Electronic supplement

Burkhardt et al. (2011): Molybdenum isotope anomalies in meteorites: Constraints on solar nebula evolution and origin of the Earth

S1 Analytical techniques

S1.1 Sample preparation and chemical separation of Mo

Samples investigated in this study represent all major chondrites groups, several Allende CAI, the major groups of iron meteorites, two pallasites, one angrite, and two martian meteorites (Table S2). For CAI A-ZH-1 to A-ZH-5, Mo was separated from material remaining after chemical separation of Hf and W (Burkhardt et al., 2008). All other samples were cleaned with abrasive paper and by ultrasonication in distilled H_2O and ethanol. Chondrites were powdered in an agate mortar and for some samples metal was separated using a hand magnet. To completely access refractory components and presolar phases, carbonaceous chondrites and CAI A-ZH-10 were fused using a CO_2 laser in ultra-pure graphite capsules under oxidizing (atmospheric) or reducing (7% H_2–93% Ar) conditions at the University of Goettingen (Pack et al., 2010). The resulting ~30 mg glass spherules were ultrasonicated in H_2O and ethanol before digestion in acids. All chondrites and achondrites were dissolved in 60 ml Savillex teflon beakers using HF-HNO_3-$HClO_4$ (6:3:1) at 180°C on a hotplate overnight. Chondrites that were not fused were kept on the hotplate for 6-9 days. All metal samples were leached in 6M HCl for ~20 minutes and then dissolved in Savillex beakers using 6M HCl with traces of HNO_3 at 120°C on a hotplate overnight. After digestion, all samples were dried down and re-dissolved in HNO_3-H_2O_2 several times to attack any remaining organic matter. After re-dissolving in 6M HCl, a ~2%

aliquot was taken for concentration determination by isotope dilution using a ^{97}Mo tracer that was calibrated against pure Mo metal.

Molybdenum was chemically separated from the sample matrix using a three-stage ion exchange procedure employing both anion and cation exchange resins (Table S1). Molybdenum (together with Ti, W, HFSE and Ru) was first separated from major elements using a cation exchange column (Bio-Rad AG 50W-X8) and 1M HCl-0.1M HF (*cf.* Patchett and Tatsumoto, 1980). Further separation of Mo from the remaining elements were achieved in HCl-HF media using an anion exchange resin (Bio-Rad AG 1-X8). Any remaining Fe, Ni and a large part of the Ru was removed from the resin with 1 M HF, while Ti, Zr, Hf and W were eluted using different HCl–HF mixtures (Kleine et al., 2004). Finally Mo together with some remaining Ru is eluted using 3 M HNO_3. The remaining Ru is removed from the Mo fraction using TRU-Spec resin and 7 M HNO_3, followed by elution of Mo with 0.1 M HNO_3. This last cleaning step was repeated up to three times, resulting in Ru/Mo and Zr/Mo $< 3\times10^{-5}$ for most samples. Total procedural blanks ranged from 0.1 to 1 ng Mo and were negligible for all samples, for which ~100 ng Mo were analysed. Yields as determined by isotope dilution ranged from 70–90%.

S1.2 Mass spectrometry

All isotope measurements were performed using the Nu Plasma 1700 MC-ICPMS at ETH Zurich. All seven Mo isotopes were measured simultaneously, as well as ^{90}Zr and ^{99}Ru to monitor potential isobaric interferences. Samples were introduced via a Cetac Aridus II desolvating nebulizer at an uptake rate of 75 µl/min, resulting in an ion beam of $3–4 \times 10^{-11}$ A on ^{96}Mo for ~100 ppb Mo. Each measurement consisted of 60 ratios obtained in 3 blocks of 20 ratios each with an integration time of 5 seconds. Instrumental mass bias and natural mass–dependent isotope fractionation was corrected by normalization to ^{98}Mo/^{96}Mo = 1.453171 (Lu and Masuda, 1994) and using the exponential law. To assess possible matrix effects or artefacts due to improper mass bias correction, measured Mo isotope ratios were also normalized to ^{92}Mo/^{98}Mo, ^{95}Mo/^{97}Mo, and ^{95}Mo/^{96}Mo. All these normalization procedures yield internally consistent results (see Tables S2-S4). Interference corrections for Zr and Ru were usually smaller than 50 ppm, except for the angrite and martian samples which required corrections of up to 6 ε units. However, tests with doped standard solutions prove the accuracy of our procedures for even larger interference corrections.

Molybdenum isotope ratios are reported as ε^{i}Mo values calculated relative to the mean of two standard runs bracketing the sample run. The external reproducibility of the standard measurements (2SD) ranged from 0.21 ε^{97}Mo to 0.72 ε^{92}Mo for normalization to ^{98}Mo/^{96}Mo. The accuracy and reproducibility of the Mo isotope measurements was evaluated by repeated analyses of natural and synthetic terrestrial standard materials (BCR-2, BHVO-2, SRM82b, SRM129c), which all yielded the terrestrial Mo isotopic composition (see Table 1 in the main text and Table S2-S4).

Table S1: Three-column separation procedure for Mo isotopic analyses

Step	**Resin volumes**	**Acid**
Cation column chemistry (Bio-Rad 50W-X8 200-400 mesh, 14 ml)		
Equilibrate	2x2	1 M HCl 0.1 M HF
Load+collect	0.6	1 M HCl 0.1 M HF
Rinse+collect	1	1 M HCl 0.1 M HF
Anion column chemistry (Bio-Rad AG1-X8 100-200 mesh, 7 ml)		
Equilibrate	3x1	1 M HF
Load	3.6	1 M HF
Wash (Fe, Ni, Ru)	2x3.6	1 M HF
Rinse	2	H_2O
Wash (Ti, Zr, Hf)	3.6	6 M HCl 0.06 M HF
Collect W	4.3	6 M HCl 1 M HF
Rinse	2x1.7	H_2O
Collect Mo	3.6	3 M HNO3
Cation column chemistry (TRU resin, 1 ml)		
Equilibrate	7	7 M HNO_3
Load	1	7 M HNO_3
Wash (Ru)	6	7 M HNO_3
Collect Mo	6	0.1 M HNO_3

S2 Evaluation of the ^{97}Tc-^{97}Mo chronometer

Molybdenum-97 is not only produced by the s- and r-processes but also by decay of now-extinct ^{97}Tc ($t_{1/2}$=4 Myr), which is only produced in the p-process. Provided that ^{97}Tc was present at the start of the solar system, the ^{97}Tc-^{97}Mo system could potentially be used as a chronometer for early solar system processes. However, several conditions must be met to utilize the ^{97}Tc-^{97}Mo system as a chronometer: (i) there needs to be sufficient Tc/Mo fractionation by early solar system processes; (ii) a proxy for the geo- and cosmochemical behavior of Tc needs to be identified because no stable Tc isotope is present today; any radiogenic contribution to ^{97}Mo needs to be deconvolved from any nucleosynthetic effect. Lazar et al. (2004) showed that Ru behaves similar to Tc during crystallization in the Fe-Ni-S system. However, only small Ru/Mo and hence Tc/Mo fractionation is expected during core crystallization, so that this process cannot be dated using the Tc-Mo system. However, Tc is highly siderophile while Mo is only moderately siderophile, metal-silicate separation during planetary core formation should result in large Tc/Mo fractionation. Therefore, core formation could potentially be dated using the Tc-Mo system.

Determining any radiogenic contribution to the ^{97}Mo abundance in a sample (^{97}Mo*) requires quantification of any potential nucleosynthetic ^{97}Mo variations. This can be achieved by using the relation of the r- and s-process contributions between ^{97}Mo and other Mo isotopes (Dauphas et al., 2002). This results in the following relationship: ε^{97}Mo*= ((ε^{97}Mo-0.52ε^{95}Mo) + (ε^{97}Mo-0.61ε^{100}Mo))/2. Fig. S1 shows that there is no relation between the calculated ^{97}Mo* anomalies in iron meteorites and chondrites and their inferred Tc/Mo. All the ^{97}Mo* anomalies are smaller than ~15 ppm. Average magmatic irons have ε^{97}Mo* = -0.01±0.14, while chondrites exhibit an average ε^{97}Mo* of 0.03±0.17

(2σ).

Using the highest observed ^{185}Re/^{96}Mo and ^{100}Ru/^{96}Mo ratios [0.94 and 2.96 for Negrillos, Re and Ru data from Petaev and Jacobsen (2004)] and a chondritic ^{185}Re/^{96}Mo=0.0454 and ^{100}Ru/^{96}Mo=0.5501 (Anders and Grevesse, 1989), a maximum ^{97}Tc/^{92}Mo of 8x10^{-7} is inferred for the time of Tc/Mo fractionation in the magmatic iron meteorites. This value is slightly lower than but of higher precision than the maximum value of 3x10^{-6} inferred by Dauphas et al., 2002. Given the old age of magmatic irons (Kleine et al., 2009) the solar system initial ^{97}Tc/^{92}Mo must have been lower than ~1x10^{-6}. Consequently, the initial abundance of ^{97}Tc at the beginning of the solar system was too low to utilized the Tc-Mo system as a chronometer for early solar system processes.

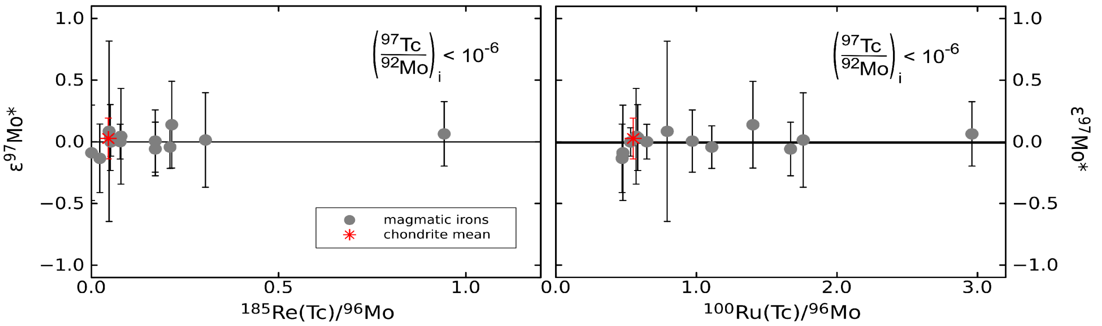

Figure S1: Plots of ε^{97}Mo* vs. Tc/Mo (using Re/Mo and Ru/Mo as proxies). The data show no positive correlations, indicating a low solar system initial ^{97}Tc/^{92}Mo.

Table S2: Mo isotopic data for meteorites and terrestrial samples normalized to ^{92}Mo/^{98}Mo.

Sample		Method[a]	N[b]	Mo[c] [µg/g]	ε^{94}Mo[d]	ε^{95}Mo[d]	ε^{96}Mo[d]	ε^{97}Mo[d]	ε^{100}Mo[d]
Terrestrial Standards									
Alfa[e]	Mo solution		737	~0.1	0.00 ± 0.28	0.00 ± 0.27	0.00 ± 0.24	0.00 ± 0.25	0.00 ± 0.44
BCR-2	Basalt	acid	15	249 ± 1	0.06 ± 0.11	0.06 ± 0.07	0.03 ± 0.05	0.01 ± 0.04	-0.05 ± 0.12
BHVO-2	Basalt	f ox, f red	7	2.28 ± 1	-0.17 ± 0.14	0.02 ± 0.15	0.01 ± 0.08	-0.07 ± 0.07	0.00 ± 0.20
SRM 82b	Cast iron	acid	4	21.50 ± 1	0.15 ± 0.12	0.17 ± 0.29	0.10 ± 0.29	0.02 ± 0.13	-0.45 ± 0.68
SRM 129c	High S-steel	acid	7	7.46 ± 5	0.11 ± 0.07	0.07 ± 0.14	0.10 ± 0.12	0.02 ± 0.09	-0.24 ± 0.25
Standard mean					0.03 ± 0.07	0.06 ± 0.05	0.05 ± 0.04	0.00 ± 0.03	-0.12 ± 0.10
Iron meteorites									
Mundrabilla	IAB	acid	2	5.17 ± 1	-0.18 ± 0.22	-0.16 ± 0.17	0.06 ± 0.17	-0.12 ± 0.19	0.06 ± 0.22
Caddo County	IAB	acid	5	6.53 ± 1	0.09 ± 0.24	-0.02 ± 0.21	-0.03 ± 0.24	-0.11 ± 0.12	0.03 ± 0.12
Odessa	IAB	acid	3	6.33 ± 1	0.06 ± 0.38	-0.03 ± 0.40	0.07 ± 0.39	0.04 ± 0.32	-0.05 ± 0.53
IAB mean					0.02 ± 0.15	-0.05 ± 0.11	0.02 ± 0.11	-0.06 ± 0.08	0.01 ± 0.13
Arispe	IC	acid	4	6.54 ± 1	0.35 ± 0.12	-0.13 ± 0.11	-0.19 ± 0.10	0.00 ± 0.12	0.54 ± 0.27
Negrillos	IIAB	acid	2	6.54 ± 1	0.28 ± 0.21	-0.22 ± 0.11	-0.40 ± 0.11	0.10 ± 0.14	0.83 ± 0.27
Sikhote Alin	IIAB	acid	3	6.42 ± 1	-0.01 ± 0.46	-0.30 ± 0.09	-0.55 ± 0.27	-0.09 ± 0.18	0.89 ± 0.60
North Chile	IIAB	acid	2	6.30 ± 1	0.22 ± 0.19	-0.04 ± 0.21	-0.39 ± 0.20	0.00 ± 0.18	0.96 ± 0.27
IIAB mean					0.14 ± 0.27	-0.20 ± 0.14	-0.46 ± 0.11	-0.01 ± 0.12	0.89 ± 0.15
Carbo	IID	acid	3	7.76 ± 1	0.17 ± 0.35	0.05 ± 0.16	-0.42 ± 0.21	0.26 ± 0.29	0.92 ± 0.56
Miles	IIE	acid	3	7.37 ± 1	0.14 ± 0.45	-0.03 ± 0.55	-0.21 ± 0.23	0.16 ± 0.16	0.69 ± 0.69
Watson	IIE	acid	4	7.01 ± 1	0.14 ± 0.23	-0.05 ± 0.08	-0.25 ± 0.14	0.00 ± 0.10	0.51 ± 0.37
IIE mean					0.14 ± 0.14	-0.04 ± 0.12	-0.23 ± 0.08	0.07 ± 0.10	0.59 ± 0.23
Henbury	IIIAB	acid	3	5.72 ± 1	0.06 ± 0.36	-0.17 ± 0.19	-0.43 ± 0.14	0.00 ± 0.06	0.62 ± 0.64
Charcas	IIIAB	acid	2	7.47 ± 1	0.10 ± 0.18	-0.28 ± 0.13	-0.48 ± 0.12	-0.14 ± 0.16	0.93 ± 0.28
Cape York	IIIAB	acid	3	6.76 ± 1	0.25 ± 0.10	-0.15 ± 0.45	-0.31 ± 0.09	0.10 ± 0.38	0.61 ± 1.15
IIIAB mean					0.14 ± 0.10	-0.19 ± 0.10	-0.40 ± 0.07	0.00 ± 0.11	0.69 ± 0.28
Carlton	IIICD	acid	2	2.64 ± 1	0.05 ± 0.23	0.09 ± 0.24	0.01 ± 0.20	-0.04 ± 0.17	0.01 ± 0.40
Stainton	IIIE	acid	5	7.51 ± 1	0.15 ± 0.21	-0.15 ± 0.22	-0.36 ± 0.19	0.02 ± 0.17	0.73 ± 0.23
Clark County	IIIF	acid	3	4.72 ± 1	0.09 ± 0.15	0.19 ± 0.39	-0.42 ± 0.37	0.16 ± 0.26	1.13 ± 0.72
Albion	IVA	acid	3	5.69 ± 1	0.04 ± 0.57	-0.18 ± 0.46	-0.27 ± 0.17	-0.08 ± 0.16	0.53 ± 0.24
Duell Hill	IVA	acid	3	5.97 ± 1	0.09 ± 0.23	-0.19 ± 0.26	-0.29 ± 0.12	-0.03 ± 0.23	0.45 ± 0.51
Gibeon	IVA	acid	2	5.02 ± 1	0.15 ± 0.19	0.04 ± 0.21	-0.22 ± 0.21	0.09 ± 0.18	0.46 ± 0.26
IVA mean					0.08 ± 0.13	-0.13 ± 0.13	-0.26 ± 0.06	-0.02 ± 0.08	0.48 ± 0.14
Tawallah Valley	IVB	acid	9	32.14 ± 1	-0.03 ± 0.15	0.03 ± 0.16	-0.65 ± 0.11	0.17 ± 0.10	1.47 ± 0.23
Santa Clara	IVB	acid	6	28.43 ± 1	0.08 ± 0.19	0.04 ± 0.19	-0.62 ± 0.14	0.15 ± 0.17	1.40 ± 0.37
Tlacotepec	IVB	acid	3	22.01 ± 1	0.15 ± 0.32	0.01 ± 0.45	-0.64 ± 0.44	0.22 ± 0.43	1.56 ± 0.55
Cape of Good Hope	IVB	acid	4	20.23 ± 1	0.24 ± 0.39	0.19 ± 0.30	-0.54 ± 0.20	0.15 ± 0.25	1.20 ± 0.19
IVB mean					0.07 ± 0.09	0.06 ± 0.09	-0.62 ± 0.06	0.17 ± 0.06	1.41 ± 0.13
Mbosi	Ungrouped	acid	5	>1.22 ± 1	0.19 ± 0.31	0.43 ± 0.17	-0.38 ± 0.22	0.30 ± 0.19	1.05 ± 0.18
Pallasites									
Brenham	Main group Pal	acid	6	5.40 ± 1	0.16 ± 0.11	-0.16 ± 0.18	-0.35 ± 0.11	-0.02 ± 0.10	0.49 ± 0.22
Eagle Station	Eagle Station Pal	acid	6	7.80 ± 1	0.14 ± 0.18	0.23 ± 0.08	-0.37 ± 0.08	0.21 ± 0.12	1.15 ± 0.14
Mars and Angrites									
Zagami	Shergottite	acid	1	>0.04 ± 1	0.42 ± 0.42	-0.12 ± 0.27	-0.17 ± 0.24	-0.04 ± 0.30	0.04 ± 0.40
DaG476	Shergottite	acid	1	>0.06 ± 1	0.30 ± 0.42	0.14 ± 0.27	0.04 ± 0.24	0.22 ± 0.30	-0.01 ± 0.40
Mars mean					0.36 ± 0.42	0.01 ± 0.27	-0.06 ± 0.24	0.09 ± 0.30	0.01 ± 0.40
NWA4801	Angrite	acid	1	>0.13 ± 1	0.03 ± 0.42	-0.10 ± 0.27	0.05 ± 0.24	0.22 ± 0.30	0.48 ± 0.40
Chondrites									
Orgueil	CI	f red	2	0.88 ± 1	-0.10 ± 0.22	0.10 ± 0.23	-0.37 ± 0.19	0.05 ± 0.21	0.72 ± 0.39
Murchison	CM2	acid	3	1.27 ± 1	0.67 ± 0.38	0.02 ± 0.32	-2.07 ± 0.43	0.70 ± 0.64	4.38 ± 0.47
Murchison	CM2	f red	2	1.02 ± 1	0.71 ± 0.20	-0.02 ± 0.22	-2.17 ± 0.17	0.57 ± 0.20	4.27 ± 0.37
Murchison	CM2	f ox	2	0.77 ± 1	0.48 ± 0.20	-0.06 ± 0.23	-2.08 ± 0.18	0.48 ± 0.21	4.35 ± 0.38
CM mean					0.63 ± 0.14	-0.02 ± 0.08	-2.10 ± 0.13	0.60 ± 0.18	4.34 ± 0.15
NWA2090	CO3	f red	2	1.16 ± 1	0.10 ± 0.21	-0.20 ± 0.23	-0.48 ± 0.17	-0.08 ± 0.19	0.84 ± 0.38
Allende	CV3	acid	4	1.47 ± 1	0.21 ± 0.09	0.01 ± 0.31	-1.06 ± 0.28	0.25 ± 0.43	2.25 ± 0.12
Allende	CV3	f red	4	1.35 ± 1	0.19 ± 0.28	0.03 ± 0.15	-1.13 ± 0.16	0.25 ± 0.24	2.10 ± 0.33
CV mean					0.20 ± 0.10	0.02 ± 0.12	-1.09 ± 0.12	0.25 ± 0.17	2.18 ± 0.14
NWA801	CR2	f red	3	1.21 ± 2	0.40 ± 0.10	-0.05 ± 0.06	-1.17 ± 0.21	0.32 ± 0.40	2.19 ± 0.31
Tafassasset metal	CR anomalous	acid	2	3.87 ± 1	-0.01 ± 0.19	-0.05 ± 0.22	-0.79 ± 0.21	0.38 ± 0.18	1.94 ± 0.28
Gujba metal	CB	acid	7	4.47 ± 1	0.17 ± 0.04	0.12 ± 0.05	-0.57 ± 0.08	0.21 ± 0.12	1.15 ± 0.17
Bremervörde	H3	acid	3	1.16 ± 1	0.12 ± 0.54	0.03 ± 0.28	-0.23 ± 0.17	0.01 ± 0.29	0.38 ± 0.35
Kernouvé	H6	acid	2	1.31 ± 1	0.03 ± 0.25	-0.06 ± 0.21	-0.21 ± 0.23	0.05 ± 0.24	0.52 ± 0.34
Bruderheim metal	L6	acid	2	1.92 ± 1	0.06 ± 0.23	-0.20 ± 0.25	-0.19 ± 0.22	-0.07 ± 0.16	0.54 ± 0.36
Ladder Creek metal	L6	acid	3	>5.67 ± 1	0.24 ± 0.12	-0.15 ± 0.13	-0.31 ± 0.63	0.04 ± 0.40	0.33 ± 0.52
St. Severin metal	LL6	acid	3	>3.86 ± 1	0.15 ± 0.30	-0.01 ± 0.20	-0.28 ± 0.37	0.01 ± 0.53	0.40 ± 0.65
OC mean					0.13 ± 0.10	-0.07 ± 0.08	-0.25 ± 0.09	0.01 ± 0.08	0.42 ± 0.14
Abee	EH4	f red	3	1.03 ± 1	0.03 ± 0.68	-0.16 ± 0.49	-0.21 ± 0.36	0.03 ± 0.47	0.49 ± 0.36
Daniel's Kuil	EL6	acid	4	1.06 ± 1	0.04 ± 0.30	0.01 ± 0.15	-0.12 ± 0.09	0.13 ± 0.14	0.09 ± 0.19
EC mean					0.03 ± 0.20	-0.05 ± 0.14	-0.15 ± 0.09	0.09 ± 0.12	0.24 ± 0.21
CAIs									
A-ZH-1	Type B	acid	5	8.27 ± 1	-0.45 ± 0.28	0.61 ± 0.08	-0.90 ± 0.08	0.34 ± 0.14	2.01 ± 0.16
A-ZH-2	Type B	acid	4	7.89 ± 1	-0.55 ± 0.18	0.81 ± 0.22	-0.77 ± 0.20	0.69 ± 0.23	2.03 ± 0.25
A-ZH-3	Type B	acid	2	6.59 ± 1	-0.73 ± 0.18	0.82 ± 0.23	-0.71 ± 0.18	0.61 ± 0.20	1.61 ± 0.38
A-ZH-4	Type B	acid	5	6.75 ± 1	-0.59 ± 0.22	0.66 ± 0.18	-1.01 ± 0.13	0.54 ± 0.11	2.26 ± 0.38
A-ZH-10	Type B	f ox	5	2.15 ± 1	-0.42 ± 0.34	0.50 ± 0.21	-1.03 ± 0.16	0.43 ± 0.19	2.11 ± 0.38
Type B mean					-0.52 ± 0.10	0.65 ± 0.08	-0.91 ± 0.07	0.50 ± 0.08	2.06 ± 0.13
A-ZH-5	Fluffy Type A?	acid	1	5.78 ± 1	2.31 ± 0.28	0.34 ± 0.27	-7.13 ± 0.24	2.53 ± 0.25	14.81 ± 0.44

[a] Digestion method: acid = tabletop acid digestion, f ox, red = laser fusion of sample powder in oxidizing or reducing conditions prior to acid digestion. [b] Number of analyses of the same solution. [c] Uncertainties for Mo concentrations refer to the last significant digit. [d] Normalized to ^{92}Mo/^{98}Mo = 0.607898, using the exponential law. $\varepsilon=((^{i}\mathrm{Mo}/^{98}\mathrm{Mo})_{sample}/(^{i}\mathrm{Mo}/^{98}\mathrm{Mo})_{standard} -1)\mathrm{x}10^4$. Uncertainties for samples measured more then twice and group means were calculated using $\sigma t_{0.95,n-1}/\sqrt{n}$. For samples measured once, errors are estimated by the standard deviation (2σ) from repeated analysis of the terrestrial standard or the internal propagated error ($\sigma^2_m=\sigma^2_{internal,\ sample}+ (\sigma^2_{internal,\ standard\ before} + \sigma^2_{internal,\ standard\ after})/2$), whichever is larger. For samples measured twice the error is estimated by $\sigma_{tot}= (\sigma^2_{m1}+ \sigma^2_{excess\ variance\ 1}+ \sigma^2_{m2}+ \sigma^2_{excess\ variance\ 2})^{0.5}/2$, were $\sigma^2_{excess\ variance}$= excess variance component of standard measurements at measurement day. [e] Uncertainties represent external reproducibility (2SD).

Table S3: Mo isotopic data for meteorites and terrestrial samples normalized to ^{97}Mo/^{95}Mo.

Sample		Method[a]	N[b]	Mo[c] [µg/g]	ε^{92}Mo[d]	ε^{94}Mo[d]	ε^{96}Mo[d]	ε^{98}Mo[d]	ε^{100}Mo[d]
Terrestrial Standards									
Alfa[e]	Mo solution		737	~0.1	0.00 ± 0.60	0.00 ± 0.33	0.00 ± 0.18	0.00 ± 0.32	0.00 ± 0.62
BCR-2	Basalt	acid	15	249 ± 1	-0.10 ± 0.16	-0.01 ± 0.12	-0.02 ± 0.04	0.00 ± 0.04	-0.01 ± 0.11
BHVO-2	Basalt	f ox f red	7	2.28 ± 1	-0.12 ± 0.36	-0.17 ± 0.12	0.02 ± 0.10	0.10 ± 0.07	0.15 ± 0.22
SRM 82b	Cast iron	acid	4	21.50 ± 1	-0.42 ± 0.76	-0.05 ± 0.31	0.01 ± 0.22	0.01 ± 0.19	-0.30 ± 0.27
SRM 129c	High S-steel	acid	7	7.46 ± 5	-0.16 ± 0.31	0.03 ± 0.21	0.05 ± 0.07	-0.01 ± 0.14	-0.17 ± 0.16
Standard mean					-0.15 ± 0.12	-0.04 ± 0.07	0.01 ± 0.03	0.02 ± 0.04	-0.04 ± 0.09
Iron meteorites									
Mundrabilla	IAB	acid	2	5.17 ± 1	0.21 ± 0.35	0.05 ± 0.24	0.19 ± 0.18	0.08 ± 0.26	0.17 ± 0.41
Caddo County	IAB	acid	5	6.53 ± 1	0.01 ± 0.57	0.08 ± 0.30	0.05 ± 0.15	0.12 ± 0.21	0.16 ± 0.33
Odessa	IAB	acid	3	6.33 ± 1	0.25 ± 0.74	0.16 ± 0.17	0.09 ± 0.12	-0.09 ± 0.45	-0.09 ± 1.01
IAB mean					0.12 ± 0.25	0.10 ± 0.13	0.09 ± 0.07	0.05 ± 0.12	0.09 ± 0.26
Arispe	IC	acid	4	6.54 ± 1	0.37 ± 0.33	0.57 ± 0.21	-0.15 ± 0.14	-0.09 ± 0.17	0.28 ± 0.47
Negrillos	IIAB	acid	2	6.54 ± 1	0.77 ± 0.28	0.66 ± 0.17	-0.32 ± 0.09	-0.24 ± 0.19	0.20 ± 0.32
Sikhote Alin	IIAB	acid	3	6.42 ± 1	0.60 ± 0.72	0.35 ± 0.54	-0.37 ± 0.03	-0.05 ± 0.43	0.65 ± 0.46
North Chile	IIAB	acid	2	6.30 ± 1	0.24 ± 0.39	0.37 ± 0.28	-0.30 ± 0.13	-0.05 ± 0.22	0.75 ± 0.56
IIAB mean					0.54 ± 0.29	0.45 ± 0.21	-0.34 ± 0.05	-0.10 ± 0.15	0.55 ± 0.25
Carbo	IID	acid	3	7.76 ± 1	0.36 ± 0.29	0.22 ± 0.12	-0.54 ± 0.24	-0.38 ± 0.23	0.30 ± 0.73
Miles	IIE	acid	3	7.37 ± 1	0.22 ± 1.01	0.24 ± 0.34	-0.25 ± 0.17	-0.22 ± 0.03	0.38 ± 0.43
Watson	IIE	acid	4	7.01 ± 1	0.07 ± 0.22	0.18 ± 0.26	-0.24 ± 0.16	0.00 ± 0.15	0.50 ± 0.20
IIE mean					0.13 ± 0.25	0.21 ± 0.13	-0.25 ± 0.07	-0.09 ± 0.13	0.45 ± 0.14
Henbury	IIIAB	acid	3	5.72 ± 1	0.52 ± 0.39	0.34 ± 0.79	-0.36 ± 0.19	-0.06 ± 0.08	0.25 ± 0.29
Charcas	IIIAB	acid	2	7.47 ± 1	0.54 ± 0.29	0.43 ± 0.19	-0.27 ± 0.10	0.02 ± 0.23	0.81 ± 0.33
Cape York	IIIAB	acid	3	6.76 ± 1	0.71 ± 1.39	0.60 ± 0.77	-0.26 ± 0.33	-0.26 ± 0.66	-0.01 ± 1.20
IIIAB mean					0.60 ± 0.28	0.46 ± 0.23	-0.30 ± 0.10	-0.12 ± 0.16	0.29 ± 0.37
Carlton	IIICD	acid	2	2.64 ± 1	-0.35 ± 0.50	-0.10 ± 0.23	0.05 ± 0.12	0.14 ± 0.23	0.31 ± 0.48
Stainton	IIIE	acid	5	7.51 ± 1	0.43 ± 0.48	0.39 ± 0.14	-0.31 ± 0.08	-0.08 ± 0.21	0.43 ± 0.52
Clark County	IIIF	acid	3	4.72 ± 1	-0.32 ± 1.23	-0.11 ± 0.38	-0.62 ± 0.49	-0.14 ± 0.54	1.07 ± 1.00
Albion	IVA	acid	3	5.69 ± 1	0.39 ± 1.02	0.32 ± 0.16	-0.16 ± 0.22	0.04 ± 0.17	0.48 ± 0.44
Duell Hill	IVA	acid	3	5.97 ± 1	0.47 ± 0.79	0.41 ± 0.13	-0.17 ± 0.21	-0.02 ± 0.25	0.25 ± 0.34
Gibeon	IVA	acid	2	5.02 ± 1	0.04 ± 0.38	0.18 ± 0.29	-0.26 ± 0.14	-0.11 ± 0.22	0.28 ± 0.56
IVA mean					0.33 ± 0.28	0.32 ± 0.09	-0.19 ± 0.08	-0.02 ± 0.08	0.35 ± 0.16
Tawallah Valley	IVB	acid	9	32.14 ± 1	0.22 ± 0.35	0.02 ± 0.19	-0.74 ± 0.06	-0.25 ± 0.10	1.04 ± 0.20
Santa Clara	IVB	acid	6	28.43 ± 1	0.15 ± 0.34	0.07 ± 0.14	-0.75 ± 0.08	-0.20 ± 0.20	1.08 ± 0.42
Tlacotepec	IVB	acid	3	22.01 ± 1	0.22 ± 0.98	0.18 ± 0.37	-0.76 ± 0.09	-0.30 ± 0.51	1.19 ± 0.92
Cape of Good Hope	IVB	acid	4	20.23 ± 1	-0.11 ± 0.68	0.01 ± 0.59	-0.73 ± 0.09	-0.16 ± 0.31	0.99 ± 0.38
IVB mean					0.14 ± 0.18	0.05 ± 0.10	-0.74 ± 0.03	-0.23 ± 0.07	1.06 ± 0.13
Mbosi	Ungrouped	acid	5	>1.22 ± 1	-0.54 ± 0.48	-0.19 ± 0.33	-0.74 ± 0.23	-0.26 ± 0.27	0.86 ± 0.58
Pallasites									
Brenham	Main group Pal	acid	6	5.40 ± 1	0.32 ± 0.29	0.38 ± 0.26	-0.28 ± 0.10	-0.06 ± 0.08	0.39 ± 0.23
Eagle Station	Eagle Station Pal	acid	6	7.80 ± 1	-0.27 ± 0.19	-0.12 ± 0.24	-0.61 ± 0.09	-0.20 ± 0.17	0.96 ± 0.37
Mars and Angrites									
Zagami	Shergottite	acid	1	>0.04 ± 1	0.26 ± 0.77	0.57 ± 0.53	-0.04 ± 0.21	0.07 ± 0.38	-0.03 ± 0.73
DaG476	Shergottite	acid	1	>0.06 ± 1	-0.07 ± 0.77	0.27 ± 0.53	-0.05 ± 0.21	-0.22 ± 0.38	-0.30 ± 0.73
Mars mean					0.09 ± 0.77	0.42 ± 0.53	-0.04 ± 0.21	-0.07 ± 0.38	-0.17 ± 0.73
NWA4801	Angrite	acid	1	>0.13 ± 1	0.68 ± 0.77	0.50 ± 0.53	0.00 ± 0.21	-0.37 ± 0.38	-0.03 ± 0.73
Chondrites									
Orgueil	CI	f red	2	0.88 ± 1	-0.15 ± 0.53	-0.16 ± 0.31	-0.49 ± 0.19	-0.06 ± 0.28	0.81 ± 0.60
Murchison	CM2	acid	3	1.27 ± 1	1.13 ± 0.53	1.05 ± 0.40	-2.42 ± 0.14	-1.02 ± 0.81	2.64 ± 1.52
Murchison	CM2	f red	2	1.02 ± 1	0.91 ± 0.51	1.01 ± 0.28	-2.48 ± 0.16	-0.84 ± 0.25	2.84 ± 0.56
Murchison	CM2	f ox	2	0.77 ± 1	0.99 ± 0.54	0.84 ± 0.29	-2.28 ± 0.17	-0.78 ± 0.26	3.03 ± 0.59
CM mean					1.03 ± 0.18	0.98 ± 0.16	-2.40 ± 0.09	-0.90 ± 0.24	2.81 ± 0.37
NWA2090	CO3	f red	2	1.16 ± 1	0.40 ± 0.53	0.37 ± 0.28	-0.30 ± 0.16	-0.03 ± 0.25	0.77 ± 0.55
Allende	CV3	acid	4	1.47 ± 1	0.26 ± 0.43	0.26 ± 0.26	-1.18 ± 0.12	-0.34 ± 0.51	1.73 ± 0.79
Allende	CV3	f red	4	1.35 ± 1	0.38 ± 0.75	0.24 ± 0.23	-1.31 ± 0.22	-0.36 ± 0.49	1.50 ± 0.44
CV mean					0.32 ± 0.30	0.25 ± 0.12	-1.24 ± 0.10	-0.35 ± 0.24	1.61 ± 0.33
NWA801	CR2	f red	3	1.21 ± 2	0.64 ± 0.44	0.62 ± 0.27	-1.30 ± 0.07	-0.48 ± 0.53	1.39 ± 1.38
Tafassasset metal	CR anomalous	acid	2	3.87 ± 1	0.61 ± 0.39	0.30 ± 0.29	-0.88 ± 0.14	-0.53 ± 0.22	1.07 ± 0.54
Gujba metal	CB	acid	7	4.47 ± 1	0.04 ± 0.15	0.10 ± 0.08	-0.69 ± 0.07	-0.25 ± 0.16	0.79 ± 0.20
Bremervörde	H3	acid	3	1.16 ± 1	0.00 ± 0.79	0.08 ± 0.31	-0.24 ± 0.12	-0.02 ± 0.36	0.35 ± 0.77
Kernouvé	H6	acid	2	1.31 ± 1	0.32 ± 0.46	0.18 ± 0.29	-0.22 ± 0.17	-0.10 ± 0.36	0.18 ± 0.61
Bruderheim metal	L6	acid	2	1.92 ± 1	0.62 ± 0.48	0.42 ± 0.29	-0.09 ± 0.14	-0.03 ± 0.21	0.21 ± 0.61
Ladder Creek metal	L6	acid	3	>5.67 ± 1	0.44 ± 0.36	0.42 ± 0.20	-0.15 ± 0.30	-0.15 ± 0.49	0.02 ± 0.88
St. Severin metal	LL6	acid	3	>3.86 ± 1	0.15 ± 1.22	0.13 ± 0.71	-0.23 ± 0.42	-0.05 ± 0.79	0.23 ± 1.67
OC mean					0.28 ± 0.21	0.24 ± 0.12	-0.19 ± 0.06	-0.07 ± 0.11	0.20 ± 0.25
Abee	EH4	f red	3	1.03 ± 1	0.30 ± 1.15	0.27 ± 0.24	-0.15 ± 0.08	-0.08 ± 0.66	0.43 ± 1.63
Daniel's Kuil	EL6	acid	4	1.06 ± 1	0.06 ± 0.26	0.09 ± 0.17	-0.18 ± 0.08	-0.13 ± 0.18	-0.01 ± 0.43
EC mean					0.15 ± 0.27	0.16 ± 0.12	-0.17 ± 0.05	-0.11 ± 0.15	0.16 ± 0.41
CAIs									
A-ZH-1	Type B	acid	5	8.27 ± 1	-1.02 ± 0.31	-1.23 ± 0.29	-1.36 ± 0.11	-0.21 ± 0.16	2.02 ± 0.30
A-ZH-2	Type B	acid	4	7.89 ± 1	-0.89 ± 0.56	-1.35 ± 0.32	-1.49 ± 0.05	-0.61 ± 0.34	1.50 ± 0.67
A-ZH-3	Type B	acid	2	6.59 ± 1	-1.12 ± 0.52	-1.59 ± 0.29	-1.42 ± 0.16	-0.51 ± 0.25	1.30 ± 0.56
A-ZH-4	Type B	acid	5	6.75 ± 1	-0.92 ± 0.45	-1.36 ± 0.27	-1.61 ± 0.10	-0.48 ± 0.11	1.88 ± 0.45
A-ZH-10	Type B	f ox	5	2.15 ± 1	-0.59 ± 0.40	-0.96 ± 0.19	-1.50 ± 0.10	-0.37 ± 0.21	1.80 ± 0.49
Type B mean					-0.88 ± 0.16	-1.25 ± 0.12	-1.48 ± 0.05	-0.42 ± 0.09	1.77 ± 0.18
A-ZH-5	Fluffy Type A?	acid	1	5.78 ± 1	2.91 ± 0.60	3.19 ± 0.33	-8.54 ± 0.18	-3.59 ± 0.32	9.08 ± 0.62

[a] Digestion method: acid = tabletop acid digestion, f ox, red = laser fusion of sample powder in oxidizing or reducing conditions prior to acid digestion. [b] Number of analyses of the same solution. [c] Uncertainties for Mo concentrations refer to the last significant digit. [d] Normalized to ^{97}Mo/^{95}Mo = 0.602083, using the exponential law. $\varepsilon = ((^{i}\text{Mo}/^{95}\text{Mo})_{\text{sample}}/(^{i}\text{Mo}/^{95}\text{Mo})_{\text{standard}} - 1) \times 10^{4}$. Uncertainties for samples measured more then twice and group means were calculated using $\sigma t_{0.95,n-1}/\sqrt{n}$. For samples measured once, errors are estimated by the standard deviation (2σ) from repeated analysis of the terrestrial standard or the internal propagated error ($\sigma^2_{m} = \sigma^2_{\text{internal, sample}} + (\sigma^2_{\text{internal, standard before}} + \sigma^2_{\text{internal, standard after}})/2$), whichever is larger. For samples measured twice the error is estimated by $\sigma_{\text{tot}} = (\sigma^2_{m1} + \sigma^2_{\text{excess variance 1}} + \sigma^2_{m2} + \sigma^2_{\text{excess variance 2}})^{0.5}/2$, were $\sigma^2_{\text{excess variance}}$ = excess variance component of standard measurements at measurement day. [e] Uncertainties represent external reproducibility (2SD).

Table S4: Mo isotopic data for meteorites and terrestrial samples normalized to ^{95}Mo/^{96}Mo.

Sample		Method[a]	N[b]	Mo[c] [µg/g]	ε^{92}Mo[d]	ε^{94}Mo[d]	ε^{97}Mo[d]	ε^{98}Mo[d]	ε^{100}Mo[d]
Terrestrial Standards									
Alfa[e]	Mo solution		737	~0.1	0.00 ± 0.82	0.00 ± 0.40	0.00 ± 0.37	0.00 ± 0.51	0.00 ± 0.96
BCR-2	Basalt	acid	15	249 ± 1	-0.14 ± 0.23	-0.03 ± 0.15	0.05 ± 0.08	0.05 ± 0.12	0.10 ± 0.17
BHVO-2	Basalt	f ox, f red	7	2.28 ± 1	0.01 ± 0.44	-0.15 ± 0.20	-0.05 ± 0.20	-0.05 ± 0.21	-0.07 ± 0.36
SRM 82b	Cast iron	acid	4	21.50 ± 1	-0.39 ± 1.16	-0.07 ± 0.50	-0.02 ± 0.44	-0.05 ± 0.77	-0.40 ± 1.00
SRM 129c	High S-steel	acid	7	7.46 ± 5	0.01 ± 0.31	0.08 ± 0.26	-0.11 ± 0.14	-0.16 ± 0.18	-0.44 ± 0.44
Standard mean					-0.10 ± 0.16	-0.04 ± 0.09	-0.01 ± 0.06	-0.02 ± 0.09	-0.10 ± 0.16
Iron meteorites									
Mundrabilla	IAB	acid	2	5.17 ± 1	0.80 ± 0.52	0.23 ± 0.29	-0.37 ± 0.36	-0.38 ± 0.41	-0.61 ± 0.74
Caddo County	IAB	acid	5	6.53 ± 1	0.05 ± 0.72	0.09 ± 0.36	-0.10 ± 0.30	-0.05 ± 0.53	-0.01 ± 0.75
Odessa	IAB	acid	3	6.33 ± 1	0.50 ± 0.80	0.26 ± 0.33	-0.18 ± 0.23	-0.33 ± 0.64	-0.64 ± 1.28
IAB mean					0.34 ± 0.38	0.17 ± 0.16	-0.18 ± 0.15	-0.20 ± 0.25	-0.32 ± 0.41
Arispe	IC	acid	4	6.54 ± 1	0.05 ± 0.72	0.45 ± 0.32	0.29 ± 0.28	0.33 ± 0.56	0.87 ± 0.64
Negrillos	IIAB	acid	2	6.54 ± 1	-0.17 ± 0.41	0.36 ± 0.21	0.64 ± 0.17	0.74 ± 0.27	1.77 ± 0.49
Sikhote Alin	IIAB	acid	3	6.42 ± 1	-0.50 ± 0.54	-0.01 ± 0.51	0.74 ± 0.05	1.10 ± 0.58	2.48 ± 0.67
North Chile	IIAB	acid	2	6.30 ± 1	-0.80 ± 0.68	0.00 ± 0.36	0.60 ± 0.26	0.91 ± 0.47	2.41 ± 0.90
IIAB mean					-0.49 ± 0.37	0.10 ± 0.21	0.67 ± 0.09	0.94 ± 0.20	2.26 ± 0.35
Carbo	IID	acid	3	7.76 ± 1	-1.30 ± 0.73	-0.33 ± 0.27	1.08 ± 0.48	1.23 ± 0.56	2.97 ± 0.51
Miles	IIE	acid	3	7.37 ± 1	-0.54 ± 1.15	0.03 ± 0.34	0.50 ± 0.35	0.52 ± 0.69	1.68 ± 0.86
Watson	IIE	acid	4	7.01 ± 1	-0.55 ± 0.70	0.02 ± 0.26	0.49 ± 0.31	0.72 ± 0.46	1.64 ± 0.93
IIE mean					-0.55 ± 0.38	0.03 ± 0.13	0.49 ± 0.15	0.63 ± 0.26	1.66 ± 0.43
Henbury	IIIAB	acid	3	5.72 ± 1	-0.54 ± 1.12	0.02 ± 0.98	0.71 ± 0.38	0.98 ± 0.50	2.03 ± 0.56
Charcas	IIIAB	acid	2	7.47 ± 1	-0.31 ± 0.53	0.19 ± 0.26	0.53 ± 0.19	0.82 ± 0.32	2.11 ± 0.60
Cape York	IIIAB	acid	3	6.76 ± 1	-0.16 ± 1.87	0.35 ± 1.06	0.52 ± 0.66	0.46 ± 1.18	1.32 ± 0.93
IIIAB mean					-0.34 ± 0.49	0.19 ± 0.31	0.59 ± 0.19	0.75 ± 0.34	1.78 ± 0.41
Carlton	IIICD	acid	2	2.64 ± 1	-0.16 ± 0.63	-0.04 ± 0.32	-0.10 ± 0.24	0.08 ± 0.35	0.10 ± 0.75
Stainton	IIIE	acid	5	7.51 ± 1	-0.45 ± 0.52	0.08 ± 0.14	0.61 ± 0.16	0.77 ± 0.24	1.84 ± 0.53
Clark County	IIIF	acid	3	4.72 ± 1	-2.11 ± 2.41	-0.74 ± 0.91	1.24 ± 0.97	1.66 ± 1.58	4.03 ± 2.28
Albion	IVA	acid	3	5.69 ± 1	-0.15 ± 1.15	0.06 ± 0.11	0.32 ± 0.45	0.53 ± 0.30	1.23 ± 0.81
Duell Hill	IVA	acid	3	5.97 ± 1	-0.02 ± 1.13	0.23 ± 0.16	0.35 ± 0.41	0.52 ± 0.51	1.05 ± 1.06
Gibeon	IVA	acid	2	5.02 ± 1	-0.66 ± 0.67	-0.09 ± 0.36	0.53 ± 0.27	0.66 ± 0.47	1.58 ± 0.92
IVA mean					-0.23 ± 0.38	0.09 ± 0.12	0.38 ± 0.15	0.56 ± 0.18	1.25 ± 0.33
Tawallah Valley	IVB	acid	9	32.14 ± 1	-2.10 ± 0.45	-0.72 ± 0.23	1.48 ± 0.12	1.94 ± 0.18	4.67 ± 0.20
Santa Clara	IVB	acid	6	28.43 ± 1	-2.15 ± 0.39	-0.70 ± 0.22	1.49 ± 0.16	1.97 ± 0.16	4.70 ± 0.54
Tlacotepec	IVB	acid	3	22.01 ± 1	-1.97 ± 1.00	-0.56 ± 0.25	1.52 ± 0.19	1.89 ± 0.63	4.67 ± 0.91
Cape of Good Hope	IVB	acid	4	20.23 ± 1	-2.44 ± 1.15	-0.77 ± 0.73	1.45 ± 0.18	1.97 ± 0.29	4.74 ± 0.80
IVB mean					-2.16 ± 0.23	-0.70 ± 0.12	1.48 ± 0.06	1.94 ± 0.09	4.69 ± 0.17
Mbosi	Ungrouped	acid	5	>1.22 ± 1	-2.96 ± 0.40	-1.01 ± 0.31	1.48 ± 0.46	2.00 ± 0.54	4.58 ± 0.77
Pallasites									
Brenham	Main group Pal	acid	6	5.40 ± 1	-0.44 ± 0.48	0.11 ± 0.29	0.56 ± 0.20	0.74 ± 0.28	1.66 ± 0.39
Eagle Station	Eagle Station Pal	acid	6	7.80 ± 1	-2.10 ± 0.39	-0.74 ± 0.20	1.21 ± 0.17	1.59 ± 0.28	3.90 ± 0.47
Mars and Angrites									
Zagami	Shergottite	acid	1	>0.04 ± 1	0.24 ± 1.14	0.75 ± 0.67	0.07 ± 0.42	-0.06 ± 0.81	-0.06 ± 1.25
DaG476	Shergottite	acid	1	>0.06 ± 1	-0.30 ± 1.14	0.08 ± 0.67	0.09 ± 0.42	0.12 ± 0.81	0.05 ± 1.25
Mars mean					-0.03 ± 1.14	0.41 ± 0.67	0.08 ± 0.42	0.03 ± 0.81	-0.01 ± 1.25
NWA4801	Angrite	acid	1	>0.13 ± 1	0.43 ± 1.14	0.45 ± 0.67	0.00 ± 0.42	-0.23 ± 0.81	0.04 ± 1.25
Chondrites									
Orgueil	CI	f red	2	0.88 ± 1	-1.63 ± 0.74	-0.70 ± 0.37	0.97 ± 0.36	1.36 ± 0.46	2.99 ± 0.83
Murchison	CM2	acid	3	1.27 ± 1	-6.27 ± 0.66	-1.39 ± 0.36	4.83 ± 0.28	6.18 ± 0.99	14.47 ± 1.48
Murchison	CM2	f red	2	1.02 ± 1	-6.72 ± 0.66	-1.56 ± 0.34	4.93 ± 0.31	6.50 ± 0.40	15.07 ± 0.69
Murchison	CM2	f ox	2	0.77 ± 1	-5.91 ± 0.71	-1.51 ± 0.36	4.54 ± 0.33	6.10 ± 0.44	14.13 ± 0.77
CM mean					-6.30 ± 0.43	-1.47 ± 0.14	4.78 ± 0.18	6.25 ± 0.33	14.55 ± 0.59
NWA2090	CO3	f red	2	1.16 ± 1	-0.54 ± 0.68	0.12 ± 0.35	0.59 ± 0.32	1.05 ± 0.40	2.36 ± 0.70
Allende	CV3	acid	4	1.47 ± 1	-3.34 ± 0.68	-0.92 ± 0.39	2.35 ± 0.24	3.18 ± 0.13	7.46 ± 0.29
Allende	CV3	f red	4	1.35 ± 1	-3.64 ± 0.60	-1.04 ± 0.26	2.61 ± 0.44	3.44 ± 0.39	7.87 ± 0.84
CV mean					-3.49 ± 0.34	-0.98 ± 0.17	2.48 ± 0.21	3.31 ± 0.18	7.66 ± 0.36
NWA801	CR2	f red	3	1.21 ± 2	-3.54 ± 0.50	-0.68 ± 0.11	2.60 ± 0.14	3.42 ± 0.63	7.83 ± 1.33
Tafassasset metal	CR anomalous	acid	2	3.87 ± 1	-2.20 ± 0.67	-0.71 ± 0.36	1.76 ± 0.28	2.15 ± 0.47	5.48 ± 0.90
Gujba metal	CB	acid	7	4.47 ± 1	-2.09 ± 0.30	-0.61 ± 0.10	1.38 ± 0.14	1.87 ± 0.20	4.22 ± 0.34
Bremervörde	H3	acid	3	1.16 ± 1	-0.80 ± 0.73	-0.09 ± 0.65	0.47 ± 0.24	0.67 ± 0.46	1.50 ± 0.40
Kernouvé	H6	acid	2	1.31 ± 1	-0.30 ± 0.51	0.04 ± 0.27	0.44 ± 0.34	0.49 ± 0.42	1.25 ± 0.71
Bruderheim metal	L6	acid	2	1.92 ± 1	0.28 ± 0.70	0.27 ± 0.35	0.18 ± 0.27	0.24 ± 0.43	0.60 ± 0.88
Ladder Creek metal	L6	acid	3	>5.67 ± 1	-0.40 ± 1.05	0.18 ± 0.52	0.31 ± 0.60	0.57 ± 1.34	1.39 ± 2.02
St. Severin metal	LL6	acid	3	>3.86 ± 1	-0.65 ± 1.08	-0.06 ± 0.63	0.47 ± 0.84	0.75 ± 0.99	1.56 ± 2.12
OC mean					-0.43 ± 0.28	0.05 ± 0.14	0.38 ± 0.13	0.57 ± 0.20	1.31 ± 0.36
Abee	EH4	f red	3	1.03 ± 1	-0.01 ± 1.39	0.17 ± 0.30	0.29 ± 0.17	0.36 ± 0.70	1.07 ± 1.41
Daniel's Kuil	EL6	acid	4	1.06 ± 1	-0.54 ± 0.42	-0.12 ± 0.11	0.36 ± 0.16	0.37 ± 0.39	0.79 ± 0.60
EC mean					-0.34 ± 0.40	-0.01 ± 0.15	0.33 ± 0.09	0.37 ± 0.23	0.90 ± 0.41
CAIs									
A-ZH-1	Type B	acid	5	8.27 ± 1	-5.15 ± 0.34	-2.61 ± 0.30	2.72 ± 0.22	3.84 ± 0.21	8.70 ± 0.40
A-ZH-2	Type B	acid	4	7.89 ± 1	-5.51 ± 0.47	-2.88 ± 0.28	2.97 ± 0.11	3.87 ± 0.26	8.85 ± 0.64
A-ZH-3	Type B	acid	2	6.59 ± 1	-5.34 ± 0.68	-2.98 ± 0.36	2.83 ± 0.32	3.66 ± 0.41	8.19 ± 0.72
A-ZH-4	Type B	acid	5	6.75 ± 1	-5.90 ± 0.59	-2.98 ± 0.41	3.20 ± 0.20	4.32 ± 0.26	9.87 ± 0.64
A-ZH-10	Type B	f ox	5	2.15 ± 1	-5.19 ± 0.60	-2.54 ± 0.29	2.98 ± 0.20	4.08 ± 0.45	9.17 ± 0.97
Type B mean					-5.42 ± 0.21	-2.77 ± 0.14	2.95 ± 0.10	4.00 ± 0.14	9.07 ± 0.32
A-ZH-5	Fluffy Type A?	acid	1	5.78 ± 1	-23.20 ± 0.82	-5.48 ± 0.40	17.04 ± 0.37	21.82 ± 0.51	51.16 ± 0.96

[a] Digestion method: acid = tabletop acid digestion, f ox, red = laser fusion of sample powder in oxidizing or reducing conditions prior to acid digestion. [b] Number of analyses of the same solution. [c] Uncertainties for Mo concentrations refer to the last significant digit. [d] Normalized to ^{95}Mo/^{96}Mo = 0.953242, using the exponential law. $\varepsilon=((^{i}\mathrm{Mo}/^{96}\mathrm{Mo})_{\mathrm{sample}}/(^{i}\mathrm{Mo}/^{96}\mathrm{Mo})_{\mathrm{standard}}-1)\times10^{4}$. Uncertainties for samples measured more then twice and group means were calculated using $\sigma t_{0.95,n-1}/\sqrt{n}$. For samples measured once, errors are estimated by the standard deviation (2σ) from repeated analysis of the terrestrial standard or the internal propagated error ($\sigma^2_{m}=\sigma^2_{\mathrm{internal,\ sample}}+(\sigma^2_{\mathrm{internal,\ standard\ before}}+\sigma^2_{\mathrm{internal,\ standard\ after}})/2$), whichever is larger. For samples measured twice the error is estimated by $\sigma_{tot}=(\sigma^2_{m1}+\sigma^2_{\mathrm{excess\ variance\ 1}}+\sigma^2_{m2}+\sigma^2_{\mathrm{excess\ variance\ 2}})^{0.5}/2$, were $\sigma^2_{\mathrm{excess\ variance}}$= excess variance component of standard measurements at measurement day. [e] Uncertainties represent external reproducibility (2SD).

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