Landslide Survey and Scale Estimate by DInSAR, GNSS, and Airborne Laser Before Landslide Failure - Landslide Survey of Mt. Inago -

Masaki MIZUNO[1*], Chunxiang WANG[2], Yutaka GONDA[3], Hideaki MARUI[3], Daisuke NISHIKAWA[4], Ikushi HIRATA[4], Daisuke SANGO[4], and Yasunari MORITA[4]

[1] Public Works Research Institute, Japan, and former Niigata University, Japan

[2] Kitac Corporation, Japan

[3] Niigata University, Japan

[4] PASCO Corporation, Japan

* Corresponding author. E-mail: m-mizuno@pwri.go.jp

INTRODUCTION

Mitigating the damage caused by a large-scale deep-seated landslide triggered by torrential rainfall, earthquakes, etc. is possible if the “location of the individual slope” of deep-seated landslides and the “scale of the landslide” can be predicted.

This study aims to establish a “method of clarifying the location, area, and scale of a landslide before a deep-seated landslide disaster”. A series of case studies are performed by combining satellite L-band differential SAR interferometry (DInSAR), global navigation satellite system (GNSS) survey, airborne laser survey, and slope stability analysis. The study area is Mt. Inago in Nagano Prefecture, which is a “landslide displacement candidate site” identified by advanced land observing satellite (ALOS, Japan) DInSAR images. This location has a disaster history. A large-scale landslide was caused by a Nankai Trough Earthquake in AD887 (approximately 350 million m^3), and its debris avalanche and sedimentation areas were a location to many homes. The probability of occurrence within 30 years of 6-lower or greater on the JMA seismic intensity scale is high. Thus, a survey of Mt. Inago is of high priority.

METHODS AND RESULTS

ALOS L-band DInSAR images of a region around Nagano prefecture were prepared, then visually interpreted to identify the landslide displacement candidate sites at 40 places (**Fig. 1**). After reconnaissance, GNSS surveys were then performed at Mt. Inago (**Fig. 2**), one of the landslide candidate sites, based on the DInSAR images. As a result, a “constant significant landslide displacement” was found at three survey points on the body of Mt. Inago (**Fig. 3**).

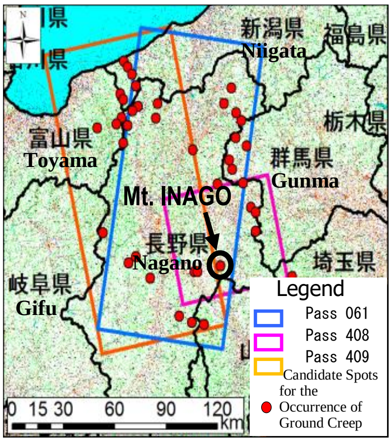

Fig. 1 Landslide displacement candidate locations according to ALOS DInSAR and the location of Mt. Inago

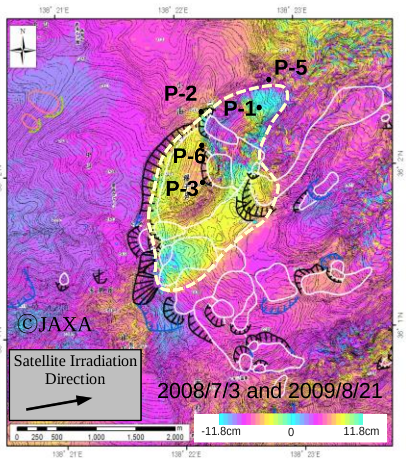

Fig. 2 ALOS DInSAR fringe image and each GNSS survey point on Mt. Inago

Therefore, the shear strength reduction method and the seismic coefficient method analysis were executed at the locations on Mt. Inago (**Fig. 3**) to calculate the "contour of maximum shear strain rate". Furthermore, based on the "fringes in the DInSAR images" and the zone of "maximum shear strain rate" of this "contour of maximum shear strain rate", the location and shape of the slip surface of Mt. Inago were presumed as shown in **Figs. 4** and **5**. The landslide volume when the entire mountain body is displacing, was calculated under these conditions. In addition, the detailed topography, including plural opening cracks, and the landslide displacement were clarified by the DInSAR images and the topographical analysis map shown in **Fig. 3**.

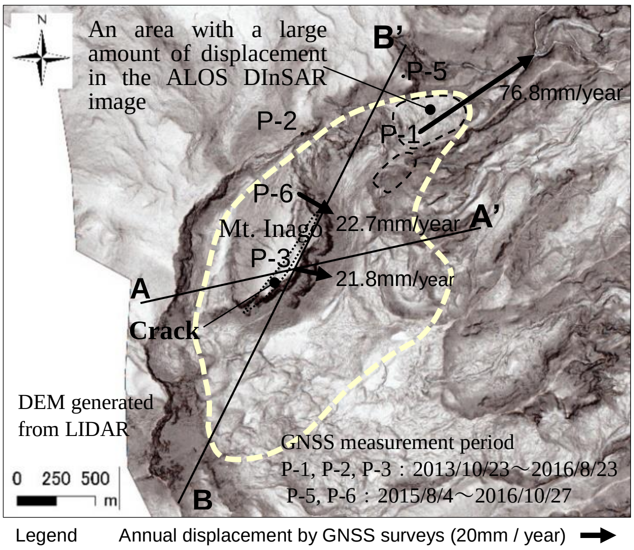

Fig. 3 "Horizontal displacement of Mt. Inago according to the GNSS survey", "location of AA' and BB' sections", and displacement area (dotted lines) estimated by interpreting the range of displacement from the ALOS DInSAR image in Fig. 2

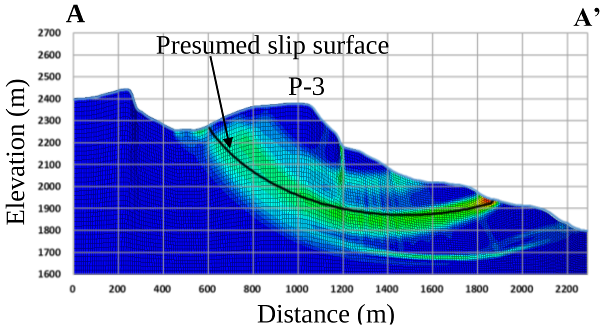

Fig. 4 "Contour of maximum shear strain rate" and presumed slip surface on the AA' section based on the seismic coefficient method
*Cracks are not considered

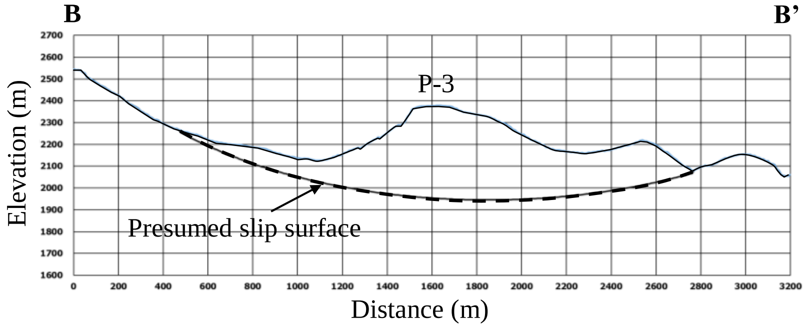

Fig. 5 Presumed slip surface on the BB' section

CONCLUSIONS

The conclusions drawn from the survey and the analysis based on DInSAR, GNSS, and the airborne laser, are as follows:

- The fringes showing the landslide displacement of the Mt. Inago body were identified from the L-band ALOS DInSAR images. The results of the GNSS surveys confirmed a constant significant ground surface displacement at three survey points. These facts implied that the entire body of Mt. Inago may be displacing.
- The results of the seismic coefficient method based slope stability analysis of Mt. Inago showed that the location and the shape of the zone of the "maximum shear strain rate", which was likely to be the slip surface, were predicted at a stage prior to a deep-seated landslide.
- The location and shape of the slip surface on Mt. Inago, were presumed from the "fringe range in the DInSAR image" and the zone of the "maximum shear strain rate". The estimated volume of the landslide body on Mt. Inago when the entire mountain body is displaced is approximately 200 million m^3.
- This study showed that the parallel use of L-band DInSAR images, GNSS, and the topographical analysis map is an effective method of exploring the locations of landslide displacement and surveying the displacement of landslides before a disaster occurs because a detailed topography can be clarified.

Keywords: deep-seated landslide, DInSAR, GNSS survey, airborne laser survey, Mt. Inago