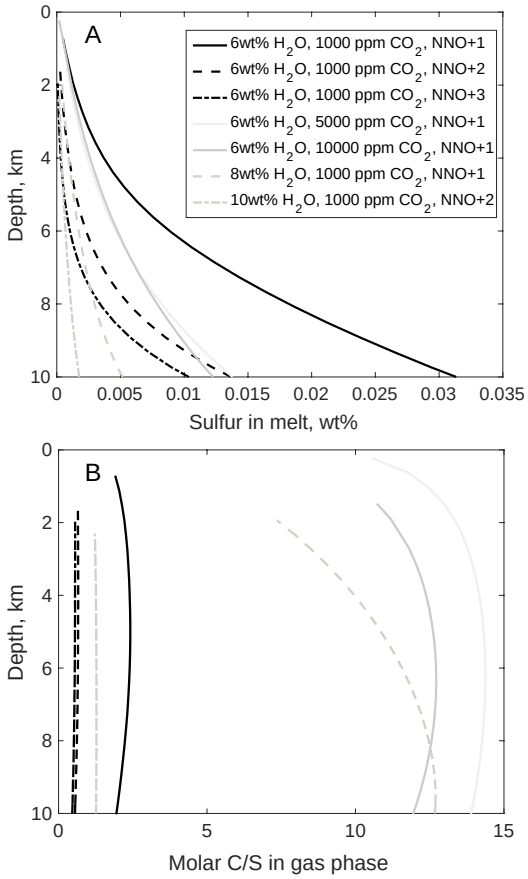
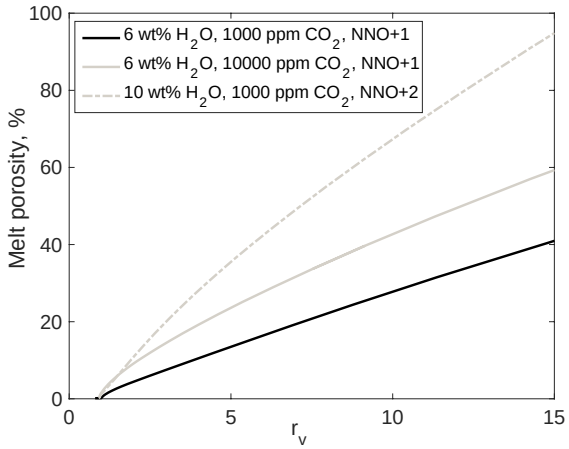
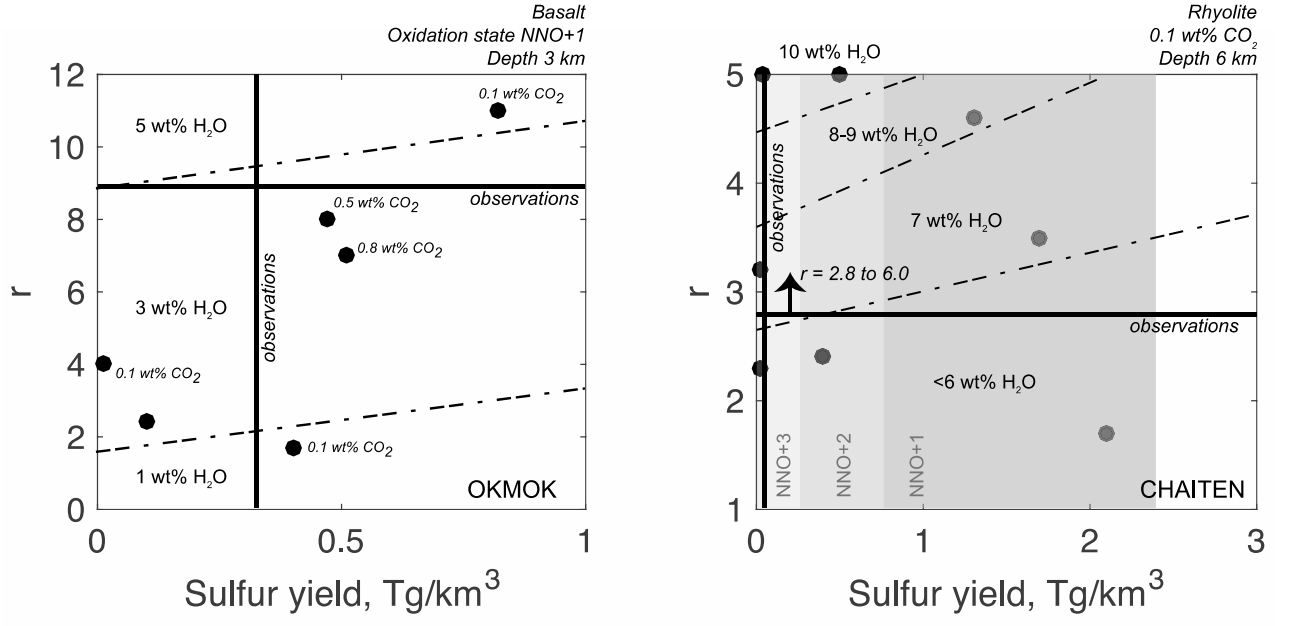


Supplementary Figure 1: **Expected volatile melt concentrations and gas compositions with depth for variable magmatic storage conditions for a metaluminous rhyolite magma**. A: Melt sulfur concentrations with depth for a range of conditions and bulk volatile contents, showing that shallower chambers, or magmas richer in CO_2 will contain more sulfur-poor melts. B: Vapor composition as a function of magma storage depth, showing the C/S ratio of gas coexisting with magma prior to eruption



Supplementary figure 2: **Magma porosity as a function of r (proportional to fraction of exsolved gas) and bulk volatile contents.**



Supplementary figure 3: Analysis of the sulfur yield and extent of ground deformation for two recent volcanic eruptions. Plots show the ratio r plotted against sulfur yield (Tg/km^3). Model runs are shown as black dots and the observations (**Table 1**) are shown as vertical and horizontal heavy black lines. The plot is contoured for melt water content. Left: the 2008 Okmok eruption case, using a basaltic magma composition at NNO+1, stored at a depth of 3 km. Model runs used H_2O contents of 1-5 wt% (marked as regions on the plot) and bulk CO_2 contents of 0.1 to 0.8 wt% (labelled beside each model run). Right: the 2008 Chaiten eruption case, using a rhyolitic melt composition, a bulk CO_2 content of 0.1 wt% and a magma chamber depth of 6 km. Model runs were carried out using a range of f_{O2} (labelled as grey shaded regions) and bulk H_2O contents (regions delineated by black dash-dot lines). The observations yielded an *r* value of 2.8 to 6.0, which is labelled.

Supplementary Table 1: A compilation of space-based ground deformation, gas and erupted volumes for volcanic eruptions. Columns are, from left: volcano name, tectonic setting, date of eruption, magma composition, erupted volume (dense rock equivalent), V_e (DRE, km^3) (minimum and maximum), mass of sulfur emitted in Tg, yield of sulfur in Tg per km^3 magma erupted (minimum and maximum), volume contraction of a model source from ground deformation data ΔV_c (km^3), the ratio r which is equal to $V_e/\Delta V_c$, and the last column contains citations to the papers that yielded these data.

	Eruption and magma type			**Erupted volume, km^3[c]**	**Sulfur output (Tg) and yield (Tg/km^3)**		**Syn-eruptive volume change, km^3[e]**	**Source geometry* and depth (km)**	**$r_v = V_e/\Delta V_c$**	**Foot-note**	**Ref.**
Volcano	**Setting[a]**	**Date**	**Comp[b]**	***V_e***	***M_S*[d]**	***(M_S/V_e)***	***ΔV_c***		***r_v***		
Chaiten	CA	2/5/08	R	0.7-0.9	0.007	0.008-0.01	0.15-0.25	Ok, 10+/- 2	2.8-6.0		1,2
Eyjafjallajokull	OI	14/4/10	B	0.18	0.233	1.3	0.013-0.015	Pe + Ok, 4.0-5.0	12-14		3,4
Grimsvotn	OI	21/5/11	B	0.2-0.3	0.15	0.5-0.75	0.027±0.003	Mogi, 1.7	7.4-11		5-8
Jebel at Tair	CR	30/9/07	B	0.017±0.008	0.04	1.6-4.4					9-11
Kelut	IA	13/2/14	BA	0.2-0.3	0.1	0.3-0.5	-		-		10,12
Merapi	IA	29/10/10	A	0.02-0.05	0.15	3-7.5					10,13,14
Nabro	CR	13/6/11	BA	0.10	1.825	18	0.07	Mogi, 6.0	1.4		15-17
Okmok	IA	12/7/08	BA	0.26	0.075	0.29	0.03	Mogi, 3.0	8.7	1	18-20
Puyehue	CA	4/6/11	D	0.25	0.1-0.25	0.4-1.0	0.15	Mogi, 5.0-9.0	1.7	2	10,21-23
Soufriere Hills	IA	11/95 to 02/11	A	0.282	1.0	3.5	0.053	Mogi, 10-12	5.3	3	24-26
Augustine	CA	29/1/06	A	0.03	0.005	0.17	<0.003	Mogi, 3-5	>10		10,27,28
Calbuco	CA	22/4/15	BA	0.11-0.13	0.2	1.5-1.8	-		-		10,29
Hekla	OI	26/2/00	BA	0.19	0.0915	0.5	0.04-0.08	Mogi, 14-18	2.4-4.8		30,31
Kasatochi	IA	7/8/08	A	0.1	1.1	11	-		-		10,32
Nyamuragira	CR	27/11/06	B	0.07	0.5	7.1	-		-		10,33
Pdl Fournaise	OI	3/4/07	B	0.13	0.115	0.88	-		-		34,35
Redoubt	IA	24/3/09	A	0.08-0.12	0.271-0.308	2.3-3.9	0.028->0.1	Ps, 7.0-15	0.8-4.3	4	10,36-38
Sarychev Peak	IA	12/6/09	BA	0.4	0.6	1.5	-		-		10,39
Sierra Negra	OI	22/10/05	B	0.15	0.635	4.2	0.08	Mogi + Ok, 2.0	1.9		10,40
Anatahan	IA	1/4/05	A	0.05	0.055	1.1					10,41,42
El Chichon	CA	1982	D	0.34	7.2	21					43
Rabaul	IA	1994	A	0.013	0.42	32					44
Fuego	CA	1974	A	0.093	3.1	33					45
Ruiz	CA	1985	A	0.029	1	34					43,46

Pinatubo	IA	1991	D	4.9	17	3.5					[43,47]
Mauna Loa	OI	1984	B	0.19	0.22	1.2					[48]

a IA: island arc; CA: continental arc; OI: ocean island; CR: continental rift.
b B: basalt; BA: basaltic andesite; A: andesite; D: dacite; R: rhyolite.
c: Erupted volumes estimated using various methods, e.g. change in topography, plume height, isopach maps (see citations).
d: Sulfur output measured using satellite-based sensors, e.g. OMI, AIRS (see citations for details).
e: volume change during eruption measured using satellite-based InSAR and/or GPS (see citations).

*Modelled source geometries: Ok: Okada, Pe: penny-shaped crack; Ps: prolate spheroid.

Footnotes
1 Okmok, 2008: erupted volume, modelled source volume and SO_2 emission for first 13 hours, explosive phase only.
2 Puyehue, 2011: Erupted volume for explosive plinian phase only[23]; inferred syn-eruptive volume change of a single spherical source during explosive phase *not* accounting for compressibility – "order of magnitude difference between erupted volume and modelled volume change"[22].
3 Soufriere Hills, 2005-2007: Data for eruptive phase 3 only, 02 Nov 2005 to 01 Apr 2007 deflationary period.
4 Redoubt, 2009: Change in volume of a prolate spheroid with its centroid at $9.17\ {}_{15.17}{}^{6.92}$ km bsl during explosive phase. OMI SO_2 for explosive phase only. Erupted volume for dome + fall +PF deposit volumes during 24 March to 4 April 2009.

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