Cause and Mechanism of Fatal Zhenxiong Landslide of January 11, 2013

by

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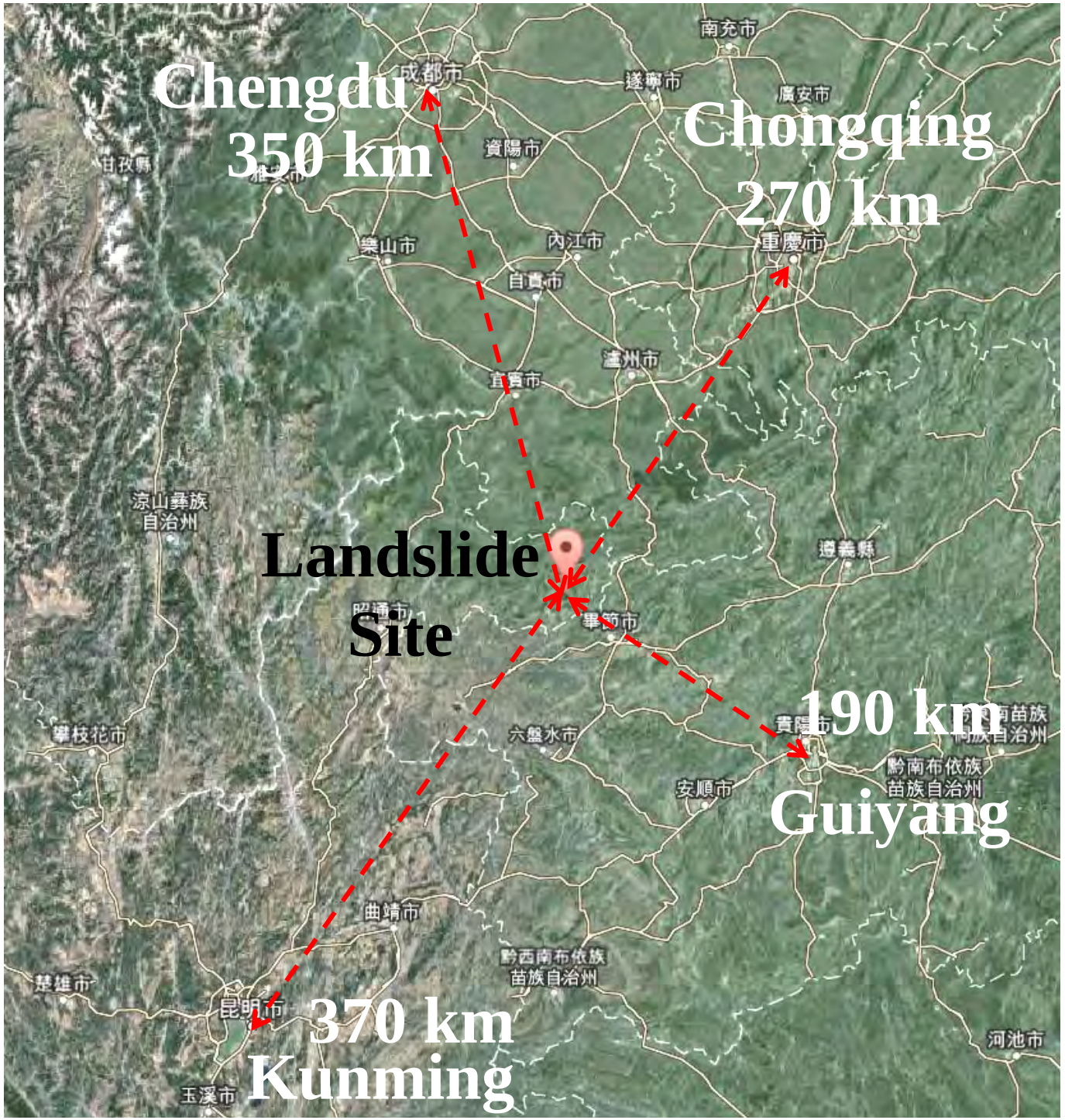
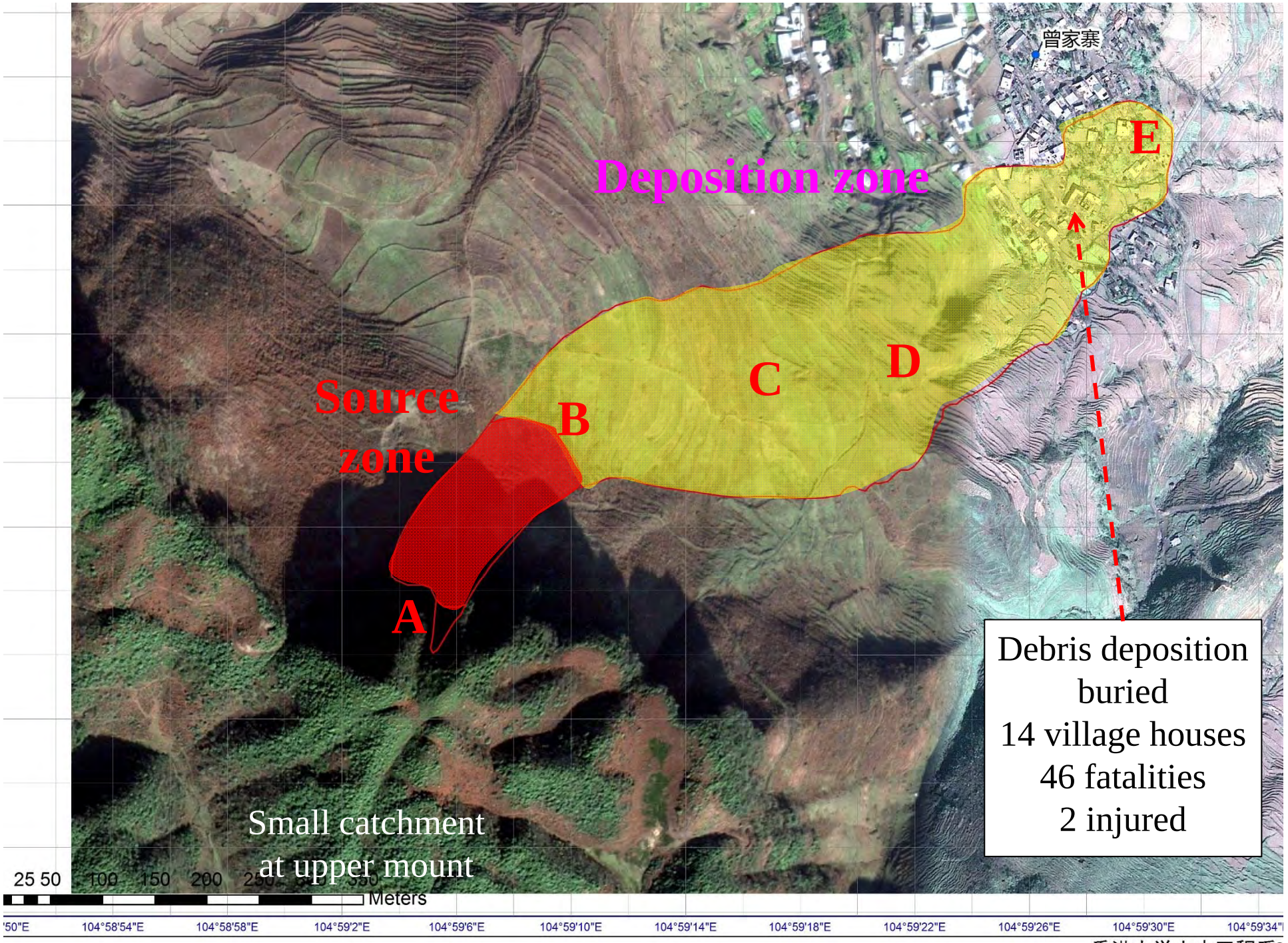


The Zhaojiagou landslide suddenly occurred at 8:00 am, January 11, 2013 in Zhenxiong County, Yunnan Province, China.

A large amount of the debris rapidly arrived and instantly buried
14 village houses
46 fatalities
2 injured
59 pigs & 5 cattles buried.


曾家寨
Deposition zone
E
D
C
B
Source zone
A
Debris deposition
buried
14 village houses
46 fatalities
2 injured
Small catchment
at upper mount
25 50 100 150 200 250 300 350
Meters
'50"E
104°58'54"E
104°58'58"E
104°59'2"E
104°59'6"E
104°59'10"E
104°59'14"E
104°59'18"E
104°59'22"E
104°59'26"E
104°59'30"E
104°59'34"
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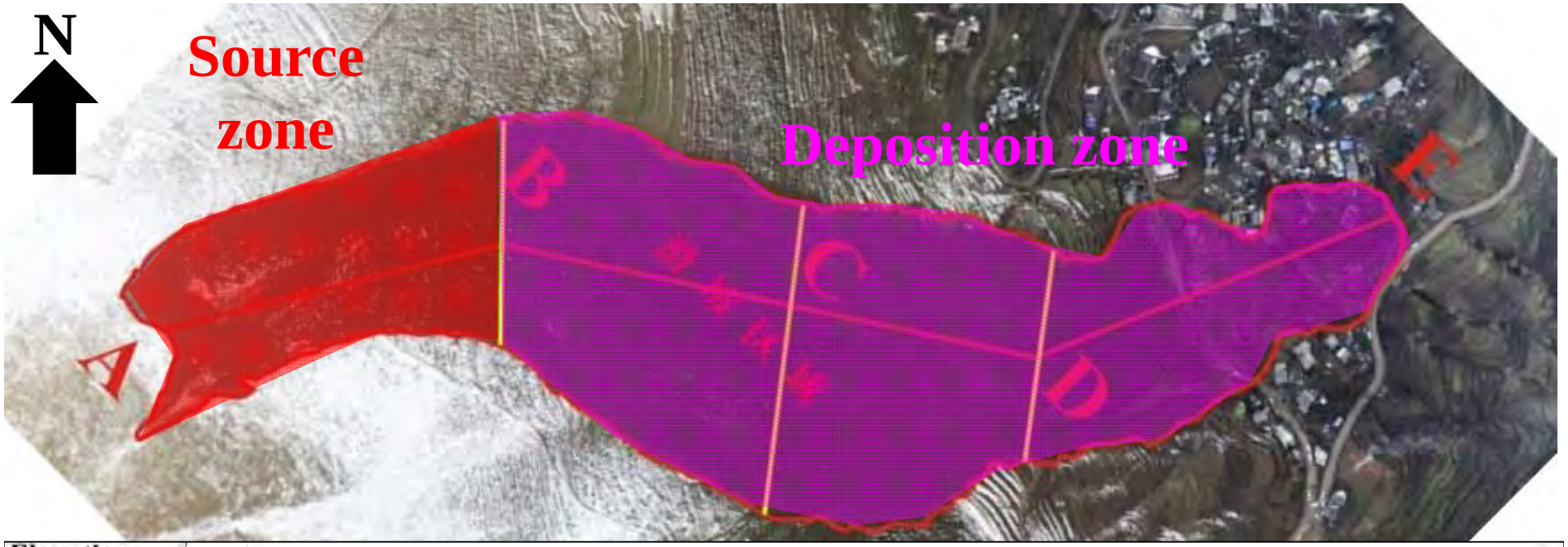
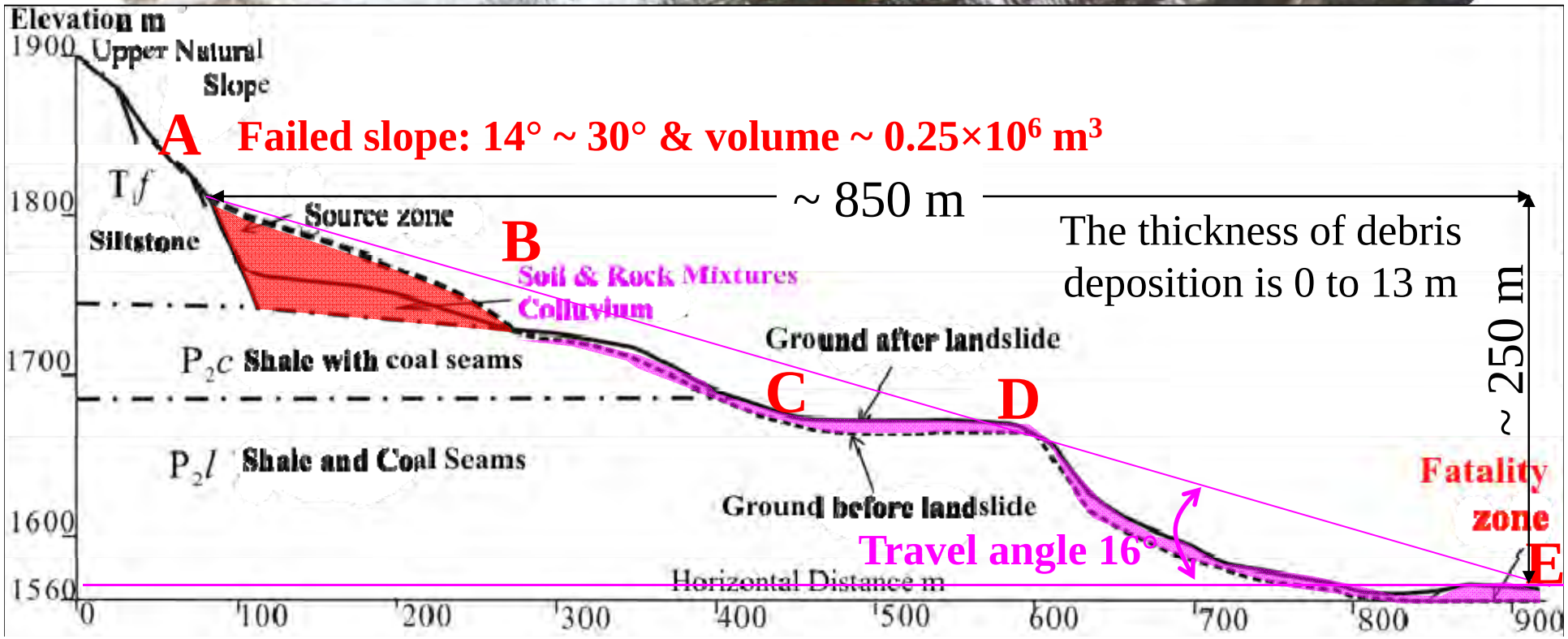
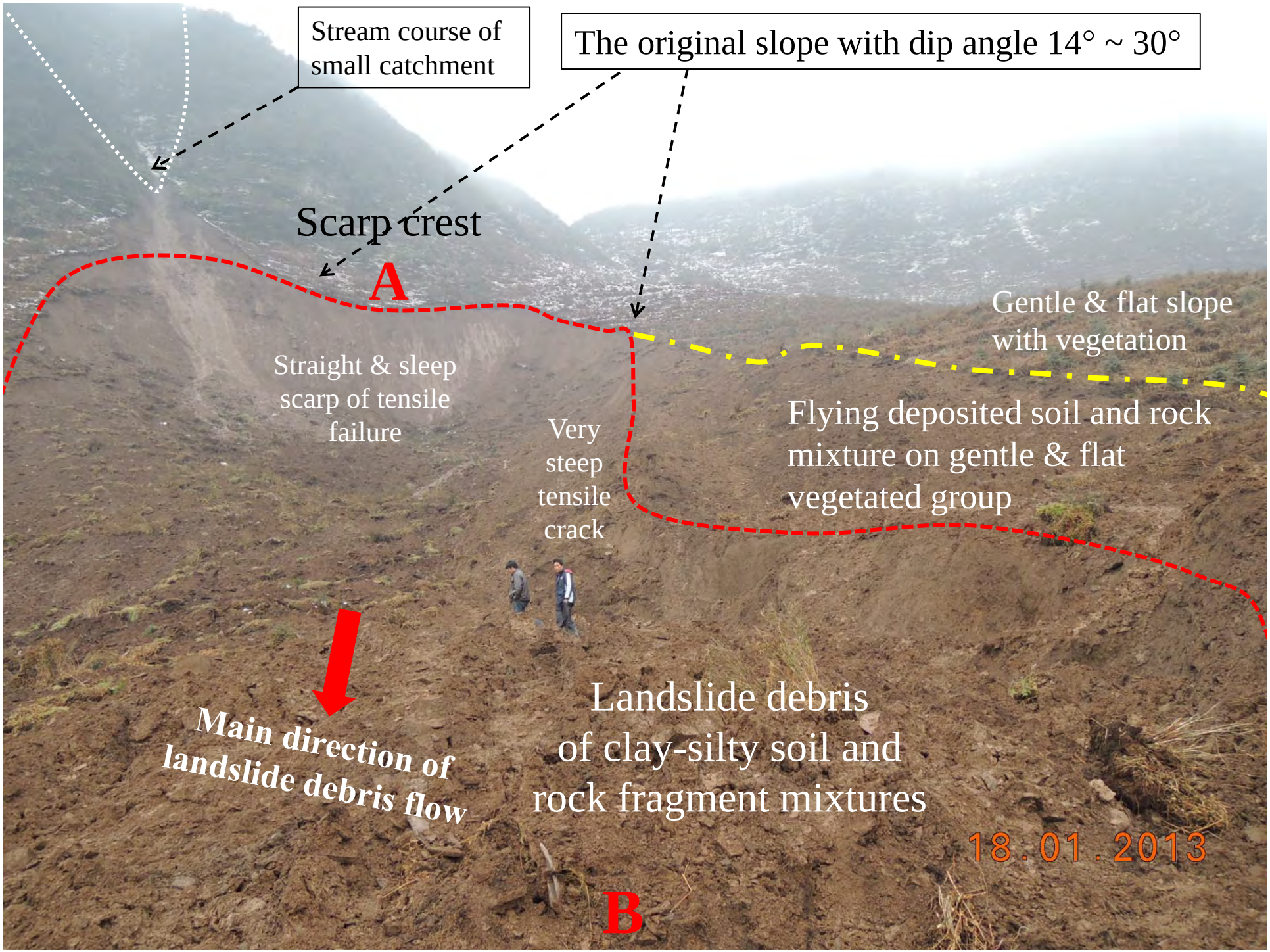
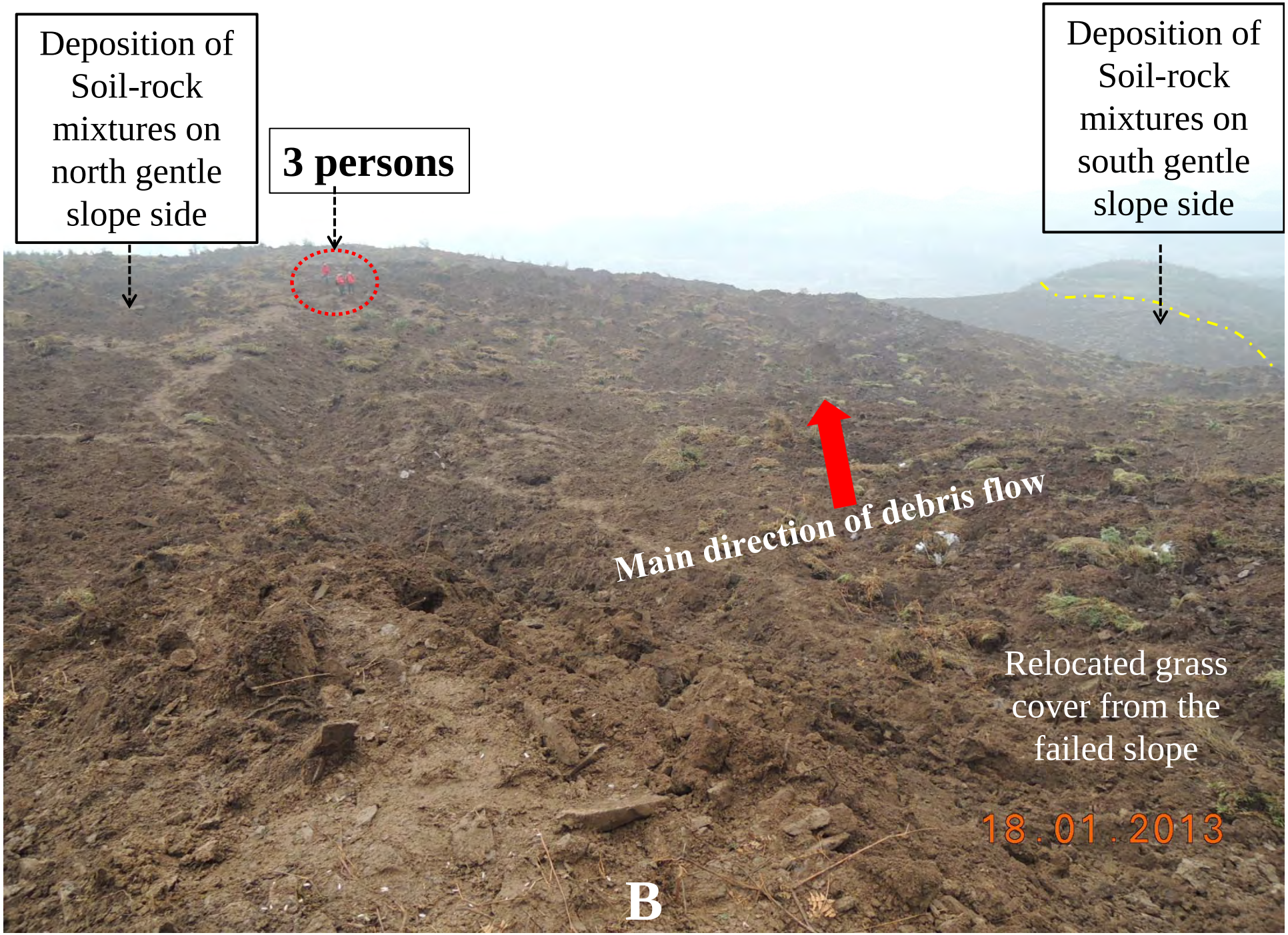
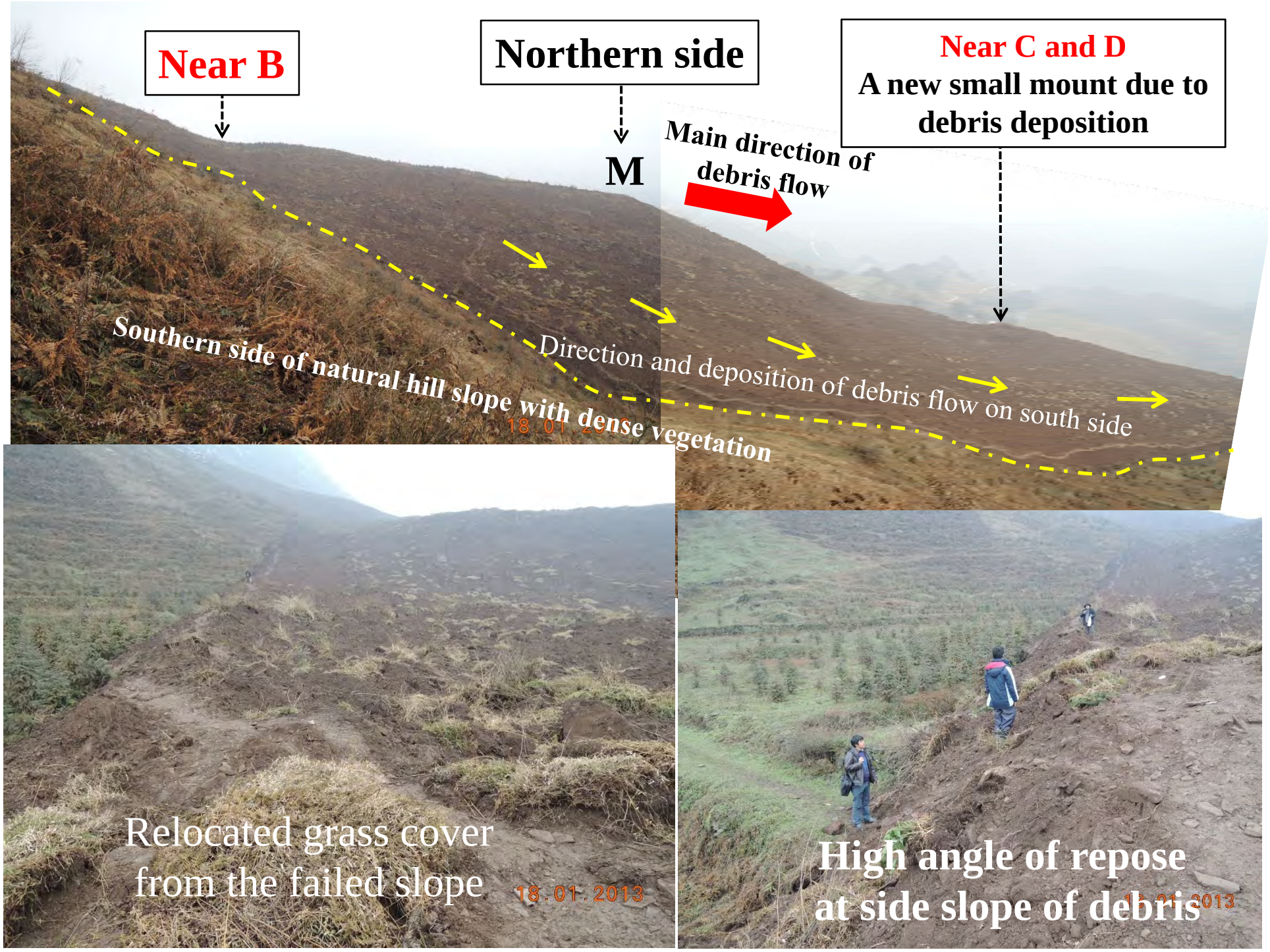

N
Source zone
Deposition zone
A
B
C
D
E

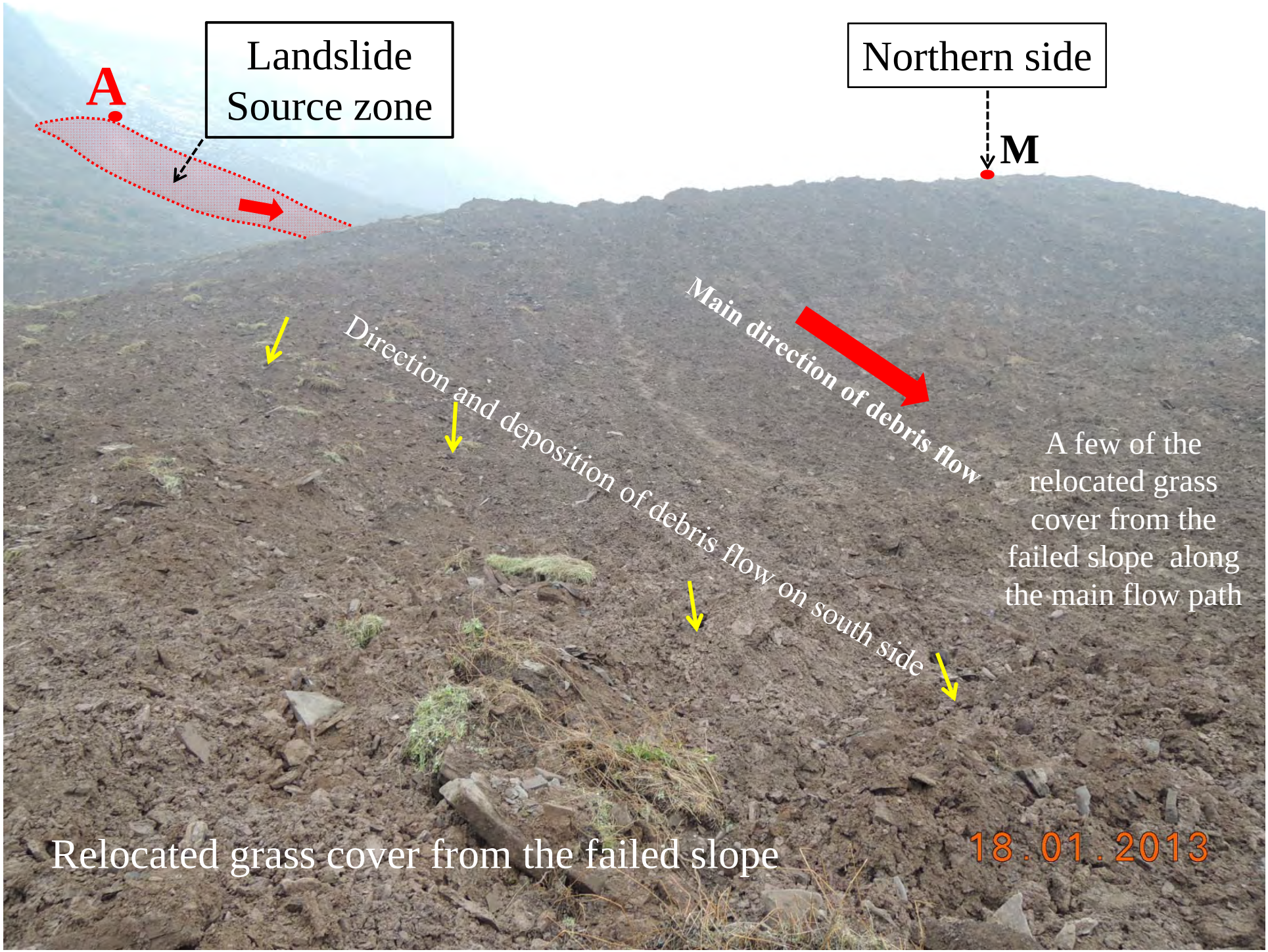

Elevation m
1900
1800
1700
1600
1560
Upper Natural Slope
A
Failed slope: 14° ~ 30° & volume ~ 0.25×10⁶ m³
Tf
Siltstone
~ 850 m
Source zone
B
Soil & Rock Mixtures
Colluvium
The thickness of debris deposition is 0 to 13 m
~ 250 m
Ground after landslide
P₂c Shale with coal seams
C
D
P₂l Shale and Coal Seams
Ground before landslide
Fatality zone
Travel angle 16°
E
Horizontal Distance m
0
100
200
300
400
500
600
700
800
900


Stream course of small catchment
The original slope with dip angle 14° ~ 30°
Scarp crest
A
Straight & sleep scarp of tensile failure
Very steep tensile crack
Gentle & flat slope with vegetation
Flying deposited soil and rock mixture on gentle & flat vegetated group
Main direction of landslide debris flow
Landslide debris of clay-silty soil and rock fragment mixtures
18.01.2013
B


Deposition of Soil-rock mixtures on north gentle slope side
3 persons
Deposition of Soil-rock mixtures on south gentle slope side
Main direction of debris flow
Relocated grass cover from the failed slope
18.01.2013
B

Video 1 on January 18, 2016
Landslide and debris source zone A to B area


Near B
Northern side
M
Near C and D
A new small mount due to debris deposition
Main direction of debris flow
Southern side of natural hill slope with dense vegetation
Direction and deposition of debris flow on south side
Relocated grass cover from the failed slope
18.01.2013
High angle of repose at side slope of debris

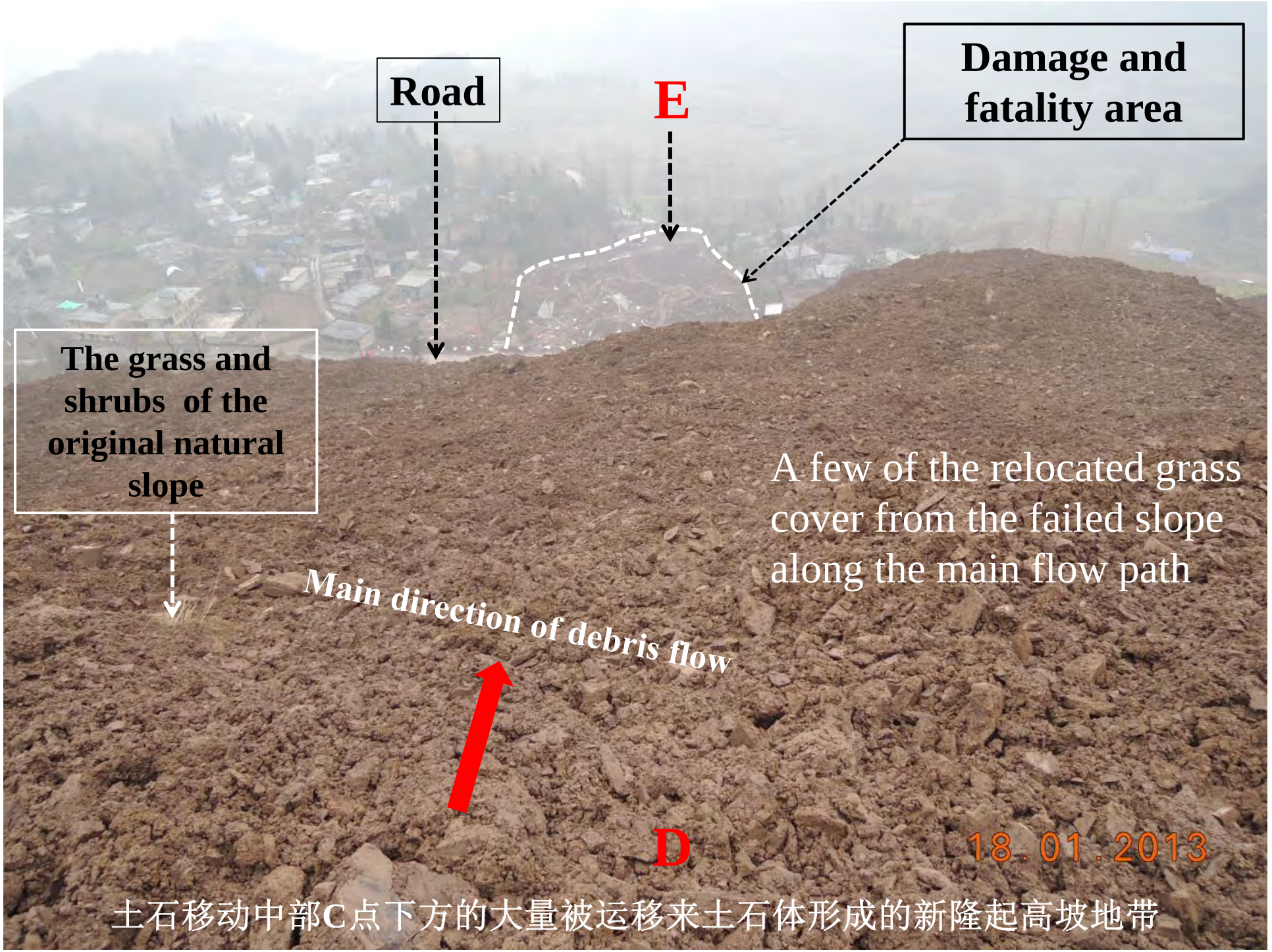

A
Landslide
Source zone
Northern side
M
Main direction of debris flow
Direction and deposition of debris flow on south side
A few of the relocated grass cover from the failed slope along the main flow path
Relocated grass cover from the failed slope
18.01.2013


at C to D
The back-steep slope of small mount of 4 to 5 m high by deposition of debris flows
Main direction of debris flow
18.01.2013

Video 2 on January 18, 2016
Debris flow and deposition B to D area

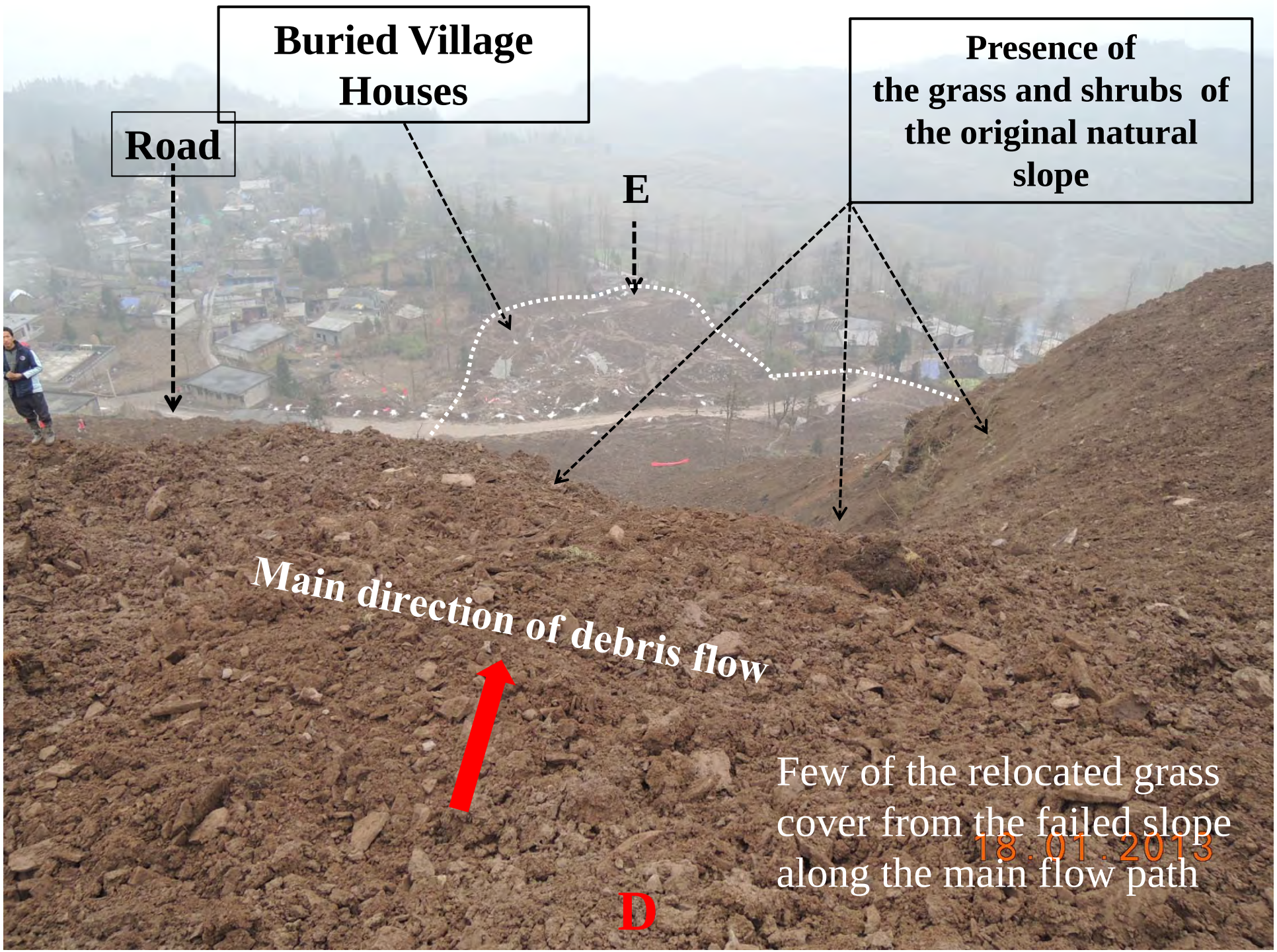
Many relocated grass cover from the failed slope on both sides of the main flow path

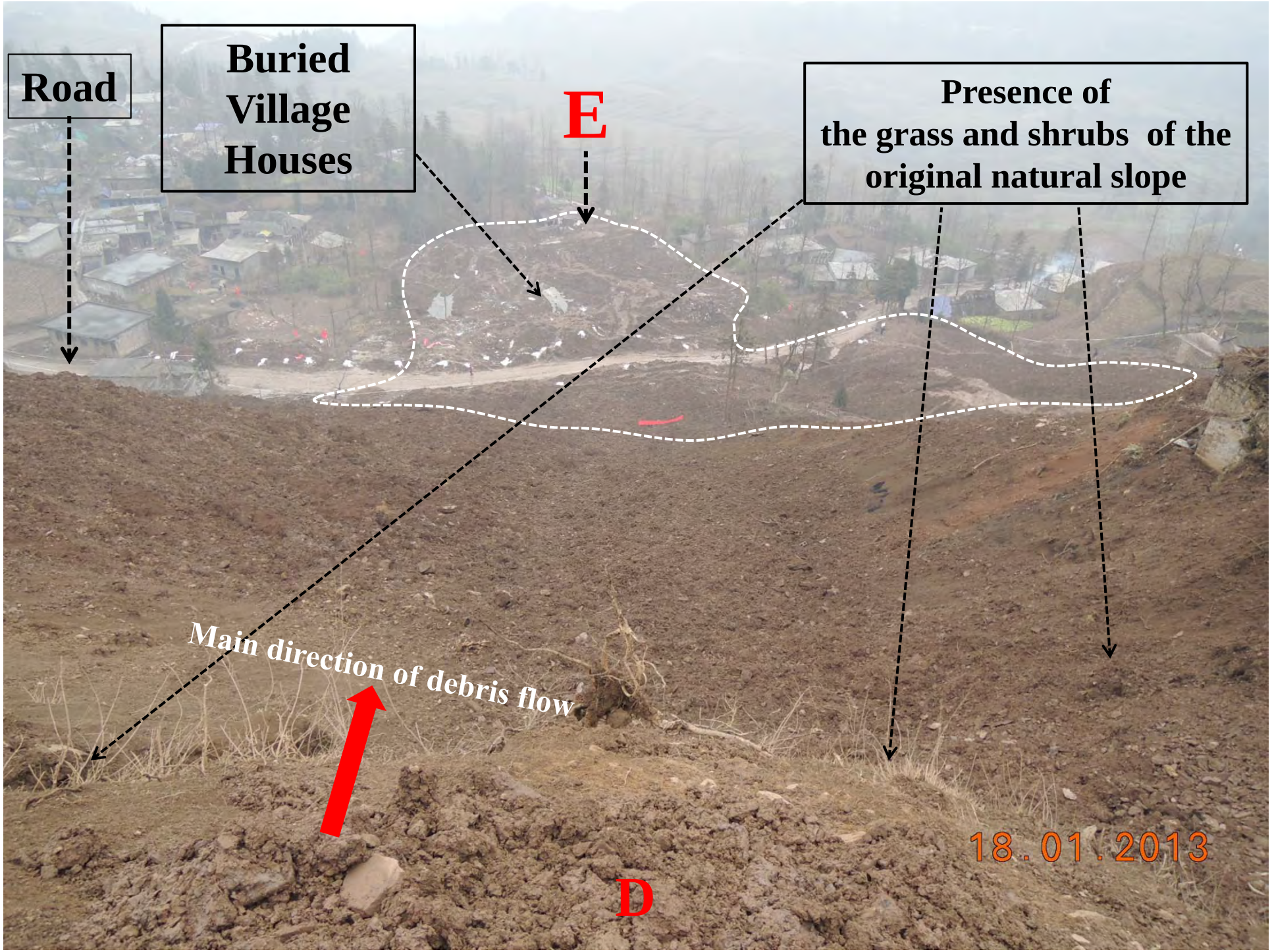
A few of the relocated grass cover from the failed slope along the main flow path



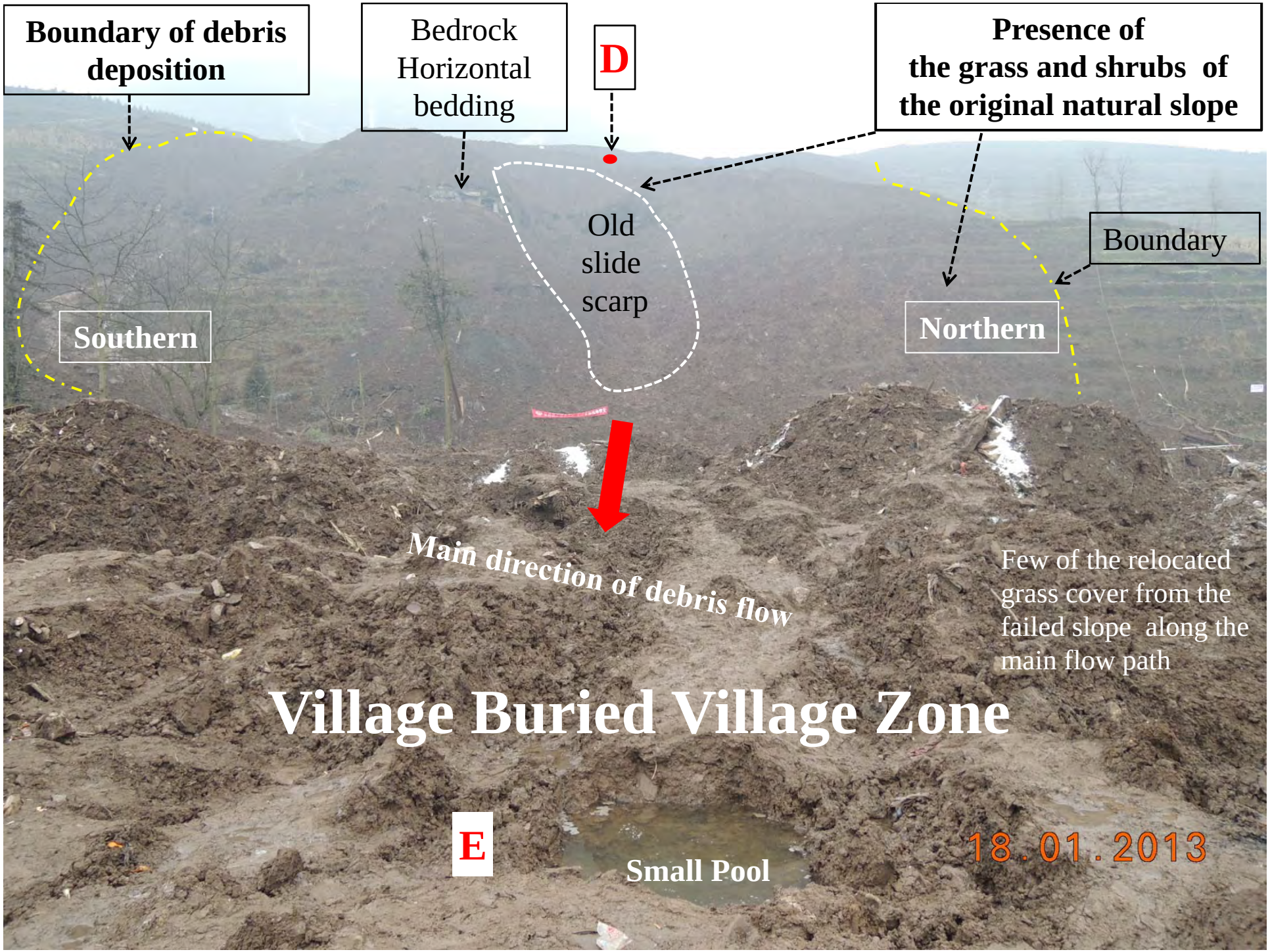
土石移动中部C点下方的大量被运移来土石体形成的新隆起高坡地带


Presence of
the grass and shrubs of the original
natural slope
Main direction of debris flow
18.01.2013


Buried Village Houses
Road
E
Presence of the grass and shrubs of the original natural slope
Main direction of debris flow
Few of the relocated grass cover from the failed slope along the main flow path
18.01.2013
D

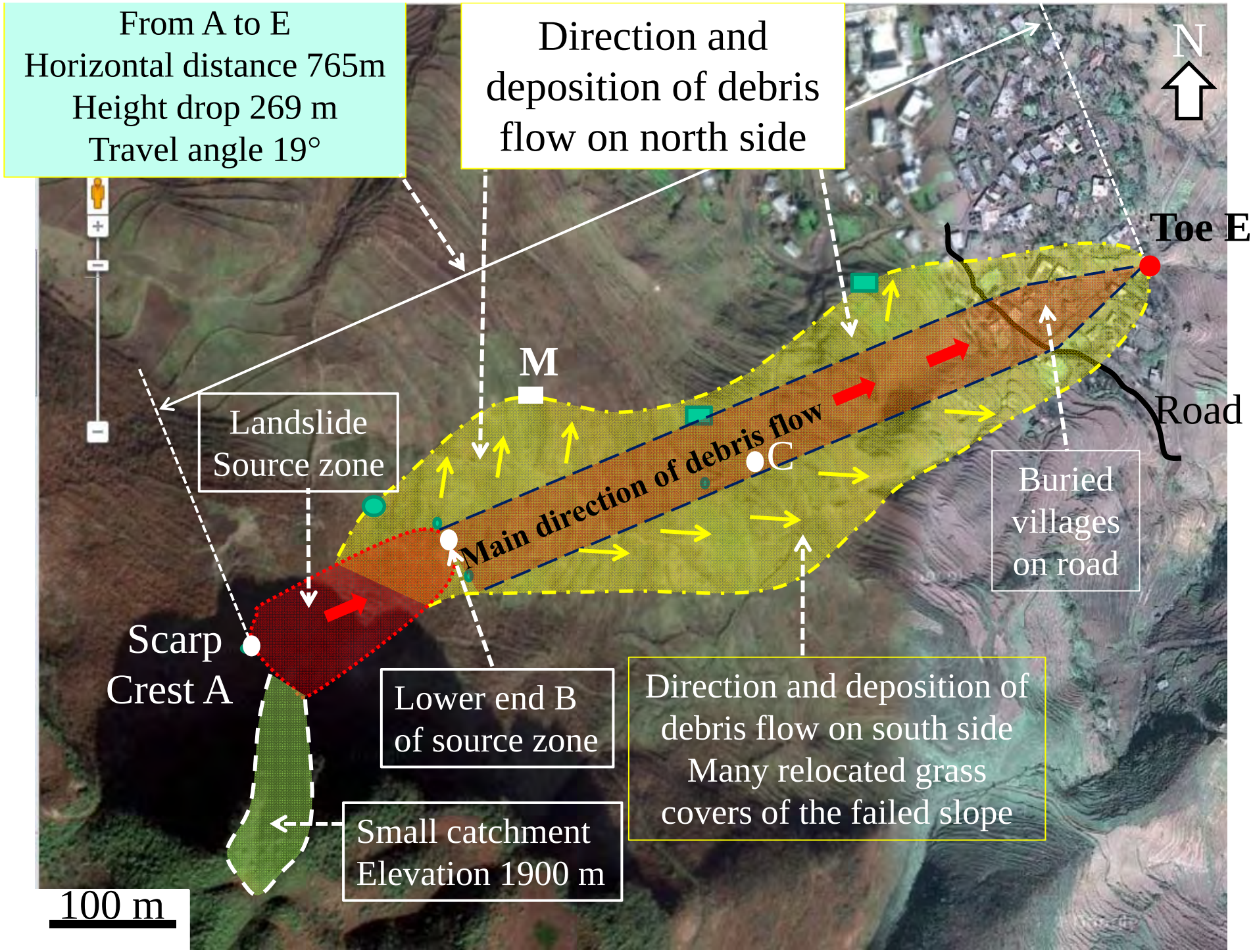

Road
Buried Village Houses
E
Presence of the grass and shrubs of the original natural slope
Main direction of debris flow
18.01.2013
D

Video 3 on January 18, 2016
Debris Flow & Deposition D to E area

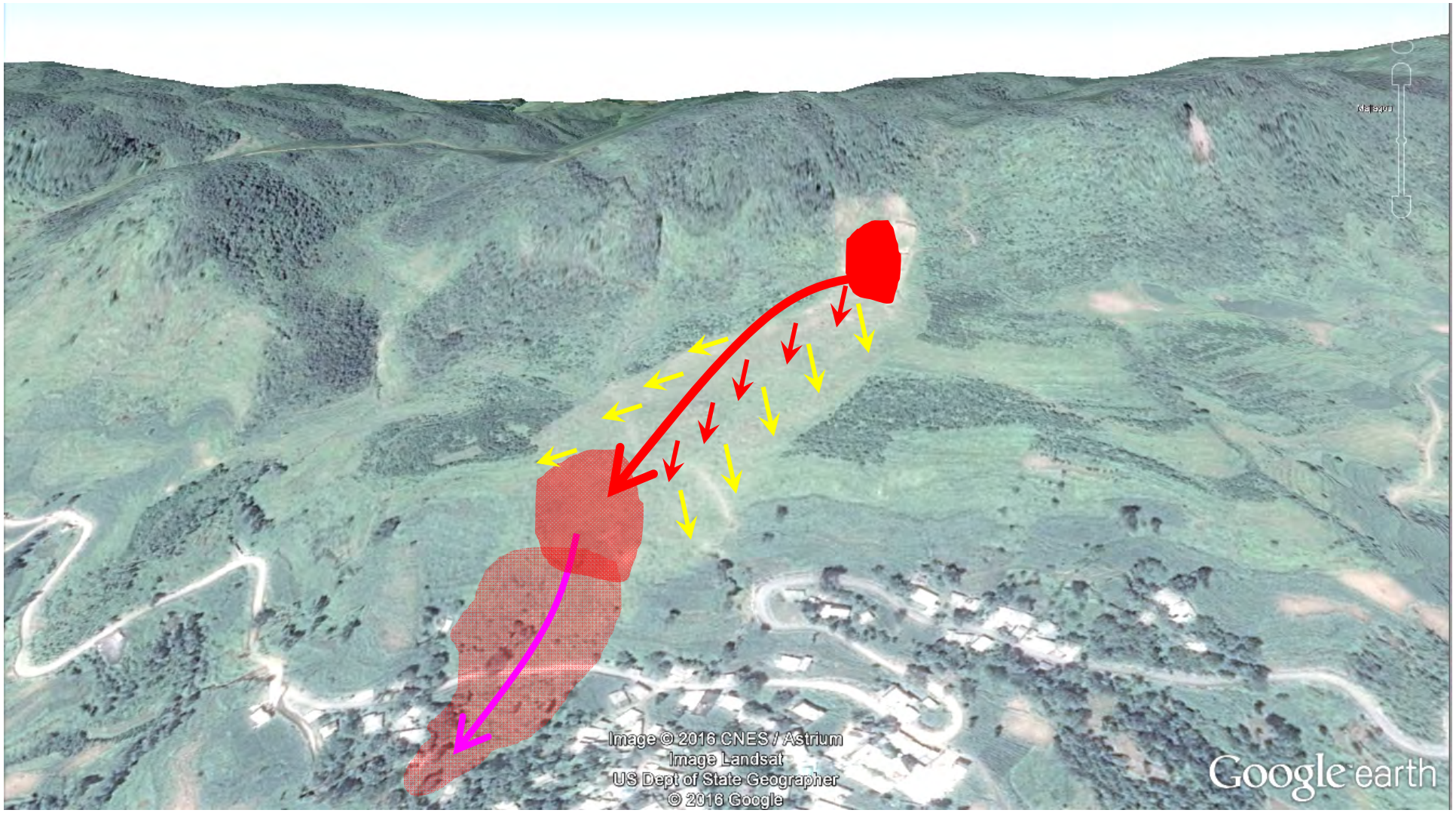

Boundary of debris deposition
Bedrock Horizontal bedding
D
Presence of the grass and shrubs of the original natural slope
Old slide scarp
Boundary
Southern
Northern
Main direction of debris flow
Few of the relocated grass cover from the failed slope along the main flow path
Village Buried Village Zone
E
Small Pool
18.01.2013

Summary of the Field Observations on January 18, 2013

1) The failed natural slope site is a typical part of the mount slopes of 8 km long and has been stable for many years and was not considered unstable at all.
2) The debris is the old landslide debris of soil and rock mixtures (colluvium).
3) The debris are mainly loosely deposited on the vast gentle natural slope
4) These natural slopes have noticeable presence of dry soils and vegetation covers.
5) The debris generally has low water content and is in loose state.
6) There is almost no sign of slipping and water flow.
7) Some soil-rock mixtures are stuck together and form blocks with wet water content.
8) The debris has high clay contents with good cohesion.
9) There are many directional depositions of new and thin soil covers with roots and vegetation on both sides of the main debris flow path.

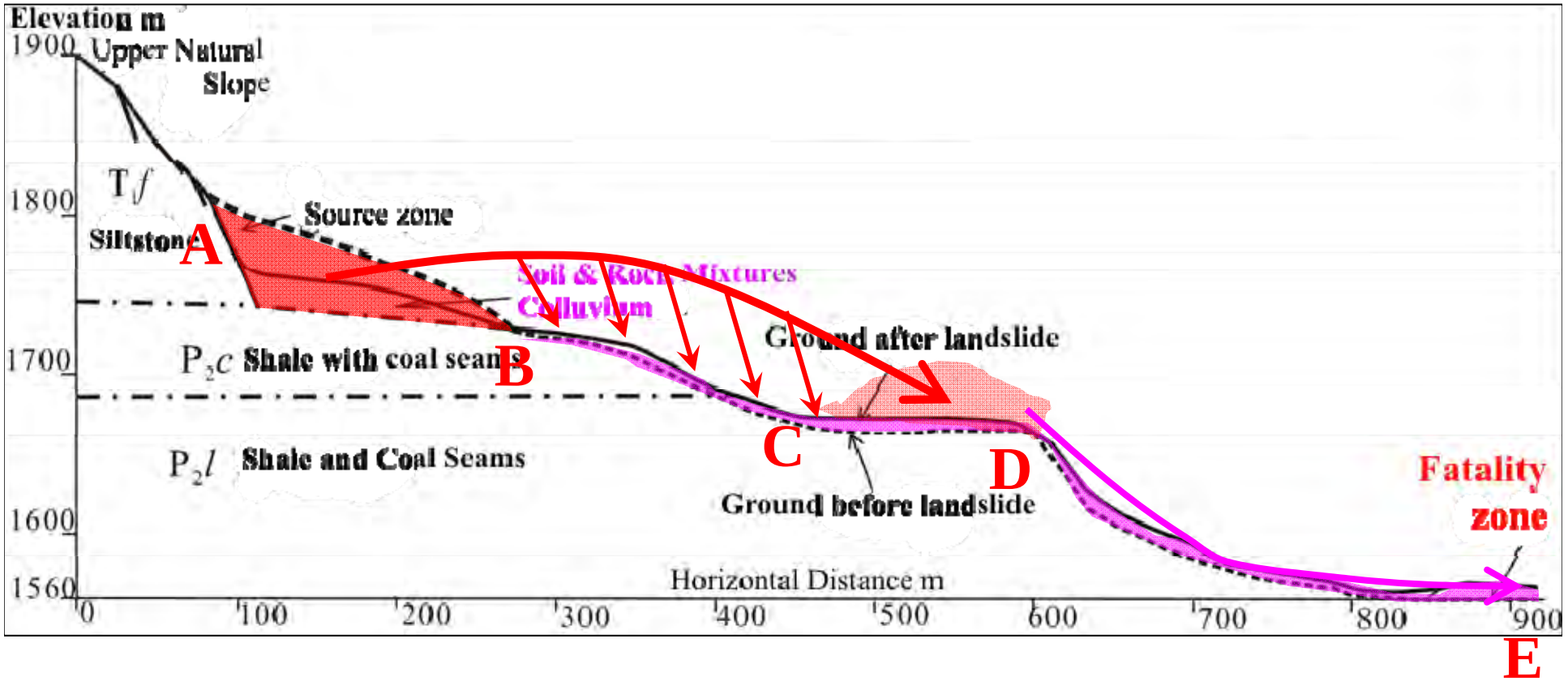

From A to E
Horizontal distance 765m
Height drop 269 m
Travel angle 19°
Direction and deposition of debris flow on north side
N
Toe E
M
Landslide Source zone
Main direction of debris flow
C
Road
Buried villages on road
Scarp Crest A
Lower end B of source zone
Direction and deposition of debris flow on south side
Many relocated grass covers of the failed slope
Small catchment
Elevation 1900 m
100 m

Likely mode and sequence of the fatal landslide



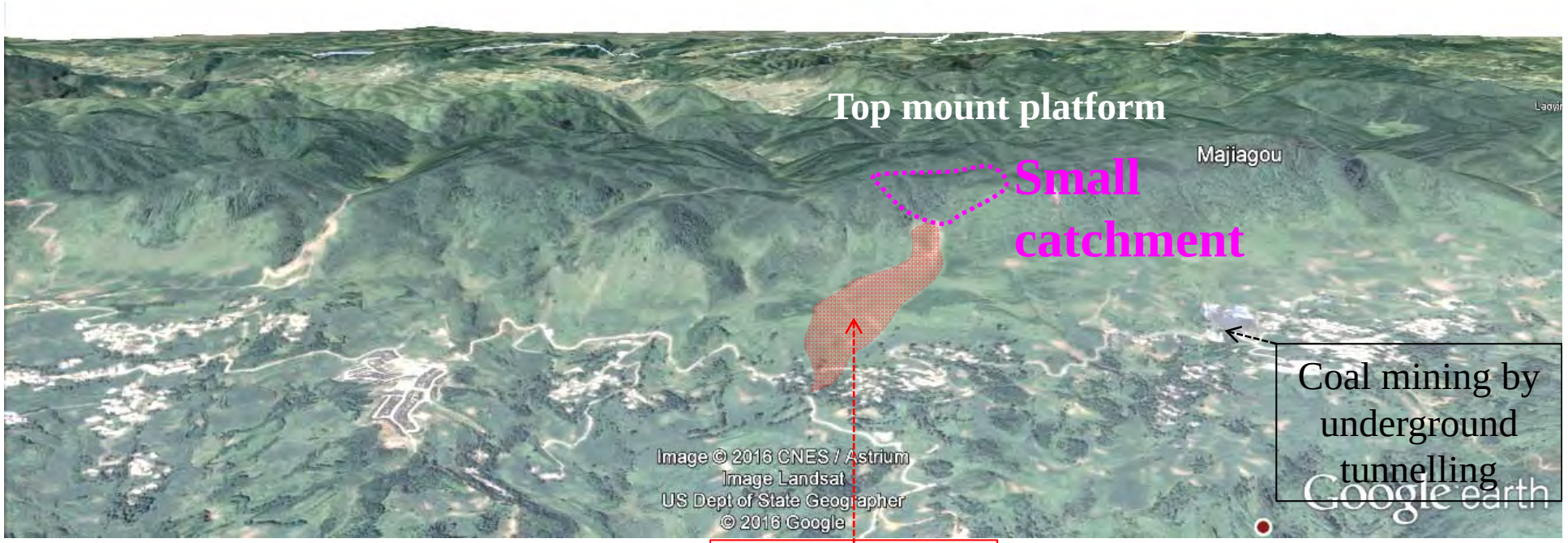
Likely mode and sequence of the fatal landslide

Failed slope: 14° ~ 30° &
volume ~ 0.25×10^6 m^3



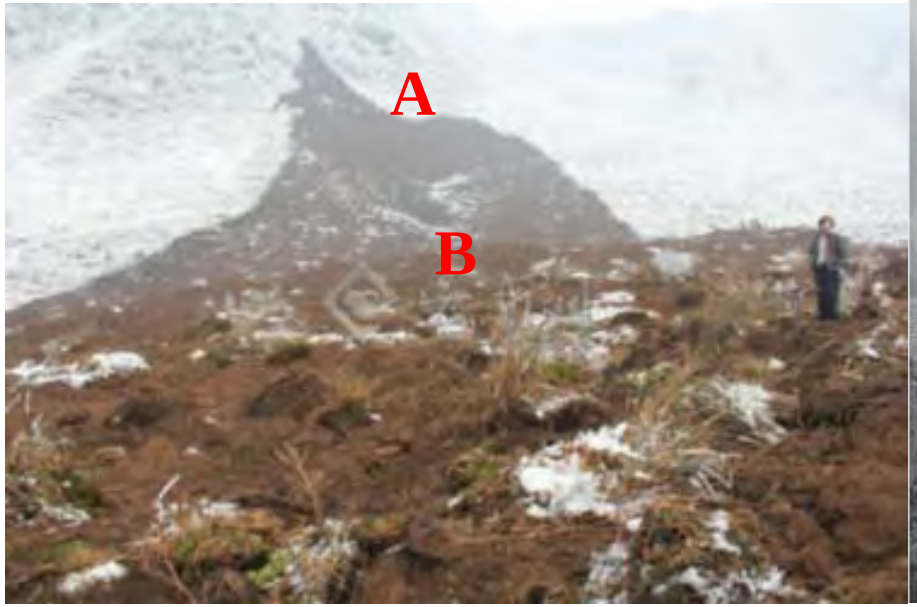
Why?

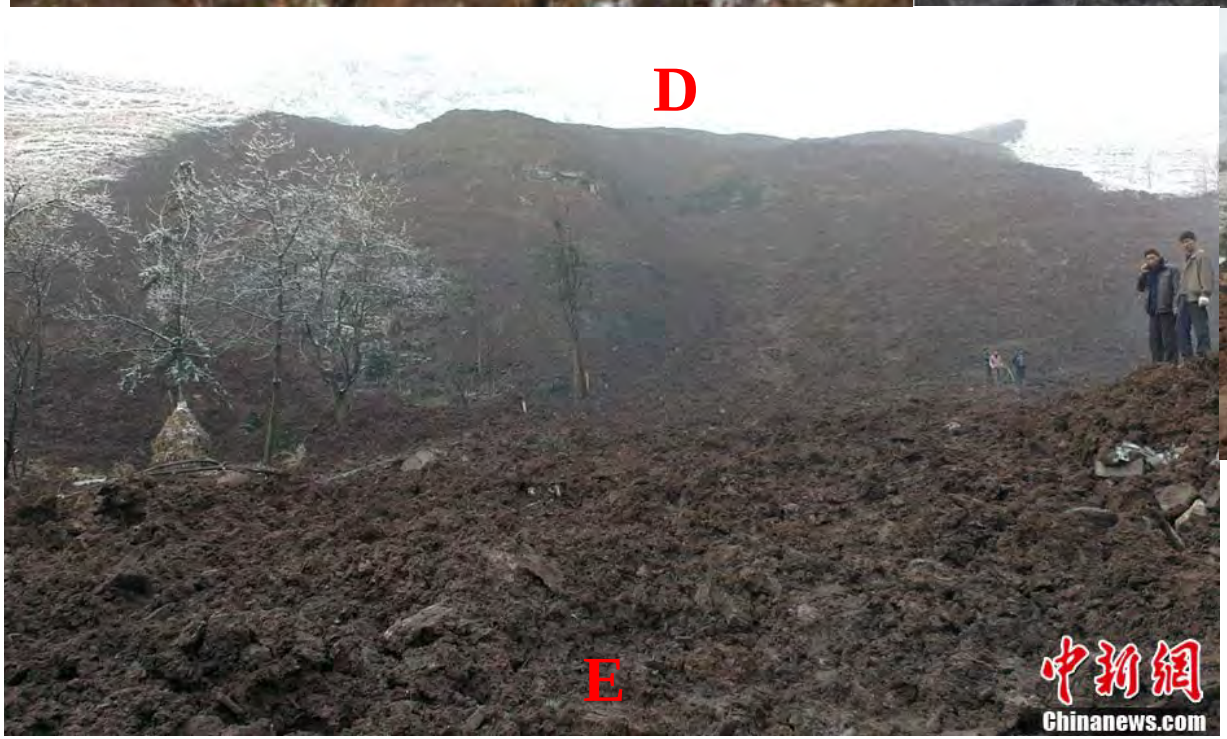
Surface water flow was not a key factor due to very small catchment



Landslide site

No Free Water and Mud on the Photographs taken on Jan. 11, 2013





E

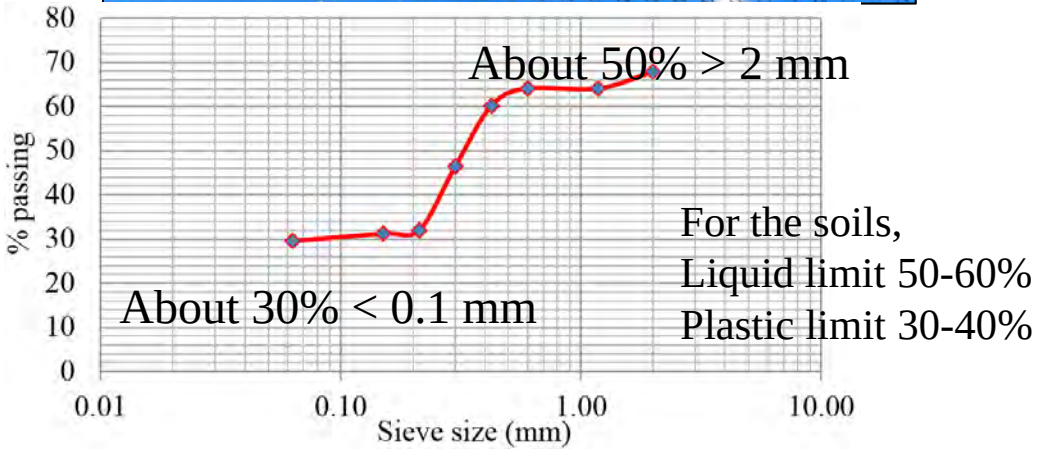
White Smoke ?

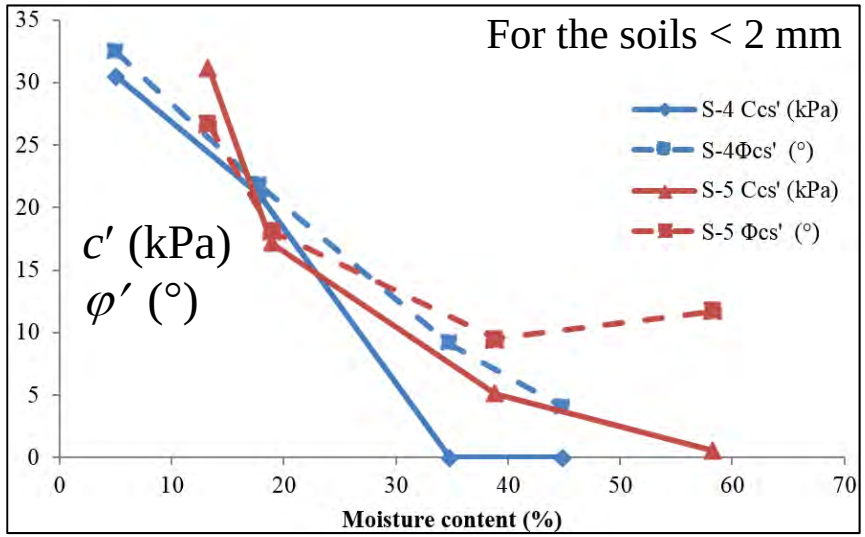
Properties of Soil and Rock Mixture (Jan. 18, 2013)

Video 4 for dry debris

Video 5 for wet debris

In dry season and no free water, so, water was not the main cause factor!





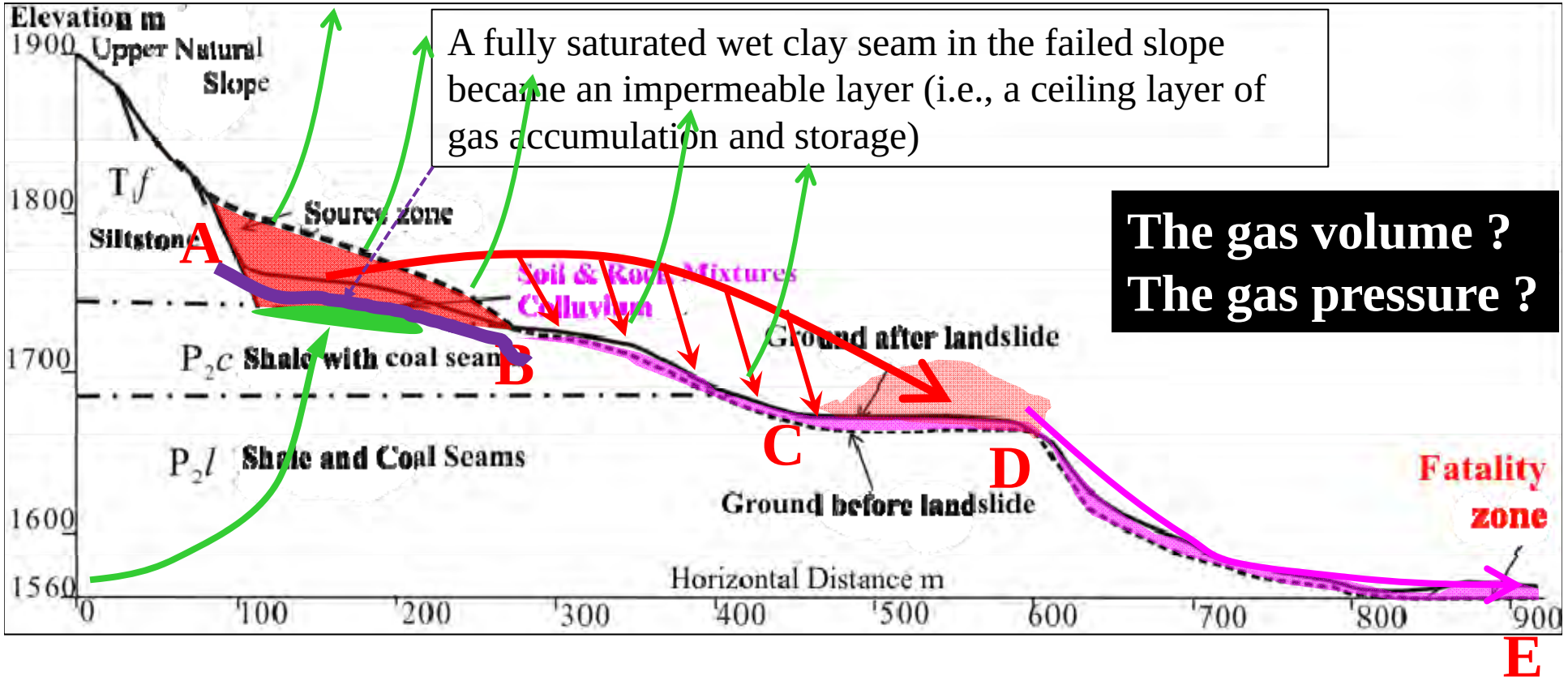
So, what is the main cause factor ?

Witnesses of Local People

1) Before its failure, the failed natural slope had smoked out white gas.
2) There was a very high explosion sound during the failure.
3) The failure looked like an eruption of volcano. It suddenly erupted. A strong gas flow from the failed slope could be felt.
4) Large clouds and dusts was appeared above the failed slope.
5) The hill soil and rock mixtures were rapidly coming down and buried the village, like end-tipping of large amount of sands from a truck.
6) A coal-truck driver observed the whole dramatic, rapid and long-distance process of the slope failure. He did his best to run to inform the villagers but failed due to the rapid flying down of the debris.
7) Since the failed slope was near the coal mining area, many people believed it was related to the explosion of the methane gas in the coal mining tunnels.

Possible scenery of migration, accumulation and eruption of highly compressed gas in the gentle natural slope to cause the fatal landslide

Failed slope: 14° ~ 30° &
volume ~ 0.25×10^6 m^3



Many thanks to you for your attention!