Recurrence Interval of Shallow Landslide on Forested Steep Slope in Yakushima Island

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ABSTRACT
Shallow landslide, rapid sliding of topsoil or topsoil-weathered subsoil, is repeated periodically at a same site as the previous landslide scar on steep hill slope covered with forest vegetation through natural reforestation and soil-debris accumulation. A purpose of this study is to estimate the recurrence interval of shallow landslide at the same site on steep hill slopes in Yakushima island. Field work for recognition of landslide scars and Koya pyroclastic flow deposits of 6300 years B.P. was carried out at the survey sites. Each landslide scar was dated using tree age of Cryptomeria japonica as indicator plant.

The landslide recurrence interval is estimated to be approximately at least 1000 to 1400 years from the age of the oldest scar on the steep hill slopes at the survey sites. It is probable that the landslide recurrence interval makes shorter the life span of Cryptomeria japonica on the steep slopes.

Key Words: shallow landslide / landslide recurrence interval / topsoil / Cryptomeria japonica / Yakushima

Landslide on a hillslope is roughly classified into two types, shallow landslide, sliding of surface materials and deep landslide, sliding of deep weathered bedrocks. The shallow landslide which is rapid movement of topsoil or topsoil-weathered subsoil with the thickness of 0.5 to 2 m, recurs at a same site as the previous landslide scar on steep hillslope as a principal factor of slope development through revegetation and soil formation in forested drainage basin under the warm and humid climate (Shimokawa, 1984; Dietrich & Dunne, 1978; Shimokawa et al., 1989). This research aims at estimating recurrence interval of the landslide at the same site on the steep hillslope consisting of granitic rock in Yakushima island.

The landslide takes the slope site off the vegetation cover as well as the topsoil and weathered subsoil. So it is assumed that the recurrence interval of landslide is related to residence time of the soil and dynamics of the forest vegetation including Cryptomeria japonica on the steep hillslopes in the Yakushima island.

AN OUTLINE OF RESEARCH SITES

Yakushima, a mountainous island with the circumference of 105 km and the area of 500 km², is located at a distance of 130 km to the south direction of Kagoshima city, southern part of Japan. High peak mountains including Miyanoura-dake peak of 1935 m in height are situated in the central part of the island. The geology is composed of Miocene Yakushima granite which occupies the greater part of the island, and Palaeogene Kumage group which is distributed around the island. A set of two joint systems with the strike of NW-SE and NE-SW and the steep dip of 70 to 80 degrees and of a joint system with the gentle dip of around 30 degrees is well developed in the granite. The drainage network shows trellis pattern, controlled by the joint systems. An average annual precipitation is about
4000 mm in the lowland along the coast and is more than 8000 mm in the mountainous area.

The field survey was carried out at three small tributary basins of R. Koyoji, R. Kuromi and R. Shiratani (Fig. 1). The Koyoji- and the Kuromi research site are situated in a range of 1100-1300 m and 850-1400 m above sea level, southwestern part of the island. The Shiratani research site is situated in the range of 850-1100 m, the northwestern part. The slopes at the three sites are steep with the gradient between 20 and 50 degrees. Main species of the forest vegetation are Cryptomeria japonica, Tsuga sieboldii, Abies firma, Trochodendron aralioides, Stewartia monadelpha, Rhododendron tashiroi and Illicium anisatum.

**METHOD FOR ESTIMATION OF LANDSLIDE RECURRENCE INTERVAL**

The younger and older landslides scarred on the steep slopes in the catchment were recognized based on observation of micro-landform of the slopes such as scarp and measurement of soil depth by steel stick. The landslide scars were dated by dendro- and tephra-chronology using tree age and Koya pyroclastic flow deposits of 6300 years B.P. erupting from Kikai volcano as indicator.

A vegetation survey was done on the several landslide scars at the two research sites to select the indicator tree plant for dating of the landslide scar (Shimokawa et al., 1984). A sort of conifer trees, Cryptomeria japonica was dominant species of the pioneer tree plants on the two young scars with age of 6 and 37-40 years as of 1985. The population of Cryptomeria japonica was high density, being 4 to 20 in number per square meter on the landslide scar of 37-40 years in age. It was supported that Cryptomeria japonica began to invade on the scar just after landslide judging from its maximum tree age. On the scar of about 180 years in age Cryptomeria japonica was one of the dominant trees with the population of about 20 per a scar. So Cryptomeria japonica was used as an effective indicator for dating of the landslide scar.
SPATIAL DISTRIBUTION OF KOYA PYROCLASTIC FLOW DEPOSITS

Fig. 2 is a map showing spatial distribution of the Koya pyroclastic flow deposits on the slopes in the small catchment, Kuromi research site. This figure was made based on the observation of soil profile at 67 points. The pyroclastic flow deposits of orange color with the thickness of 0.3 to 1 m were usually observed under A horizon of soil profile, covering widely the gentle ridge slope less than 20-30 degrees in gradient. In contrast the deposits are almost never observed on the steep slope of more than 30 degrees in gradient excluding a partial distribution on the gentler convex slopes. This indicates that almost all the deposits on the steep slopes were eroded by landslide erosion during the past 6300 years. In the other words the landslide recurrence interval on the steep slopes is less than 6300 years in this research site. The tephra-chronology by only the Koya pyroclastic flow deposits in the research site, however, is not effective for the estimation of the landslide recurrence interval.

LANDSLIDE CHRONOSEQUENCE AND RECURRENCE INTERVAL IN A SMALL CATCHMENT

The landslide scars of 98 and 102 in number were recognized at the Koyoji and the Shiratani research
site, respectively. The major part of scars have been formed by shallow landslide and the minor part by sliding of rock slope along the joints on the torrential side slope and cliff. Fig.3 shows a example of the spatial distribution of the landslide scars at the Koyoji research site (Shimokawa et al., 1984). The scars nearly cover all the research area except ridges and spurs, although each scar is small-scale with area of less than 1000 m$^2$ and sliding depth of 0.5 to 1.5 m. At some slope parts the younger and older landslide scars overlap each other.

The chronological ages of 49 scars (50%) for the Koyoji research site and of 41 scars (40%) for the Shiratani research site in which Cryptomeria japonica was one of the dominant plants, were dated using the tree age of Cryptomeria japonica as indicator. The approximate age ranges 38 years of the youngest scar to 980 years of the oldest one at the Koyoji research site and 64 years to 1350 years at the Shiratani research site as of 1985. The landslide has occurred at an interval of several decades to one hundred and several decades years in the small catchments. The recurrence interval at the same slope site as the previous landslide scar is estimated to be at least about 1000 years at the Koyoji research site and about 1400 years at the Shiratani research site from the age of the oldest landslide scar.

**TREE AGE COMPOSITION OF Cryptomeria japonica IN A SMALL CATCHMENT**

It is assumed that the landslide recurrence cuts down the life span of Cryptomeria japonica on the
steep slopes. Fig.4 shows the frequency distribution of the stem circumference length at the height of 1 to 2 m above the ground on ridges and steep hillslopes at the Koyoji research site (Shimokawa et al., 1984). The greatest length of stem circumference on the steep hillslopes is shorter than that on the ridges. Estimating from a relationship between stem circumference length and tree age, the longest life span was 900-1000 years on the steep hillslopes and around 2000 years on the ridges, the Koyoji research site.

CONCLUSION

The field survey was done to estimate the landslide recurrence interval at the same site as the previous landslide scar at the upper reaches of R. Koyoji, R. Kuromi and R. Shiratani in Yakushima island. The landslide recurrence interval is estimated to be approximately at least 1000 to 1400 years from the dendrochronology of Cryptomeria japonica. It is probable that the landslide recurrence interval makes shorter the life span of Cryptomeria japonica on the steep hillslopes.

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下川悦郎, 地頭篠隆　屋久島の花崗岩急斜面における表層崩壊の周期
山崩れは大きく、斜面の表層を薄く覆う表層土（または風化土）のすぺりによる表層崩壊と、厚い風化層で構成される斜面の深層崩壊の二つに分類される。このうち、温暖多湿の気候下の森林で覆われた流域内の急斜面では、表層崩壊はその跡地における森林植生と崩壊物質としての表層土の再生を通じて、斜面の同じ部位を周期的に繰り返し発生している。この調査の目的は、屋久島の花崗岩からなる急斜面での表層崩壊の周期を推定することである。
島内の小栗子川、黒潮川、白谷川の上流域に位置する小集水域内の急斜面で、6300 年前の喜界火山起源の单斜火砕流堆積物の分布、および表層崩壊跡地の分布とその形成年代について調査した。小集水域内には、深層崩壊流堆積物が分布しないことから、過去 6300 年間に急斜面は少なくとも 1 度は崩れていなかった。また長命の屋久スギを指標植物にして推定した表層崩壊跡地の周期は 1000 年から 1500 年であることが明らかになった。この周期は急斜面のスギの寿命を制限し、スギを含む屋久島の森林植生の維持機構に影響を及ぼすものと考えられる。