Original Article

Distribution and features of slope failures in Tarumizu City, Kagoshima Prefecture caused by typhoon Nabi in September 2005

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Summary

To clarify the distributions and features of slope failures in Tarumizu City, Kagoshima Prefecture, caused by typhoon Nabi in September 2005, field surveys and interpretations of aerial photographs were carried out. The results were characterized as follows:

(1) Many slope failures were distributed on steep slopes, and within ranges investigated they were seen to have debris flows among them. Several types of erosion and slope failures were observed within the ranges investigated; shallow landslides resulting from the infiltration of rain water into Ito pyroclastic flow deposit slopes, sedimentary rock and granite; failures occurring on the shoulder reaches of cutting slopes and the upper reaches of slope failure scars that resulted from the infiltration of rain water into Ito pyroclastic flow deposit and granite slopes; and deep-seated landslides resulting from groundwater between sedimentary rock, and the volcanic ash and volcanic pumice layer, combined with an influx of rain water, in sedimentary rock slopes.

(2) The areas of slope failures generated on Ito pyroclastic flow deposit slopes varied between 27 m^2 and 1,487 m^2 (average 390 m^2), the areas of slope failures generated on sedimentary rock slopes varied between 21 m^2 and 2,572 m^2 (average 437 m^2), and the areas of slope failures generated on granite slopes varied between 101 m^2 and 670 m^2 (average 357 m^2). About 80 percent of the slope failure areas were less than 600 m^2. Deep-seated landslides resulting from groundwater between sedimentary rock, and the volcanic ash and volcanic pumice layer, combined with an influx of rain water on sedimentary rock slopes showed a large value compared with other types of erosion and slope failures within the ranges investigated.

Key Words: Typhoon Nabi, Tarumizu City, slope failure

1. Introduction

The sediment-related disaster following typhoon Nabi occurred over a wide areas of Kyushu, Chugoku and Shikoku from the 6th to 7th September 2005. From the 4th to the 6th, a total rainfall of 600 mm or more fell (Takatoge automated meteorological data acquisition system, 2005), resulting in slope failures and frequent debris and mud flows on the Osumi peninsula in Kagoshima Prefecture. The sediment-related disaster caused the deaths of five people and considerable damage to houses, engineering works and the agriculture, forestry and fishing industries in Tarumizu City Kagoshima Prefecture. The typhoon also stopped traffic on the national road passing through Tarumizu City due to the large amount of sediment, and a village was temporarily isolated (Taniguchi et al., 2005).

Sediment-related disasters due to slope failures, and debris and mud flows have occurred frequently in Tarumizu City. For example, the sediment-related disaster caused by slope failures and debris and mud flows due to the heavy rainfall of typhoon No.11 in July, 1989 and the sediment-related disasters caused by heavy rainfall in 1992 and 1993 (Jitousono and Shimokawa, 1995).

The authors carried out field investigations and interpretations of aerial photographs to clarify the distribution and features of slope failures in Tarumizu City as a result of typhoon Nabi. The results of this investigation are presented and discussed in this paper.

2. Rainfall generated by typhoon Nabi

Rainfall from the 4th to 6th September, as recorded by a Takatoge automated meteorological data acquisition system, revealed a maximum hourly rainfall of 38 mm. Further, total rainfall was 600 mm or more and heavy rainfall due to typhoon Nabi continued for a comparatively long time.

3. Study area and method

The study area was Tarumizu City in Kagoshima Prefecture, situated to the east of Sakurajima Volcano (**Fig. 1**). Sediment-related disasters have occurred frequently in Tarumizu City; recent sediment-related disasters caused by slope failures, and debris and mud flows due to the heavy rainfall include that from typhoon No.11 in July, 1989, and those in 1992 and 1993 (Shimokawa & Jitousono, 1994; Jitousono & Shimokawa, 1995).

After typhoon Nabi, an aerial photograph was taken and ranges set as enclosed by the solid line in Fig. 1. A distribution chart detailing slope failures and debris flow scars was made within those ranges. Further, to clarify the nature and scale of the slope failures caused by typhoon Nabi, we investigated the form of slope failure, geological and geomorphological features, the presence of spring water, shapes of slopes, inclination of slopes, vegetation, and the magnitude of slope failure within the same ranges.

Fig. 2 shows superficial geological map (Kagoshima Prefecture, 1990) of the study area. The geology of the study area consists of sedimentary rock and granite intruded into the sedimentary rock, overlaid with pyroclastic falls and flow deposits, volcanic ash and volcanic pumice resulting from successive eruptions of the Sakurajima Volcano.

4. Distribution and features of slope failures generated by typhoon Navi in Tarumizu City

Fig. 3 shows a chart of slope failures and debris flow scars made up from aerial photographs taken after typhoon Nabi within the ranges noted in Fig. 1. **Fig. 4** shows a chart of slope failures and debris flow scars made up from a combination of aerial photographs taken after typhoon Nabi within the ranges noted in Fig. 1 and the superficial geological map. 254 slope failures were detected within the ranges; 171 were generated on slopes consisting of Ito pyroclastic flow deposits, 75 on slopes consisting of sedimentary rock, and 8 on slopes consisting of granite. Many failures were on steep slopes, and debris flows were seen to have occurred among them.

The area of a slope failure due to an individual slope failure was calculated from the chart of the slope failure scars. **Fig. 5** shows frequency distributions of areas of slope failures for each geological division within the noted ranges. About 80 percent of the slope failure areas were less than 600 m^2.

The area of slope failures generated on slopes consisting of Ito pyroclastic flow deposits ranged from 27 m^2 to 1,487 m^2, with an average of 390 m^2. The main types of erosion and slope failures in Ito pyroclastic flow deposits were shallow landslides resulting from infiltration of rain water into slopes (**Fig. 6**), failures occurring on the shoulder reaches of a cutting slope, and the upper reaches of slope failure scars resulting from infiltration of rain water into slopes.

The areas of slope failures generated on slopes consisting of sedimentary rock ranged from 21 m^2 to 2,572 m^2, with an average of 437 m^2. The main types of erosion and slope failures in sedimentary rock were shallow landslides resulting from the infiltration of rain water into slopes (**Fig. 7**), deep-seated landslides resulting from groundwater between sedimentary rock, and the volcanic ash and volcanic pumice layer combined with an influx of rain water (**Fig. 8**). A part of the sedimentary rock has weathered due to the effect of groundwater. The area of slope failure caused by deep-seated landslides was above 2,000 m^2. Deep-seated landslides showed a large value compared with other types of erosion and slope failures within the noted ranges. This type of slope failure caused a large-scale sediment-related disaster and four deaths in Tarumizu City (Taniguchi et al., 2005).

The areas of slope failures on granite ranged from 101 m^2 to 670 m^2, with an average of 357 m^2. The main types of erosion and slope failures were the same as those on Ito pyroclastic flow deposits (**Fig. 9**).

Acknowledgements

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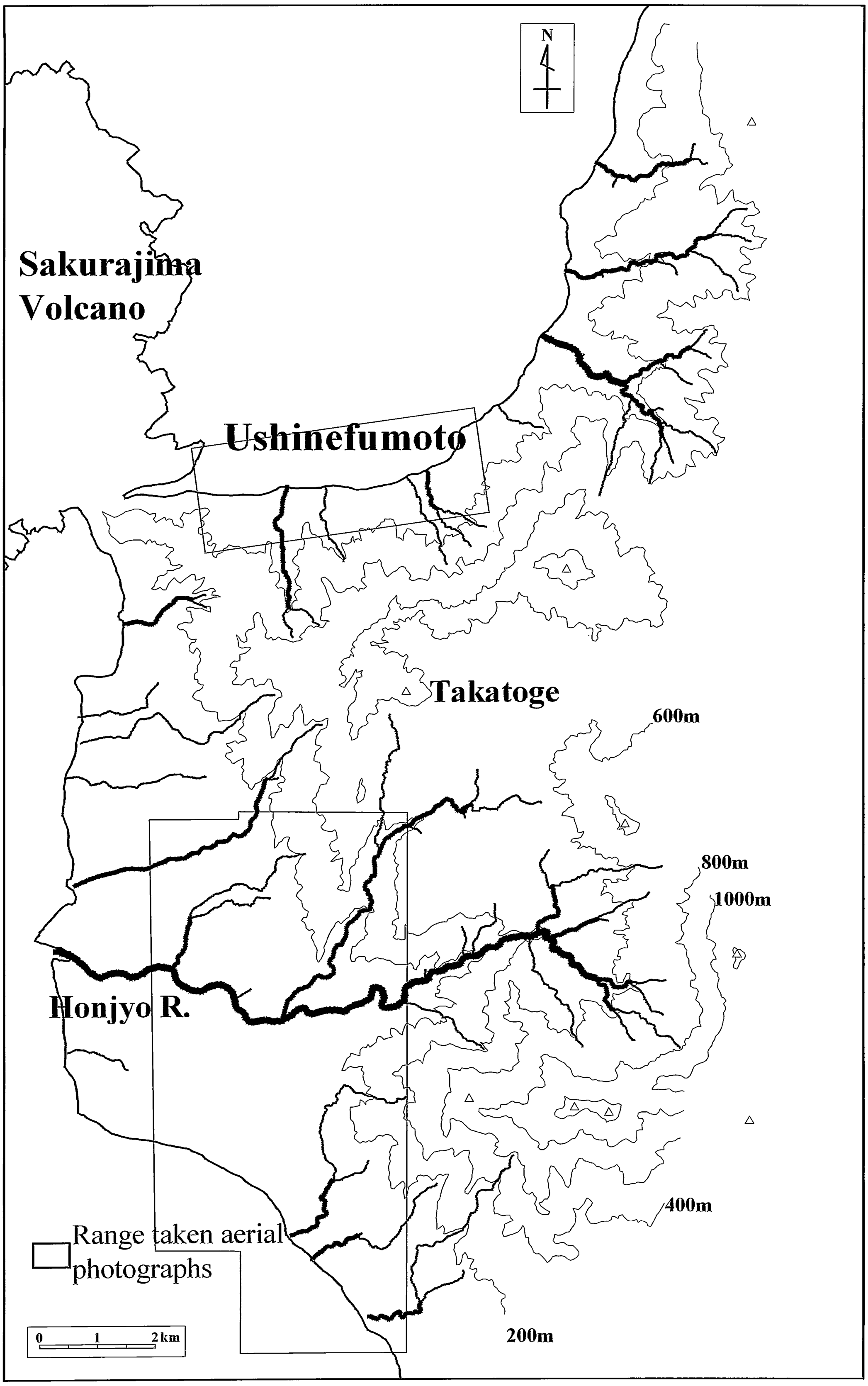

Fig. 1 Location of the study area.

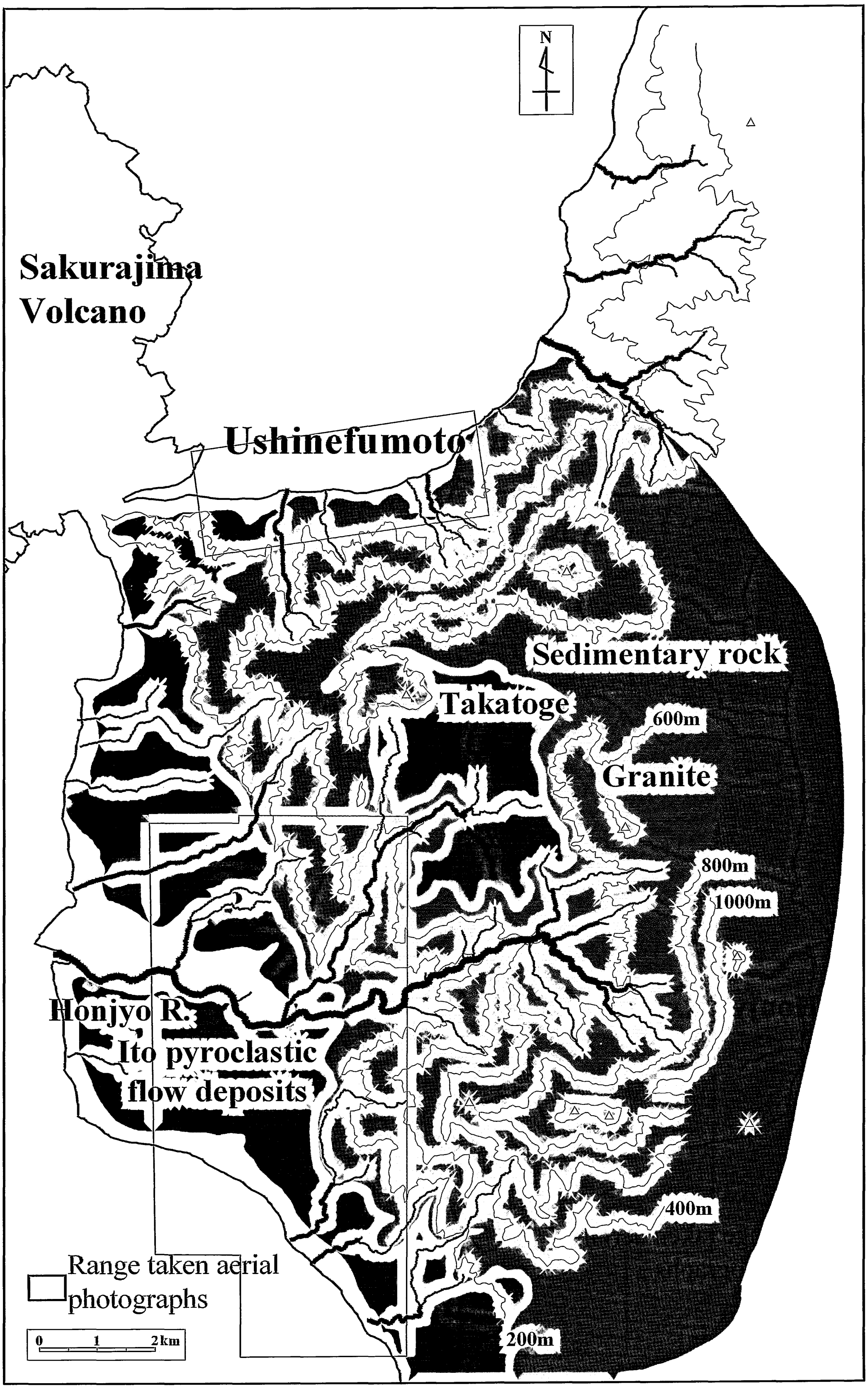

Fig. 2 Superficial geological map of the study area.

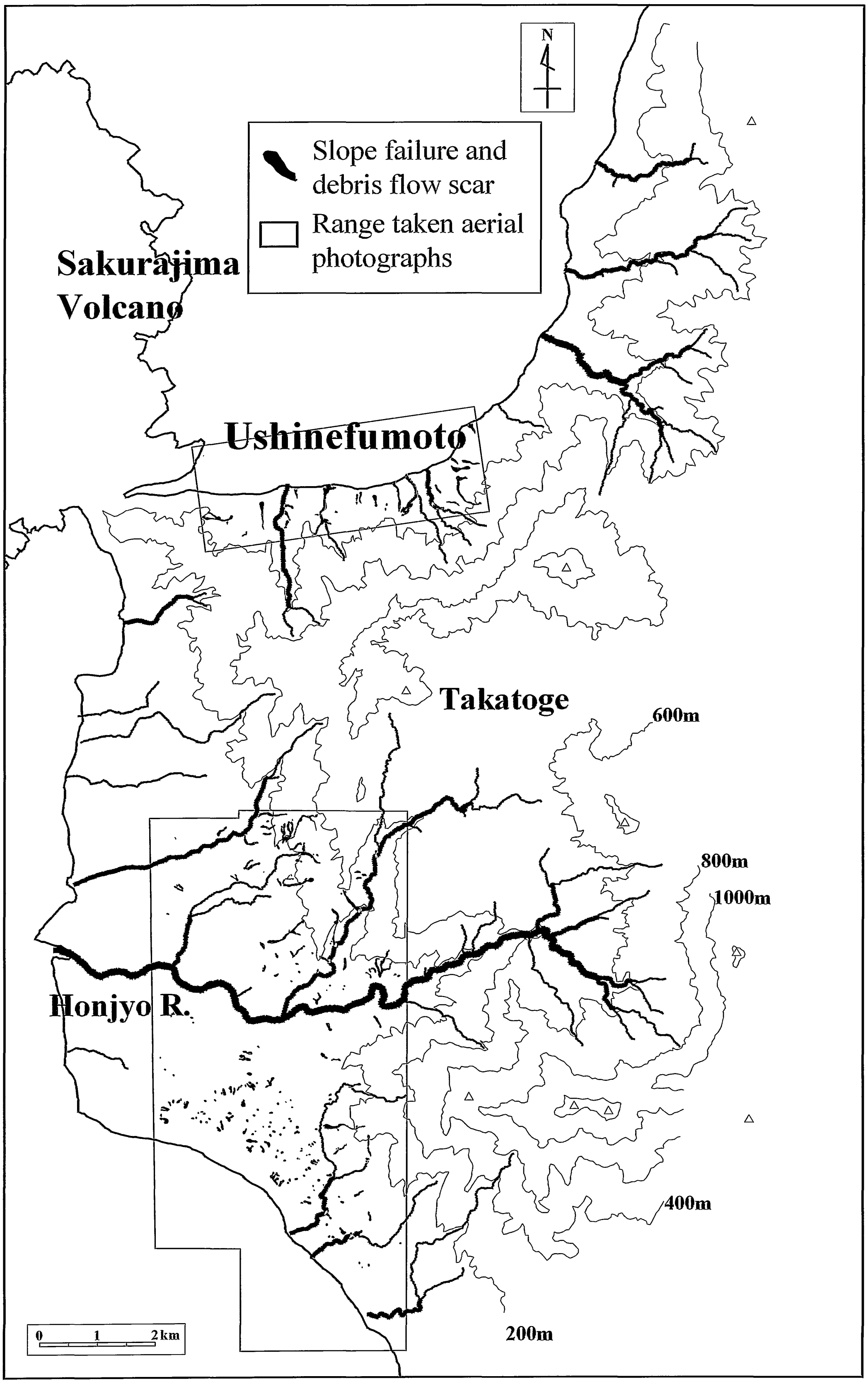

Fig. 3 Chart showing the distribution of slope failures and debris flow scars made up from aerial photographs taken after typhoon Nabi and within the ranges enclosed with a solid line in Fig. 1.

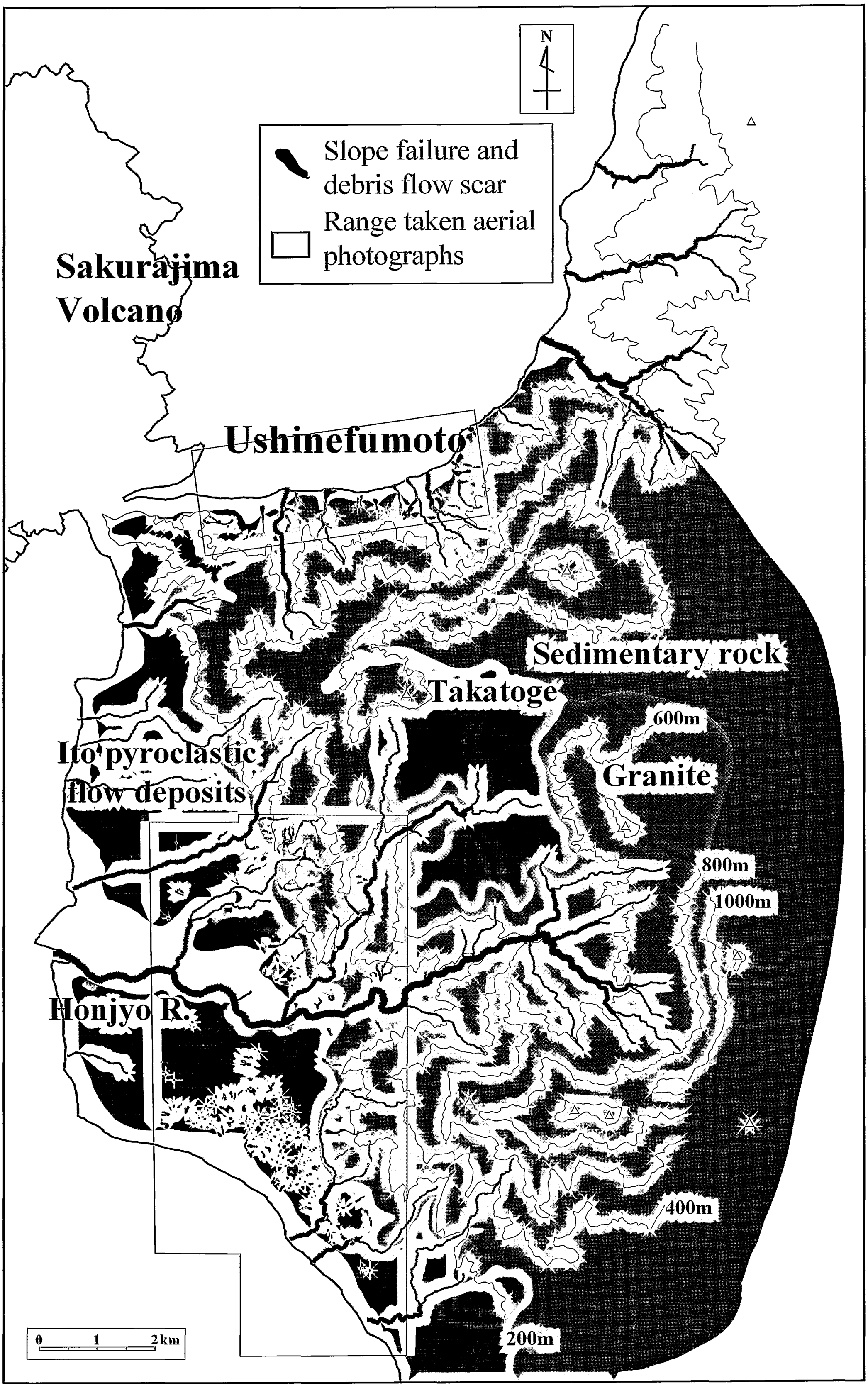

Fig. 4 Chart of the distribution of slope failures and debris flow scars made up from a combination of aerial photographs taken after typhoon Nabi and the superficial geological map.

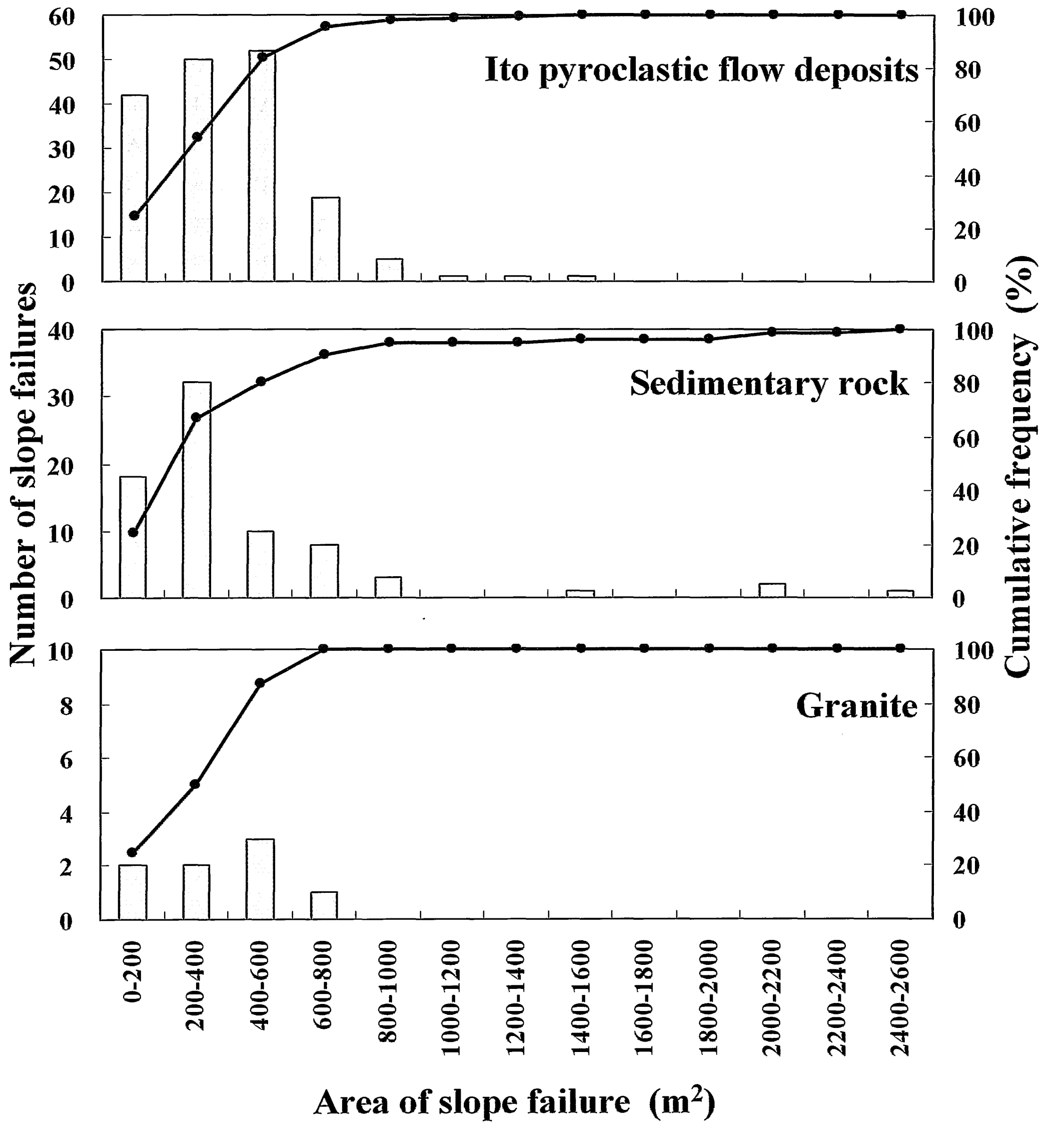

Fig. 5 Frequency distributions of area of slope failure for each geological division within the ranges enclosed with a solid line in Fig. 1.

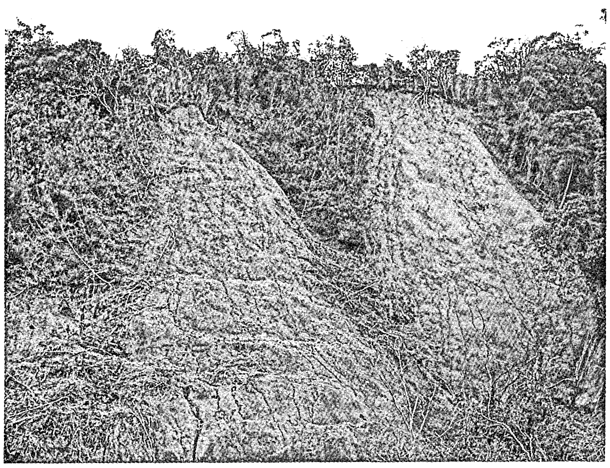

Fig. 6 State of a shallow landslide generated on a Ito pyroclastic flow deposit slope.

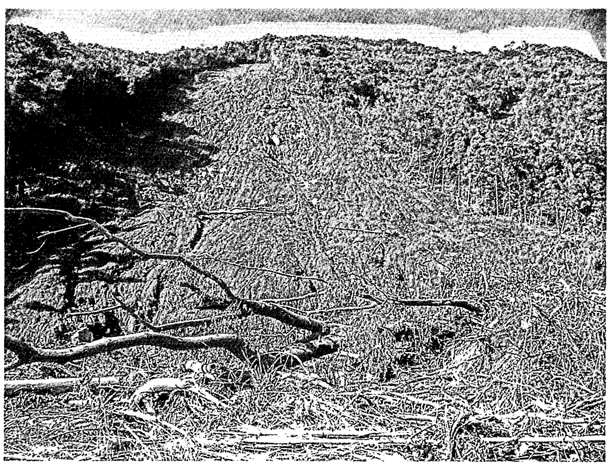

Fig. 7 State of a shallow landslide generated on a sedimentary rock slope.

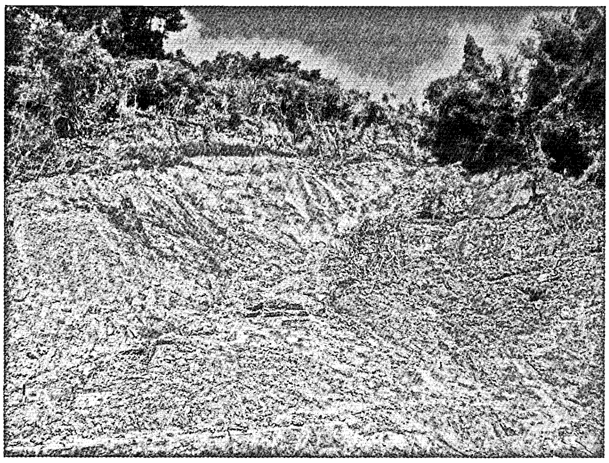

Fig. 8 State of a deep-seated landslide generated on a sedimentary rock slope.

Fig. 9 State of a shallow landslide generated on a granite slope.

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2005年９月の台風14号に伴い垂水市で発生した斜面崩壊の分布と特徴

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要　旨

鹿児島県垂水市において，2005年９月の台風14号に伴い発生した斜面崩壊の分布と特徴を明らかにするため，現地調査および空中写真判読を行った。得られた結果は以下の通りである。

(1) 調査対象区域においては，多数の斜面崩壊が急斜面で発生していた。さらに，斜面崩壊が土石流化したものも確認された。調査対象区域内でみられた侵食・斜面崩壊のタイプとして，シラス，堆積岩および花崗岩の斜面における雨水の浸透による表層崩壊，シラスおよび花崗岩の切り取り法面，斜面肩部および崩壊跡地上部の斜面における雨水の浸透による崩壊，さらに堆積岩の斜面とその上部を覆う火山灰および軽石層において，浸透した雨水と地下水の集中，地下水圧の上昇に起因した深層崩壊が挙げられる。

(2) 調査対象区域においては，シラスの斜面で発生した斜面崩壊の面積は27～1,487m^{2}の範囲（平均390m^2），堆積岩の斜面で発生した斜面崩壊の面積は21～2,572m^{2}の範囲（平均437m^2），花崗岩の斜面で発生した斜面崩壊の面積は101～670m^{2}の範囲（平均357m^2）であった。調査対象区域において発生した斜面崩壊の面積の約80%が600m^{2}未満であった。堆積岩の斜面とその上部を覆う火山灰および軽石層において，浸透した雨水と地下水の集中，地下水圧の上昇に起因して発生した深層崩壊は，調査対象区域においてみられた他の侵食・斜面崩壊のタイプに比べ大きな規模を示した。

キーワード：2005年９月の台風14号，鹿児島県垂水市，斜面崩壊