

4. Landforms made by wind

4.2 Sand dunes

Barchan dunes show a very similar form in any deserts in the world (Fig.4.4). This means that barchans migrate keeping the typical form after reaching a steady state. The migration with no change in the form is realized under the condition that sand transport flux is proportional to height.

When Δx is a constant in Fig.4.5, the amount of lowering of the dune surface at any point is q/γ , where q is sand transport flux and γ is the density of sand layer. This is equal to surface gradient multiplied by Δx :

$$\Delta q/\gamma = f'(x)\Delta x \quad (4.9)$$

$$\frac{dq}{dx} = \gamma \frac{dz}{dx} \quad (4.10)$$

Integrating (4.10)

$$q = \gamma z + q_0 \quad (4.11)$$

is derived, where q_0 is sand transport flux at the front. In a steady state amount of sand transport is proportional to height.

Continuity equation is given by

$$\frac{\partial z}{\partial t} = -\frac{\partial q}{\partial x} \quad (4.12)$$

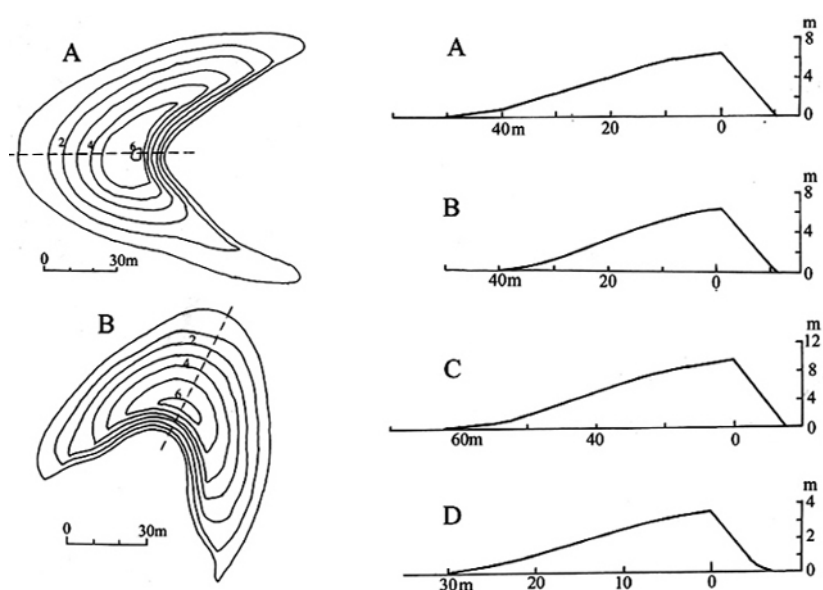


Fig.4.4 Typical barchan dunes A:California, B:Morocco, C:Oman, D:Namib

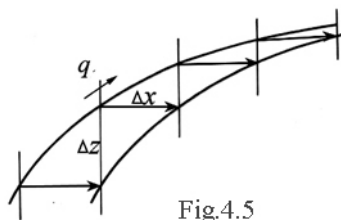


Fig.4.5
Migration keeping an equilibrium form

Simulation of the evolution of barchan dune in the process of migration has been conducted using (4.11) and (4.12). Initial forms of sand dune are arc and triangular (Fig.4.7). Equation (4.12) is applied at the windward slope. At the back (lee) slope, q is set at 0 because wind velocity decreases suddenly just behind the crest. The blowing sand over the crest is deposited at the top of the back slope. The deposited sand falls over the lee slope by the action of gravity, making a slip slope. The maximum slope is the angle of repose of deposition for dry sand, 34 degrees. Fig.4.8 shows very early stage of barchan evolution. The growth of typical barchan form is very rapid. Forward migration does not occur until slip slope evolves over entire lee slope.

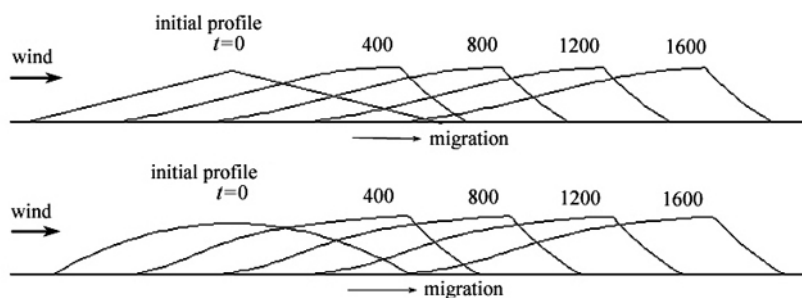


Fig.4.7 Simulation of the evolution of barchan dunes

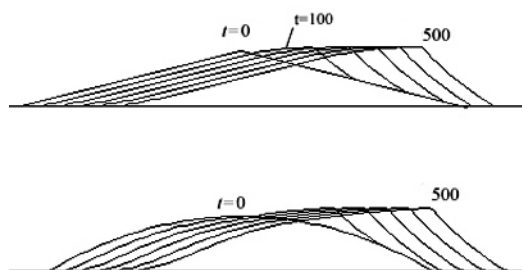


Fig.4.8
Early stage of evolution

Forward migration is done by the growth of slip face slope as shown in Fig.4.9.

$$q_p / \gamma = dV = ch \quad (4.13)$$

$$c = q_p / \gamma h \quad (4.14)$$

The speed of migration is inversely proportional to the height of the crest.

The crescent plan form of barchan is resulted from the difference in the height of the crest. At the lateral side migration speed is larger because the crest is lower. The speed is highest at the lateral margin. Fig.4.11 shows the formation of crescent-like form by simply connecting the results of one-dimensional simulations.

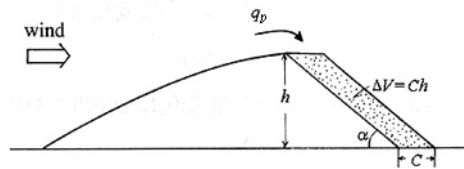


Fig.4.9
Migration speed of barchan

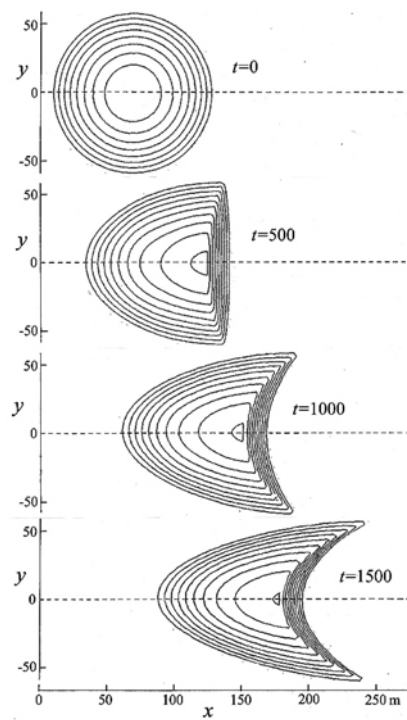


Fig.4.11
Evolution of barchan