

7. Landforms made by tectonic processes

7.2 Long-term landform change

Very long-term change in the landform of large scale mountain block has been simulated by the combination of isostatic compensation, tectonic uplift and fluvial erosion. The mechanism of erosion by running water is approximated by the following simple relations:

$$q = kxS \quad (7.12)$$

$$\frac{\partial z}{\partial t} + \frac{\partial q}{\partial x} = 0 \quad (7.13)$$

The erosion is assumed to proceed by the development of V-shaped valleys. The erosion rate can be assumed to be roughly proportional to mean height h_m of mountain block as follows:

$$\Delta E = kh_m \Delta t \quad (7.14)$$

The decrease in the weight of mountain block due to erosion causes isostatic uplift and offsets the lowering by erosion. The amount of uplift by isostasy is given by

$$\Delta U = \frac{\rho_c}{\rho_m} \Delta E \quad (7.15)$$

where E is the lowering of mean altitude due to erosion, ρ_c , is density of crust and ρ_m is density of mantle.

The lowering rate of mean height is

$$\frac{dh_m}{dt} = \frac{dE - dU}{dt} = \frac{\rho_m - \rho_c}{\rho_m} kh_m \quad (7.16)$$

Integrating the relation, mean height of mountain block is

$$h_m = h_0 e^{-t/K} \quad (7.17)$$

$$K = \frac{k\rho_m}{(\rho_m - \rho_c)}$$

Life-span of mountain block is longer when isostatic compensation occurs. The density of mantle is about 3.4 and that of crust is about 2.7. Therefore, about 80% of the lowering by erosion is set off by isostasy and the lowering rate is fairly slow (Fig.7.8) as compared with the case when isostasy does not act (Fig.7.9).

In the case when highly uplifted peneplain is eroded, the top of the ridge become higher than the altitude of original peneplane owing to isostatic uplift (Fig.7.10).

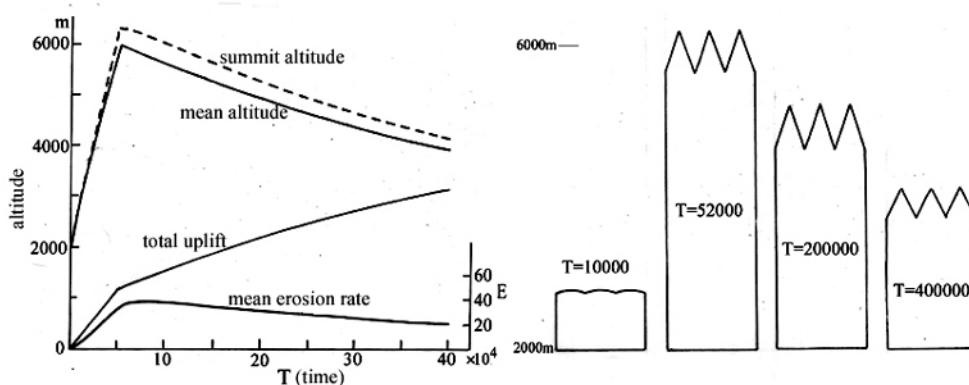


Fig.7.8 Long term change in the form of large scale mountain block with isostatic uplift
Initial landform is a flat surface with the altitude of 2000m. Tectonic uplift occurs during $T=0 \sim 52000$. Erosion and isostatic compensation act all the time. Erosion proceeds with the development of V-valleys. Base level is 2000m.

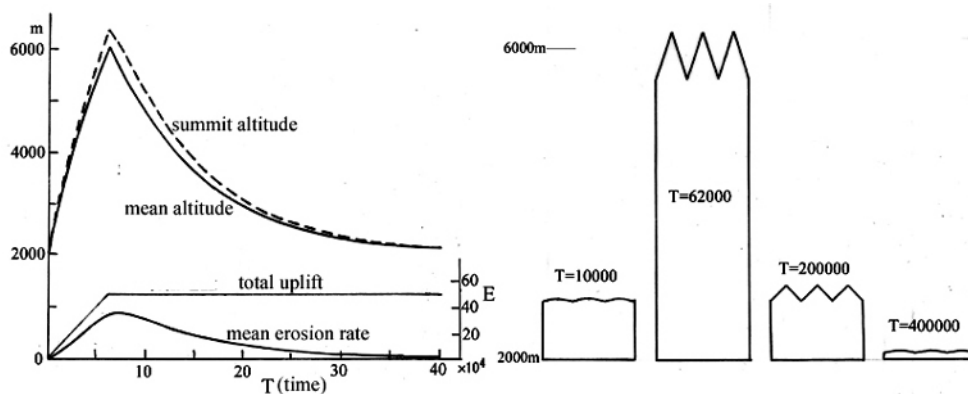


Fig.7.9 Long term change in the form of mountain block without isostatic uplift
Initial landform is a flat surface with the altitude of 2000m. Tectonic uplift occurs during $T=0 \sim 62000$. Erosion proceeds all the time forming V-valleys.

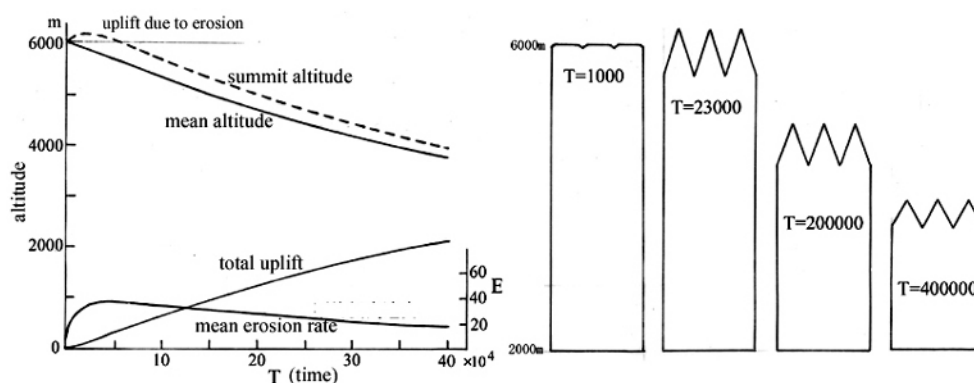


Fig.7.10 Long term change in the form of large scale mountain block
Initial landform is a peneplain with the altitude of 6000m. Erosion and isostatic compensation act all the time.