78}Se/^{74}Se	^{82}Se/^{74}Se
0.6017377	0.0002899	0.0000131

Table A3 - Cup configuration for Se isotope measurements on the Nu Plasma MC-ICP-MS. Interfering species are taken from (Zhu et al., 2008). The on-peak zero signals refer to measured intensities on 1M HCl.

cup	L5	L4	L3	L2	Ax	H2	H4	H5	H6
mass	74	75	76	77	78	79	80	81	82
Se	$^{74}Se^{+}$		$^{76}Se^{+}$	$^{77}Se^{+}$	$^{78}Se^{+}$		$^{80}Se^{+}$		$^{82}Se^{+}$
Ar	$^{36}Ar^{38}Ar^{+}$		$^{40}Ar^{38}Ar^{+}$	$^{40}Ar^{36}Ar^{1}H^{+}$	$^{40}Ar^{38}Ar^{+}$		$^{40}Ar_2^{+}$	$^{40}Ar_2{}^{1}H^{+}$	$^{40}Ar_2{}^{1}H_2^{+}$
			$^{38}Ar_2^{+}$	$^{38}Ar_2{}^{1}H^{+}$		$^{40}Ar^{38}Ar^{1}H^{+}$	$^{40}Ar^{38}Ar^{1}H_2^{+}$		
SeH		$^{74}SeH^{+}$		$^{76}SeH^{+}$	$^{77}SeH^{+}$	$^{78}SeH^{+}$		$^{80}SeH^{+}$	
ArCl		$^{40}Ar^{35}Cl^{+}$		$^{40}Ar^{37}Cl^{+}$					
		$^{38}Ar^{37}Cl^{+}$							
Kr, Br					$^{78}Kr^{+}$	$^{79}Br^{+}$	$^{80}Kr^{+}$	$^{81}Br^{+}$	$^{82}Kr^{+}$
							$^{79}Br^{1}H^{+}$		$^{81}Br^{1}H^{+}$
Ge, As	$^{74}Ge^{+}$	$^{75}As^{+}$	$^{75}As^{1}H^{+}$	$^{76}Ge^{1}H^{+}$					
		$^{74}Ge^{1}H^{+}$	$^{76}Ge^{+}$						
NiO	$^{58}Ni^{16}O^{+}$		$^{60}Ni^{16}O^{+}$	$^{61}Ni^{16}O^{+}$	$^{62}Ni^{16}O^{+}$		$^{64}Ni^{16}O^{+}$		
On-peak zero signal [mV]	0.2	0.7	3.9	0.3	0.9	6.8	635	13	0.2

Table A4 - Literature compilation of Se concentrations in chondrite falls and finds. Sulfur concentrations and calculated S/Se are from the same studies but not always from the same sample aliquot. The 2 s.d. of Se and S concentrations and S/Se ratios refer to the average of the averages of measurements on single meteorites. No weighing of the literature data was performed because the measured variations in chemical abundances in meteorites are thought to reflect small-scale sample heterogeneities that were established by aqueous alteration and thermal metamorphism on the parent bodies. These processes are assumed to occur in a closed system, which does not change the chemical composition inherited established during by the accretion from nebular condensates but may lead to statistically larger uncertainties (Lodders, 2003).

Name	Type	Fall/Find	S [%]	Se [µg/g]	S/Se [‰]	$\delta^{82/78}$Se [‰]	source
CI chondrites							
Ivuna	CI1	Fall	5.35	21.1	2536		(Dreibus et al., 1995)
			5.32	21.1	2521		(Wang et al., 2015)
				20.0			(Wang et al., 2013)
				26.0			(Greenland, 1967)
				19.5			(Krähenbühl et al., 1973)
Orgueil	CI1	Fall		22.8		-0.08	this work
			5.39	21.4	2519		(Dreibus et al., 1995)
			5.49	21.4	2565		(Dreibus et al., 1995)
				21.1			(Friedrich et al., 2002)
				18.5			(Wolf et al., 2005)
			5.39	20.4	2642		(Wang et al., 2015)
				20.0			(Krähenbühl et al., 1973)
				20.9			(Wang et al., 2013)
				27.0			(Greenland, 1967)
				19.2			(Krähenbühl et al., 1973)
				18.8			(Xiao and Lipschutz, 1992)
Alais	CI1	Fall		20.8			(Kallemeyn and Wasson, 1981)
				21.1			(Krähenbühl et al., 1973)
average CI (falls)			**5.38**	**21.2**	**2552**		
2 s.d.			**0.12**	**0.6**	**66**		
$n_{meteorites}$			**2**	**3**	**2**		
$n_{analysis}$			**5**	**18**	**5**		
CM chondrites							
Cold Bokkeveld	CM2	Fall		13.39		0.06	this work
			3.02	12.20	2475		(Dreibus et al., 1995)
Murchsion	CM2	Fall		12.32		-0.14	this work
			3.03	12.80	2367		(Dreibus et al., 1995)
				13.10			(Friedrich et al., 2002)
				12.50			(Wolf et al., 2005)
			3.04	13.80	2203		(Wang et al., 2015)
				14.10			(Wang and Becker, 2013)
				11.30			(Krähenbühl et al., 1973)
				12.60			(Xiao and Lipschutz, 1992)

				13.30			(Matza and Lipschutz, 1977)
			2.70	12.30	2195		(Makishima and Nakamura, 2009)
Murray	CM2	Fall	3.49	13.90	2511		(Dreibus et al., 1995)
				10			(Greenland, 1967)
Nogoya	CM2	Fall	3.46	13.50	2563		(Dreibus et al., 1995)
Mighei	CM2	Fall		13.90			(Kallemeyn and Wasson, 1981)
				14			(Greenland, 1967)
				14			(Wang and Becker, 2013)
				12			(Krähenbühl et al., 1973)
Santa Cruz	CM2	Fall		13			(Kallemeyn and Wasson, 1981)
average CM (falls)			**3.22**	**12.89**	**2451**		
2 s.d.			**0.59**	**1.08**	**271**		
$n_{meteorites}$			**4**	**6**	**4**		
$n_{analysis}$			**6**	**20**	**6**		
Belgica 7904	C2-ung	Find	4.90	16.70	2934		(Dreibus et al., 1995)
Cochabamba	CM2	Find	3.02	13.60	2221		(Dreibus et al., 1995)
				14.00			(Kallemeyn and Wasson, 1981)
Acfer 094	C2-ung	Find	2.21	14.90	1483		(Dreibus et al., 1995)
Y-74662	CM2	Find	3.56	12.30	2894		(Dreibus et al., 1995)
Y-82042	CM1/2	Find	2.70	12.40	2177		(Dreibus et al., 1995)
ALHA77306	CM2	Find		13.50			(Kallemeyn and Wasson, 1981)
Y-74662	CM2	Find		13.10			(Kallemeyn and Wasson, 1981)
EET 83334	CM1	Find		12.30			(Friedrich et al., 2002)
ALH 83100	CM1/2	Find		12.50			(Friedrich et al., 2002)
MAC 88100	CM2	Find		14.10			(Friedrich et al., 2002)
				14.5			(Xiao and Lipschutz, 1992)
Y-793321	CM2	Find		13.30			(Friedrich et al., 2002)
				14.70			(Xiao and Lipschutz, 1992)
ALHA81002	CM2	Find		16.90			(Xiao and Lipschutz, 1992)
ALH 84039	CM2	Find		17.20			(Xiao and Lipschutz, 1992)
ALH 83100	CM1/2	Find		9.64			(Xiao and Lipschutz, 1992)
ALH 85013	CM2	Find		11.50			(Xiao and Lipschutz, 1992)
EET 83334	CM1	Find		12.20			(Xiao and Lipschutz, 1992)
EET 83389	CM2	Find		12.00			(Xiao and Lipschutz, 1992)
EET 87522	CM2	Find		12.90			(Xiao and Lipschutz, 1992)
GRO 85202	CM2	Find		12.10			(Xiao and Lipschutz, 1992)
LEW 85311	CM2	Find		13.60			(Xiao and Lipschutz, 1992)
LEW 87022	CM2	Find		13.10			(Xiao and Lipschutz, 1992)
LEW 87148	CM2	Find		11.60			(Xiao and Lipschutz, 1992)
LEW 88001	CM2	Find		11.70			(Xiao and Lipschutz, 1992)
MAC 88101	CM2	Find		11.50			(Xiao and Lipschutz, 1992)
MAC 88176	CM2	Find		16.20			(Xiao and Lipschutz, 1992)
ALH 88045	CM1	Find		12.90			(Wlotzka et al., 1989)
ALH 88052	CM2	Find		13.90			(Wlotzka et al., 1989)

CO chondrites							
Ornans	CO3.4	Fall	2.62	9.2	2848		(Dreibus et al., 1995)
Warrenton	CO3.7	Fall	1.94	7.2	2694		(Dreibus et al., 1995)
				11			(Greenland, 1967)
Felix	CO3.3	Fall		7.3			(Kallemeyn and Wasson, 1981)
				11			(Greenland, 1967)
Kainsaz	CO3.2	Fall		7.49		-0.14	this work
				7.5			(Kallemeyn and Wasson, 1981)
Lancé	CO3.5	Fall		7.4			(Kallemeyn and Wasson, 1981)
				11			(Greenland, 1967)
mean CO (falls)			**2.28**	**8.8**	**2771**		
2 s.d.			**0.96**	**1.5**	**217**		
$\mathbf{n_{meteorites}}$			**2**	**5**	**2**		
$\mathbf{n_{analysis}}$			**2**	**9**	**2**		
Isna	CO3.8	Find	2.06	7.9	2608		(Dreibus et al., 1995)
Colony	CO3.0	Find	0.54	5.26	1027		(Dreibus et al., 1995)
Acfer 202	CO3.5	Find	0.49	5.59	877		(Dreibus et al., 1995)
ALH 83108	CO3.5	Find		7.03			(Friedrich et al., 2002)
				5.14			(Xiao and Lipschutz, 1992)
ALH 85003	CO3.5	Find		7.96			(Xiao and Lipschutz, 1992)
Y-791717	CO3.3	Find		7.43			(Xiao and Lipschutz, 1992)
Dar al Gani 194	CO3	Find	2.06	7.29			(Makishima and Nakamura, 2009)

CV chondrites							
Allende	CV3	Fall		7.95		-0.26	this work
			2.06	9.1	2264		(Dreibus et al., 1995)
			2.01	8.25			(Wang et al., 2015)
				8			(Wolf et al., 2005)
			2.05	8.74	2346		(Wang and Becker, 2013)
				13.5			(Zhang et al., 1995)
				8.5			(Weeks and Sears, 1985)
				8.25			(Kadlag and Becker, 2016)
			2.07	7.94	2607		(Makishima and Nakamura, 2009)
Bali	CV3	Fall	2.42	8.8	2750		(Dreibus et al., 1995)
Vigarano	CV3	Fall	2.28	8.9	2562		(Dreibus et al., 1995)
				6.5			(Greenland, 1967)
Mokoia	CV3	Fall		9.4			(Kallemeyn and Wasson, 1981)
				9.6			(Greenland, 1967)
mean CV (falls)			**2.25**	**8.73**	**2572**		
2 s.d.			**0.38**	**1.50**	**345**		
$\mathbf{n_{meteorites}}$			**3**	**4**	**3**		

$n_{analysis}$			**6**	**14**	**5**		
Leoville	CV3	Find		7.00		-0.34	this work
Efremovka	CV3	Find	2.04	8.63	2364		(Dreibus et al., 1995)
Arch	CV3	Find	0.36	5.46	659		(Dreibus et al., 1995)
Axtell	CV3	Find	0.13	4.58	284		(Dreibus et al., 1995)
Acfer 082	CV3	Find	0.76	6.81	1116		(Dreibus et al., 1995)
Acfer 086	CV3	Find	0.21	2.00	1050		(Dreibus et al., 1995)
Acfer 272	CV3	Find	0.15	6.71	224		(Dreibus et al., 1995)
Dar al Gani 521	CV3	Find	0.28	2.49	1124		(Makishima and Nakamura, 2009)

CK chondrites							
Maralinga	CK4-an	Find	0.05	1.96	255		(Dreibus et al., 1995)
ALH 82135	CK4	Find		6.35			(Xiao and Lipschutz, 1992)
EET 83311	CK5	Find		7.21			(Xiao and Lipschutz, 1992)
EET 87507	CK5	Find		6.89			(Xiao and Lipschutz, 1992)
				5.56			(Xiao and Lipschutz, 1992)
PCA 82500	CK4/5	Find		4.81			(Xiao and Lipschutz, 1992)
EET 87860	CK5/6	Find		6.76			(Xiao and Lipschutz, 1992)
LEW 87009	CK6	Find		5.65			(Xiao and Lipschutz, 1992)
mean CK (finds)			**0.05**	**5.6**	**255**		
2 s.d.			**0**	**3.5**	**0**		
$n_{meteorites}$			**1**	**7**	**1**		
$n_{analysis}$			**1**	**8**	**1**		

CR chondrites							
Renazzo	CR2	Fall	1.10	5.61	1963		(Dreibus et al., 1995)
Average CR (falls)			**1.10**	**5.61**	**1963**		
2 s.d.			**0**	**0**	**0**		
$n_{meteorites}$			**1**	**1**	**1**		
$n_{analysis}$			**1**	**1**	**1**		
Acfer 097	CR2	Find	0.78	4.68	1656		(Dreibus et al., 1995)
Acfer 209	CR2	Find	0.61	4.16	1454		(Dreibus et al., 1995)
Acfer 270	CR2	Find	0.73	3.72	1965		(Dreibus et al., 1995)
MAC 87320	CR2	Find		7.19			(Xiao and Lipschutz, 1992)
EET 87770	CR2	Find		2.41			(Xiao and Lipschutz, 1992)

CH chondrites							
Acfer 182	CH3	Find	0.45	3.85	1166		(Dreibus et al., 1995)
ALH 85085	CH3	Find		3.45			(Xiao and Lipschutz, 1992)
mean CH (finds)			**0.45**	**3.7**	**1166**		
2 s.d.			**0**	**0.6**	**0**		

$n_{meteorites}$			**1**	**2**	**1**		
$n_{analysis}$			**1**	**2**	**1**		

H chondrites							
ZAG	H3-6	Fall		7.07		-0.21	this work
Zaoyang	H5	Fall	2.49	9.59	2596		(Dreibus et al., 1995)
Wuan	H6	Fall	2.21	9.47	2334		(Dreibus et al., 1995)
Allegan	H5	Fall		6.1			(Greenland, 1967)
Ehole	H5	Fall		6.4			(Greenland, 1967)
Pantar	H5	Fall		4.8			(Greenland, 1967)
Beardsley	H5	Fall		10.8			(Schindewolf, 1960)
Forest City	H5	Fall		8.6			(Schindewolf, 1960)
				11.8			(Kiesl et al., 1970)
Bremervörde (L/H)	H/L3.9	Fall		8.6			(Laul et al., 1973)
Tieschitz (L/H)	H/L3.6	Fall		8.1			(Laul et al., 1973)
Bath	H4	Fall		7.2			(Laul et al., 1973)
Bielokrynitschie	H4	Fall		11			(Laul et al., 1973)
Ochansk	H4	Fall		8.4			(Laul et al., 1973)
Tysnes Island	H4	Fall		7.2			(Laul et al., 1973)
Allegan	H5	Fall		9.1			(Laul et al., 1973)
Cangas de Onis	H5	Fall		8.9			(Laul et al., 1973)
Pantar	H5	Fall		9.9			(Laul et al., 1973)
Pultusk	H5	Fall		11.6			(Laul et al., 1973)
				10.9			(Kiesl et al., 1970)
Richardton	H5	Fall		7.7			(Laul et al., 1973)
Charsonville	H6	Fall		7.6			(Laul et al., 1973)
Doroninsk	H5-7	Fall		3.6			(Laul et al., 1973)
Supuhee	H6	Fall		9			(Laul et al., 1973)
Average H (falls)			**2.35**	**8.3**	**2465**		
2 s.d.			**0.40**	**3.9**	**372**		
$n_{meteorites}$			**2**	**22**	**2**		
$n_{analysis}$			**2**	**24**	**2**		
Dimmitt (DM0)	H3.7	Find		6.97		0.13	this work
Dimmitt (DM1)	H3.7	Find		8.08		-0.09	this work
Y-793408	H3.2an	Find	0.48	7.63	630		(Kimura et al., 2002)
Tell	H6	Find		9.1			(Kiesl et al., 1970)
Burdett	H5	Find		13.6			(Kiesl et al., 1970)
WSG 95300	H3.3	Find		9.67			(Wang and Lipschutz, 2007)
GRA 95208	H3.7	Find		10.1			(Wang and Lipschutz, 2007)
FRO 84005	H3	Find		6.69			(Wang and Lipschutz, 2007)

L chondrites							
Mezö-Madaras (hell)	L3.7	Fall		9.5		-0.08	this work

Mezö-Madaras (dunkel)		Fall		10.41		-0.20	this work
Zhaodong	L4	Fall	2.00	8.85	2260		(Dreibus et al., 1995)
Bruderheim	L6	Fall		9.67			(Wolf et al., 2005)
				6.40			(Greenland, 1967)
				10.40			(Friedrich et al., 2004)
Mocs	L5-6	Fall		7.30			(Greenland, 1967)
				12.00			(Kiesl et al., 1970)
Peace River	L6	Fall		6.40			(Greenland, 1967)
Walters	L6	Fall		8.20			(Greenland, 1967)
Holbrook	L/LL6	Fall		13.30			(Schindewolf, 1960)
				8.50			(Friedrich et al., 2003)
Modoc (1905)	L6	Fall		6.50			(Schindewolf, 1960)
				9.84			(Friedrich et al., 2004)
Salles	L5-6	Fall		7.90			(Laul et al., 1973)
Ceniceros	L3.7	Fall	3.10	13.50	2296		(Kadlag and Becker, 2016)
Bachmut	L6	Fall		8.50			(Kiesl et al., 1970)
				9.56			(Friedrich et al., 2003)
Bjurböle	L/LL4	Fall		12.80			(Kiesl et al., 1970)
				6.70			(Friedrich et al., 2003)
Homestead	L5	Fall		10.40			(Kiesl et al., 1970)
				9.93			(Friedrich et al., 2004)
Atarra	L4	Fall		8.8			(Friedrich et al., 2004)
Bald Mountain	L4	Fall		13.5			(Friedrich et al., 2004)
Rio Negro	L4	Fall		9.38			(Friedrich et al., 2004)
Saratov	L4	Fall		8.61			(Friedrich et al., 2004)
Tennasilm	L4	Fall		8.17			(Friedrich et al., 2004)
Ausson	L5	Fall		9.04			(Friedrich et al., 2004)
Baszkówka	L5	Fall		9.76			(Friedrich et al., 2004)
Crumlin	L5	Fall		9.37			(Friedrich et al., 2004)
Elenovka	L5	Fall		10.7			(Friedrich et al., 2004)
Farmington	L5	Fall		7.52			(Friedrich et al., 2004)
Guibga	L5	Fall		8.94			(Friedrich et al., 2004)
Honolulu	L5	Fall		10.5			(Friedrich et al., 2004)
Innisfree	L5	Fall		9.53			(Friedrich et al., 2004)
Jhung	L5	Fall		10.4			(Friedrich et al., 2004)
Malakal	L5	Fall		9.66			(Friedrich et al., 2004)
Monte das Fortes	L5	Fall		8.6			(Friedrich et al., 2004)
Shelburne	L5	Fall		7.28			(Friedrich et al., 2004)
Tané	L5	Fall		9.27			(Friedrich et al., 2004)
Apt	L6	Fall		9.93			(Friedrich et al., 2004)
Aumale	L6	Fall		10.6			(Friedrich et al., 2004)
Chantonnay	L6	Fall		9.15			(Friedrich et al., 2004)
Denver	L6	Fall		9.66			(Friedrich et al., 2004)
Girgenti	L6	Fall		9.82			(Friedrich et al., 2004)
Karkh	L6	Fall		11.1			(Friedrich et al., 2004)
Kunashak	L6	Fall		10.2			(Friedrich et al., 2004)

Kuttippuram	L6	Fall		11.1			(Friedrich et al., 2004)
Kyushu	L6	Fall		9.48			(Friedrich et al., 2004)
La Criolla	L6	Fall		11.1			(Friedrich et al., 2004)
L'Aigle	L6	Fall		10.7			(Friedrich et al., 2004)
Leedey	L6	Fall		9.45			(Friedrich et al., 2004)
Louisville light	L6	Fall		9.41			(Friedrich et al., 2004)
Nejo	L6	Fall		10.7			(Friedrich et al., 2004)
New Concord	L6	Fall		8.9			(Friedrich et al., 2004)
Paranaiba	L6	Fall		9.12			(Friedrich et al., 2004)
Ramsdorf	L6	Fall		7.33			(Friedrich et al., 2004)
Segowlie	L6	Fall		10.1			(Friedrich et al., 2004)
Tathlith	L6	Fall		9.6			(Friedrich et al., 2004)
Tourinnes-la-Grosse	L6	Fall		9.82			(Friedrich et al., 2004)
Tuan Tuc	L6	Fall		7.88			(Friedrich et al., 2004)
Utrecht	L6	Fall		9.17			(Friedrich et al., 2004)
Valdinizza	L6	Fall		7.26			(Friedrich et al., 2004)
Vouillé	L6	Fall		12.1			(Friedrich et al., 2004)
Wethersfield (1971)	L6	Fall		11.3			(Friedrich et al., 2004)
Wethersfield (1982)	L6	Fall		10.5			(Friedrich et al., 2004)
Aïr	L6	Fall		12.0			(Friedrich et al., 2003)
Aumieres	L5	Fall		10.1			(Friedrich et al., 2003)
Forksville	L6	Fall		8.73			(Friedrich et al., 2003)
Kandahar	L6	Fall		10			(Friedrich et al., 2003)
Kiel	L6	Fall		9.54			(Friedrich et al., 2003)
Milena	L6	Fall		8.14			(Friedrich et al., 2003)
Narellan	L6	Fall		7.51			(Friedrich et al., 2003)
Santa Isabel	L6	Fall		10.1			(Friedrich et al., 2003)
Cynthiana	L/LL4	Fall		8.05			(Friedrich et al., 2003)
Knyahinya	L/LL5	Fall		9.85			(Friedrich et al., 2003)
Sultanpur	L/LL6	Fall		8.32			(Friedrich et al., 2003)
Jackalsfontein	L6	Fall		10.50			(Kiesl et al., 1970)
Knyahinya	L/LL5	Fall		11.70			(Kiesl et al., 1970)
Average L (falls)			**2.55**	**9.59**	**2278**		
2 s.d.			**1.56**	**2.99**	**51**		
$n_{meteorites}$			**2**	**73**	**2**		
$n_{analysis}$			**2**	**79**	**2**		
JaH 091	L5	Find		8.97		-0.15	this work
Sinawan 001	L6	Find	2.56	9.76	2623		(Dreibus et al., 1995)
Bluff (a)	L5	Find		11			(Kiesl et al., 1970)
Densmore (1879)	L6	Find		11.7			(Kiesl et al., 1970)
Edmonson (a)	L6	Find		11.3			(Kiesl et al., 1970)
Long Island	L6	Find		8.3			(Kiesl et al., 1970)
McKinney	L4	Find		10.1			(Kiesl et al., 1970)
Ness County (1894)	L6	Find		7.7			(Kiesl et al., 1970)

Clovis (no. 2)	L6	Find		10.7			(Kiesl et al., 1970)
QUE 97008	L3.05	Find	2.48	10.1	2455		(Kadlag and Becker, 2016)
				11.8			(Wang and Lipschutz, 2007)
LEW 86102	L3.4	Find		8.41			(Wang and Lipschutz, 2007)
MET 96515	L3.5	Find		8.14			(Wang and Lipschutz, 2007)
EET 90161	L3.05	Find		8.65			(Wang and Lipschutz, 2007)
MET 96503	L3.10	Find		9.28			(Wang and Lipschutz, 2007)
GRO 95544	L3.2	Find		8.74			(Wang and Lipschutz, 2007)
LEW 87208	L3.4	Find		9.76			(Wang and Lipschutz, 2007)
EET 90628	L3.4	Find		8.98			(Wang and Lipschutz, 2007)
LEW 87248	L3.5	Find		9.68			(Wang and Lipschutz, 2007)
LEW 87284	L3.5	Find		13.5			(Wang and Lipschutz, 2007)
Y74191	L3.7	Find		7.82			(Wang and Lipschutz, 2007)
WSG 95307	L3.8	Find		8.2			(Wang and Lipschutz, 2007)
ALH 84120	L3.8	Find		14.5			(Wang and Lipschutz, 2007)
ALH 84205	L3.9	Find		11.1			(Wang and Lipschutz, 2007)
EET 96188	L/LL3.2	Find		11.3			(Wang and Lipschutz, 2007)

LL chondrites							
Chainpur	LL3.4	Fall		10.39		-0.47	this work
				9			(Greenland, 1967)
				9.8			(Laul et al., 1973)
Parnallee	LL3.6	Fall		8.11		-0.08	this work
				6.3			(Laul et al., 1973)
Semarkona	LL3.00	Fall		13.41		-0.22	this work
Hamlet	LL4	Fall		18.4			(Laul et al., 1973)
Soko-Banja	LL4	Fall		4.5			(Laul et al., 1973)
				5.6			(Kiesl et al., 1970)
				8.29			(Friedrich et al., 2003)
Olivenza	LL5	Fall		6.1			(Laul et al., 1973)
				8.91			(Friedrich et al., 2003)
Jelica	LL6	Fall		8.9			(Laul et al., 1973)
		Fall		10.0			(Kiesl et al., 1970)
Manbhoom	LL6	Fall		6.4			(Laul et al., 1973)
Ottawa	LL6	Fall		9.1			(Laul et al., 1973)
St. Mesmin	LL6	Fall		5.8			(Laul et al., 1973)
Dhurmsala	LL6	Fall		11.6			(Kiesl et al., 1970)
Appley Bridge	LL6	Fall		8.7			(Friedrich et al., 2003)
Athens	LL6	Fall		6.57			(Friedrich et al., 2003)
Bandong	LL6	Fall		9.62			(Friedrich et al., 2003)
Ensisheim	LL6	Fall		8.35			(Friedrich et al., 2003)
Mangwendi	LL6	Fall		11.2			(Friedrich et al., 2003)
Average LL (falls)				**9.2**			
2 s.d.				**6.4**			
$n_{meteorites}$				**17**			

$n_{analysis}$				**23**			
Kelly	LL4	Find		8.2			(Laul et al., 1973)
Y-74442	LL4	Find	2.24	9.55	2346		(Dreibus et al., 1995)
GRO 95658	LL3.3	Find		12.7			(Wang and Lipschutz, 2007)
ALH 84126	LL3.4	Find		9.54			(Wang and Lipschutz, 2007)
LEW 87254	LL3.5	Find		8.05			(Wang and Lipschutz, 2007)
GRO 95596	LL3.8	Find		7.58			(Wang and Lipschutz, 2007)

Rumuruti chondrites							
Rumuruti, dark matrix	R3.8-6	Fall	4.14	14.4	2875		(Dreibus et al., 1995)
Rumuruti, light-colored clast	R3.8-6	Fall	3.99	14.7	2714		(Dreibus et al., 1995)
Average Rumuruti (falls)			**4.07**	**14.55**	**2795**		
2 s.d.			**0**	**0**	**0**		
$n_{meteorites}$			**1**	**1**	**1**		
$n_{analysis}$			**2**	**2**	**2**		
Acfer 217	R3.8-5	Find	0.717	13.2	543		(Dreibus et al., 1995)
ALH 85151	R3.6	Find		15.3			(Xiao and Lipschutz, 1992)

EH chondrites							
Indarch	EH4	Fall		33.16		-0.34	this work
				25.4			(Kallemeyn and Wasson, 1986)
				41.0			(Binz et al., 1974)
				34.0			(Greenland, 1967)
Qingzhen	EH3	Fall		26.05		-0.24	this work
				22.3			(Kaczaral et al., 1988)
				21.5			(Zhang et al., 1995)
				22.3			(Weeks and Sears, 1985)
				22.3			(Kallemeyn and Wasson, 1986)
				20.7			(Kong et al., 1997)
Parsa	EH3	Fall		24			(Bhandari et al., 1980)
				24.8			(Kallemeyn and Wasson, 1986)
St. Mark's	EH5	Fall		25.5			(Kallemeyn and Wasson, 1986)
				30.0			(Binz et al., 1974)
Saint-Sauveur	EH5	Fall		31.8			(Kallemeyn and Wasson, 1986)
				27.5			(Laul et al., 1973)
Abee	EH4	Fall		28.1			(Biswas et al., 1980)
				34.0			(Ikramuddin et al., 1976)
				34.3			(Binz et al., 1974)
				11.0			(Greenland, 1967)
				24.5			(Laul et al., 1973)
Adhi Kot	EH4	Fall		16.1			(Laul et al., 1973)
Average EH (falls)				**25.74**			

2 s.d.				**11.1**			
$n_{meteorites}$				**7**			
$n_{analysis}$				**22**			
Sahara 97072	EH3	Find	4.02	23.6	1704		(Kadlag and Becker, 2015)
Kota-Kota	EH3	Find	4.23	22.6	1872		(Kadlag and Becker, 2015)
				23.3			(Kallemeyn and Wasson, 1986)
				28.0			(Binz et al., 1974)
Y-691	EH3	Find		23			(Kaczaral et al., 1988)
ALH 84206	EH3	Find		10			(Zhang et al., 1995)
ALH 84170	EH3	Find		20			(Zhang et al., 1995)
				26			(Kong et al., 1997)
EET 87746	EH4	Find		24.5			(Zhang et al., 1995)
				28.8			(Kong et al., 1997)
LEW 88180	EH5	Find		22.0			(Zhang et al., 1995)
				27.9			(Kong et al., 1997)
ALHA77295	EH3	Find		19.9			(Weeks and Sears, 1985)
				23.1			(Kallemeyn and Wasson, 1986)
RKPA80259	EH5	Find		16.1			(Weeks and Sears, 1985)
				18.3			(Kallemeyn and Wasson, 1986)
ALHA81189	EH3	Find		22.3			(Kallemeyn and Wasson, 1986)
PCA 82518	EH3	Find		19.7			(Kallemeyn and Wasson, 1986)
Y-691	EH3	Find		21.5			(Kallemeyn and Wasson, 1986)
Y-74370	EH4	Find		20.6			(Kallemeyn and Wasson, 1986)
PCA 91238	EH3	Find		23.3			(Kong et al., 1997)

EL chondrites							
Pillistfer	EL6	Fall		12.13		-0.36	this work
				11.7			(Kallemeyn and Wasson, 1986)
				14.0			(Binz et al., 1974)
				13.0			(Greenland, 1967)
Hvittis	EL6	Fall		10.86		-0.22	this work
				14.5			(Kallemeyn and Wasson, 1986)
				21			(Binz et al., 1974)
				10			(Greenland, 1967)
				12.3			(Laul et al., 1973)
Jajh deh Kot Lalu	EL6	Fall		11.2			(Kallemeyn and Wasson, 1986)
Daniel's Kuil	EL6	Fall		21.0			(Binz et al., 1974)
				19.0			(Greenland, 1967)
Khairpur	EL6	Fall		16.3			(Kallemeyn and Wasson, 1986)
				24.0			(Binz et al., 1974)
				24.0			(Greenland, 1967)
				18.4			(Laul et al., 1973)
Average EL (falls)				**15.7**			
2 s.d.				**8.7**			

$n_{meteorites}$				**5**			
$n_{analysis}$				**16**			
Happy Canyon	EL6/7	Find		3.21		0.11	this work
MAC 88184	EL3	Find		19.5			(Zhang et al., 1995)
MAC 88180	EL3	Find		15			(Zhang et al., 1995)
MAC 88136	EL3	Find		17			(Zhang et al., 1995)
				19.1			(Kong et al., 1997)
ALH 85119	EL3	Find		16			(Zhang et al., 1995)
				20.3			(Kong et al., 1997)
LEW 87119	EL6	Find		13			(Zhang et al., 1995)
ALHA81260	EL6	Find		13.0			(Kallemeyn and Wasson, 1986)
PCA 91020	EL6	Find		18.1			(Kong et al., 1997)
TIL 91714	EL5	Find		11.6			(Kong et al., 1997)
ALHA81021	EL6	Find		13.5			(Kong et al., 1997)
LEW 88714	EL6	Find		15.9			(Kong et al., 1997)
Blithfield	EL6	Find		6.2			(Laul et al., 1973)
Atlanta	EL6	Find		16.0			(Binz et al., 1974)

4. References

Bhandari, N., Shah, V.B., Wasson, J.T., 1980. The Parsa enstatite chondrite. Meteoritics 15, 225-233.

Binz, C.M., Kurimoto, R.K., Lipschutz, M.E., 1974. Trace elements in primitive meteorites—V. Abundance patterns of thirteen trace elements and interelement relationships in enstatite chondrites. Geochim. Cosmochim. Acta 38, 1579-1606.

Biswas, S., Walsh, T., Bart, G., E. Lipschutz, M., 1980. Thermal metamorphism of primitive meteorites—XI. The enstatite meteorites: origin and evolution of a parent body. Geochim. Cosmochim. Acta 44, 2097-2110.

Brenan, J.M., 2015. Se–Te fractionation by sulfide–silicate melt partitioning: Implications for the composition of mantle-derived magmas and their melting residues. Earth Planet. Sci. Lett. 422, 45-57.

Carignan, J., Wen, H., 2007. Scaling NIST SRM 3149 for Se isotope analysis and isotopic variations of natural samples. Chem. Geol. 242, 347-350.

Dreibus, G., Palme, H., Spettel, B., Zipfel, J., Wänke, H., 1995. Sulfur and selenium in chondritic meteorites. Meteoritics 30, 439-445.

Elwaer, N., Hintelmann, H., 2008a. Precise selenium isotope ratios measurement using a multimode sample introduction system (MSIS) coupled with multicollector inductively coupled plasma mass spectrometry (MC-ICP-MS). J. Anal. At. Spectrom. 23, 1392-1396.

Elwaer, N., Hintelmann, H., 2008b. Selective separation of selenium (IV) by thiol cellulose powder and subsequent selenium isotope ratio determination using multicollector inductively coupled plasma mass spectrometry. J. Anal. At. Spectrom. 23, 733-743.

Friedrich, J.M., Bridges, J.C., Wang, M.-S., Lipschutz, M.E., 2004. Chemical studies of L chondrites. VI: variations with petrographic type and shock-loading among equilibrated falls1. Geochim. Cosmochim. Acta 68, 2889-2904.

Friedrich, J.M., Wang, M.-S., Lipschutz, M.E., 2002. Comparison of the trace element composition of Tagish Lake with other primitive carbonaceous chondrites. Meteoritics & Planetary Science 37, 677-686.

Friedrich, J.M., Wang, M.-S., Lipschutz, M.E., 2003. Chemical studies of L chondrites. V: compositional patterns for 49 trace elements in 14 L4-6 and 7 LL4-6 falls. Geochim. Cosmochim. Acta 67, 2467-2479.

Greenland, L., 1967. The abundances of selenium, tellurium, silver, palladium, cadmium, and zinc in chondritic meteorites. Geochim. Cosmochim. Acta 31, 849-860.

Ikramuddin, M., Binz, C.M., Lipschutz, M.E., 1976. Thermal metamorphism of primitive meteorites—II. Ten trace elements in Abee enstatite chondrite heated at 400–1000°C. Geochim. Cosmochim. Acta 40, 133-142.

Kaczaral, P.W., Dennison, J.E., Verkouteren, R.M., Lipschutz, M.E., 1988. On volatile/mobile trace element trends in E3 chondrites. Antarctic Meteorite Research 1, 113.

Kadlag, Y., Becker, H., 2015. Fractionation of highly siderophile and chalcogen elements in components of EH3 chondrites. Geochim. Cosmochim. Acta 161, 166-187.

Kadlag, Y., Becker, H., 2016. 187Re–187Os systematics, highly siderophile element, S–Se–Te abundances in the components of unequilibrated L chondrites. Geochim. Cosmochim. Acta 172, 225-246.

Kallemeyn, G.W., Wasson, J.T., 1981. The compositional classification of chondrites—I. The carbonaceous chondrite groups. Geochim. Cosmochim. Acta 45, 1217-1230.

Kallemeyn, G.W., Wasson, J.T., 1986. Compositions of enstatite (EH3, EH4,5 and EL6) chondrites: Implications regarding their formation. Geochim. Cosmochim. Acta 50, 2153-2164.

Kiesl, W., Grass, F., Böckl, R., Ponta, U., 1970. Cosmochemical abundances of trace elements in meteorites. J Radioanal Nucl Ch 6, 447-452.

Kimura, M., Hiyagon, H., Palme, H., Spettel, B., Wolf, D., Clayton, R.N., Mayeda, T.K., Sato, T., Suzuki, A., Kojima, H., 2002. Yamato 792947, 793408 and 82038: The most primitive H chondrites, with abundant refractory inclusions. Meteoritics & Planetary Science 37, 1417-1434.

Kong, P., Mori, T., Ebihara, M., 1997. Compositional continuity of enstatite chondrites and implications for heterogeneous accretion of the enstatite chondrite parent body. Geochim. Cosmochim. Acta 61, 4895-4914.

Krähenbühl, U., Ganapathy, R., Morgan, J.W., Anders, E., 1973. Volatile elements in Apollo 16 samples: Implications for highland volcanism and accretion history of the moon, Lunar and Planetary Science Conference Proceedings, p. 1325.

Laul, J.C., Ganapathy, R., Anders, E., Morgan, J.W., 1973. Chemical fractionations in meteorites—VI. Accretion temperatures of H-, LL- and E-chondrites, from abundance of volatile trace elements. Geochim. Cosmochim. Acta 37, 329-357.

Layton-Matthews, D., Leybourne, M.I., Peter, J.M., Scott, S.D., Cousens, B., Eglington, B.M., 2013. Multiple sources of selenium in ancient seafloor hydrothermal systems: Compositional and Se, S, and Pb isotopic evidence from volcanic-hosted and volcanic-sediment-hosted massive sulfide deposits of the Finlayson Lake District, Yukon, Canada. Geochim. Cosmochim. Acta 117, 313-331.

Makishima, A., Nakamura, E., 2009. Determination of Ge, As, Se and Te in Silicate Samples Using Isotope Dilution-Internal Standardisation Octopole Reaction Cell ICP-QMS by Normal Sample Nebulisation. Geostandards and Geoanalytical Research 33, 369-384.

Marin, L., Lhomme, J., Carignan, J., 2001. Determination of selenium concentration in sixty five reference materials for geochemical analysis by GFAAS after separation with thiol cotton. Geostandards Newsletter 25, 317-324.

Matza, S.D., Lipschutz, M.E., 1977. Thermal metamorphism of primitive meteorites. VI - Eleven trace elements in Murchison C2 chondrite heated at 400-1000 C, in: Merril, R.B. (Ed.), Lunar and Planetary Science Conference Proceedings, pp. 161-176.

Mitchell, K., Mason, P.R.D., Van Cappellen, P., Johnson, T.M., Gill, B.C., Owens, J.D., Diaz, J., Ingall, E.D., Reichart, G.-J., Lyons, T.W., 2012. Selenium as paleo-oceanographic proxy: A first assessment. Geochim. Cosmochim. Acta 89, 302-317.

Pettersson, J., Olin, A., 1991. The rate of reduction of selenium(VI) to selenium(IV) in hydrochloric-acid. Talanta 38, 413-417.

Pogge von Strandmann, P.A.E., Coath, C.D., Catling, D.C., Poulton, S.W., Elliott, T., 2014. Analysis of mass dependent and mass independent selenium isotope variability in black shales. J. Anal. At. Spectrom. 29, 1648-1659.

Rouxel, O., Ludden, J., Carignan, J., Marin, L., Fouquet, Y., 2002. Natural variations of Se isotopic composition determined by hydride generation multiple collector inductively coupled plasma mass spectrometry. Geochim. Cosmochim. Acta 66, 3191-3199.

Rudge, J.F., Reynolds, B.C., Bourdon, B., 2009. The double spike toolbox. Chem. Geol. 265, 420-431.

Schilling, K., Johnson, T.M., Wilcke, W., 2011. Isotope fractionation of selenium during fungal biomethylation by alternaria alternata. Environmental Science & Technology 45, 2670-2676.

Schindewolf, U., 1960. Selenium and tellurium content of stony meteorites by neutron activation. Geochim. Cosmochim. Acta 19, 134-138.

Stueken, E.E., Foriel, J., Nelson, B.K., Buick, R., Catling, D.C., 2013. Selenium isotope analysis of organic-rich shales: advances in sample preparation and isobaric interference correction. J. Anal. At. Spectrom. 28, 1734-1749.

Vollstaedt, H., Mezger, K., Nägler, T., Leya, I., Trinquier, A., 2016. Selenium isotope analysis by N-TIMS: Potential and challenges. International Journal of Mass Spectrometry 401, 55-63.

Wang, M.-S., Lipschutz, M.E., 2007. Trace elements in primitive meteorites—VII Antarctic unequilibrated ordinary chondrites. Geochim. Cosmochim. Acta 71, 1062-1073.

Wang, Z., Becker, H., 2013. Ratios of S, Se and Te in the silicate Earth require a volatile-rich late veneer. Nature 499, 328-331.

Wang, Z., Becker, H., Gawronski, T., 2013. Partial re-equilibration of highly siderophile elements and the chalcogens in the mantle: A case study on the Baldissero and Balmuccia peridotite massifs (Ivrea Zone, Italian Alps). Geochim. Cosmochim. Acta 108, 21-44.

Wang, Z., Becker, H., Wombacher, F., 2015. Mass Fractions of S, Cu, Se, Mo, Ag, Cd, In, Te, Ba, Sm, W, Tl and Bi in Geological Reference Materials and Selected Carbonaceous Chondrites Determined by Isotope Dilution ICP-MS. Geostandards and Geoanalytical Research 39, 185-208.

Weeks, K.S., Sears, D.W.G., 1985. Chemical and physical studies of type 3 chondrites—V: The enstatite chondrites. Geochim. Cosmochim. Acta 49, 1525-1536.

Wen, H., Carignan, J., 2011. Selenium isotopes trace the source and redox processes in the black shale-hosted Se-rich deposits in China. Geochim. Cosmochim. Acta 75, 1411-1427.

Wlotzka, F., Spettel, B., Palme, H., Schultz, L., 1989. Two new CM chondrites from Antarctica: Different mineralogy, but same chemistry. Meteoritics 24, 341.

Wolf, S.F., Unger, D.L., Friedrich, J.M., 2005. Determination of cosmochemically volatile trace elements in chondritic meteorites by inductively coupled plasma mass spectrometry. Analytica Chimica Acta 528, 121-128.

Xiao-Quan, S., Kai-Jing, H., 1985. Matrix modification for determination of selenium in geological samples by graphite-furnace atomic-absorption spectrometry after preseparation with thiol cotton fibre. Talanta 32, 23-26.

Xiao, X., Lipschutz, M.E., 1992. Labile trace elements in carbonaceous chondrites: A survey. Journal of Geophysical Research: Planets 97, 10199-10211.

Yu, M., Tian, W., Sun, D., Shen, W., Wang, G., Xu, N., 2001. Systematic studies on adsorption of 11 trace heavy metals on thiol cotton fiber. Analytica Chimica Acta 428, 209-218.

Zhang, Y., Benoit, P.H., Sears, D.W.G., 1995. The classification and complex thermal history of the enstatite chondrites. Journal of Geophysical Research: Planets 100, 9417-9438.

Zhu, J.-M., Johnson, T.M., Clark, S.K., Zhu, X.-K., 2008. High precision measurement of selenium isotopic composition by hydride generation multiple collector inductively coupled plasma mass spectrometry with a ^{74}Se-^{77}Se double spike. Chinese Journal of Analytical Chemistry 36, 1385-1390.