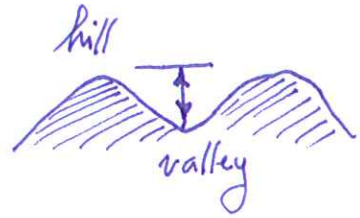
Factors that control the rate of erosion:

- climate (and vegetation)
- rock type
- relief ≡ elevation change



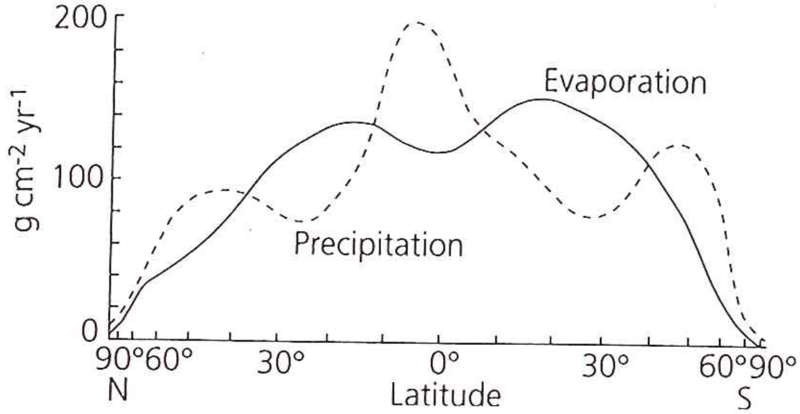


Fig. 1.19 Zonally averaged precipitation and evaporation as a function of latitude.

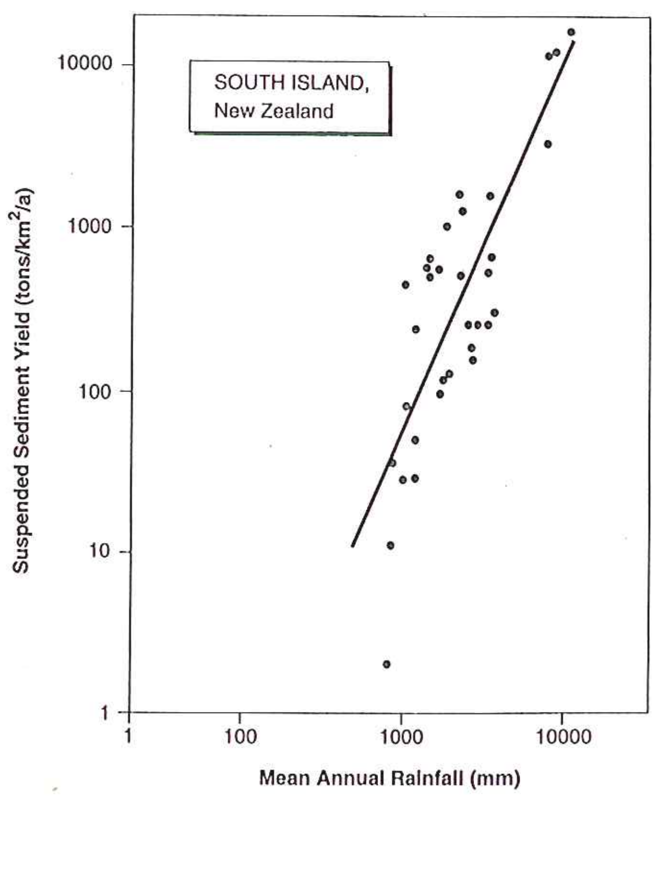


Figure 3-11
Log-log plot of suspended sediment yield versus mean annual precipitation for South Island of New Zealand. Suspended sediment yield is positively correlated with mean annual precipitation (from Walling and Webb, 1983).

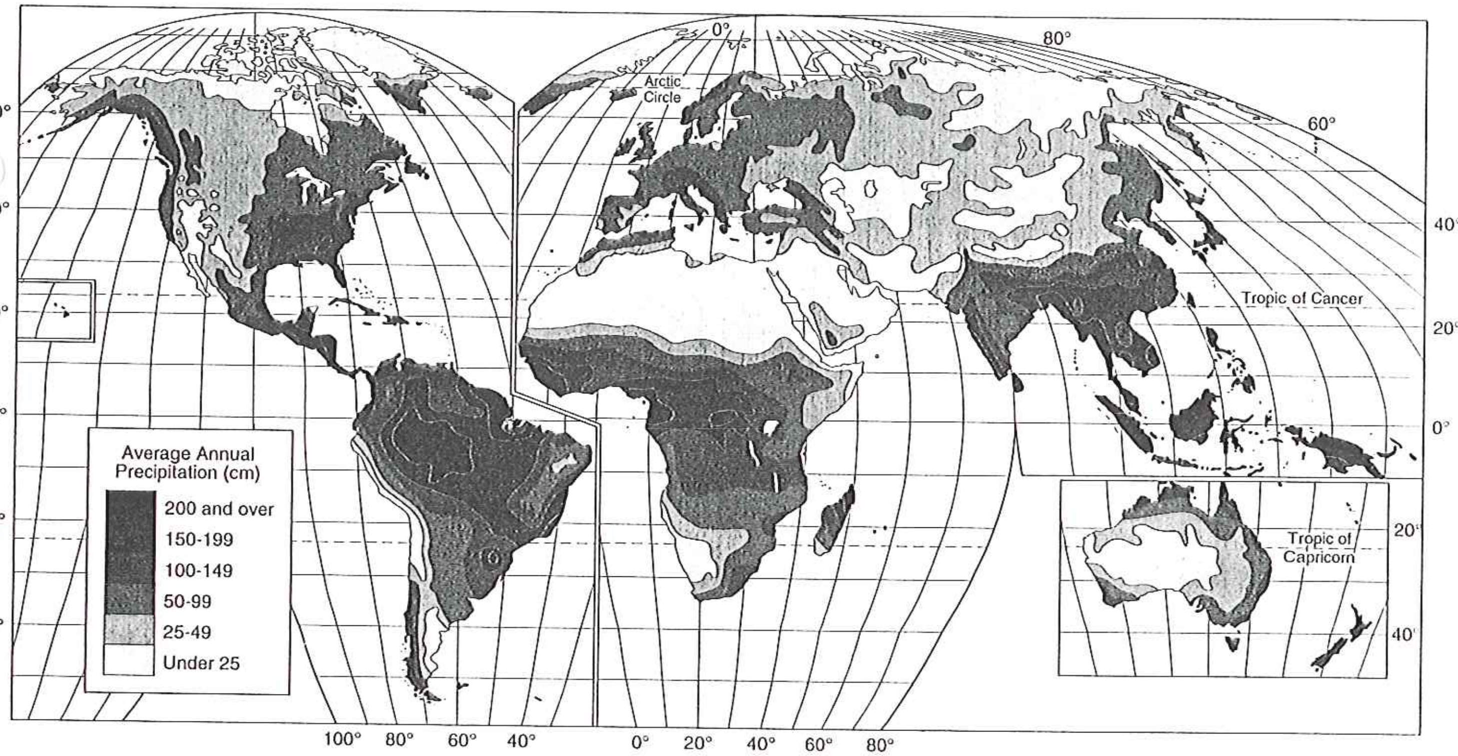


Figure 1.2 Global average annual precipitation. (From Tom L. Mc Knight, *Physical Geography: A Landscape Appreciation*, 5th ed. Copyright © 1996 Prentice Hall, Inc., Upper Saddle River, N.J.)

conversion to erosion rate

$$100 \frac{\text{tons}}{\text{km}^2\,\text{yr}} = 0.04 \frac{\text{km}}{\text{Myr}}$$

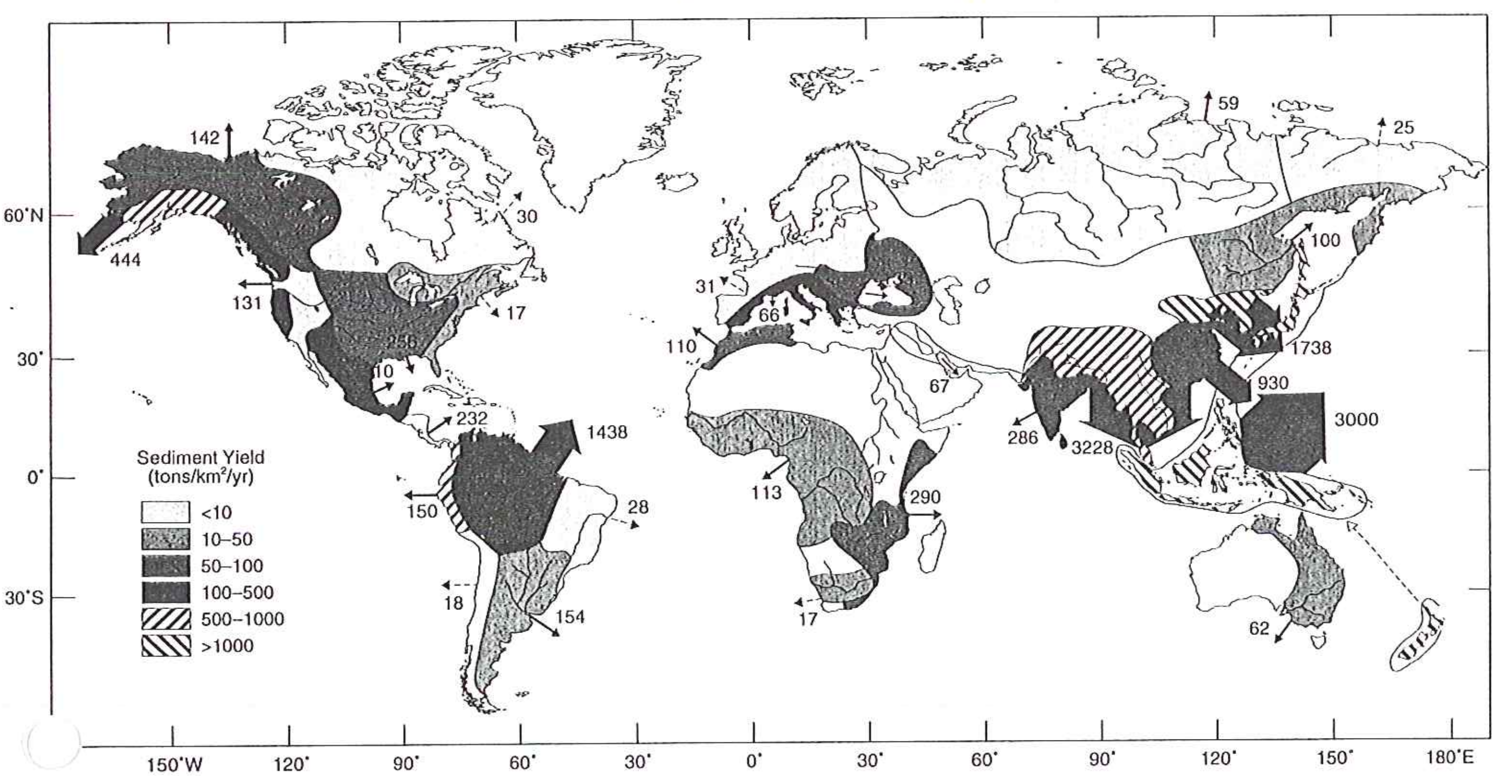


Figure 5.1. Discharge of suspended sediment from world drainage basins (in 10^6 tons/yr) as indicated by arrows. Sediment yield (tons/km²/yr) for various drainage basins is also shown by appropriate pattern (see legend). Open pattern indicates essentially no sediment discharges to the oceans. [After J. D. Milliman and R. H. Meade. "World-Wide Delivery of River Sediment to the Oceans," *Journal of Geology* 91(1): 16. Copyright © 1983 by The University of Chicago Press, reprinted by permission of the publisher.]

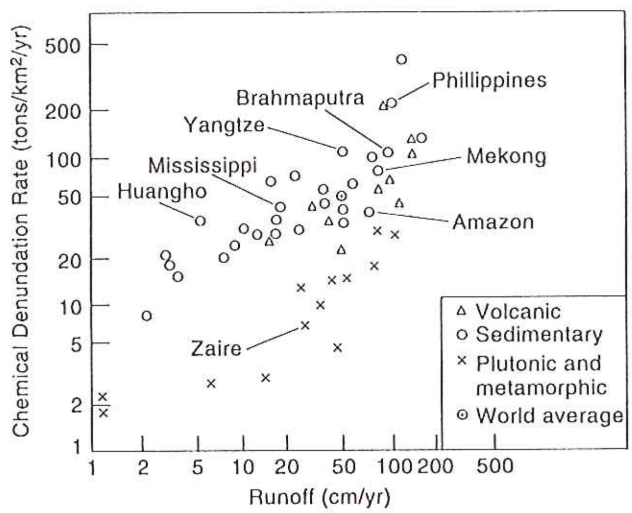


Figure 5.7. Influence of rock composition on total dissolved load per unit area (chemical denudation rate) versus runoff per unit area for major world rivers and some small basins. Certain major rivers discussed in the text are also included. (Adapted from Meybeck 1980; additional data from Hu et al. 1982.)

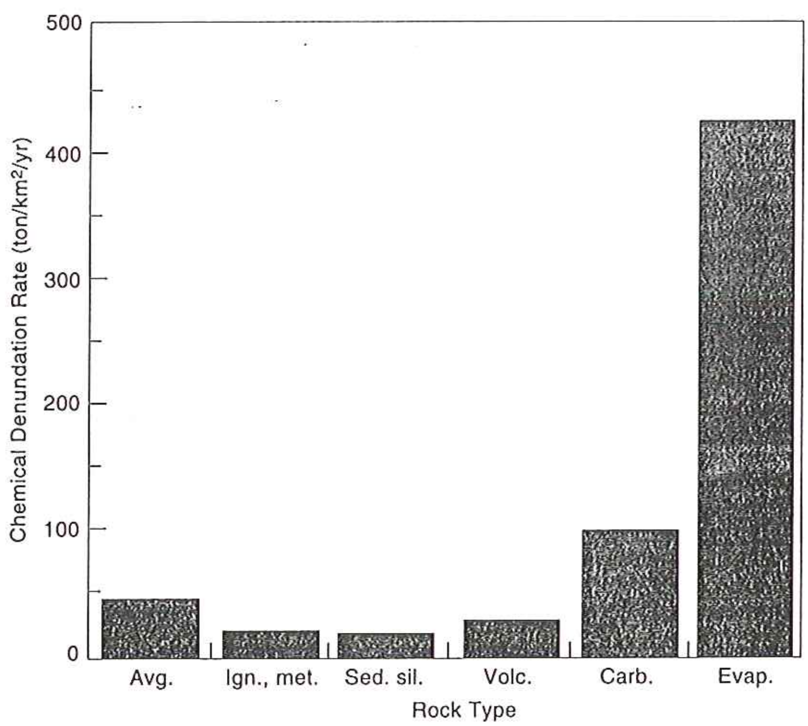
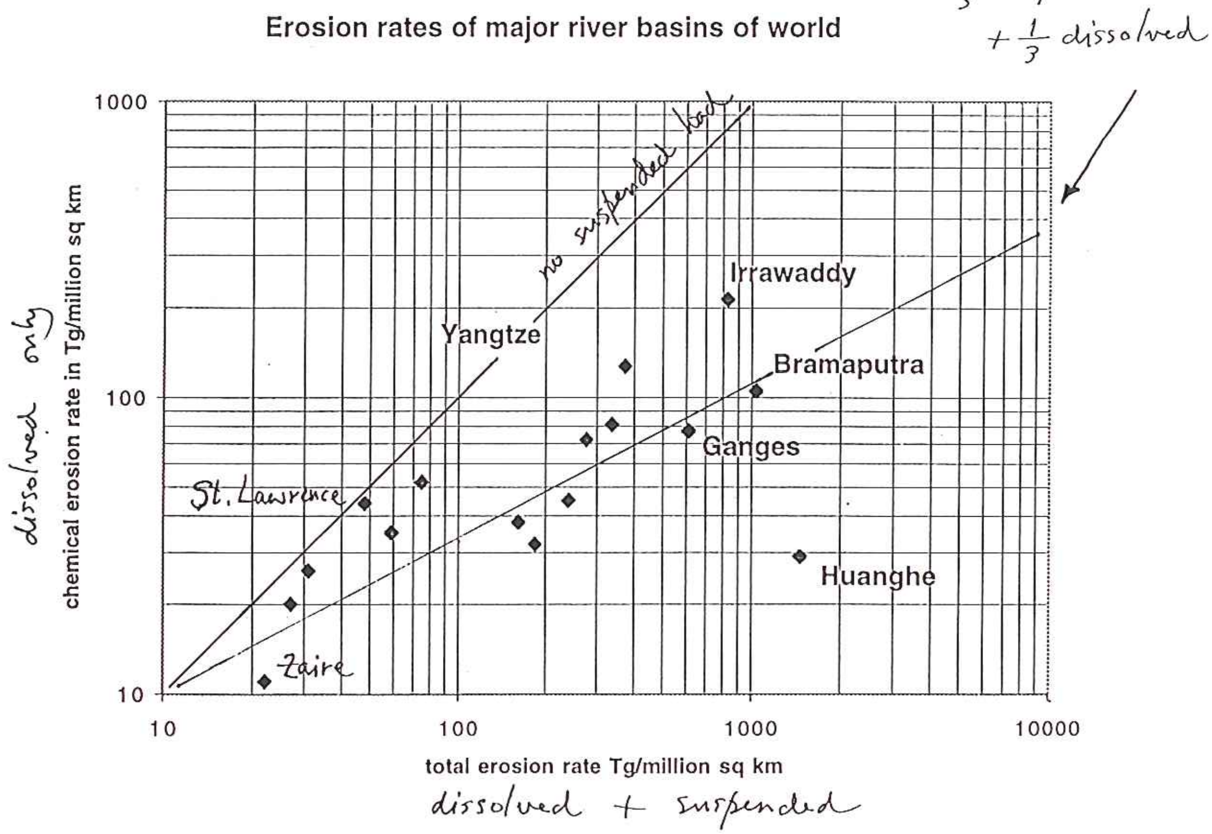


Figure 5.8. Relative chemical denudation rate in tons/km²/yr of various rock types compared to the average rate. Abbreviations for rock types are as follows: avg. = average; ign., met. = igneous and metamorphic; sed. sil. = sedimentary silicates; volc. = volcanics; carb. = carbonates; evap. = evaporites. (Data from Meybeck 1987.)



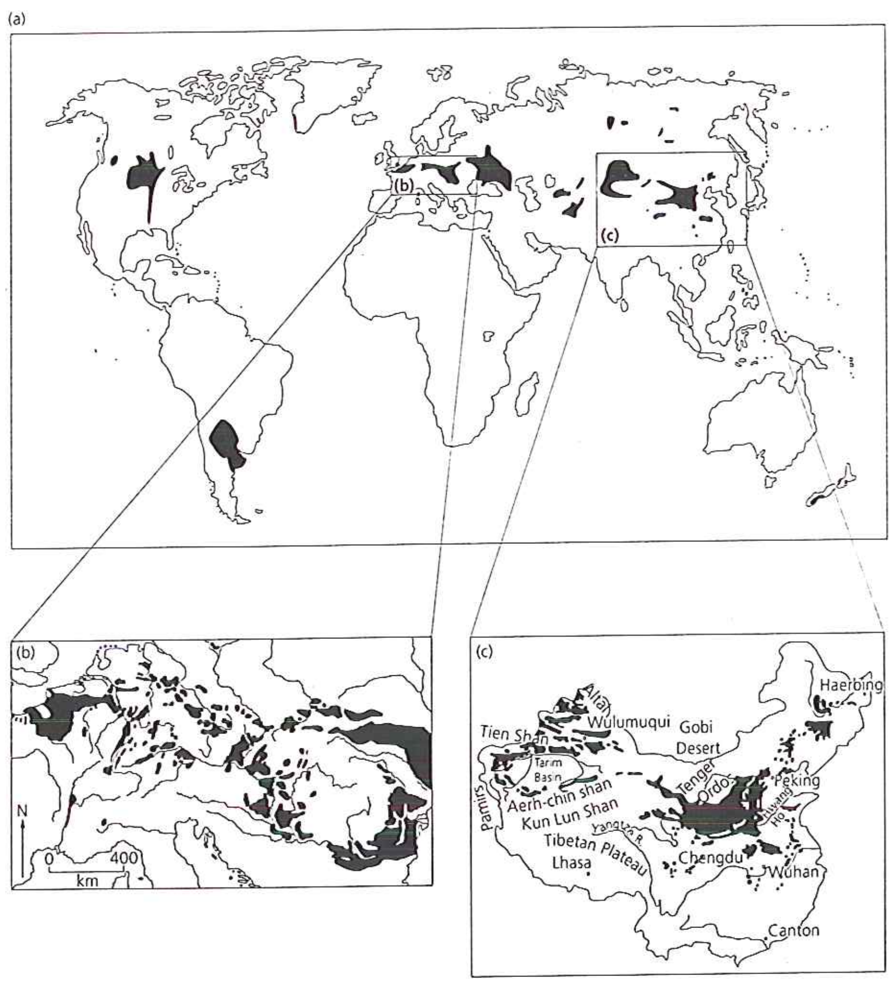


Fig. 2.12 Occurrence of loess. (a) Global distribution of main deposits. Distribution of loess in (b) Europe and (c) China. After Pye (1987) [14].

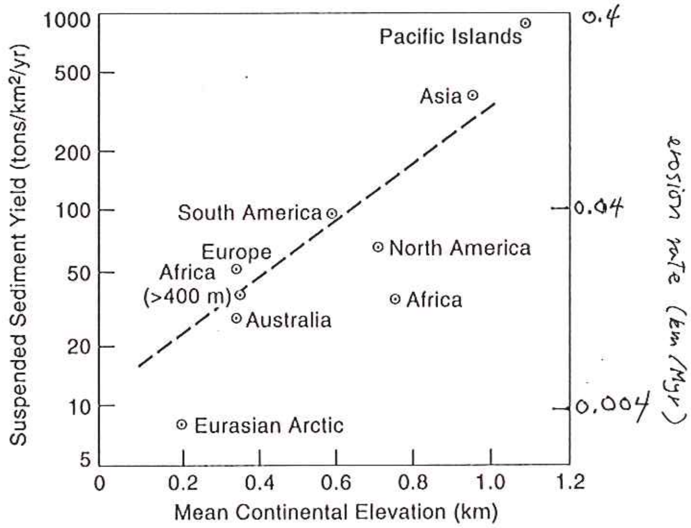


Figure 5.2. Suspended sediment yield (tons/km²/yr) versus mean continental elevation (km). [Suspended sediment data from Milliman and Meade (1983); mean continental elevation from Fairbridge (1968), except for the Pacific Islands and Eurasian Arctic, which are our rough estimates.]

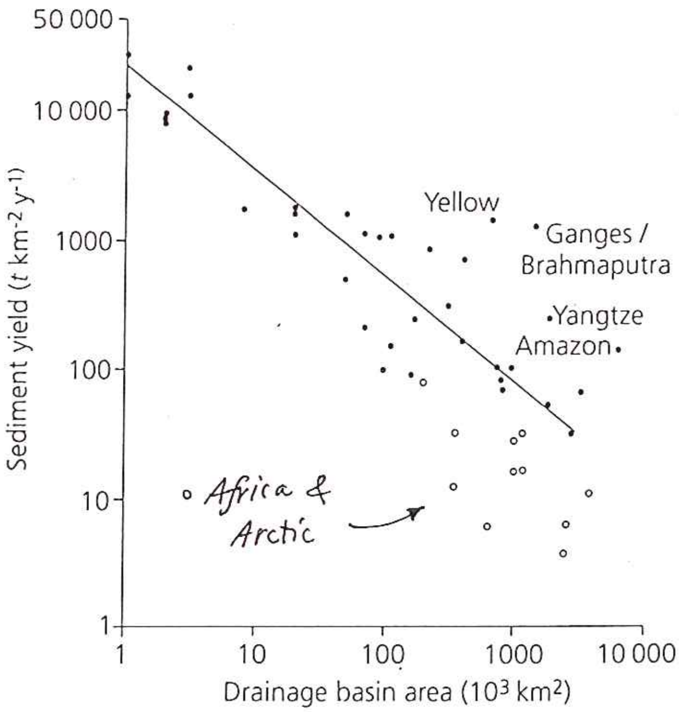


Fig. 3.29 Sediment yield versus drainage basin area for the world's major sediment discharging rivers (over 10 Mt y^{-1}). The open circles are the low yield rivers of Africa and the Eurasian Arctic. The named large rivers all have very high yields compared to their drainage basin area. The slope of the correlation line reflects the area averaging involved in calculating sediment yield, with larger basins having relatively larger proportions of lowland and smaller basins having relatively larger proportions of highland. After Milliman & Meade (1983) [29].

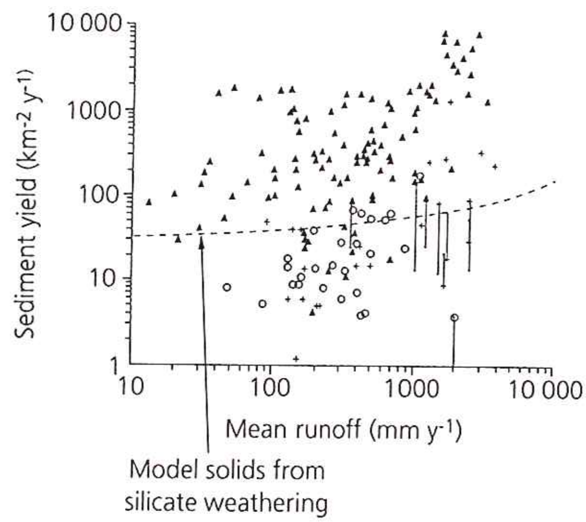
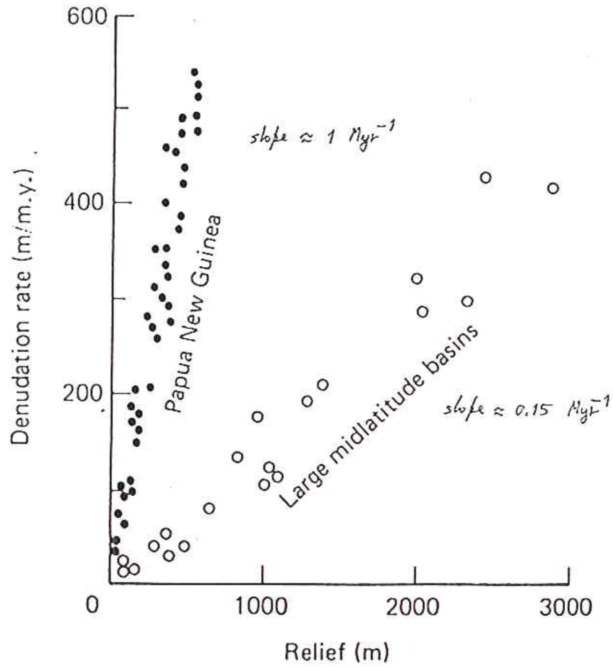


Fig. 3.26 Relation between mean runoff and sediment yield for rivers throughout the world. Open circles, coastal plain (0–100 m headwaters) and lowland (100–500 m); crosses, upland rivers (500–1000 m); solid triangles, mountain (1–3 km) and high mountain (>3 km). Model curve is prediction for solids derived by silicate weathering (after Stallard (1995) [33]), showing that mountainous catchments provide high solid yields for a given runoff, whereas lowland rivers provide low solid yields for the same runoff.

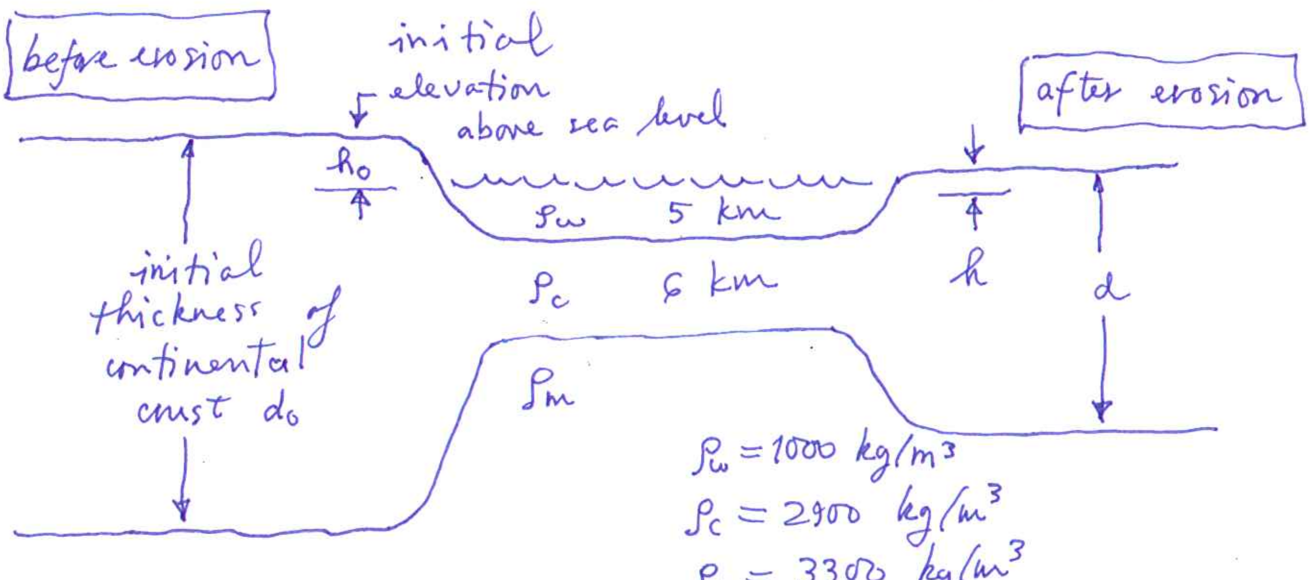


Ruxton & McDougall (1967)
Ahnert (1970)

erosion rate (km/Myr) → $\dot{e} = \alpha h$ ← relief (km)

α: slope of line $(\mathrm{Myr})^{-1}$

Isostatic picture of continental-scale erosion



Balancing an uneroded continental column against an oceanic column of the same height:

$$d_0 = 35 + \frac{h_0}{1-\rho_c/\rho_m}$$

↑ thickness of lowland (sea-level) crust

Likewise: $$d = 35 + \frac{h}{1-\rho_c/\rho_m}$$

Total thickness of eroded material:

$$e = d_0 - d = \frac{h_0 - h}{1 - \rho_c/\rho_m}$$

$$h_0 - h = (1 - \rho_c/\rho_m)\, e$$

$$\frac{dh}{dt} = -(1 - \rho_c/\rho_m)\frac{de}{dt} = -\left(1 - \frac{\rho_c}{\rho_m}\right)\alpha h$$

$$\boxed{\frac{dh}{dt} = -\lambda h \quad \text{where} \quad \lambda = (1 - \rho_c/\rho_m)\alpha}$$

<u>Exponential decay</u> of <u>landscape</u>:

$$h = h_0 e^{-\lambda t} \quad \text{where} \quad \lambda = \alpha(1 - \rho_c/\rho_m)$$

(λ: decay rate; α: climate, rock type, etc.; $(1 - \rho_c/\rho_m)$: isostatic factor)

If $\alpha = 0.15\ (\text{Myr})^{-1}$ the decay rate is

$$\lambda = 0.15\left(1 - \frac{2900}{3300}\right) = 0.018\ (\text{Myr})^{-1}$$

Corresponding <u>half-life</u> of landscape:

$$t_{1/2} = \frac{\ln 2}{\lambda} = 40\ \text{Myr}$$

$$h = h_0 e^{-\lambda t}$$

$$d = 35 + \frac{h}{1-\rho_c/\rho_m} = 35 + 8 h_0 e^{-\lambda t}$$

$$e = \frac{h_0 - h}{1-\rho_c/\rho_m} = 8 h_0 (1 - e^{-\lambda t})$$

Total depth of erosion in limit $t \to \infty$ extends to 8x initial elevation

Example: $h_0 = 1$ km: