Supplementary Information

to accompany:

Modification of mantle cargo by turbulent ascent of kimberlite

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Supplementary methods: Energy and impact calculations

The impact stress (σ_{im}) of olivine particle colliding with a surface was approximated as follows. Firstly, as the olivine particle hits the surface a compression wave followed by a recovery wave travels through the material at speed $\sqrt{E/\rho}$. Where E and ρ are the Young's modulus and particle density respectively. For an equant particle of dimension, l, the contact time, t is given by:

$$t = \frac{2l}{\sqrt{E/\rho}} \qquad \text{[A1]}$$

Now, using the impulse-momentum principle and assuming that the magnitude of velocity, V is the same before and after the collision (i.e. perfectly elastic collision), the following expression can be derived:

$$2m\mathrm{V} = \mathrm{F} \times \frac{2l}{\sqrt{E/\rho}} \qquad \text{[A2]}$$

where m is the particle mass and F is the force. Finally, given that stress is F/l^2 and that $m = l^3\rho$ Equation A2 can be re-arranged for the impact stress, σ_{im}:

$$\sigma_{im} = \mathrm{V}\sqrt{\rho \mathrm{E}} \qquad \text{[A3]}$$

Video S1: High speed camera video demonstrating fountaining behaviour of olivine particles at experimental conditions of 20 L min^{-1} and a mass of 70 g (experiment A4-1). Video taken at 1000 frames per second at a height of 300 mm above the base of the attrition tube. For scale, the horizontal field of view is ~ 3 cm.

Video S2: High Speed camera video demonstrating pneumatic behaviour of olivine particles at experimental conditions of 85 L min^{-1} and input mass of 10 g (experiment E4). Video taken at 1000 frames per second at a height of 300 m above the base of the attrition tube. For scale, the horizontal field of view is ~ 3 cm.

Table S1. Compositions of olivine used in this study.

	Wt. %
SiO_2	41.68
Al_2O_3	0.27
Cr_2O_3	0.22
FeO	8.30
MnO	0.1
MgO	49.7
CaO	0.05
Na_2O	0.06
K_2O	0.02
Total	100.40

Table S2. Optimized model parameters fitted to experimental datasets A-E.

Experiment #	No. Exp'ts	q (L min^{-1})	m_0 (g)	Peak m_d/m_0	a	b (h^{-1})	RMSE
A	7	85.5	70	0.2548	0.2312	0.6738	0.0164
B	7	45	70	0.1253	0.1137	0.5802	0.0085
C	7	20	70	0.0660	0.0628	0.4941	0.0073
D	6	85.5	35	0.3693	0.32826	0.54966	0.02734
E	8	85.5	10	0.5054	0.48369	0.25312	0.04827
Sum	35						

Table S3. Grain size distributions modelled as multiple normalized log normal distributions with median grain size (d), weightings (p), and standard deviations (sd). Also reported are calculated values of Entropy of Information (EoI) for each grain size population.

Label	q	m_0	t_r	Peaks	D3				D2				D1				Parent			
	(m^3 s^{-1})	(g)	(h)	No.	d (µm)	p	sd	EoI	d (µm)	p	sd	EoI	d (µm)	p	sd	EoI	d (µm)	p	sd	EoI
A0				1													473.7	1	0.282	6.31
A1	1.50E-03	70	1	2									64.7	0.010	0.292	4.36	447.7	0.990	0.344	6.46
A2	1.50E-03	70	2	3					12.3	0.070	1.084	4.01	64.7	0.020	0.240	4.16	447.7	0.924	0.358	6.50
A3	1.50E-03	70	5.25	4	2	0.026	0.747	1.82	12.3	0.053	0.648	3.50	56.4	0.021	0.269	4.14	447.7	0.911	0.338	6.44
A4	1.50E-03	70	8	4	2	0.028	0.724	1.79	16.3	0.081	0.746	3.91	56.4	0.030	0.316	4.30	447.7	0.873	0.364	6.51
A4-1	1.50E-03	70	8	4	2	0.043	0.829	1.92	14.2	0.116	0.726	3.75	56.4	0.034	0.321	4.31	447.7	0.819	0.353	6.48
A4-2	1.50E-03	70	8	4	2	0.035	0.788	1.87	12.3	0.075	0.688	3.56	56.4	0.028	0.303	4.26	447.7	0.876	0.344	6.45
A5	1.50E-03	70	16	4	2	0.035	0.733	1.80	10.7	0.084	0.699	3.43	56.4	0.026	0.295	4.23	447.7	0.865	0.338	6.44
A6	1.50E-03	70	24	4	2	0.028	0.753	1.83	16.3	0.094	0.861	4.06	56.4	0.029	0.394	4.52	447.7	0.854	0.380	6.55
B1	7.70E-04	70	1	1													447.7	1	0.317	6.38
B2	7.70E-04	70	2	2					12.3	0.025	0.861	3.78					447.7	0.982	0.311	6.36
B3	7.70E-04	70	5	2					12.3	0.026	0.858	3.78					447.7	0.984	0.311	6.36
B4	7.70E-04	70	8	3					14.2	0.036	0.865	3.92	64.7	0.011	0.210	4.03	447.7	0.961	0.310	6.35
B5	7.70E-04	70	16	4	2	0.021	0.659	1.69	9.4	0.047	0.748	3.36	64.7	0.015	0.225	4.10	447.7	0.929	0.303	6.33
B6	7.70E-04	70	24	4	2	0.038	0.733	1.80	10.7	0.041	0.689	3.42	64.7	0.018	0.260	4.24	514.1	0.914	0.336	6.57
C1	3.40E-04	70	0.5	1													514.1	1	0.318	6.51
C2	3.40E-04	70	2	1													514.1	1	0.322	6.53
C3	3.40E-04	70	7.67	2					12.3	0.041	1.120	4.04					514.1	0.967	0.317	6.51
C4	3.40E-04	70	16	2					12.3	0.028	0.894	3.82					514.1	0.981	0.328	6.55
C5	3.40E-04	70	24	2					12.3	0.038	0.955	3.88					514.1	0.971	0.326	6.54
D1	1.50E-03	35	1	4	2	0.022	0.632	1.65	10.7	0.034	0.703	3.44	56.4	0.018	0.249	4.06	447.7	0.942	0.325	6.40
D2	1.50E-03	35	4	4	2	0.048	0.701	1.76	10.7	0.107	0.805	3.58	64.7	0.024	0.283	4.33	447.7	0.828	0.364	6.51
D3	1.50E-03	35	7.5	4	2	0.046	0.734	1.80	9.4	0.133	0.865	3.51	56.4	0.026	0.322	4.32	447.7	0.801	0.382	6.56
D4	1.50E-03	35	16	4	2	0.062	0.846	1.95	9.4	0.144	0.800	3.43	56.4	0.024	0.290	4.21	447.7	0.779	0.358	6.49
D5	1.50E-03	35	24	4	2	0.062	0.721	1.78	12.3	0.173	0.673	3.54	56.4	0.018	0.267	4.13	447.7	0.757	0.376	6.54
E1	1.50E-03	10	1	3	2				10.7	0.103	1.856	4.41	56.4	0.010	0.184	3.76	447.7	0.920	0.364	6.51
E2	1.50E-03	10	4	4	2	0.036	0.684	1.73	10.7	0.060	0.803	3.57	56.4	0.027	0.284	4.19	390.0	0.892	0.381	6.42
E3	1.50E-03	10	5	4	2	0.049	0.819	1.91	14.2	0.102	0.788	3.83	42.8	0.042	0.423	4.31	390.0	0.820	0.393	6.45
E4	1.50E-03	10	6.75	3	2				4.1	0.189	1.095	2.917	49.1	0.020	0.295	4.09	390.0	0.806	0.339	6.30
E5	1.50E-03	10	13	4	2	0.070	0.868	1.97	6.2	0.113	0.838	3.06	49.1	0.108	1.296	5.57	390.0	0.730	0.460	6.61
E6	1.50E-03	10	16	4	2	0.096	0.819	1.91	10.7	0.149	0.843	3.62	56.4	0.086	1.170	5.61	390.0	0.679	0.384	6.43
E7	1.50E-03	10	24	4	2	0.070	0.802	1.89	9.4	0.188	0.945	3.60	56.4	0.013	0.231	3.98	339.7	0.737	0.429	6.40