MASS WASTING (GRAVITY TRANSPORT OF MATERIAL)

The concept of mass wasting was advocated by Sharpe in 1938. The gravity transport also brings substantial changes on the crust of the earth and it therefore has been recognised as an important geomorphic process. Mass movement is the downslope transfer of material through the direct action of gravity. The process can be rapid like landslide, or imperceptibly slow, as creep of soil down the gentle slope of gravity covered field.

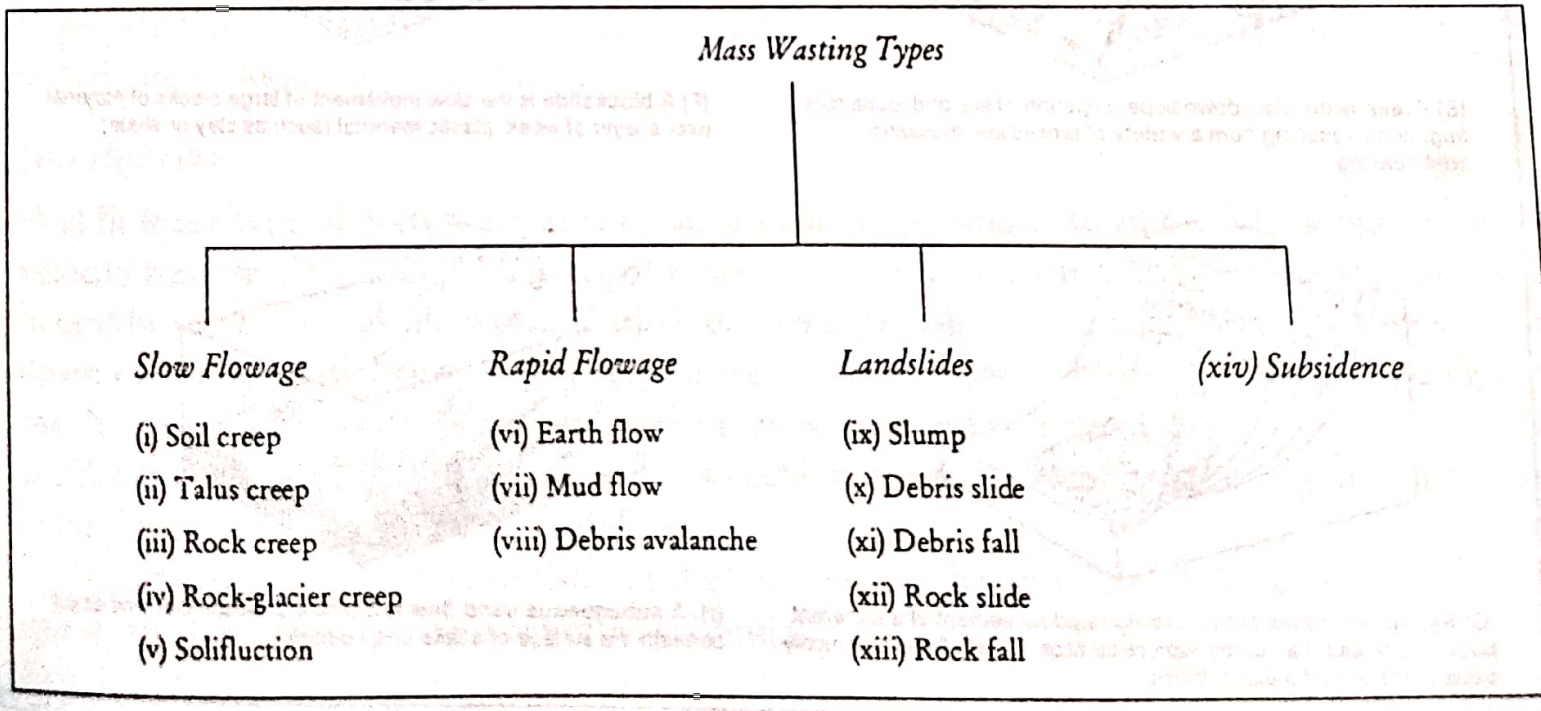
Rock material may move under the influence of gravity either as a movement of weathering products down a slope, or as mass movement of rock along joint planes, bedding planes, etc. The main causes of mass wasting are the structure, composition and permeability of rocks, climatic factor, vegetation cover and water availability and its pressure. In fact, rapid mass wasting takes place after heavy rains or rapid melting of snow cover. The role of slope gradient on mass wasting is equally important.

Gravity is the driving force for the downslope movement of material, but several factors are important in overcoming inertia and causing movement to occur. Most important among them are: (i) saturation of material with water, (ii) vibrations from earthquakes, (iii) oversteepening of slopes by undercutting, and (iv) alternating freezing and thawing. Sharpe has recognised four major classes of mass wasting, which he designated as: (a) slow flowage, (b) rapid flowage, (c) landslides, and (d) subsidence (Fig. 14.6).

(a) Slow Flowage

(i) Soil Creep

The imperceptible but continuous movement of soil down a slope in response to gravity is known as soil creep. Soil creep occurs under all types of climates where there is a slope gradient, but is



thought to be one of the most significant of the geomorphic processes in the humid maritime parts of the periglacial environment. Individual soil particles are lifted and distributed by the expansion of soil moisture as it freezes, by cycles of moistness and dryness by daily temperature variations, or even by grazing livestock or digging animals. Various strategies are used to arrest the mass movement of slope material, like grading the terrain, building terraces and retaining walls, planting ground cover—but the persistence of creep always wins.

(ii) Talus Creep

Talus is generally regarded as a synonym for scree. Talus is the slow downslope movement of rock fragments or scree (accumulation of fragmented rock waste below a cliff or rock face) (Fig. 14.6).

(iii) Rock Creep

The movement of rock fragments across an inclined surface by means of intermittent slip along a plane between the fragments and the ground surface. Such movement may be initiated by heating and cooling or by the growth of ice crystals beneath the rock fragments. It is also referred to as *surficial rock creep*.

(iv) Rock-Glacier Creep

Rock-glacier creep is the downslope movement of tongues of rock waste.

(v) Solifluction

The slow downhill movement of masses of rock debris which are saturated with water and not confined to definite channels.

(b) Rapid Flowage

(vi) Earth Flow

The rapid movement of water-laden soil material down a slope is known as earth flow. It results from slope instability, perhaps due to human interference (removal of vegetation, undercutting of slopes, etc.), but can occur on any steep slope after a period of heavy rainfall, especially when the underlying rocks are impermeable.

(vii) Mud Flow

Mud flow is a type of mass movement on an unstable slope, similar to an earth flow but of greater velocity because of the high percentage of water present in the mixture. It constitutes a considerable hazard in some parts of the world (*Lahar*), but generally comes to a halt before moving very far down-valley. It has an abrupt, well-defined margin and decreases in thickness towards the tongue or toe. It is usually poorly sorted owing to the presence of large boulders and many small pebbles in the clay/silt matrix, although some mud flows exhibit rudimentary graded bedding. It is difficult to distinguish from a *till* when it has solidified.

Mud flows are the characteristic of the drier regions because in such areas the vegetation is sparse and the infrequent rains are often torrential.

(viii) Debris Avalanche

A sudden downslope (gravitational) movement of *debris* due to saturation by heavy rain. In fact, it is a *debris slide*, in which the mass of material moves downslope without any rotational movement. It generally occurs in narrow tracts of humid regions. These are much like snow avalanches except that rock debris rather than snow makes up the bulk of their mass (Fig. 14.6).

(c) Landslides (Landslips)

The downslope gravitational movement of a body of rock or earth as a unit owing to failure of the material. It may be induced by natural agencies (e.g., heavy rain, earthquake) or it may be caused by human interference with the slope stability.

In general, landslides are those types of movement that are perceptible and involve relatively dry masses of earth debris.

(ix) Slump

The downward slipping of one or several units of rock debris usually with a backward rotation with respect to the slope over which movement takes place. Undercutting of slopes by streams and man are the main causes of slumping. The surface of the slumped mass has a number of step-like terraces.

(x) Debris Slide

The rapid rolling or sliding of unconsolidated earth debris without backward rotation of the mass. In debris slide the amount of water is usually small.

(xi) Debris Fall

The nearly free fall of earth debris from a vertical or overhanging cliff or bluff. It is mainly found along the undercut banks of streams.

(xii) Rock Slide

The sliding or falling of individual rock masses down bedding, joint or fault surfaces (Fig. 14.6).

(xiii) Rock Fall

The free falling of rock blocks over any steep slope. In this process small blocks of rock become detached from a cliff face and fall freely through space to the cliff foot. They are most frequent in mountainous areas during spring months. They may result into loss of lives and severe damage to property.

(d) Subsidence

Subsidence is the downward displacement of superficial earth material without a free surface and horizontal displacement. Rift valley and solution collapse (karst region) are some of the typical examples of subsidence.

The most common cause of subsidence is slow removal of material beneath the subsiding mass. For example, removal of material at depth by mining, and removal of fluid lava beneath a solid crust.

Weathering and mass wasting are also the important agents of gradation of the earth's surface to a much greater degree than is usually realised. These processes significantly help in the general lowering of the landscape as well as in the shaping of topography of an area.

EROSION

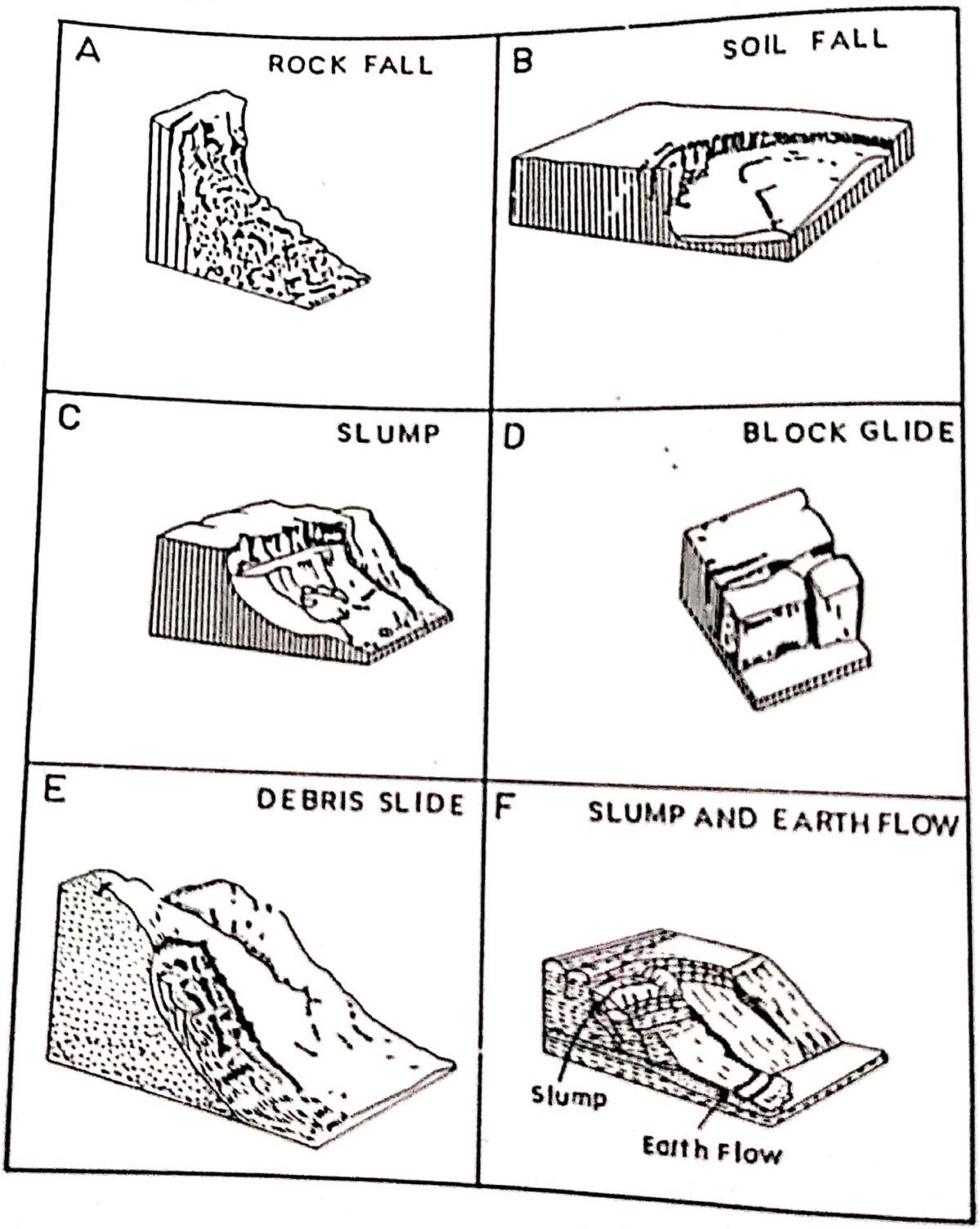
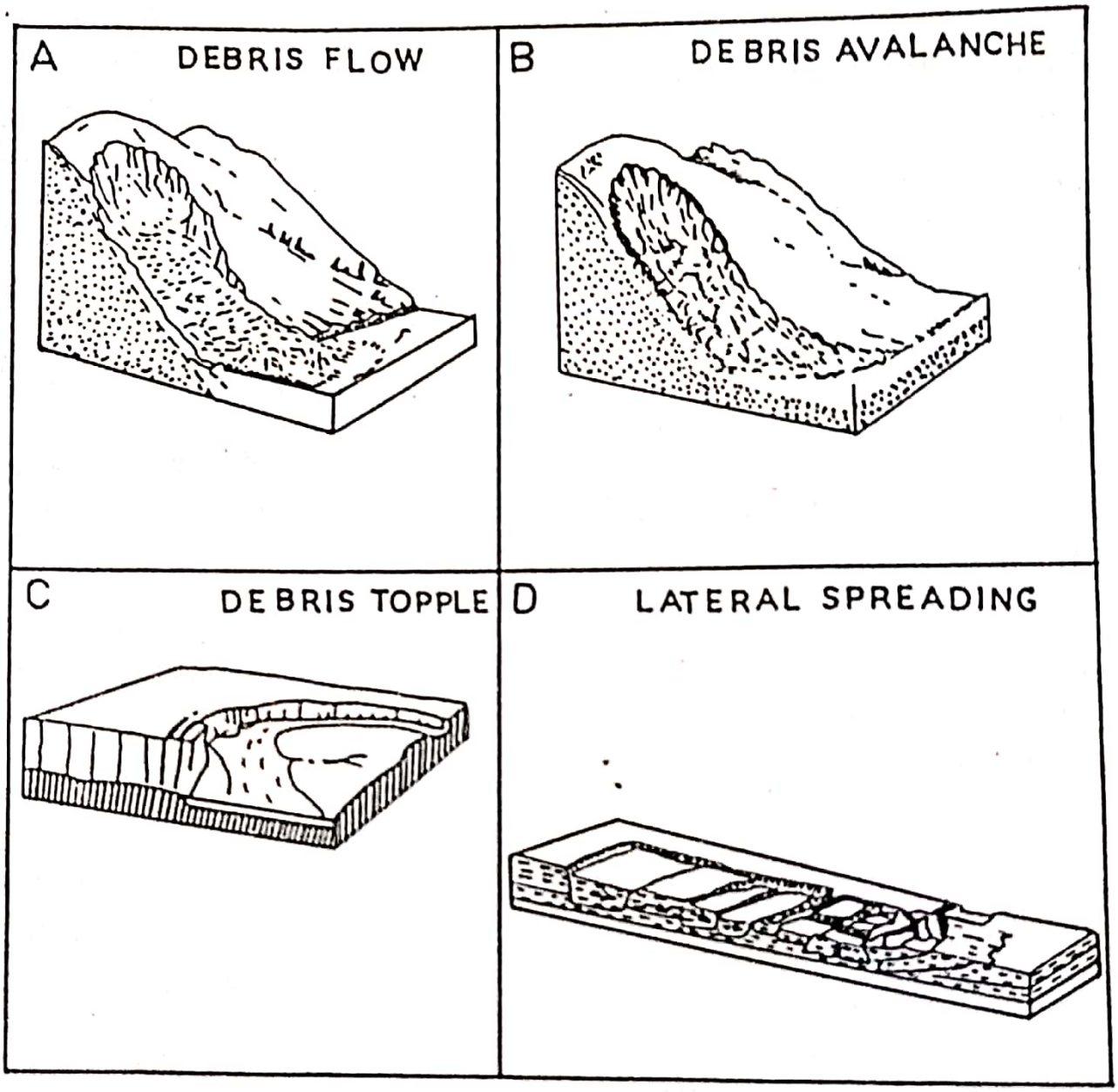
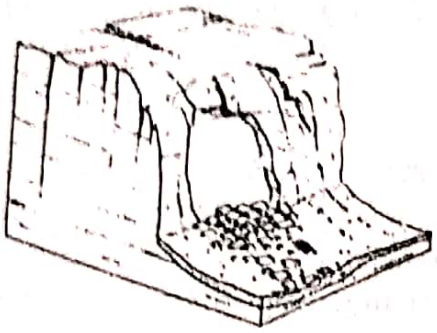


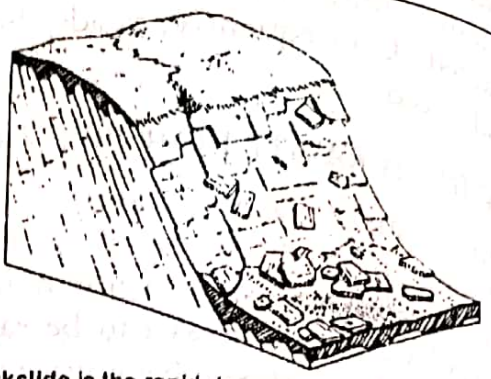
Fig. 14.1 : Different types of mass movements, rock fall (A), soil fall (B), slump (C), block glide (D), Debris slide (E) and slump and earth flow (F). Source : D.J. Varnes (1978), M.J. Selby (1982) and R.J. Chorley et. al (1985).



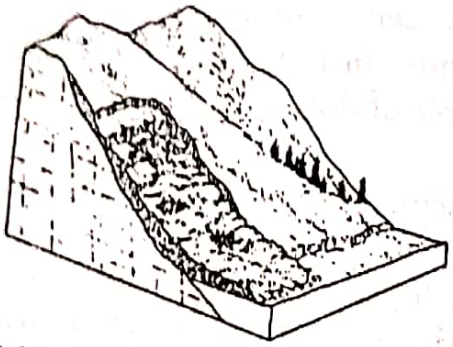
14.2 : Different types of mass movements : debris flow (A), debris avalanche (B), debris topple (C) a spreading (D). Source : D.J. Varnes, (1978), M.J. Selby (1982) and R.J. Chorley et. al (1985).



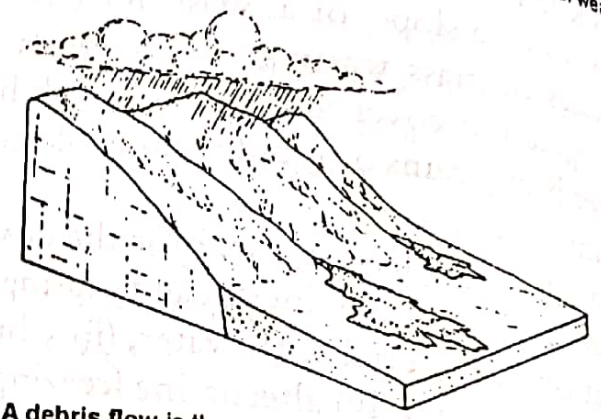
(A) A rockfall is the free fall of rock from steep cliffs.



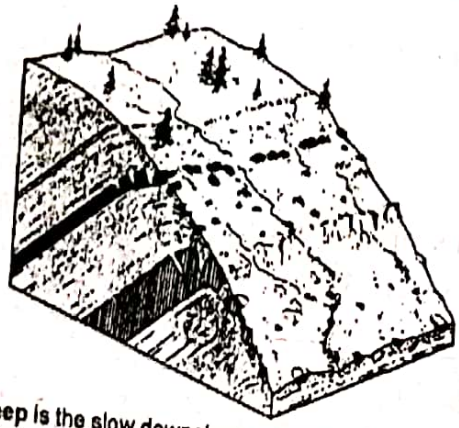
(B) A rockslide is the rapid downslope movement of rock material along a bedding plane, joint, or other plane of structural weakness.



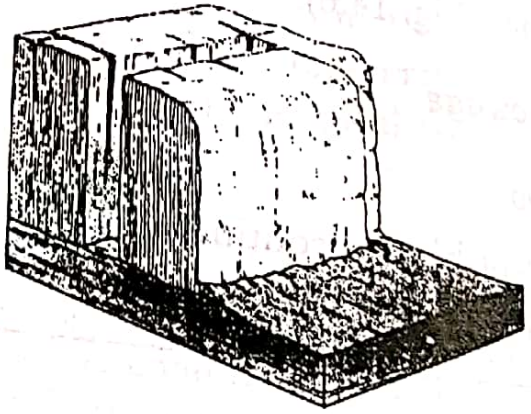
(C) A debris slide is the rapid movement of soil and loose rock fragments. The mass can be dry or moderately wet.



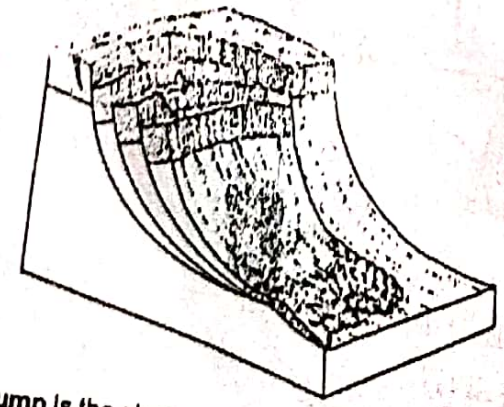
(D) A debris flow is the rapid flow of a mixture of rock fragments, soil, mud, and water. The mixture generally contains a large proportion of mud and water.



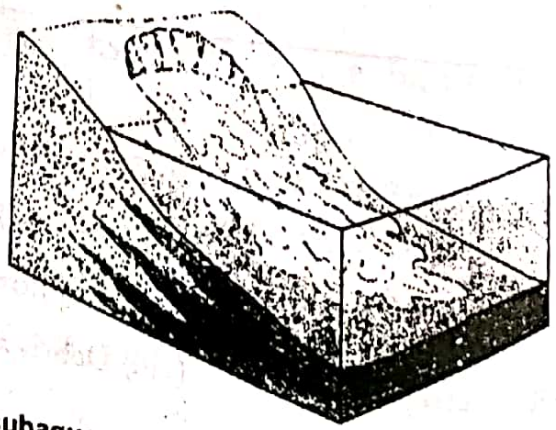
(E) Creep is the slow downslope migration of soil and loose rock fragments, resulting from a variety of processes, including frost heaving.



(F) A blockslide is the slow movement of large blocks of material over a layer of weak, plastic material (such as clay or shale).



(G) Slump is the slow or moderately rapid movement of a coherent body of rock along a curved rupture surface. Debris flows commonly occur at the end of a slump block.



(H) A subaqueous sand flow is the flow of saturated sand or silt beneath the surface of a lake or an ocean.