

Exercises Chapter 9

Exercise 9.2

Using the bulk granulometry estimated for the famous 79 AD Vesuvius eruption that destroyed the Roman town of Pompeii (Table 9A, from Macedonio *et al.*, 1988), and the properties of the Standard Atmosphere (Table 9B), calculate the settling velocity of the different particle classes reported in Table 9A and the relative fraction of each settling velocity class at (i) sea level, and (ii) at 30 km a.s.l., by assuming that particles have a sphericity $\psi=0.9$. Average densities of 1500 kg m^{-3} and 2600 kg m^{-3} can be assumed for the juvenile and lithic particles, respectively.

NOTE: Particle settling velocity can be calculated from the formula

$$v_s = \sqrt{4gd\rho_p/(3C_d\rho_a)} ,$$

deriving the drag coefficient according to Ganser's (1993) parameterization:

$$C_d = \frac{24}{\text{Re } K_1} \left\{ 1 + 0.1118 [\text{Re}(K_1 K_2)]^{0.6567} \right\} + \frac{0.4305 K_2}{1 + 3305/(\text{Re } K_1 K_2)} ,$$

where $\text{Re} = \rho_a v_s d / \eta_a$ is the particle Reynolds number, ρ_a and η_a are the density and the viscosity of air, ρ_p is the particle density, and K_1 and K_2 are two particle shape factors that depend on the particle sphericity ψ : $K_1 \equiv 3/(1 + 2\psi^{-0.5})$ and $K_2 = 10^{1.84148(-\log \psi)^{0.5743}}$.

Because the drag coefficient depends on the settling velocity v_s , build an Excel spreadsheet to calculate v_s iteratively using at least three iterations.

Table 9A. Granulometric population of the 79 AS Vesuvius eruption

Φ	Diameter (mm) $d = 2^{-\phi}$	Juveniles (wt%)	Lithics (wt%)	Total (wt%)
-4	16	4.0	1.7	5.7
-3	8	6.0	1.5	7.5
-2	4	7.1	4.3	11.4
-1	2	6.2	6.0	12.2
0	1	6.7	6.9	13.6
1	0.5	7.9	6.7	14.6
2	0.25	5.5	4.0	9.5
3	0.125	4.8	2.9	7.7
4	0.063	2.5	1.4	3.9
≥ 4	<0.063	8.8	5.0	13.8

Table 9B. Physical properties of the Standard Atmosphere in SI units

Altitude (m)	Temperature (K)	Pressure (Pa)	Density (kg m ³)	Viscosity (Pa s)
-1000	294.7	1.139×10^5	1.347	1.821×10^{-5}
0	288.2	1.013×10^5	1.225	1.789×10^{-5}
1000	281.7	8.988×10^4	1.112	1.758×10^{-5}
2000	275.2	7.950×10^4	1.007	1.726×10^{-5}
3000	268.7	7.012×10^4	9.093×10^{-1}	1.694×10^{-5}
4000	262.2	6.166×10^4	8.194×10^{-1}	1.661×10^{-5}
5000	255.7	5.405×10^4	7.364×10^{-1}	1.628×10^{-5}
6000	249.2	4.722×10^4	6.601×10^{-1}	1.595×10^{-5}
7000	242.7	4.111×10^4	5.900×10^{-1}	1.561×10^{-5}
8000	236.2	3.565×10^4	5.258×10^{-1}	1.527×10^{-5}
9000	229.7	3.080×10^4	4.671×10^{-1}	1.493×10^{-5}
10000	223.3	2.650×10^4	4.135×10^{-1}	1.458×10^{-5}
15000	216.7	1.211×10^4	1.948×10^{-1}	1.422×10^{-5}
20000	216.7	5.529×10^3	8.891×10^{-2}	1.422×10^{-5}
30000	226.5	1.197×10^3	1.841×10^{-2}	1.475×10^{-5}
40000	250.4	2.871×10^2	3.996×10^{-3}	1.601×10^{-5}
50000	270.7	7.978×10^1	1.027×10^{-3}	1.704×10^{-5}

Exercise 9.3

Using an eruption column height of 30 km for the gray pumice phase of the 79 AD Vesuvius eruption, and a duration of about 9 hours (Carey and Sigurdsson, 1987), estimate the total erupted mass during this phase, using

- (a) the model of Wilson and Walker (1987)
- (b) the diagrams of Sparks (1986).

Exercise 9.4

Assuming a wind profile with speed increasing linearly up to a maximum of 27 m s^{-1} at 11 km blowing towards the SSE (175 degrees from north), a constant wind speed of 25 m s^{-1} above 11 km blowing towards the E (93 degrees from north), and the information contained in the Exercises 9.2 and 9.3, use the computer program HAZMAP (download from <http://datasim.ov.ingv.it/Hazmap.html>) to derive the isomass maps corresponding to the gray pumice phase of the 79 AD Vesuvius eruption.

References

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