

5. Landforms made by glacier

5.2 Glacial cirque

The amount of erosion depth E due to basal sliding of glacier is given by

$$E = Ku_b^2 \quad (5.10)$$

$$u_b = k\tau^3 N^{-1} \quad (5.11)$$

$$\tau = \rho gh \sin \alpha \quad (5.12)$$

$$N = \rho gh \cos \alpha \quad (5.13)$$

where u_b is basal sliding velocity, h is thickness of glacier, α is slope angle ρ is density of ice (Fig.5.7).

Equation of continuity for glacier ice is given by

$$\frac{\partial h}{\partial t} + \frac{\partial Q}{\partial x} = B\{z - (z_0 + at)\} \quad (5.14)$$

$$Q = (u_b + u_p)h \quad (5.15)$$

$$u_p = A\tau^3 h \quad (5.16)$$

where Q is ice flow flux, x is horizontal distance, z is altitude, B is mass balance of glacier ice, t is time, $z_0 + at$ is equilibrium line altitude which changes with time, u_p is velocity of plastic flow. Simulation of cirque profile evolution using above equations has been conducted by giving conditions of actual cirques in Japan (Fig.5.8).

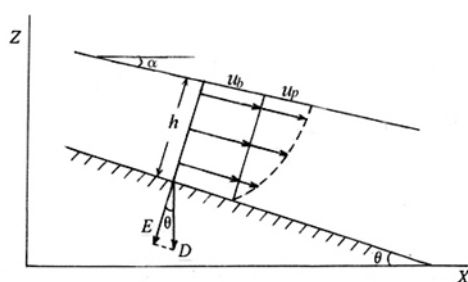


Fig.5.7
Movement of glacier
 u_b : basal sliding
 u_p : plastic flow

Initial profiles are given by straight lines and convex curves which bury entire of hollows of cirques. The width of calculation grid is 10m and time step is 1 year. Equilibrium line altitude are given by a function of time, and fixed at a certain altitude for long times when most of erosion proceeds. Two equilibrium line altitude are given for the cirques where lines of end moraines are formed within the cirques. Simulated profiles fit well with actual profiles as shown in Fig. (5.9), (5.10), (5.11), (5.14). Erosion proceeds intensively around equilibrium line because the thickness of ice is largest there. Characteristic concave profile of cirques is inferred to be the result of the difference in the thickness of glacier.

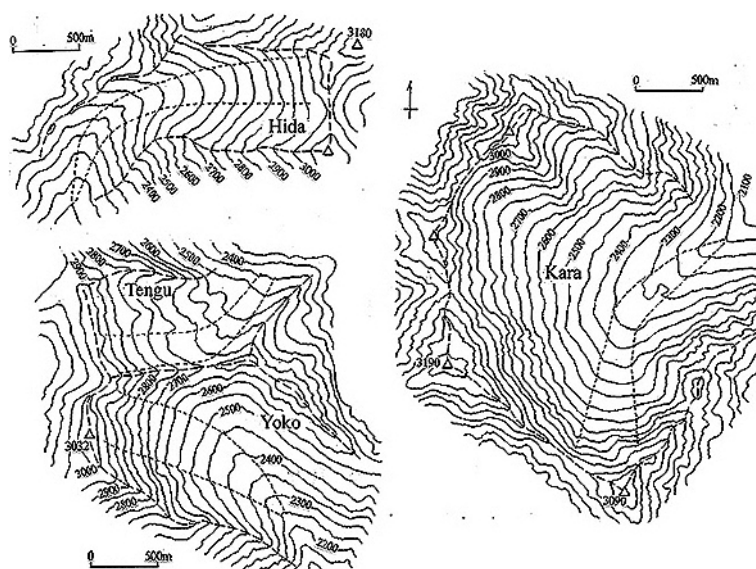


Fig.5.8 Four cirques on Mt.Hotaka,Central Japan
Average longitudinal profiles within dotted areas are measured

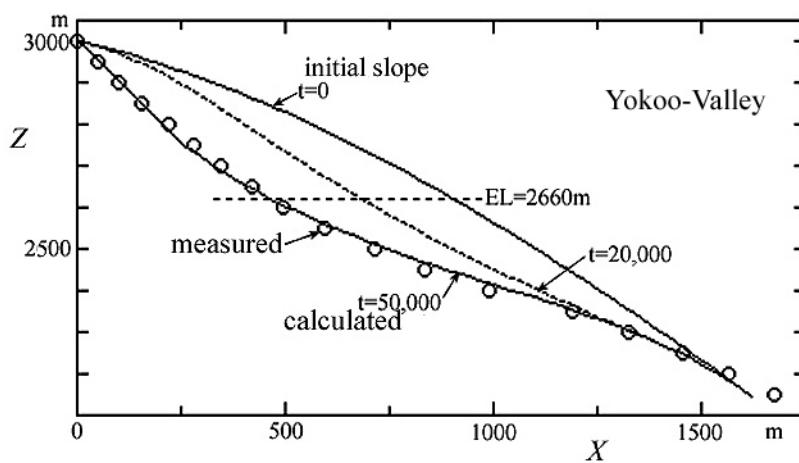
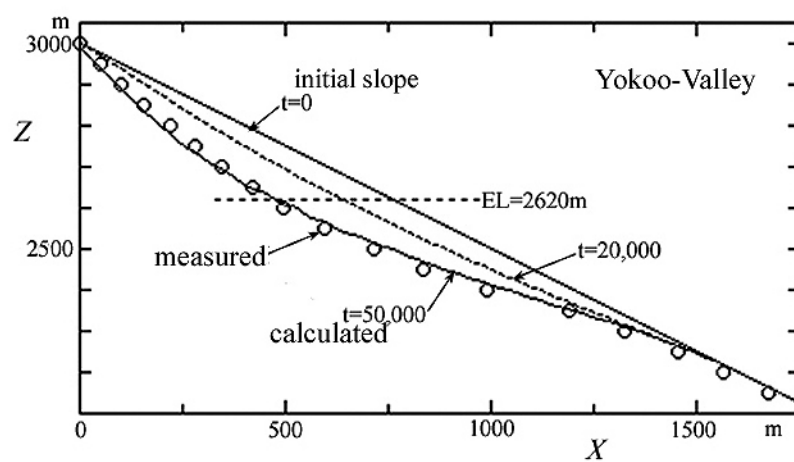


Fig.5.9 Simulation of cirque profile evolution -- Yokoo-Valley
EL: equilibrium line altitude ($T=5000 \sim 45000$)

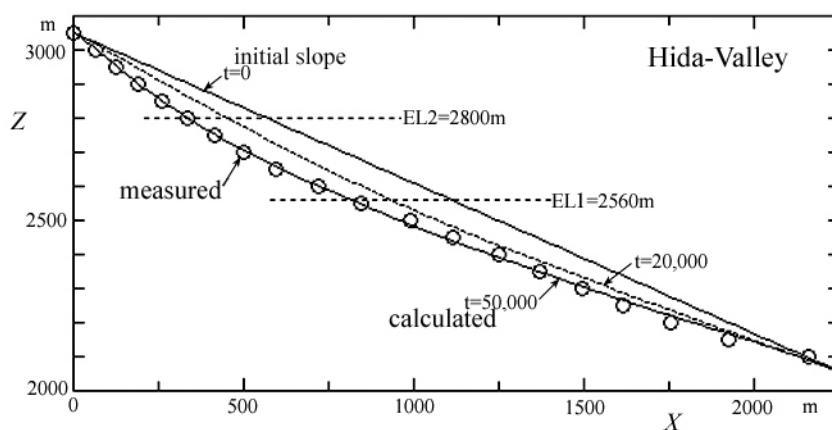


Fig.5.10 Simulation of cirque profile evolution — Hida-Valley
 EL1: equilibrium line altitude during $T=5000 \sim 35000$
 EL2: equilibrium line altitude during $T=37500 \sim 47500$

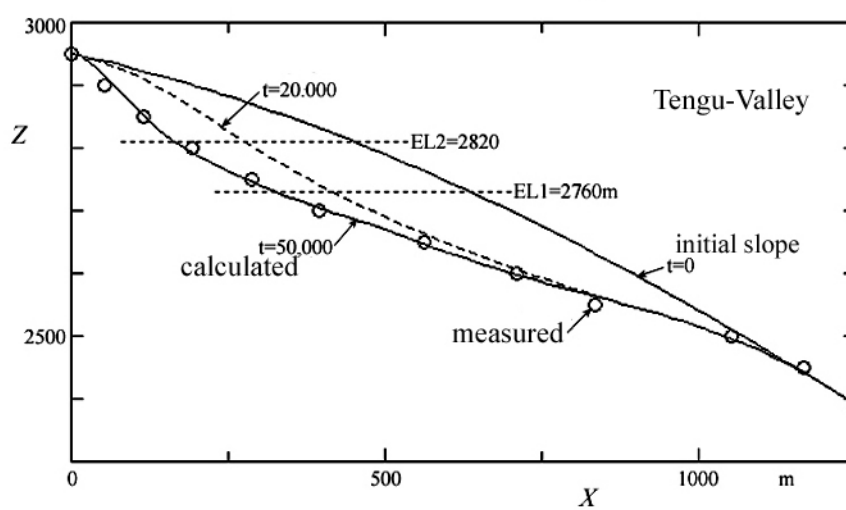
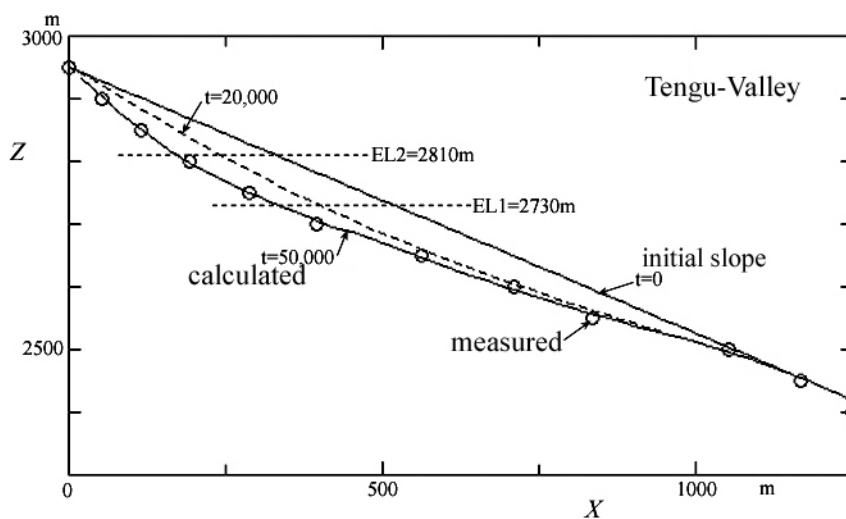


Fig.5.11 Simulation of cirque profile evolution -- Tengu-Valley
 EL1: equilibrium line altitude during $T=5000 \sim 35000$
 EL2: equilibrium line altitude during $T=36500 \sim 47500$

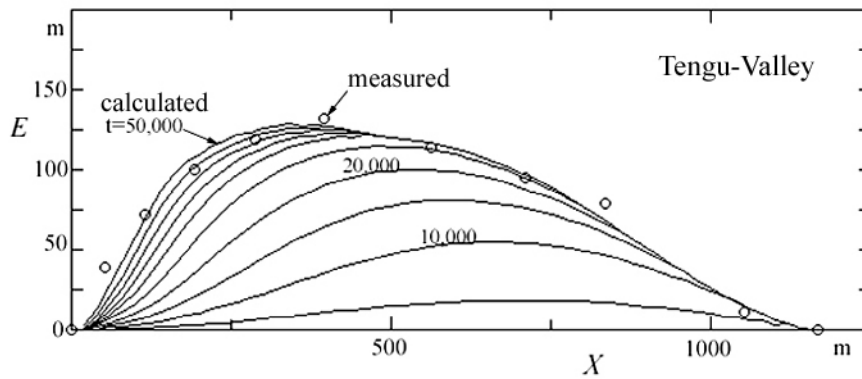


Fig.5.12 Change of erosion depth with time for the case shown in the lower of Fig.5.11

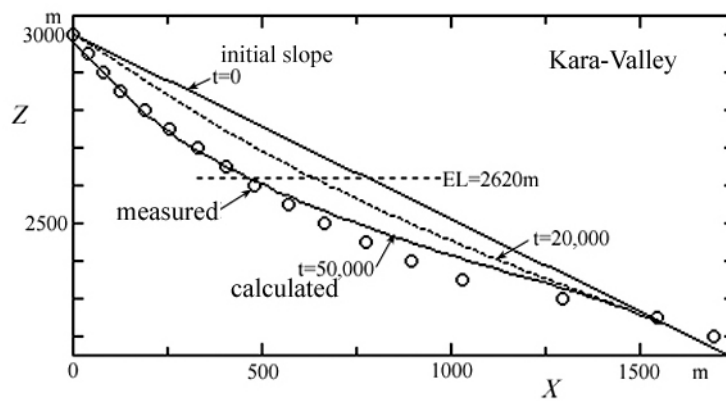


Fig.5.15 Simulation of cirque profile evolution -- Kara-Valley
 EL: equilibrium line altitude during $T=5000 \sim 45000$
 Because the cirque has very wide sector form (Fig.5.8), the agreement of the calculated with the measured is not good at the lower part.