Nevado Del Ruiz, 1985 - Lahars

Lecture Objectives

-Basics of lahars: definition, characteristics

-Ruiz case study: hazards, impacts

Mt. Pinatubo lahar footage by Mike Dolan (MTU)

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Lahars

(from Vallance, 2000, Encyclopedia of Volcanoes)

Definition: water-saturated sediment flow that moves downslope under the influence of gravity, with forces driving both solid and fluid phase flow.

Lahars include debris flow (50-60% sediments by volume) and hyperconcentrated flow (water > solids), which have fluvial characteristics but carry lots of sediment.

Floods and muddy streamflows carry abundant sediment but are differentiated by the main fluvial processes and depositional characteristics (e.g., sorting, cross-bedding)

Lahar Genesis

(1) abundant water source: pore, lake, snow/ice, rainfall

(2) abundant unconsolidated debris: eruption deposits or ashfall, glacial till, colluvium, soil

(3) steep slopes and high relief

(4) a triggering mechanism: flank collapse, pyroclastic flow, melting, dam breakage

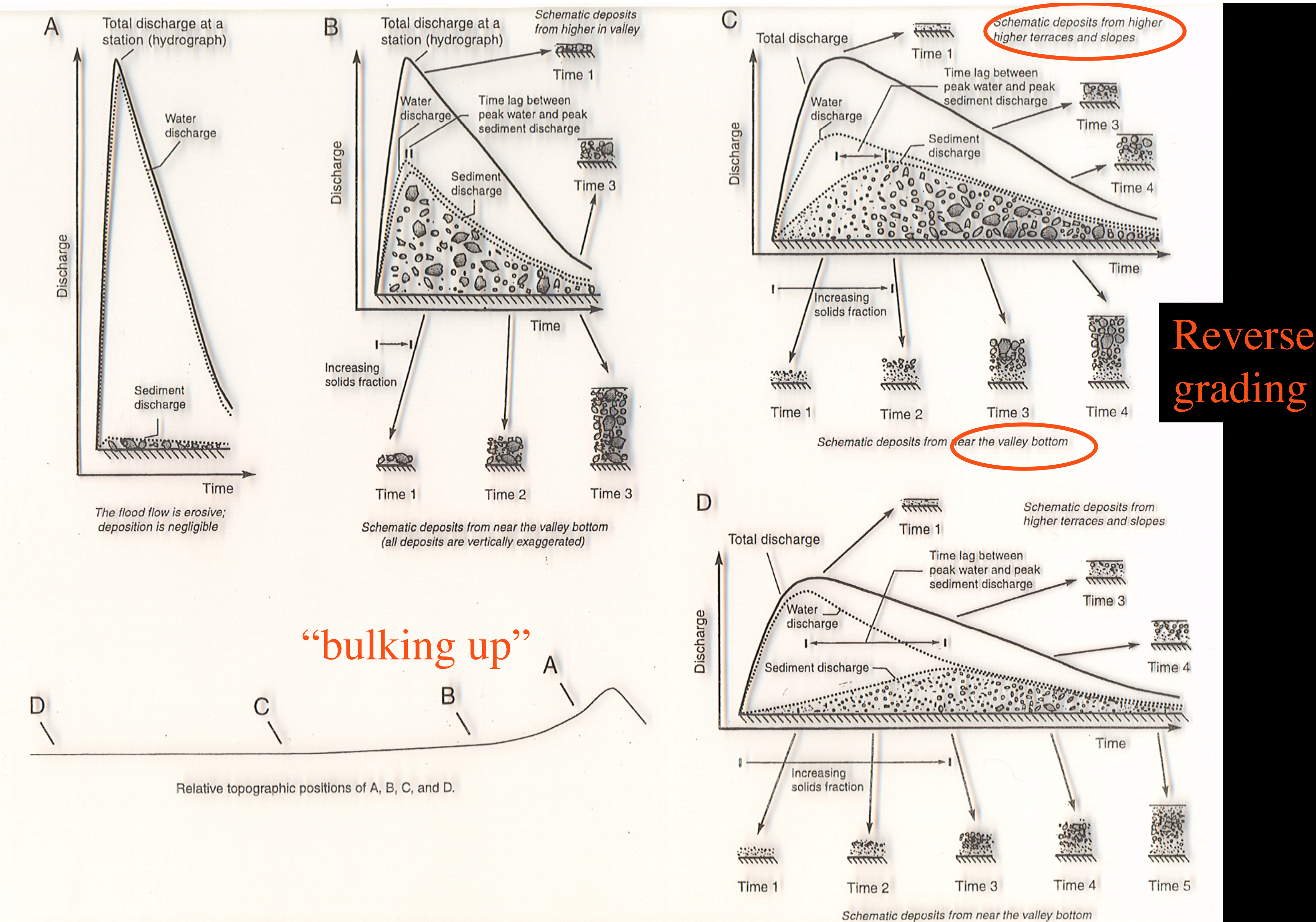


FIGURE 1 Schematic hydrographs showing how lahars beginning with water floods are initiated and behave when they undergo downstream dilution. Flood phase is shown in A, debris-flow phase is shown in B; and transitional phases are shown in C and D. The diagram also illustrates the progressive-aggradation model of inverse grading in C and D.

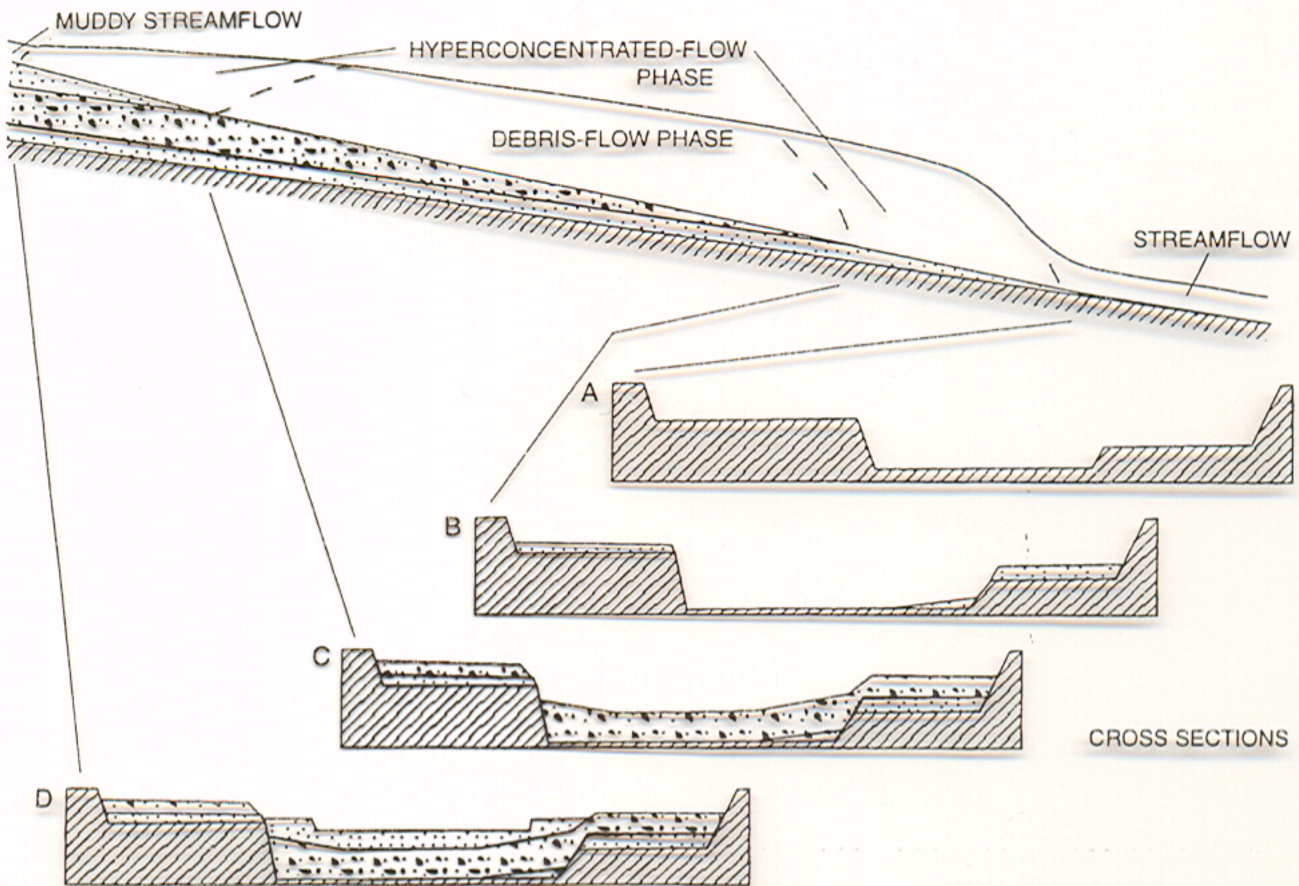


FIGURE 2 Schematic model of a lahar moving down a river undergoing downstream dilution from debris-flow phase to hyperconcentrated-flow phase and deposit facies derived from it [adapted from Fig. 3.31 in Pierson and Scott (1999), "Surficial Hydrological Hazards at Volcanoes," U.S. Geological Survey Open-file Report]. The model shows the expected sequences of hyperconcentrated- and debris-flow deposits in cross section (A–D).

Hyperconcentrated flow gets segregated by density; particle sizes grade downstream.

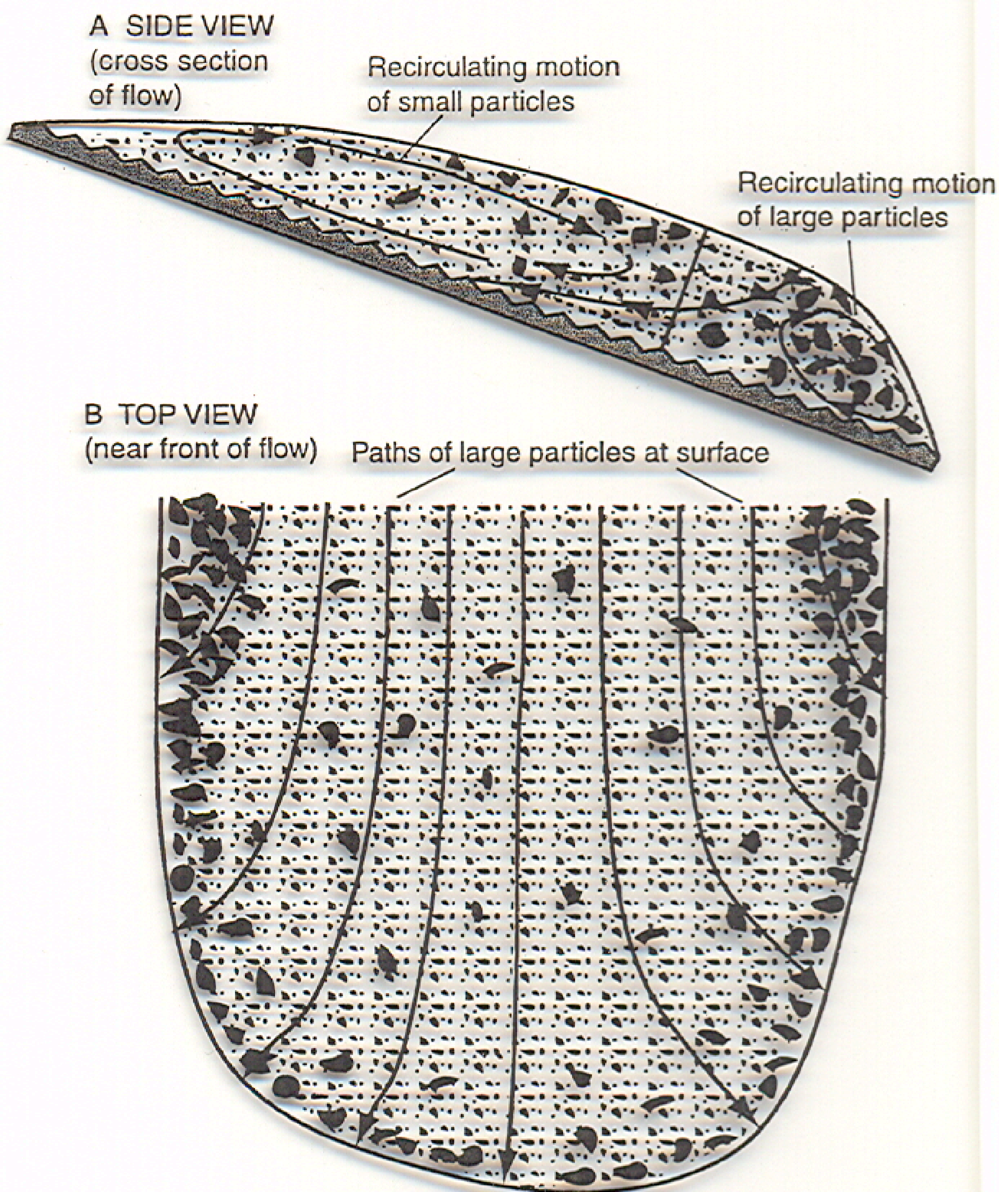
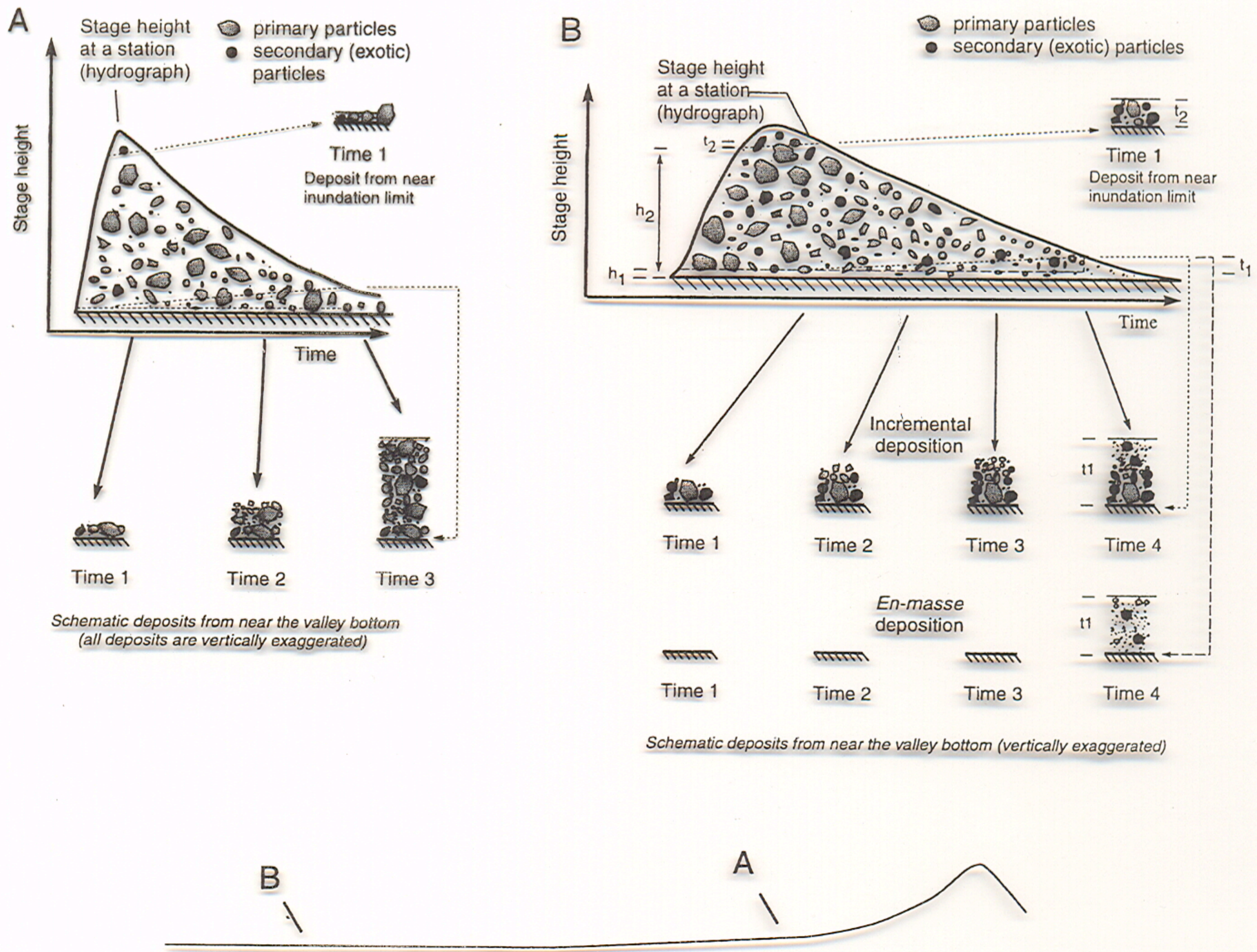


FIGURE 3 Schematic diagram illustrating how inverse particle-size segregation results in (A) longitudinally and (B) laterally graded flows.

-"Kinetic sieving": small particles preferentially move downwards through voids; large pieces are transported towards the flow boundaries (reverse grading).

-Large particles are carried by the flow fronts, which generate additional destructive force.

-Velocity is also highest at the near-surface regions. But, friction at channel boundaries reduces flow speed, causing large particles to drop out (levees).



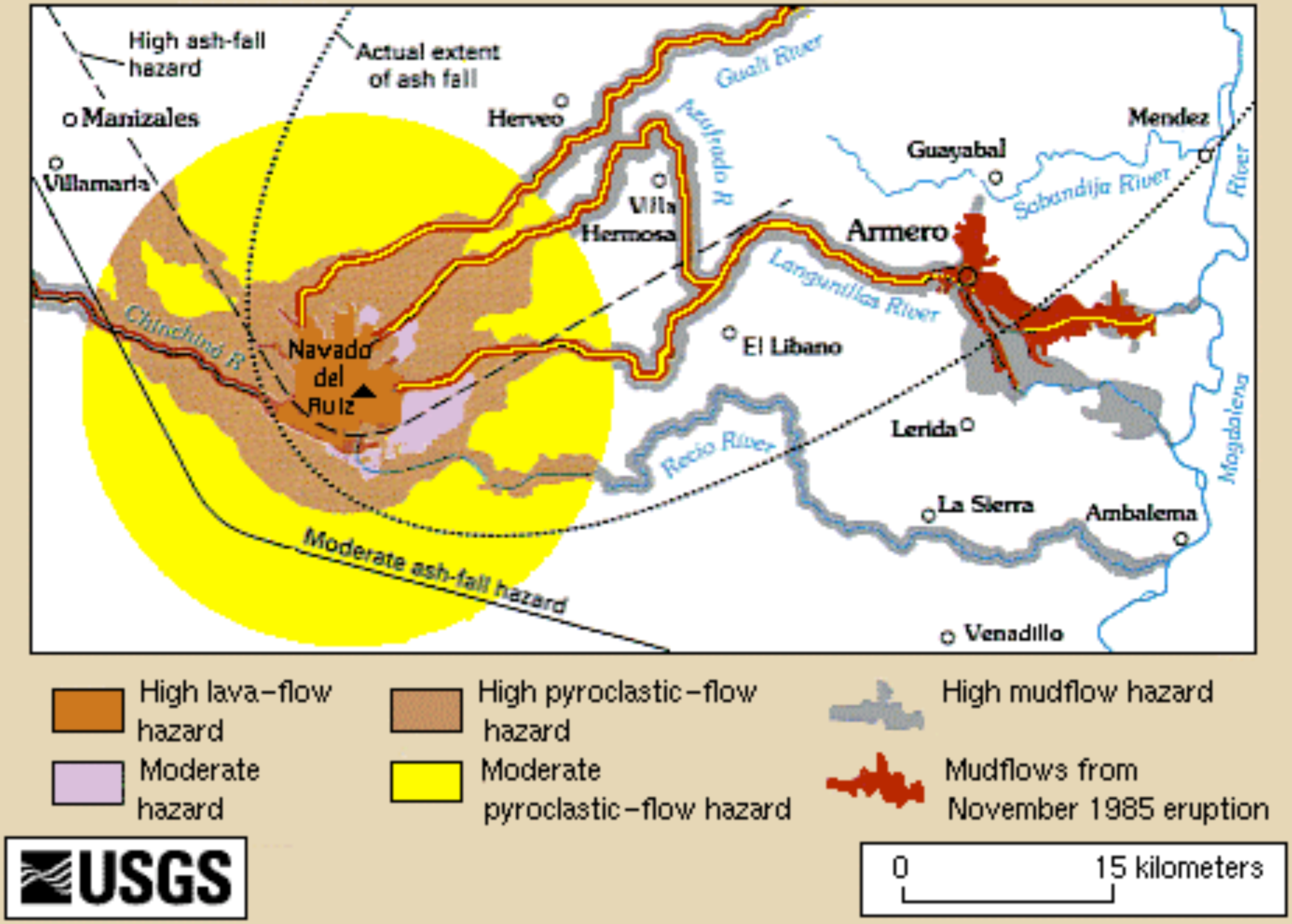
Relative topographic positions of A and B.

FIGURE 4 Schematic hydrographs showing the behavior and downstream changes of lahars that begin as avalanches of water-saturated debris. Note that with distance downstream (A to B), the lahar incorporates secondary exotic particles, especially near its flow front. The diagram (B) also illustrates how an inverse longitudinally graded flow can accrete incrementally to form a normally graded deposit [adapted from Vallance and Scott (1997)]. Exotic particles are most common at the base of normally graded deposits and at inundation limits (B).

Nevado Del Ruiz, November 26, 1985

Ruiz summit; late November, 1985

Hazard–Zone Map, Nevado del Ruiz, Colombia



Topinka, USGS/CVO, 1998, Modified from: Wright and Pierson, 1992, USGS Circular 1073

Some of the lahar flow characteristics

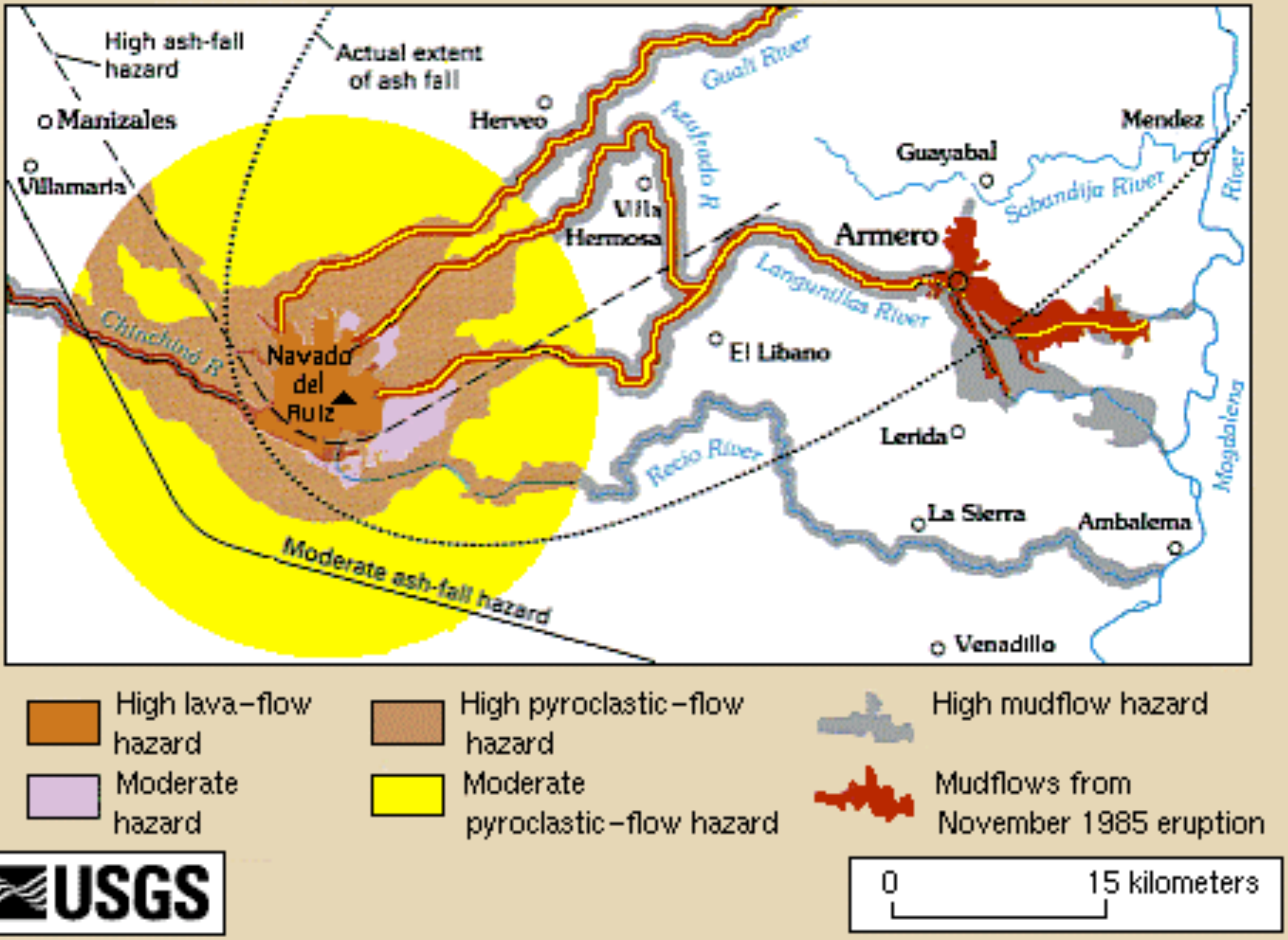
Location	Distance from crater (Km)	Mean peak velocity (m/s)	Mean peak discharge (m3/s)	Characteristics
Molinos/ Nereidas lahar	**3.9-11.2**	**14.7**	**19,900**	Flowed down the western flank of Ruiz into the Chinchina River causing serious damage to the town of Chinchina, killing 1000. The pyroclastic material was relatively small thus resulting in very fluid-rich lahars.
Guali lahar	**17.9**	**12.0**	**20,500**	On the northern flank of the volcano stripping vegetation and soil from the valley sides. The lahar reached Mariquita at 23:30 and Honda at 02:00. The lahar was 8m thick and 250m wide. The high fluid content allowed the lahar to spread out to give deposits up to 1m thick. The lahar carried boulders with a mean size of 2m down the valley and out on to the plain. The lahar destroyed over 20 houses and killed 2 in Honda.
Azufrado lahar	**9.6**	**14.6**	**48,000**	On the eastern and NE flanks of the volcano, lahars from these valleys joined, killing 23,000 people in Armero. The lahars stripped soil and vegetation from the valley walls and sides.
Lagunillas lahar	**4.1-27.4**	**11.3**	**3,100**	The lahar branched into 3 lobes as it emerged from the Lagunillas Valley, with the main lobe destroying the southern part of Armero. Only the parts of the city that were slightly elevated were not destroyed. One lobe travelled north to Guayabal while the smallest lobe travelled down the Lagunillas river bed. Most of the debris was carried as far as 16 km by the lahars. Most of the victims of the lahars died as a result of massive lacerations received from abrasion with coarse particles and acid burns due to the high sulfate content of the flows.

Ruiz; Guali River headwaters

Guali River

Guali River

Hazard–Zone Map, Nevado del Ruiz, Colombia



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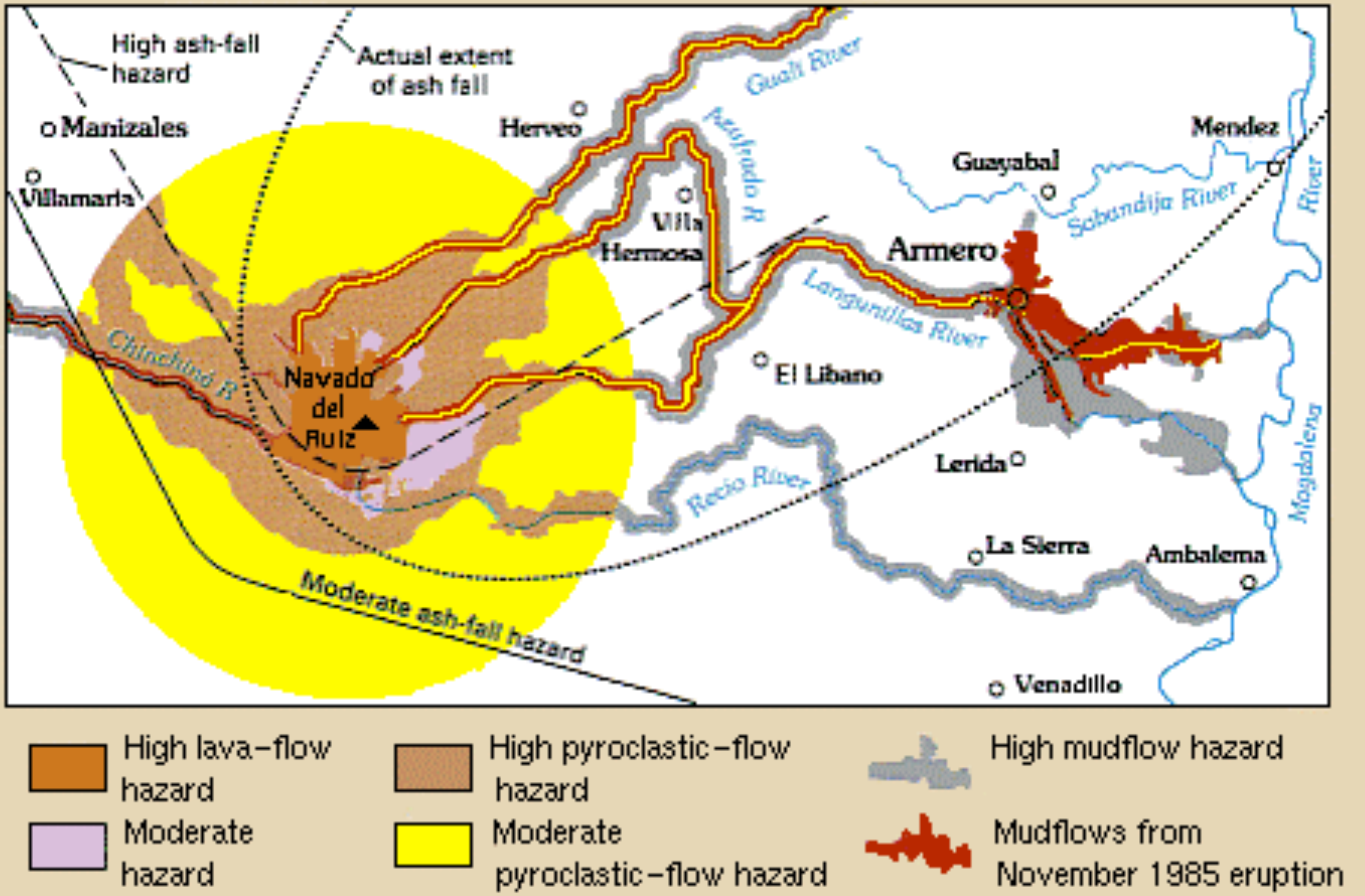
Nevado del Ruiz; Azufrado River headwaters

Hazard–Zone Map, Nevado del Ruiz, Colombia



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The first lahar pulse from the Azufrado River was so powerful it flowed up the Lagunillas valley for several hundred meters

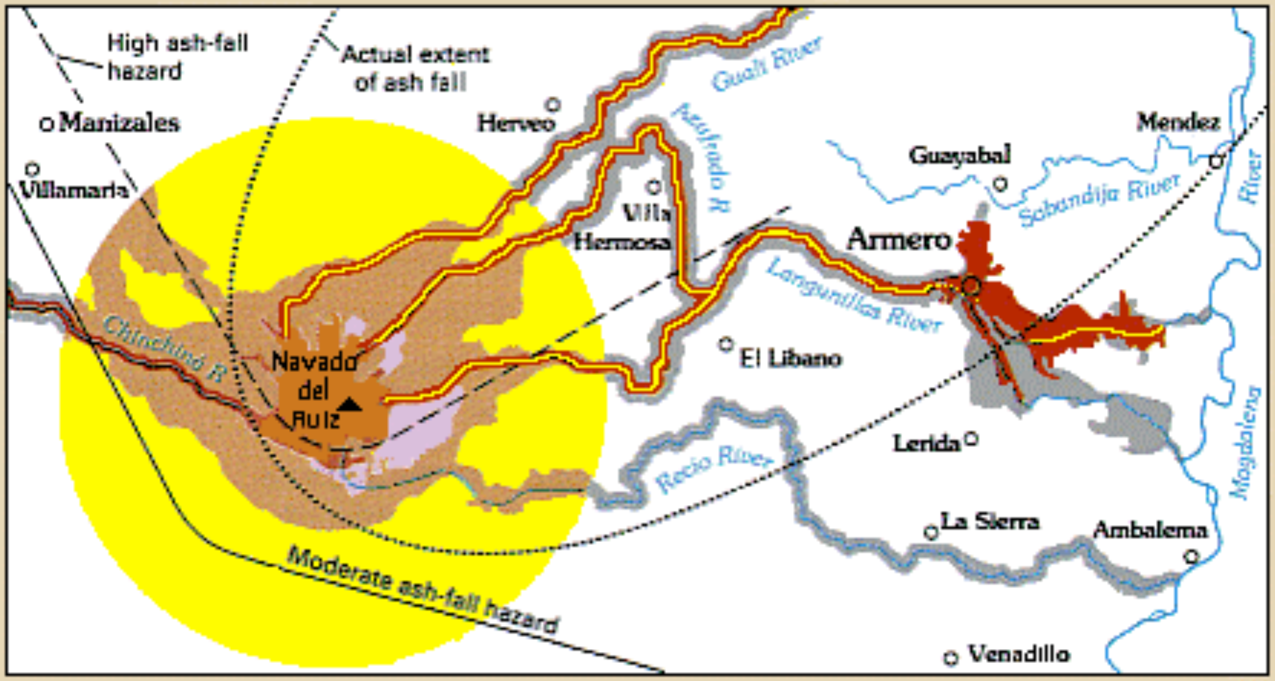
Armero was located in the center of the photo

3 initial, devastating pulses: 11:25, 11:35 and 11:50; the final lahar struck Armero just after 1 am.

Lahar entering the outskirts of Armero

Armero; Lagunillas River

Hazard–Zone Map, Nevado del Ruiz, Colombia



High lava–flow hazard
Moderate hazard
High pyroclastic–flow hazard
Moderate pyroclastic–flow hazard
High mudflow hazard
Mudflows from November 1985 eruption

USGS

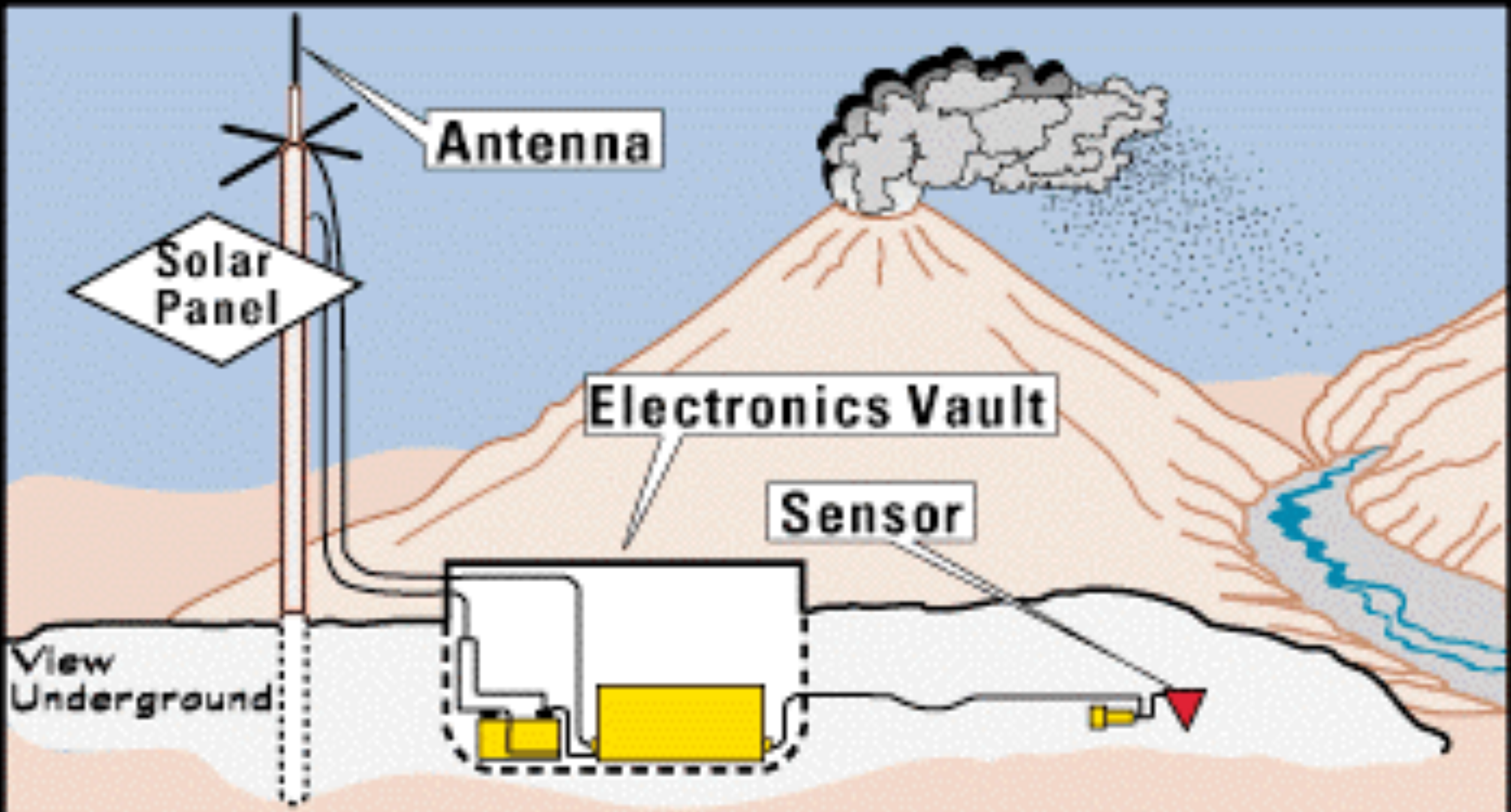
0 15 kilometers

Topinka, USGS/CVO, 1998, Modified from: Wright and Pierson, 1992, USGS Circular 1073

Map showing hazards expected from an eruption of Nevado del Ruiz, Colombia. Such a map was prepared by INGEOMINAS (Colombian Institute of Geology and Mines) and circulated 1 month prior to the November 13, 1985, eruption of Nevado del Ruiz. Map shows danger from mudflows in the valley occupied by the town of Armero, Colombia, as well as those areas affected by the hazards that resulted from this eruption. Circle denotes 20–kilometer (12.5–mile) limit.

Installation of lahar monitoring system at Pinatubo, Philippines

Acoustic Flow Monitor (AFM)



The AFM system relies on a series of acoustic-flow monitors, which are sensitive to the characteristic vibrations created by lahars.