Occurrence mechanism of rockslide at the time of the Chuetsu earthquake in 2004 - A dynamic response analysis by using a simple cyclic loading model -

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The point of this presentation

Recent trend in seismic response analysis

Problems:

Not easily applicable for reviewing the occurrence mechanism of the landslide in mountainous area during an earthquake.

Solutions:

Application of UW model capable of dealing with dynamic deformation characteristics and shear strength together.

Case study analysis: The Hitotsu-minesawa Landslide

The Hitotsu-minesawa Landslide was induced by the Niigata Chuetsu Earthquake which occurred in Japan 2004.

Results:

1. A large increase of horizontal acceleration is in action at the ridge area.
2. A large shear stress is in action at the valley area.

Map of the landslide damaged area (from the Chuetsu earthquake, 2004)

<Profile of the earthquake>

Date:

at 17:56 on 23rd October 2004

Location:

E.L. 138° 52' 00''±24''

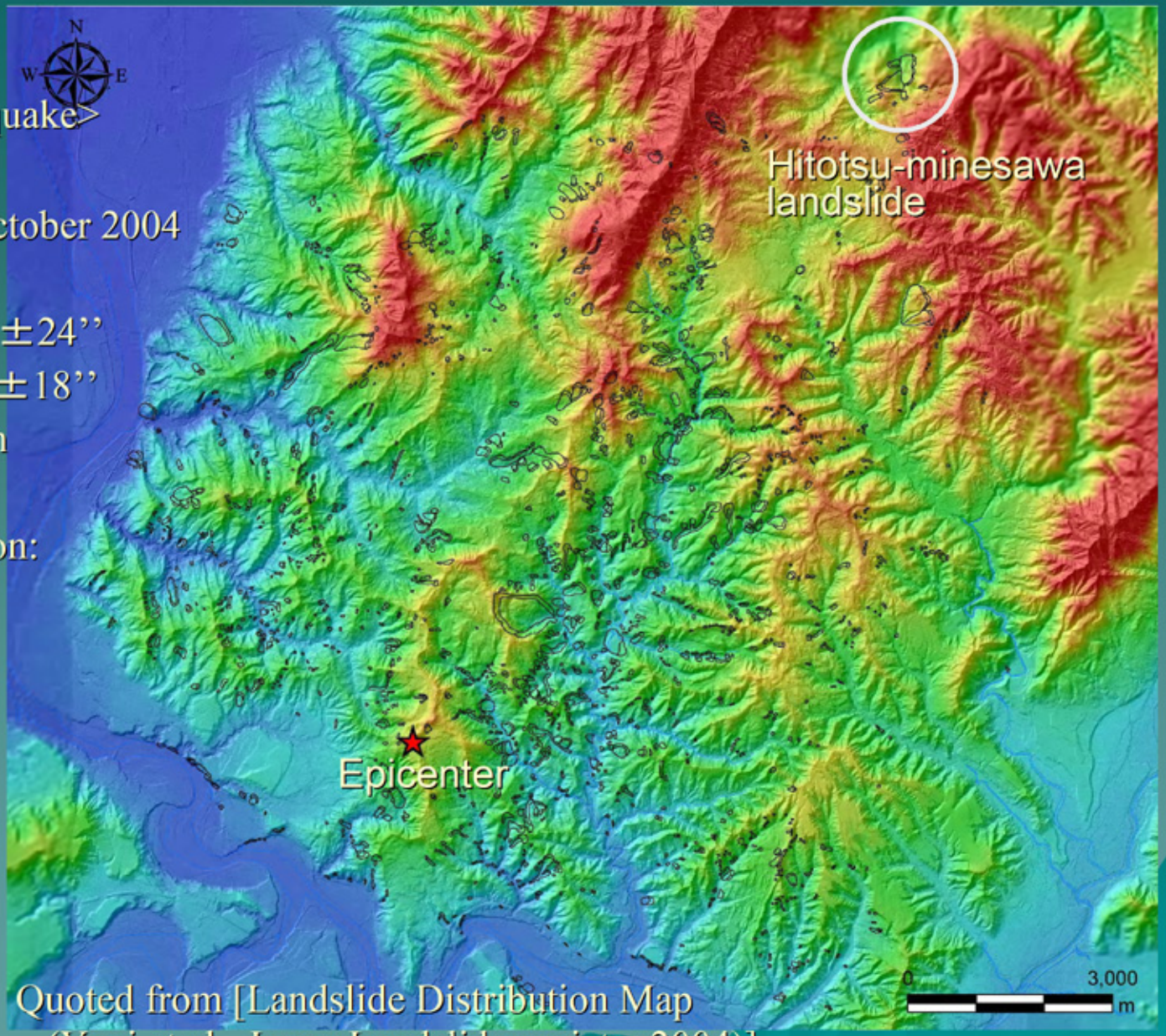
N.L. 37° 17' 30 ''±18''

Depth of focus: 13km

Magnitude: 6.8

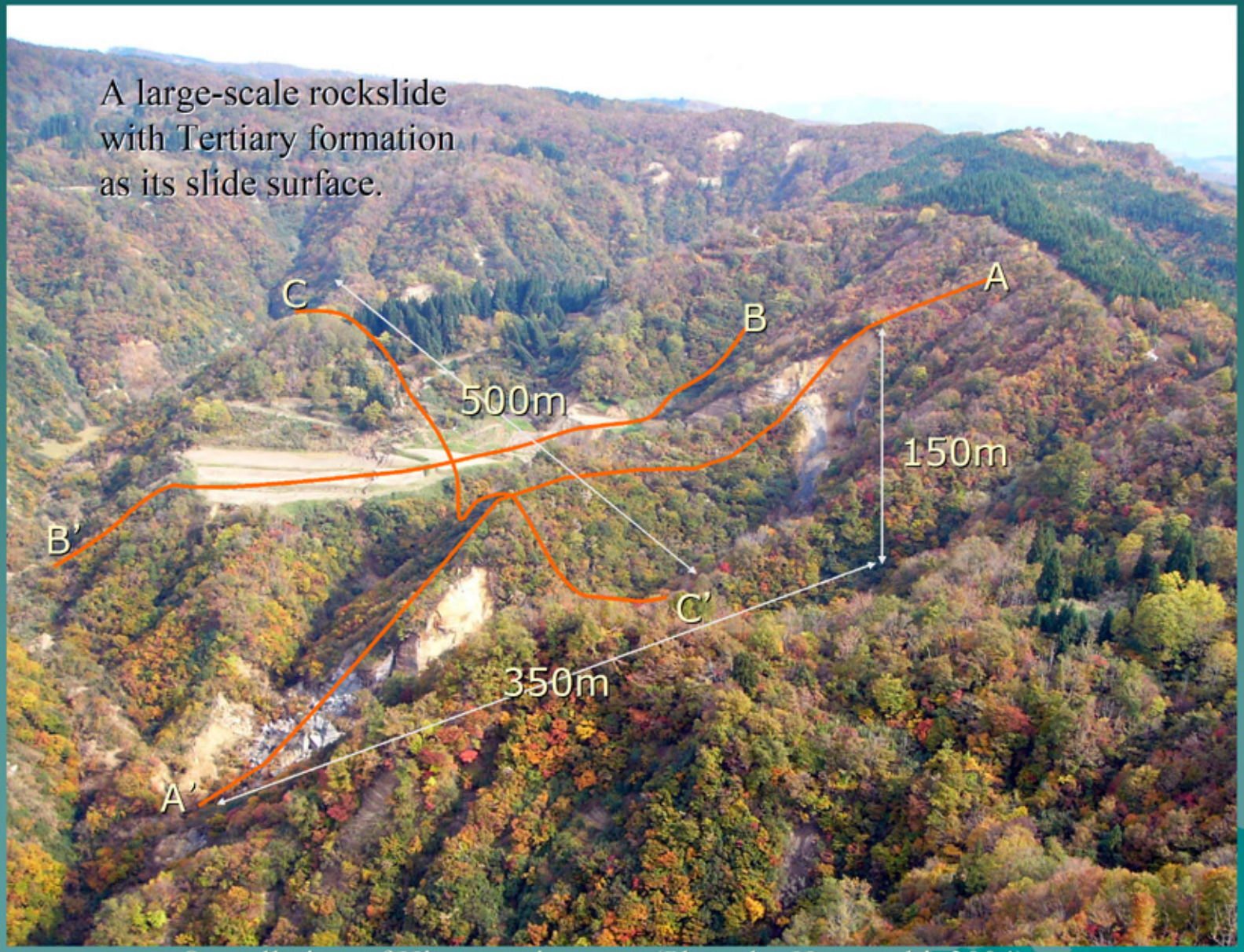
Maximum acceleration:

over 1000 gal



Quoted from [Landslide Distribution Map (Yagi et al. ,Japan Landslide society, 2004)]

The Hitotsu-minesawa Landslide: Profile 1

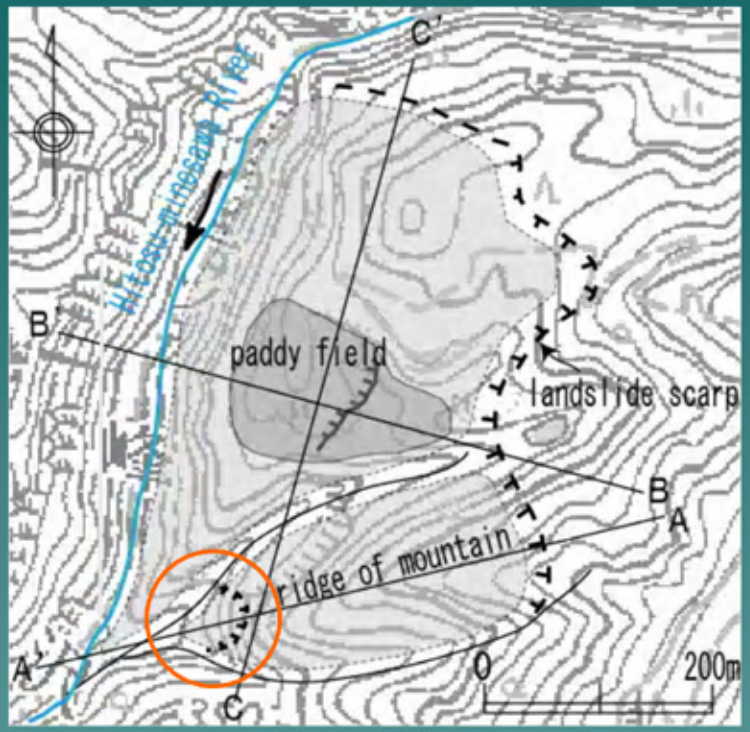


Overall view of Hitotsu-minesawa (Photo by Haraguchi, 2004)

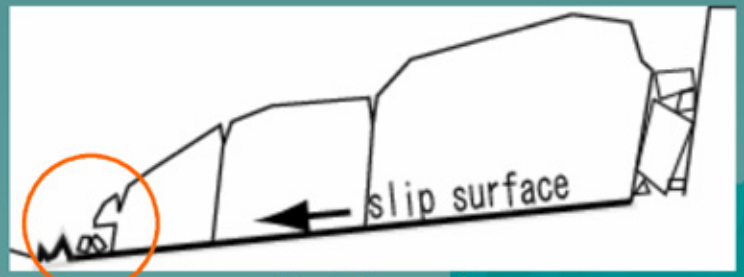
The Hitotsu-minesawa Landslide: Profile 2

Severe fractures at the front-end of the slide

A summary by the photograph (Photo by Haraguchi, 2004)



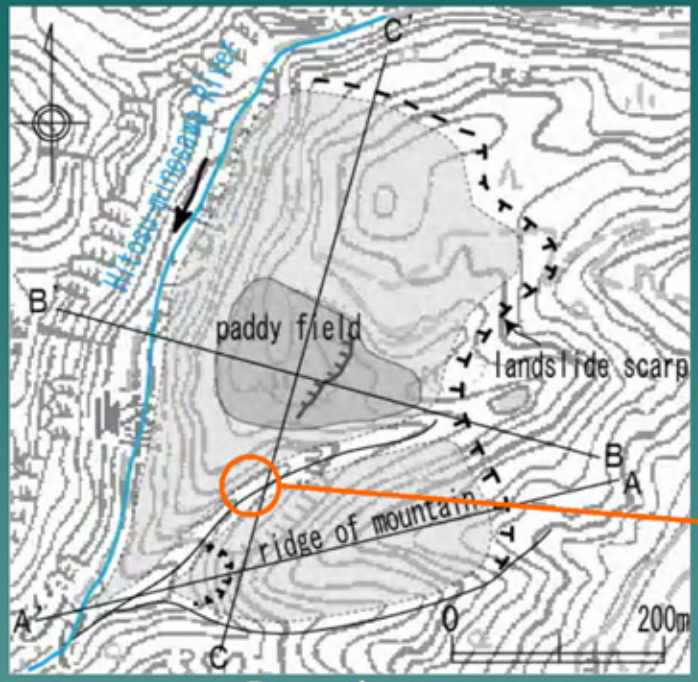
<Location>



<A-A' section>

The Hitotsu-minesawa Landslide: Profile 3

Many cracks occurred in the stream by the ridges.

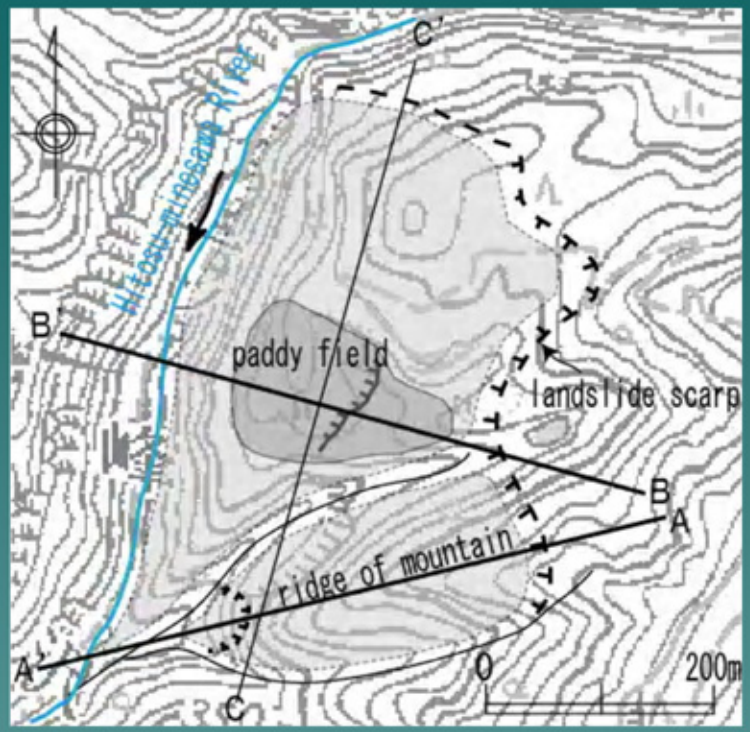


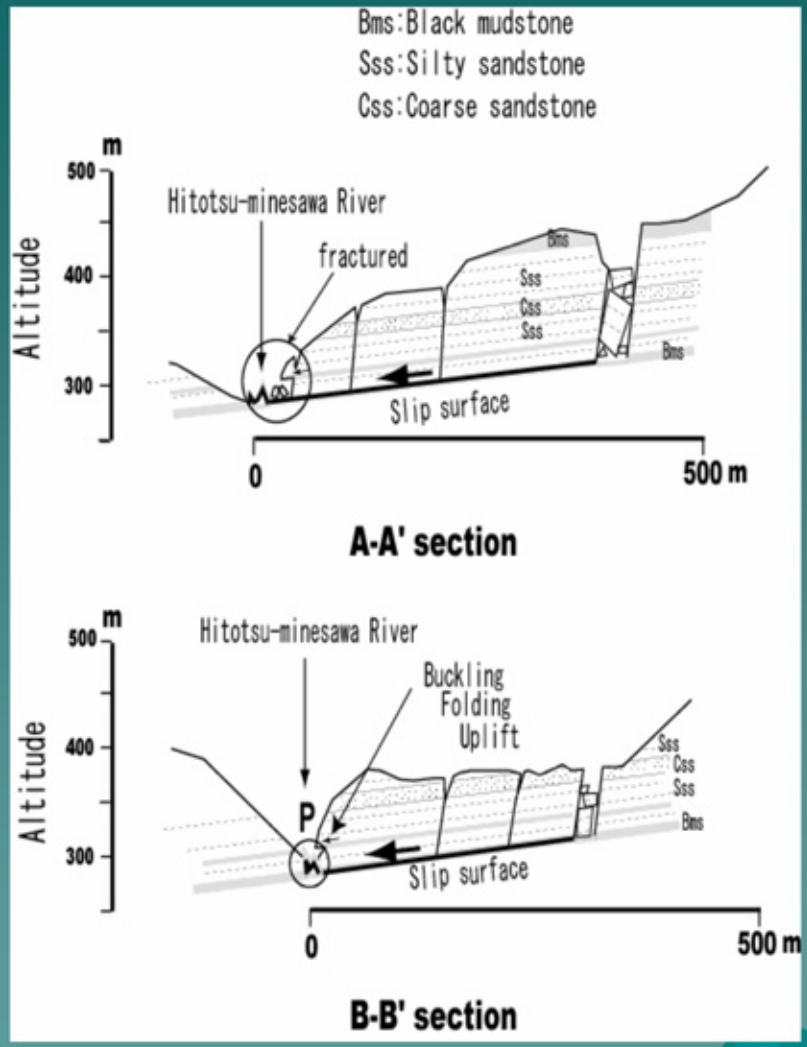
<Location>

・The fractures at the front end of the landslide body
・Many cracks occurred in the stream

→ Suggestion : Strong inertial force being at work on the slope-end.

The geological structure of the Hitotsu-minesawa landslide





Moving zone:
mainly of silty sandstone
Slip surface:
black mudstone
Strike and dip of the layer:
approx. N15° E、0～5° W

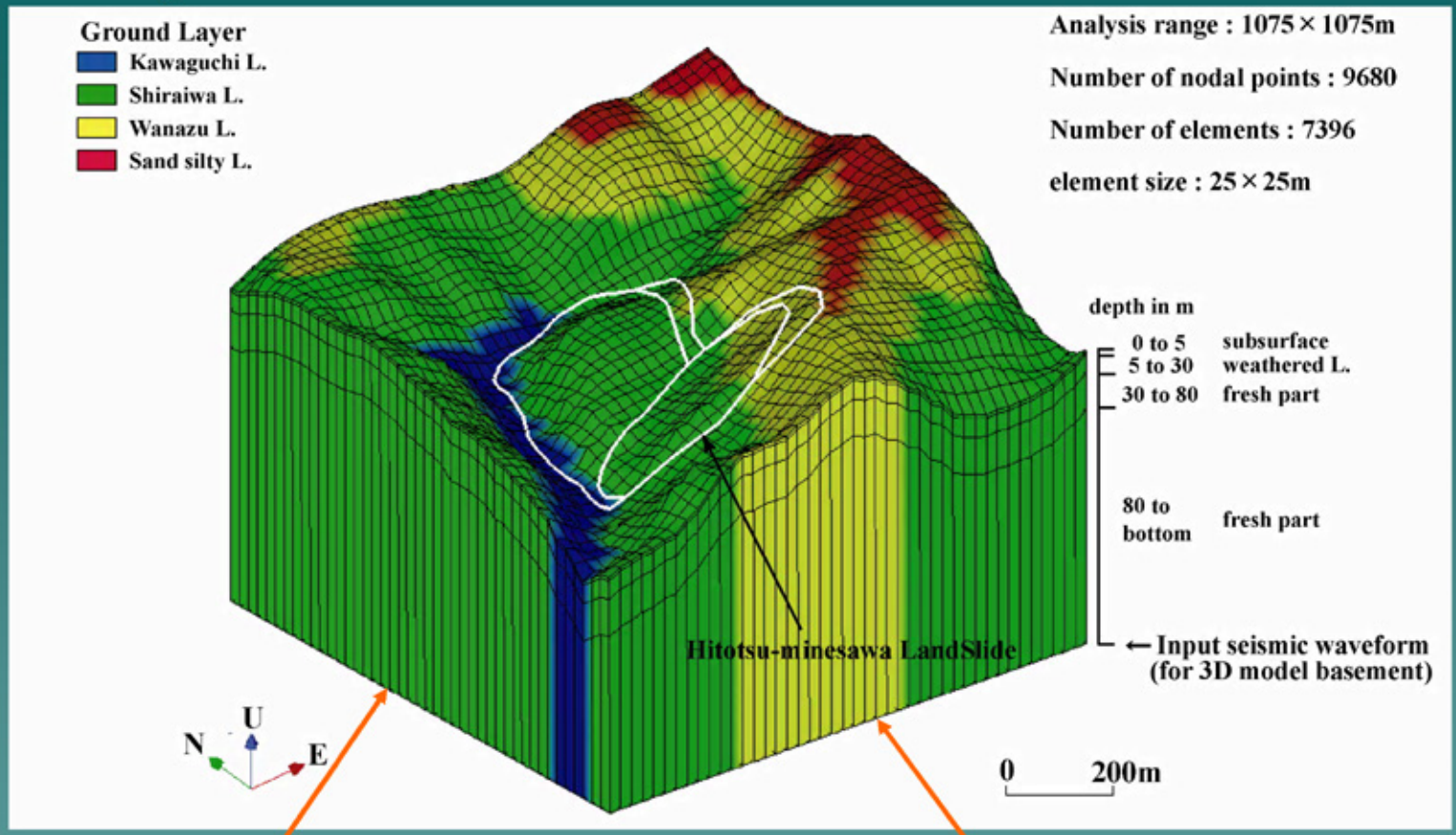
3D dynamic response FEM applied to the mountainous area

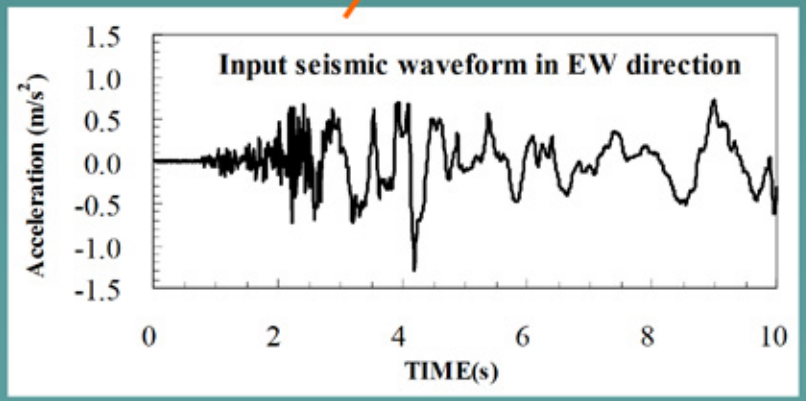
Response analysis method
applied to the Hitotsu-minesawa landslide:
A simple cyclic loading model (Ugai & Wakai model)

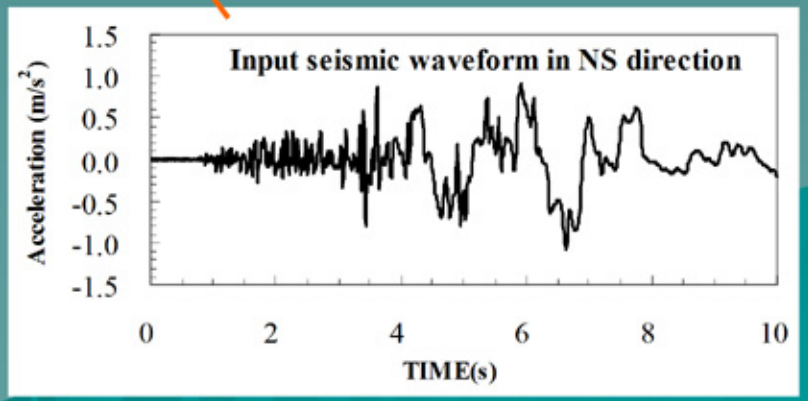
<Characteristics>

1. Shear strength is based on the Mohr-Coulomb standard
2. Capacity to take G-γ, h-γ relationship into consideration
3. Employment of the substructure calculation algorism for time and memory saving purpose (ability to analyze wide area using a generally available PC)
4. Both wide area geology and physical properties per geological attribution can be taken into consideration

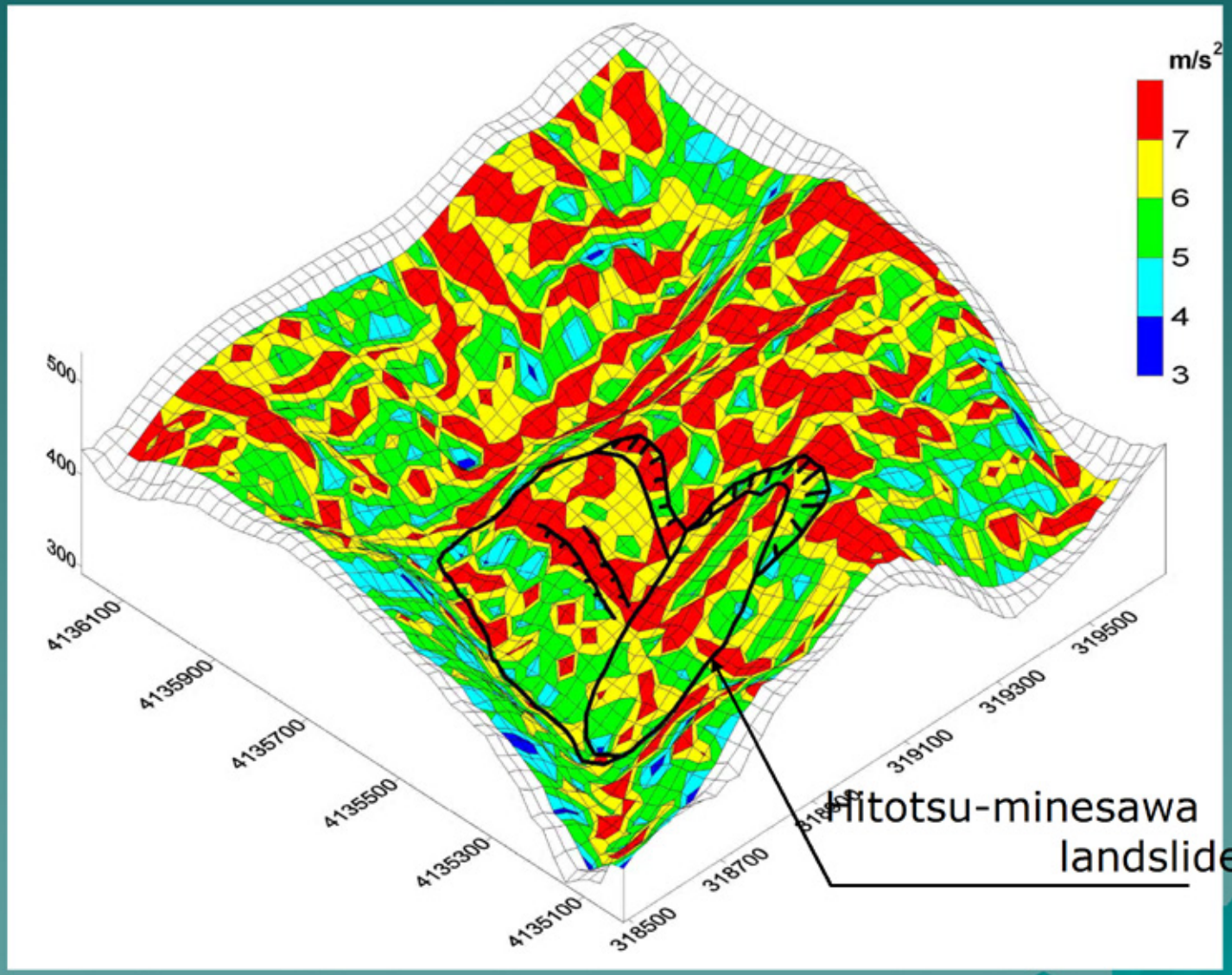
3D Analysis Model





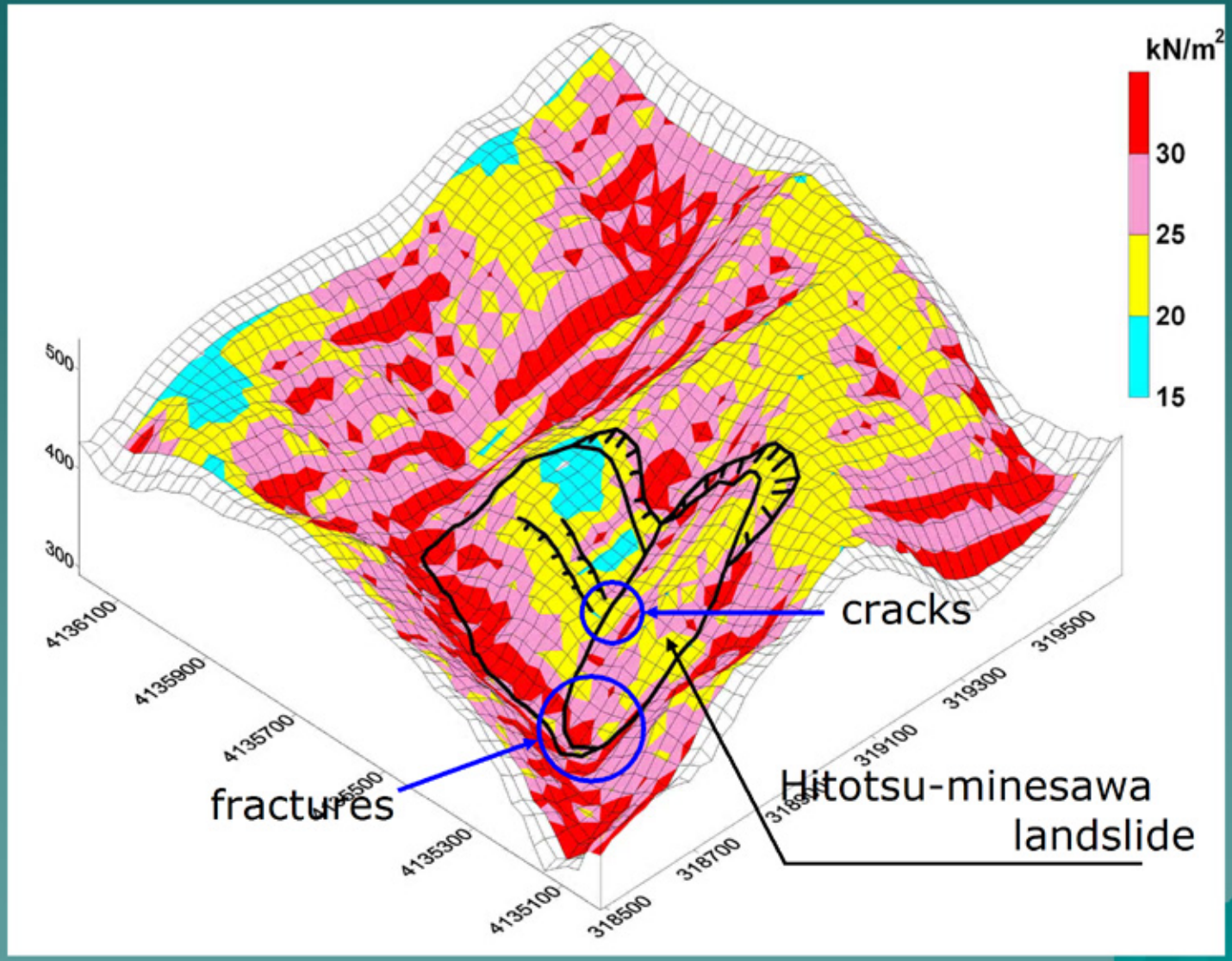


3D Dynamic Response Analysis Results (maximum horizontal acceleration)



Markedly amplified acceleration at topographically sharp area

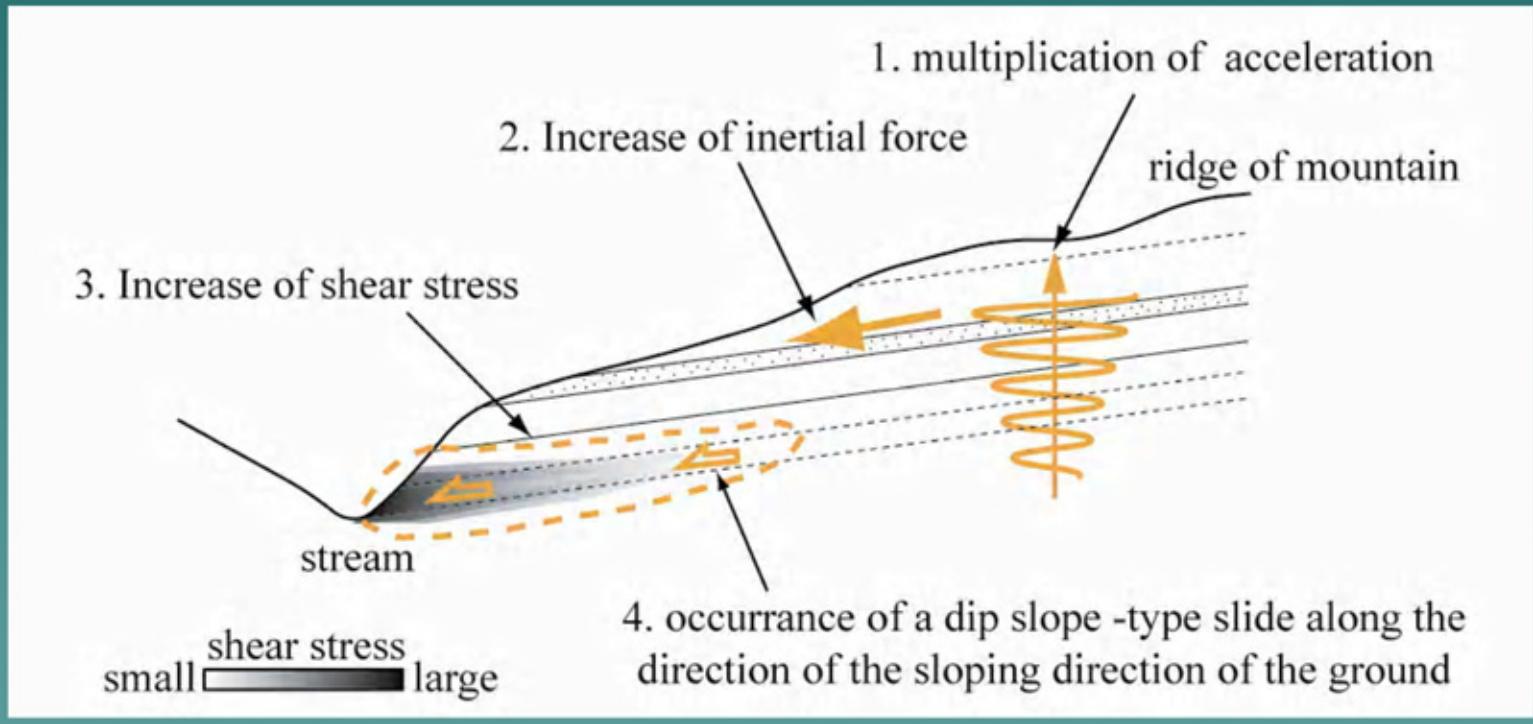
3D Dynamic Response Analysis Results (maximum shear stress)



Tendency of shear stress increase at the stream area

Discussion on the Occurrence mechanism of landslides

1. A large increase of horizontal acceleration at the ridge area
2. Development of inertial force induced by amplified acceleration.
3. A large shear stress at the valley area
4. A highly developed inertial force induces the slip surface formation.



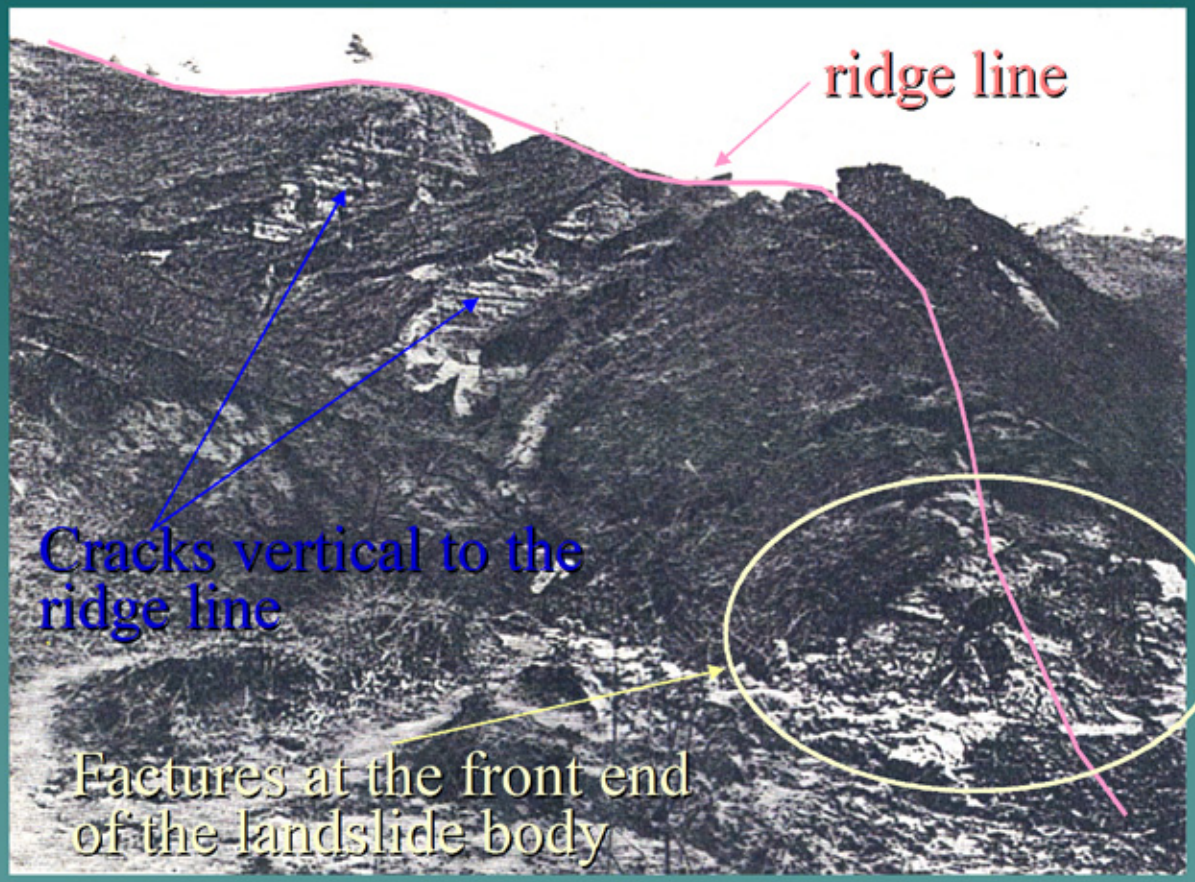
<Additional causing factors>
The ridge protrusion and the slope of the layer point to the same direction.
The both sides of the ridge are open.

Similar case

Togawa landslide:
A rockslide of primary landslide with the Senpoku earthquake

Geology:
Sandstone and mudstone from the Oligocene-Neogene

Senpoku earthquake:
15th March 1914
Magnitude: 7.1
(direct hit earthquake)



Quoted from [Seismic intensity and geomorphological/geological feature of landslides due to earthquakes in the area of Tertiary strata in Japan.
(S.Abe et al. Journal of the Japan Landslide Society,Vol.43,No.3,pp.27-34, 2006)]

Conclusion

Occurrence mechanism of rockslide at the time of earthquake:

A highly developed inertial force generating plasticised boundary that promoted the formation of slip slid surface.

- Above findings are supported by the evidence found at the subject area.
- Some questions on rockslide occurrence mechanism have been answered.
- A step nearer to accurately predicting the behavior of slopes at the time of a large-scale earthquake.