Table S1: Representative analyses of spinel structured oxides in this study

Sample	ALH 77256	GRA 98108	ALH 84025	EET 99402	CMS 04071	QUE 99679	SMT-1	MGV-19	TMV-6	ALH 84001	GRA 06128	MET 01198	EET 84302	LAP 04840
	chr	chr	chr	chr	chr	magnt	chr	chr	chr	chr	chr	chr	chr	chr
SiO_2	0	0.06	0.07	0.06		0.05	0.08	0.1	0.11	0	0	0.06	0.01	0.2
TiO_2	0.9	1.31	1.33	0.99	0.04	0.79	1.21	0.39	2.08	2.47	11.65	1.2	1.07	1.26
Al_2O3	21.53	15.49	7.68	14.13	1.73	0.49	16.91	24.16	21.95	8.19	4.55	6.7	8.04	2.28
Cr_2O_3	45.25	50.34	57.17	51.09	67.02	3.35	38.3	35.75	29.45	48.03	38.4	61.3	60.6	18.5
V_2O_3	-	-	-	-	-	0.1	-	0.07	0.1	0	2.77	-	0.5	0.67
FeO_t	26.66	26.64	28.84	28.99	22.62	86.43	29.57	24.27	31.62	36.43	41.44	18	15.15	64.56
MnO	0.46	0.5	0.37	0.32	-	0.02	0.32	0.26	0.27	0.43	0.53	1.5	1.12	0.23
MgO	6.54	5.96	3.88	4.48	5.4	0.11	10.44	11.97	10.28	3.93	1.48	9.3	11.1	1.63
CaO	0.01	0	0.01	0	-	0.06	-	-	-	0.01	-	0.08	-	1.21
NiO	-	-	-	-	-	0.23	-	0.11	0.15	-	-	-	-	-
Total	101.34	100.32	99.34	100.06	97.21	91.65[a]	96.85	97.11	96.03	99.49	100.89	98.2	98.12	90.59[b]
reference	ts	ts	ts	ts	1	2	3	3	3	ts	4	5	6	2

1 – Danielson et al. (2009); 2 – Righter and Neff (2007); 3 – Righter et al. (2008b); 4 – Shearer et al. (2010); Rubin (2007); 6 – Mittlefehldt et al. (1996); ts = this study.

a) Total is 101.24 when FeO and Fe_2O_3 are recalculated to 0.25 and 95.77, respectively, based on stoichiometry and charge balance following the method of Carmichael (1966).
b) Total is 97.65 when FeO and Fe_2O_3 are recalculated to 0.44 and 71.23, respectively, based on stoichiometry and charge balance following the method of Carmichael (1966).

Table S2: Literature sources of oxygen fugacity data

Primitive materials

sample	material	Approach	Oxygen fugacity (ΔIW)	T (°C), logfO_2 (if available)	reference
Torajiro	Stardust particle	Thermodynamic calculations - MELTS	IW+2.4	1090, -12	Gainsforth et al. (2015)
Iris	Stardust particle	Thermodynamic calculations - MELTS	IW-0.25	1000, -13.3	Gainsforth et al. (2015)
Inti	Stardust particle	EELS Ti^{3+}/Ti^{4+}	IW-6.5 (solar)	-	Simon et al. (2008)
R chondrites	ol-opx-sp	Fa-Fs-Mgnt equilibrium – thermodynamic calcs.	IW-0.5 to IW+3.5	-	Righter and Neff (2007)
R chondrites LAP04840	spinel	V XANES	IW-0.56 ti IW+1.63	-	This study
CK chondrites	magnetite	V XANES	IW+2.55 to IW+3.11	-	This study
ordinary chondrites	ol-opx-Fe	Metal-oxide equilibria	IW-0.6 to IW-4.0	-	Schrader et al. (2013)
ordinary and carb chondrules	ol-opx-Fe	Si-Fe-Cr equilibria	IW-0.4 to IW-4.4	1600, -8.4 to -12.4	Zanda et al. (1994)
OC chondrules	olivine	Ti XANES	IW-4 to IW-2	-	S.B.Simon et al. (2011, 2015)
H, L, LL	ol-opx-Fe	Fa-Fs-Fe equilibria	IW-1.25 to IW-1.75	-	Righter and Drake (1996)
EL olivine	olivine	Cr XANES	IW-6 to IW-8	-	McKeown et al. (2014)
CAI	pyroxene	Ti XANES	IW-5 to IW-2	-	Simon et al. (2007)
CAI	spinel, pyroxene	V and Ti XANES	IW-5 to IW-2.5	-	Paque et al. (2013)
refractory inclusions	hibonite	Hibonite color	IW-5.5 to IW-1.5	1430, -11 to -15	Ihinger and Stolper (1986)
CAI	melilite, pyroxene	"Fassaite"[a] and melilite equilibrium	IW-8	1236, -19.8	Grossman et al. (2008)
CH metal	metal	Thermodynamic calculations – ZONMET	IW-6.5 (solar)	-	Petaev et al. (2003)

Achondrites

angrites		Phase equilibrium	IW+1	-	McKay et al. (1994)
angrites		Experimental petrology	IW+1	-	Jurewicz et al. (1993)
brachinites	chromite	V XANES	IW-0.56 to IW+0.41	-	This study
GRA06128/129	chromite	V XANES			This study
pallasites	olivine-metal	Electrochemical measurements	IW-0.5	-	Righter et al. (1990)
pallasites	chromite	V XANES	IW-0.88 to IW-1.05	-	This study
diogenites and mesosiderites	whole rock	Electrochemical measurements	IW+0.5 to IW-0.5		Hewins and Ulmer (1984)
diogenites	chromite	V XANES	IW-0.41 to IW-1.98	-	This study
eucrites		Phase equilibria	IW	1170, -13.3	Stolper (1977)
ureilites	chromite, olivine	Cr XANES	IW-1.6 to IW-3.1	-	Goodrich et al. (2013)
winonaites	ol-opx-Fe	thermodynamics	IW-2.4 to IW-2.7	-	Benedix et al. (2005)
acapulcoites	ol-opx-Fe	thermodynamics	IW-1.75 to IW-2.25	-	Righter and Drake (1996)
acapulcoites/lodranites	chromite	V XANES	IW-0.88 to IW-3.09	-	This study
aubrites	ol-opx-Fe	thermodynamics	IW-5.0 to IW-6.5	-	Righter and Drake (1996) Fogel (2005)
IIE, IIICD, IAB irons	ol-opx-Fe	Thermodynamics	IW-1.25 to IW-2.75	-	Righter and Drake (1996)

Planetary samples

Mexico lamprophyres	whole rock	Fe^{3+}/Fe^{2+}equilibria	IW+7 to IW+8.5	-	Carmichael (1991)
Mexico basalt and andesite	whole rock	"	IW+0.5 to IW+6	-	Carmichael (1991); Righter et al. (2008b)
Kilauea	glass	"	IW+2.5 to IW+4	-	Carmichael (1991)
MORB	glass	"	IW+1 to IW+3	-	Carmichael (1991)
Abyssal peridotite	ol-opx-sp	Spinel-oliv-opx	IW+1 to IW+3.5	-	Carmichael (1991)
Continental xenoliths	ol-opx-sp	Spinel-oliv-opx	IW+0.5 to IW+3.5	-	Carmichael (1991)

Lunar glasses	glass	C-CO-CO_2 equilibrium	IW-1 IW-0.9 to -1.3	1350, -11.2	Nicholis and Rutherford (2009) Weitz et al. (1997)
Lunar glasses	glass	V XANES	IW-1.0 to IW-1.9	-	Sutton et al. (2005)
Lunar basalt Ap12,15	glass	electrochemistry	IW-0.8 to IW-1.2	-	Sato et al. (1973)
LAR06319	ol-opx-sp	Various equilibria	IW+1.5 to IW+4	-	Peslier et al. (2010)
shergottites	ol-opx-sp	Oliv-opx-spinel	IW-1 to IW+2	-	Righter and Drake (1996)
nakhlites	Ilmenite-magnetite	2 oxide thermobarometry	IW to IW+4	-	Righter et al. (2014)
ALH84001	chromite	V XANES chromite	IW+0.26 to IW+0.53	-	This study
Mercury mantle	spectroscopy	MESSENGER	IW-6.3 to IW-2.6	-	McCubbin et al. (2012)
Venus mantle	XRF	Venera	IW-2 to IW-0.5	-	Treiman (2007)

a - “Fassaite” refers to a Ti and Al-rich variety of clinopyroxene; Dowty and Clark, 1973.