



Rock fall

("Fragmental" rock fall)

Fragments travel independently, not as a mass. They contact the ground – free fall, rolling, bouncing



Yosemite, 2002



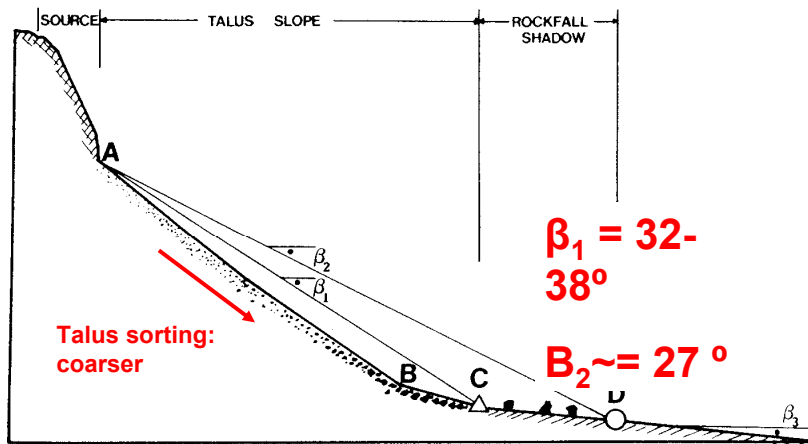


Rock fall, Salmon Arm
British Columbia
Block 5x5x2 m

Sunnybrae rock
fall, 1982



Talus cones, Keremeos



How far does rock fall reach?

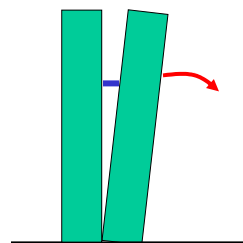
Talus deposits, rock fall shadow

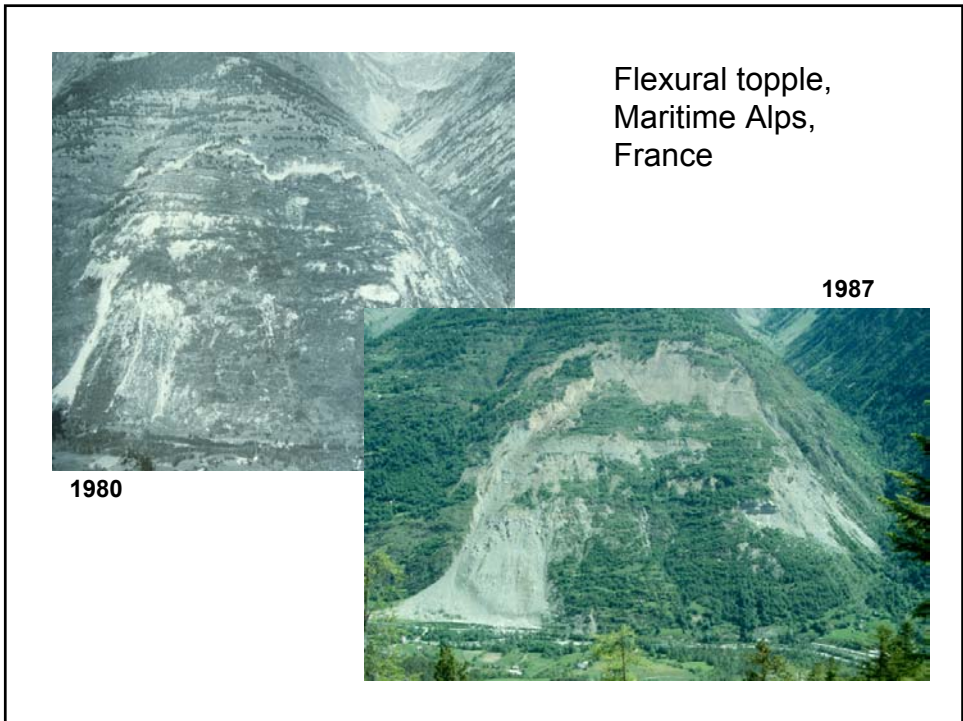
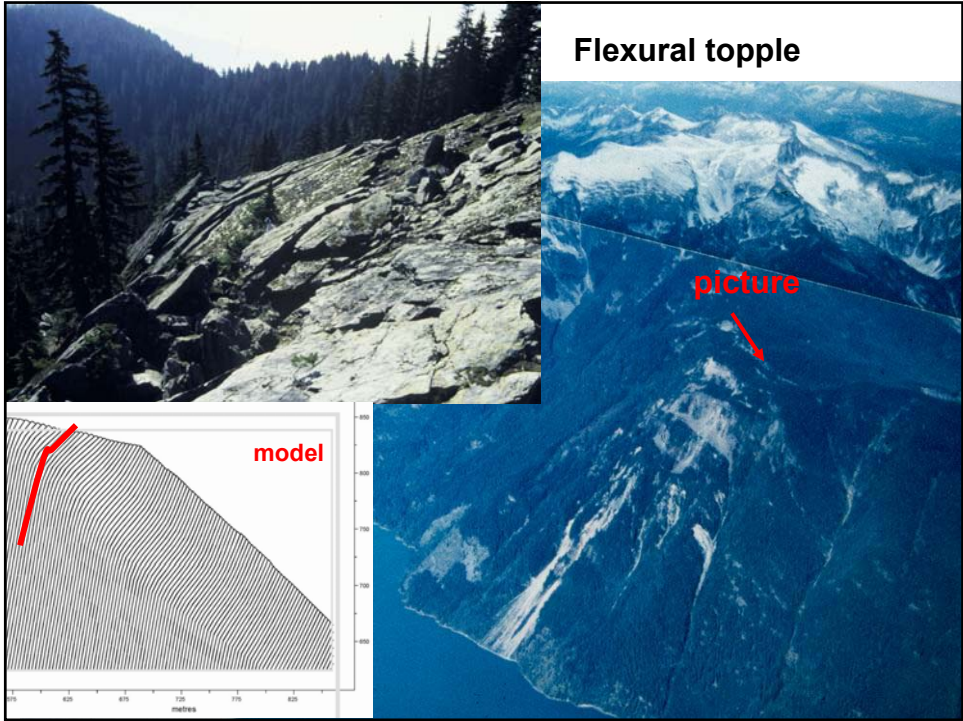


Rock fall hazards



Rock block topple
Chaco Canyon,
New Mexico



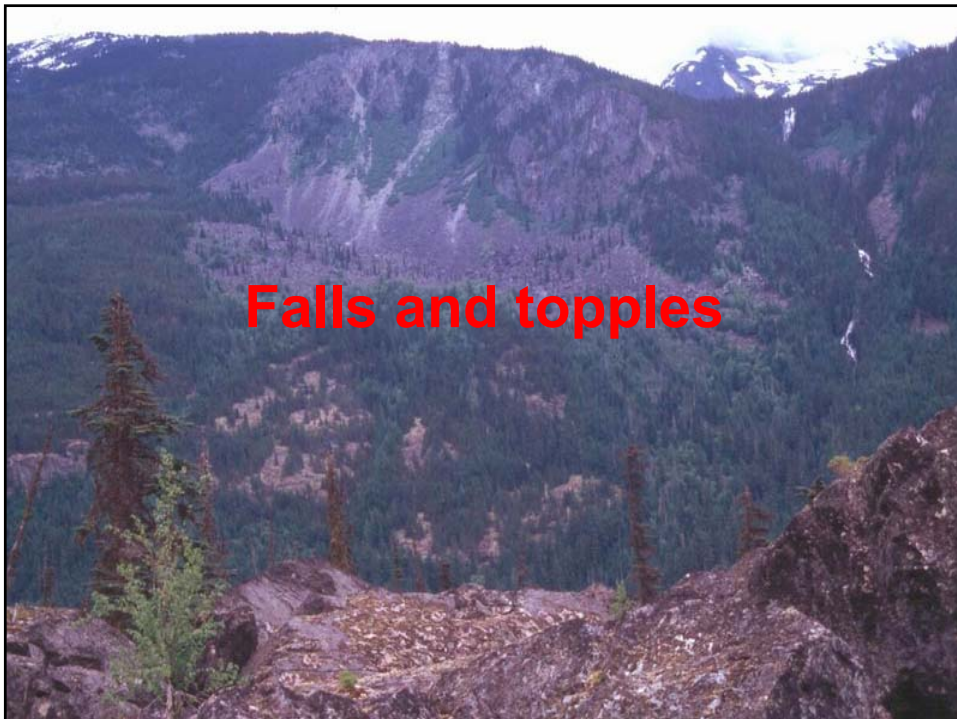


Rock fall and topple, definitions

Rock Fall: Detachment, fall, rolling and bouncing of rock fragments. May occur singly or in clusters, but there is little dynamic interaction between individual particles. Usually of small volume.

Rock Block Topple: Forward rotation and overturning of rock columns or plates (one or many) separated by closely-spaced, steeply-dipping joints. The rock is relatively massive and rotation occurs on well-defined basal discontinuities. Movement may begin slowly, but the last stage of failure is extremely rapid. Occurs at all scales.

Rock Flexural Topple: Bending and forward rotation of a rock mass characterized by very closely-spaced, steeply dipping joints or schistose partings. The rock is relatively weak and fissile. There are no well-defined basal discontinuities that could allow for rotation of blocks. The movement is generally slow and tends to self-stabilize. However, secondary rotational sliding may develop in the hinge zone of the toppling. Occurs at large scale.





Yosemite, 2002

Rock Fall: *Detachment, fall, rolling and bouncing of rock fragments. May occur singly or in clusters, but there is little dynamic interaction between individual particles. Usually of small volume.*



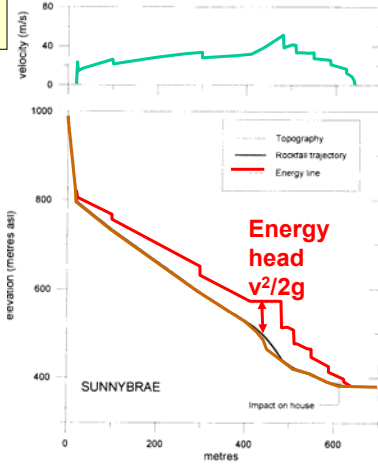
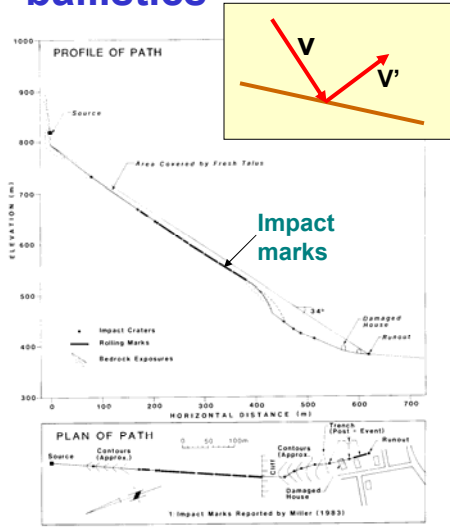
**Rock fall, Salmon Arm
British Columbia, 1982.
Block 5x5x2 m fell and then
rolled, two fatalities**

Rock fall ballistics

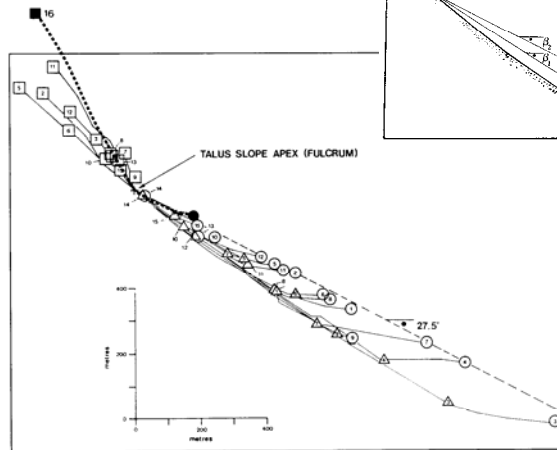
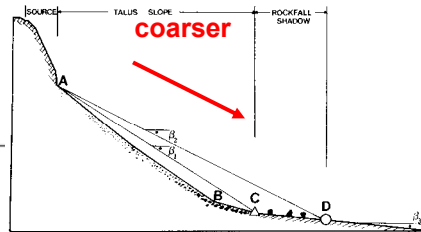
$$v'_n = v_n k_n$$

$k_n, k_t =$ normal, tangential restitution coefficients (~0.7, 0.9)

$$v'_t = v_t k_t$$



Talus deposits, "rock fall shadow"



$$\beta_1 = 32-38^\circ$$

$$B_2 \sim 27^\circ$$

(Evans and Hungr, 1993)

FIG. 10. Profiles of 16 surveyed rockfall paths from British Columbia (modified from Hungr and Evans 1988). The profiles have been plotted with the talus apex as a common point. Δ , base of the talus slope; \square , distal margin of the rockfall shadow; \circ , either known source areas or the crest of the source cliff. 1, Hedley; 2, Similkameen A (Swath-of-Joe)[†]; 3, Similkameen B (rock-slide); 4, Similkameen C (kane); 5, Similkameen D (Winters-Creek); 6, Similkameen E (campground); 7, Similkameen F (speedway); 8, Pukaist; 9, Sunnybrae; 10, Barnhartvale[†]; 11, Silverhope A; 12, Silverhope B; 13, Silverhope C; 14, Silverhope D; 15, Hope North[†]; 16, Stawamus Chief[†] (asterisks denote sites where fresh debris was found in the rockfall shadow area).

Talus cones, Keremeos



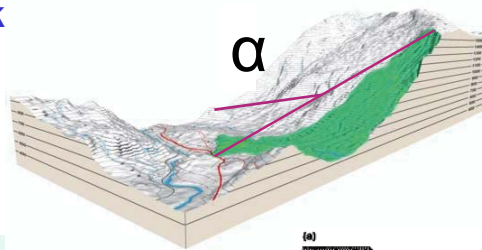
Chaco Canyon, New Mexico

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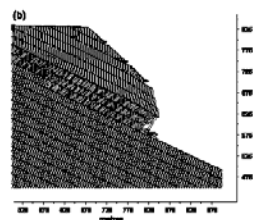
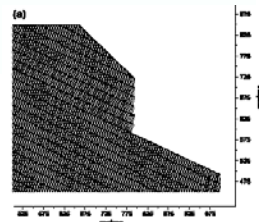


Multiple block topple
Czech Republic

A catastrophic block topple?



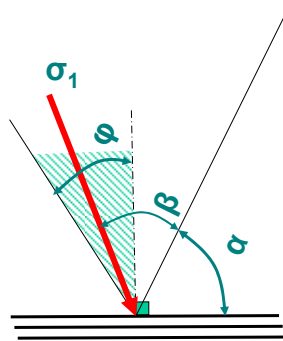
Mystery Creek rock avalanche (Nichol et al., 2002)





Rock Flexural Topple: Bending and forward rotation of a rock mass characterized by very closely-spaced, steeply dipping joints or schistose partings. The rock is relatively weak and fissile. There are no well-defined basal discontinuities that could allow for rotation of blocks. The movement is generally slow and tends to self-stabilize. However, secondary rotational sliding may develop in the hinge zone of the toppling. Occurs at large scale.

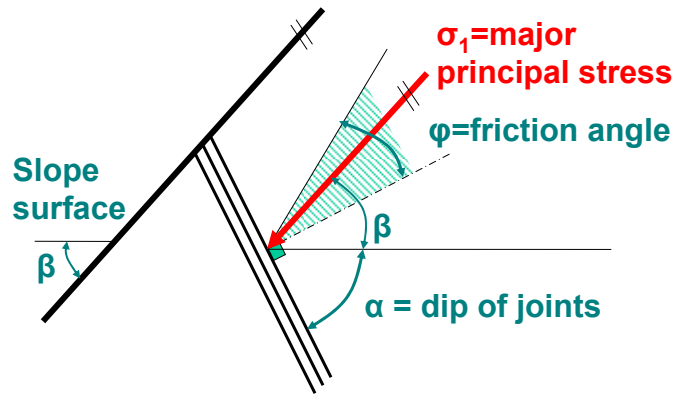
Frictional sliding criterion



Sliding occurs only if the arrow is outside the shaded area

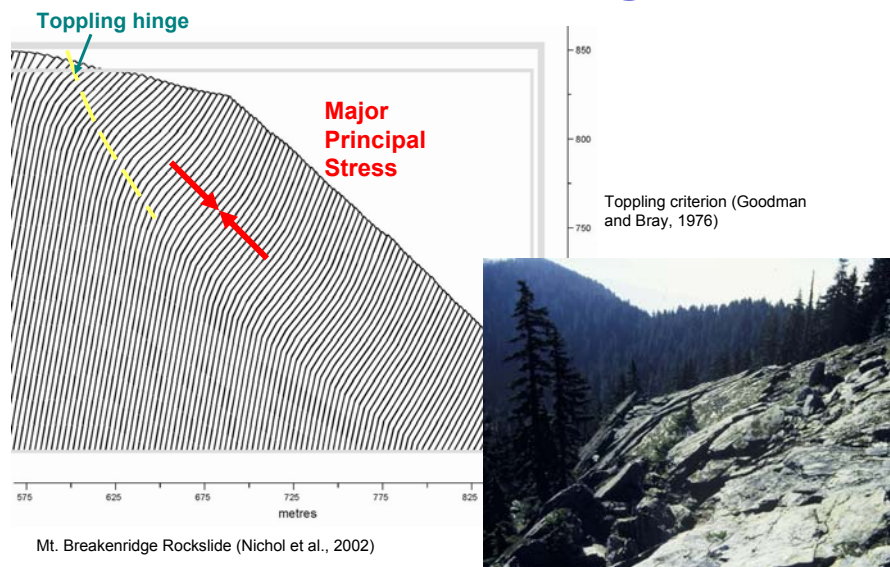
Kinematic test for block toppling

(Cruden, 1989, Goodman and Bray, 1976)



$$\alpha + \beta + (90^\circ - \phi) \geq 180^\circ$$

Flexural toppling



La Clapiere, France

Flexural topple
changing to a rock
slump



1982



1987

