UNIVERSITÉ DE GENÈVE

Gravity currents in volcanology

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Volcanic flows

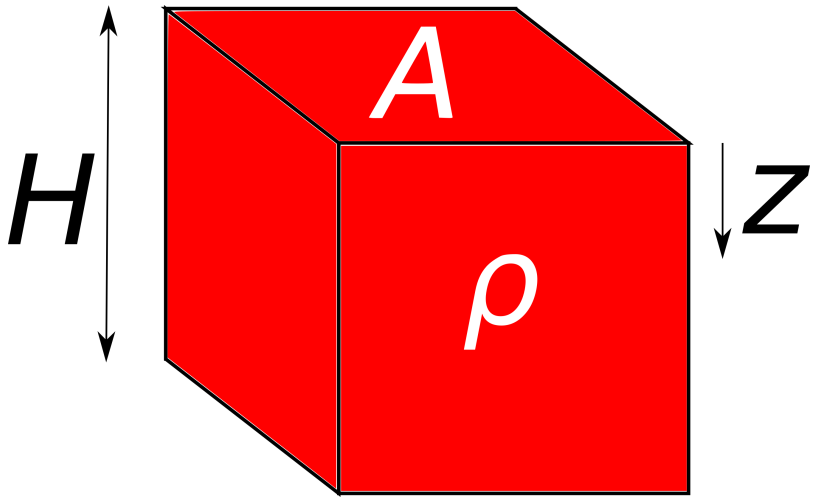
Lava flows

Cloud spreading

Pyroclastic density currents (PDCs)

Lahars

Hydrostatic gradients



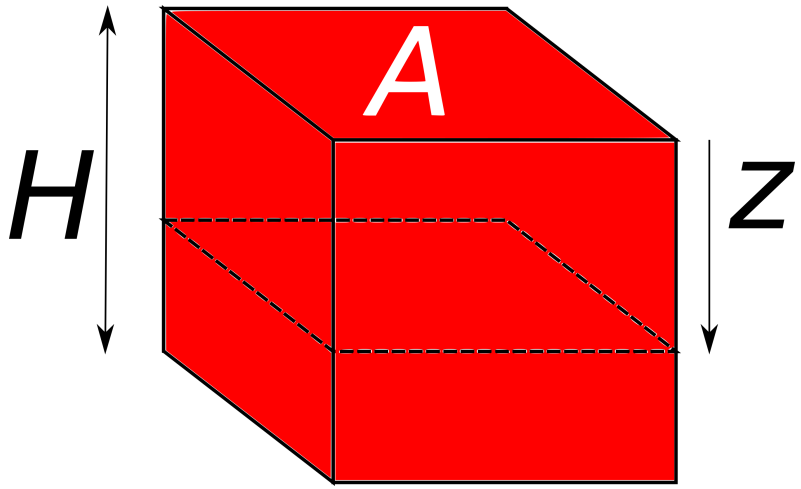
Consider a volume of fluid of :

- Density ρ
- Height H
- Horizontal cross section A

z = Negative vertical coordinate (depth below top surface)

Consider horizontal plane at depth z
What are the forces acting on this plane?

- **Weight** of overlying fluid
$$W = \rho A z g$$
- Balanced by **hydrostatic pressure**
$$F_p = PA$$

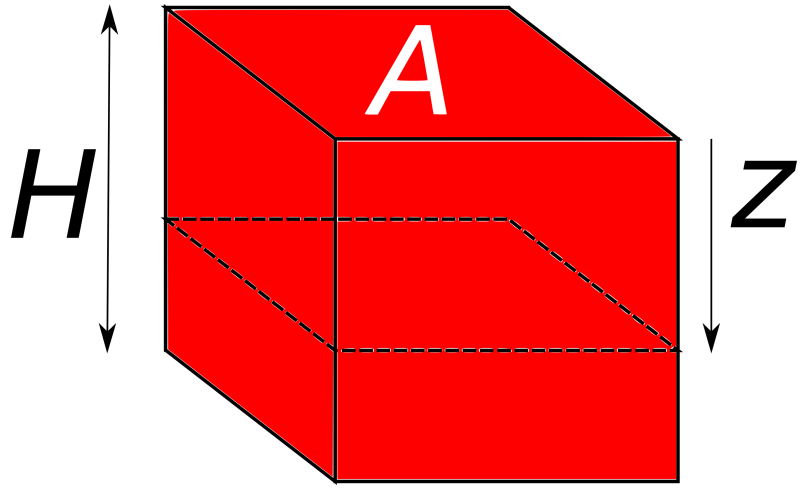


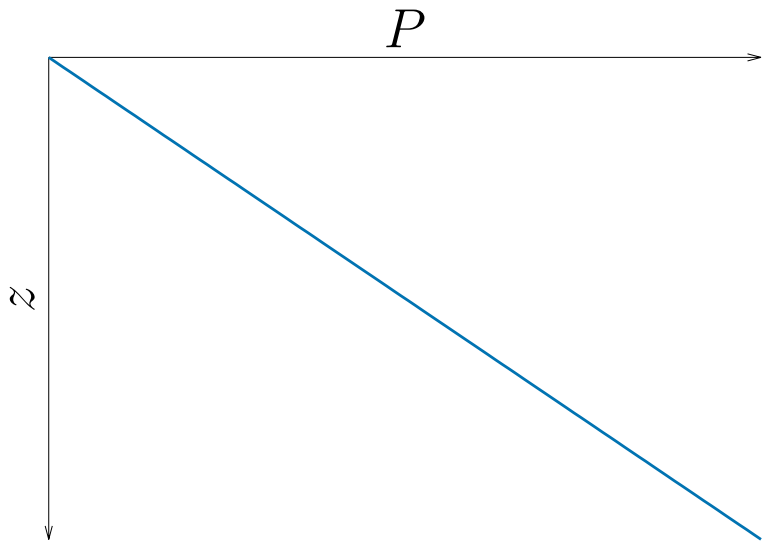
Hydrostatic gradients

Nothing is moving $\Longrightarrow$ **Mechanical equilibrium**

$$W = F_p$$

$$P = \rho g z$$





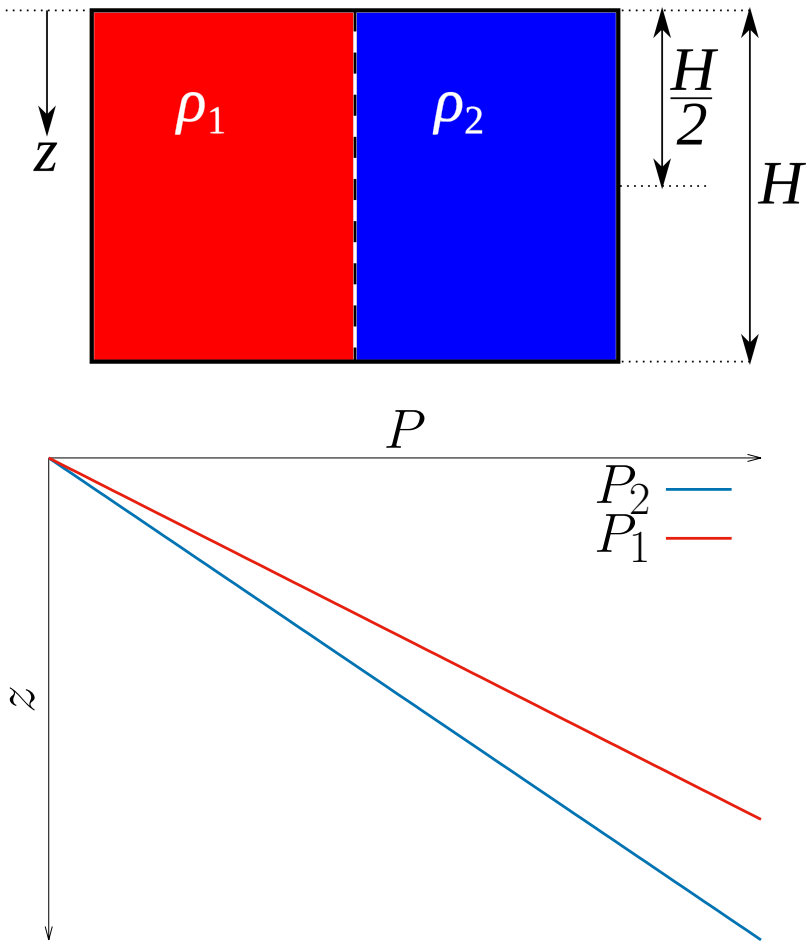
P increases linearly with z

Hydrostatic gradient:

$$\frac{\mathrm{d}P}{\mathrm{d}z} = \rho g$$

Gravity currents - Hydrostatic gradients

Gravity current - A horizontal flow in a gravitational field that is driven by a density difference



Consider two fluids (densities ρ_1 and ρ_2, $\rho_1 > \rho_2$) initially side-by-side and separated by a vertical barrier
Vertical pressure gradient:

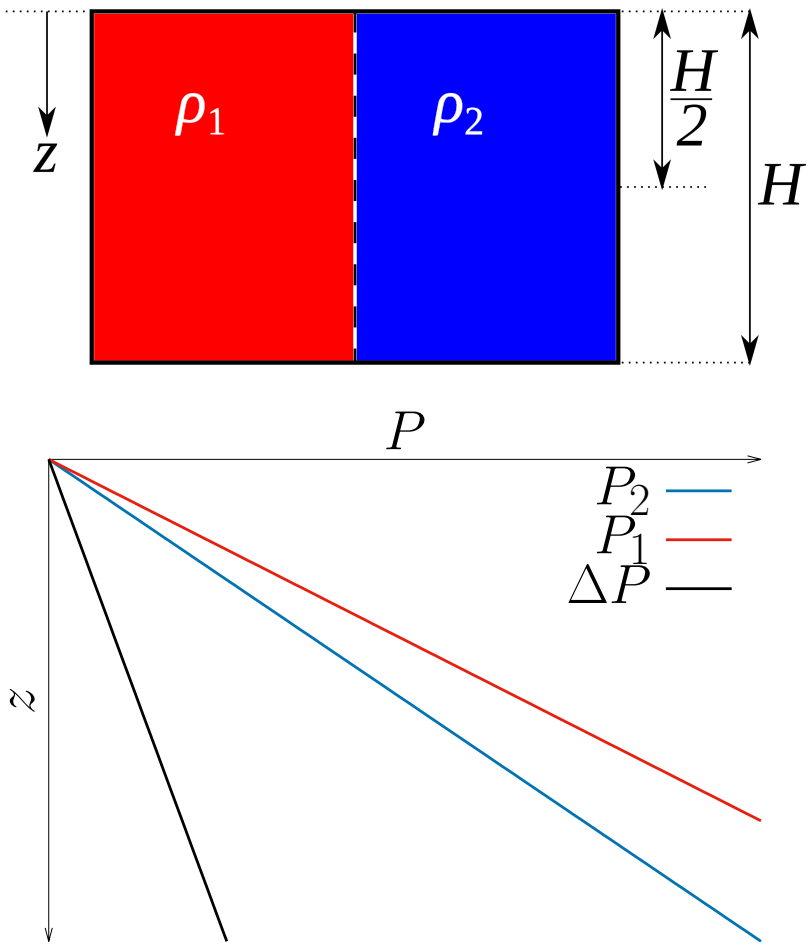
$$\frac{\mathrm{d}P}{\mathrm{d}z} = \rho g$$

$$\mathrm{d}P = \rho g \mathrm{d}z$$

$$\int_0^P \mathrm{d}P = \rho g \int_0^z \mathrm{d}z$$

$$P = \rho g z$$

Gravity currents - Horizontal force balance

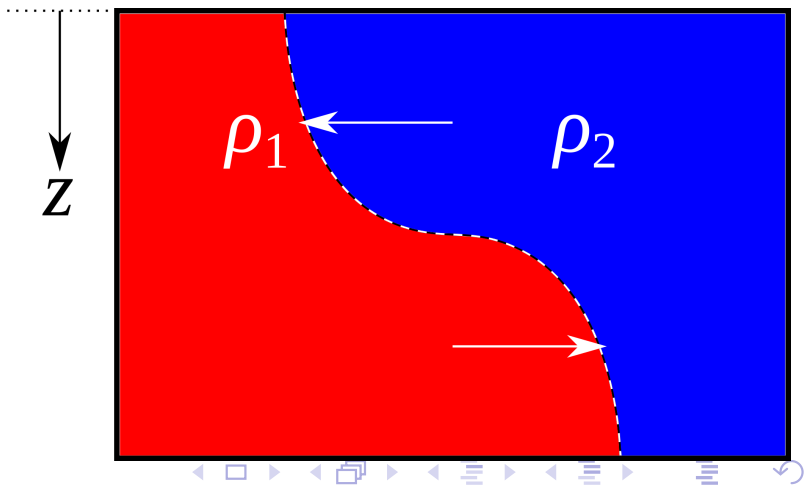


Remove barrier, and consider pressure difference ΔP across line

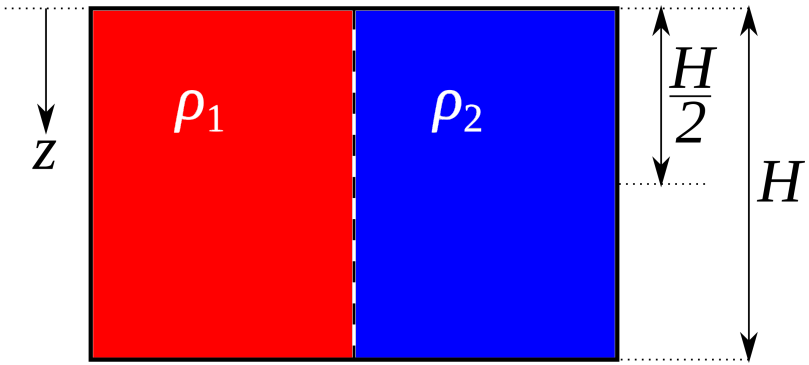
ΔP increases with depth

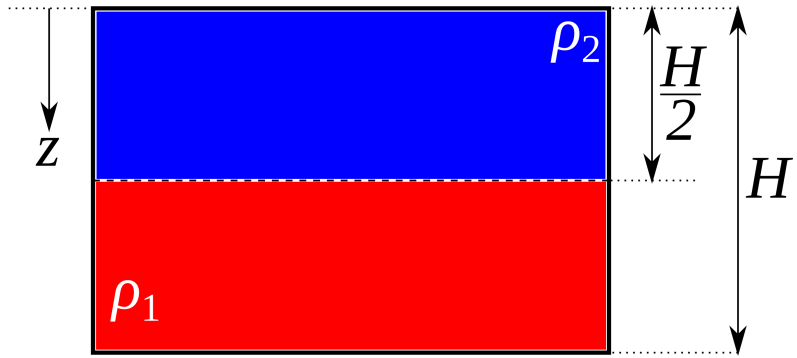
Flow follows a pressure gradient - but horizontal pressure gradient is greatest at the depth

This initiates from from high to low pressure at the base, which is compensated by return flow at the top



Gravity currents - Energy minimisation





Gravitational potential energy $= U = g \int_0^H \rho \mathrm{d}z$

$$U = \frac{g(\rho_1 + \rho_2)H}{2}$$

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