Disasters Induced by Sediment Yields －Historical Review－

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Importance of Composite Disasters (複合災害の重要性)

- River flooding has been designed just for precipitation, using the statistical data of rains. Other factors such as volcanic action, land slide, earthquake, etc. have not been considered for the design.
- The other factors produced catastrophic disasters historically in Japan, and therefore, they cannot be neglected.

Types of Composite Disasters

- 1. Heavy rains-induced land-slide produces natural dams, and they eventually collapse to yield flooding. Typical examples are heavy rain induced land slides in Taiwan, 2009 and Japan, 2011, which may be correlated with global warming.
- 2. Deposit of volcanic falls on the ground are eroded by rains to flow into rivers, which aggrade river bed and induce flooding. Eruption of Mt. Fuji（富士山）in 1707 belongs to this type

Continued

- 3. Volcanic eruption and the associated pyroclastic flow（火砕流）generate natural dams, and they collapse to yield flooding. A typical example is the eruption of Mt. Asama in 1793.
- 4. Earthquake-induced land-slide which produces natural dams and flooding. An example is found at Gyoganji river（常願寺川）of Tateyama, Japan occurred in 1858.

Map

Maps of the Historical Disasters in Japan

Mt. Fuji behind Lake Ashi

Mt. Asama: danger in beauty

Mt. Tateyama behind Mikurigaike Pond

Eruption of Mt. Fuji in 1707 and Subsequent Flooding

- A large Houei eruption（宝永噴火）of Mt. Fuji occurred after two large earthquakes, 1703 (Genroku Earthquake, M8.0～8.2) and 1707 (Houei Earthquake, M.8.6～8.7) at Surugawan trough and Nankai trough（南海トラフ）, respectively.
- The eruption blew the mountain body off with a scale of 1 billion cubic meters, and fine ashes were transported toward the east by wind.

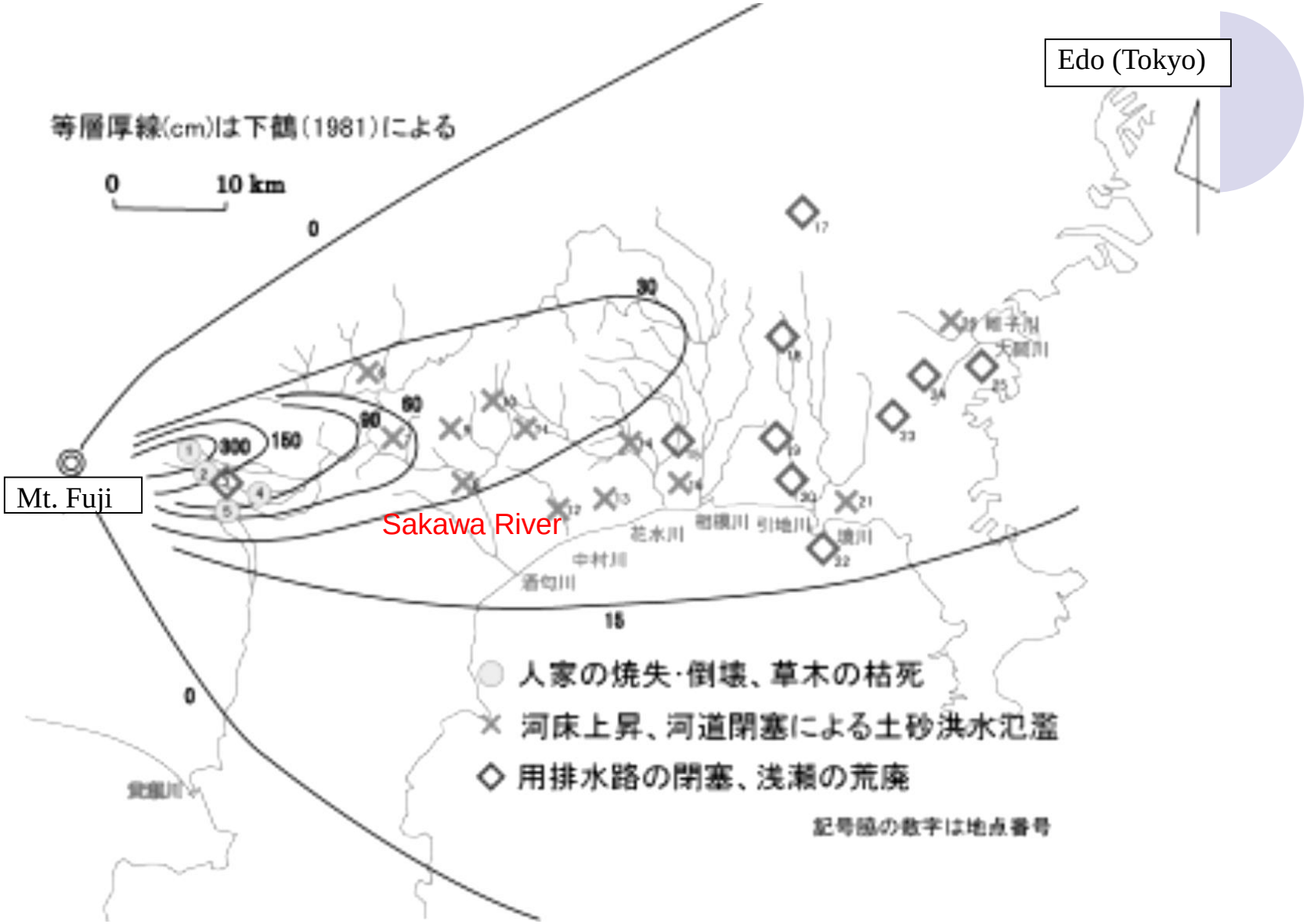


Fig. 1 Spread of volcanic falls toward the east at Houei eruption of Mt. Fuji in 1707 (After H. Sumiya et al., Ref. 1)

Disasters Induced

- These deposited volcanic falls were eroded at rains to be transported to Sakawa river, which induced severe aggradation of the river bed（河床上昇）.
- After the eruption, large flooding occurred in 1708, 1709, 1711 successively, which yielded drastic reduction of rice product in this area. The recovery of the rice production needed almost 90 years after the eruption.

Toward Future

- After the eruption, large flooding occurred in 1708, 1709, 1711 successively.
- A mega earthquake along Nankai trough（東南海沖地震）is anticipated to occur in the near future, and it is warned the danger of huge tsunami along the coast of west Japan. Except for the tsunami, the eruption of Mt. Fuji and the subsequent river flooding also should be considered and prepared.

Eruption of Mt. Asama in 1783 and Long Duration of the Effects on Tone River

- Mt. Asama has a long history of eruptions. 685, 887, 1108, 1281, 1532, 1598, 1721, 1783, before Meiji era started in 1868.
- The largest one called Tenmei eruption（天明噴火）occurred in 1783. Three large pyroclastic flows moved toward the north, destroying villages, killing more than 1400 people. The largest pyroclastic flow reached Agatsuma river (Fig. 2), a tributary of Tone river, and created a natural dam（天然ダム）.

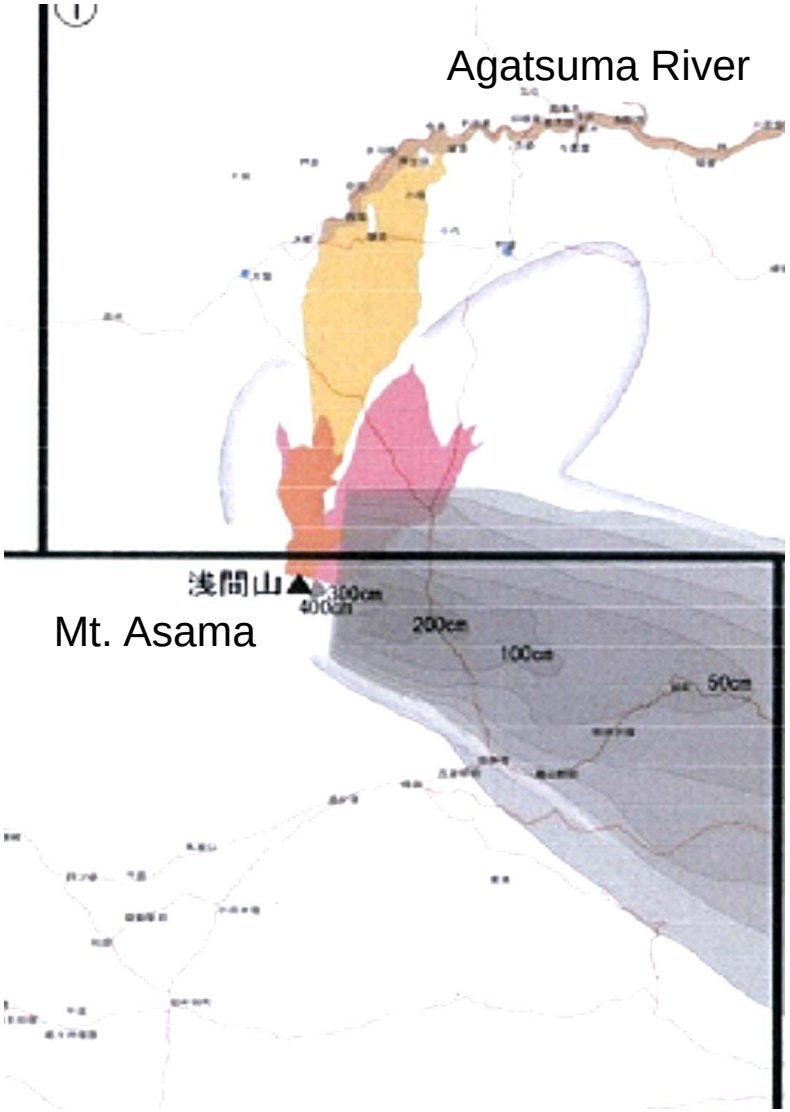
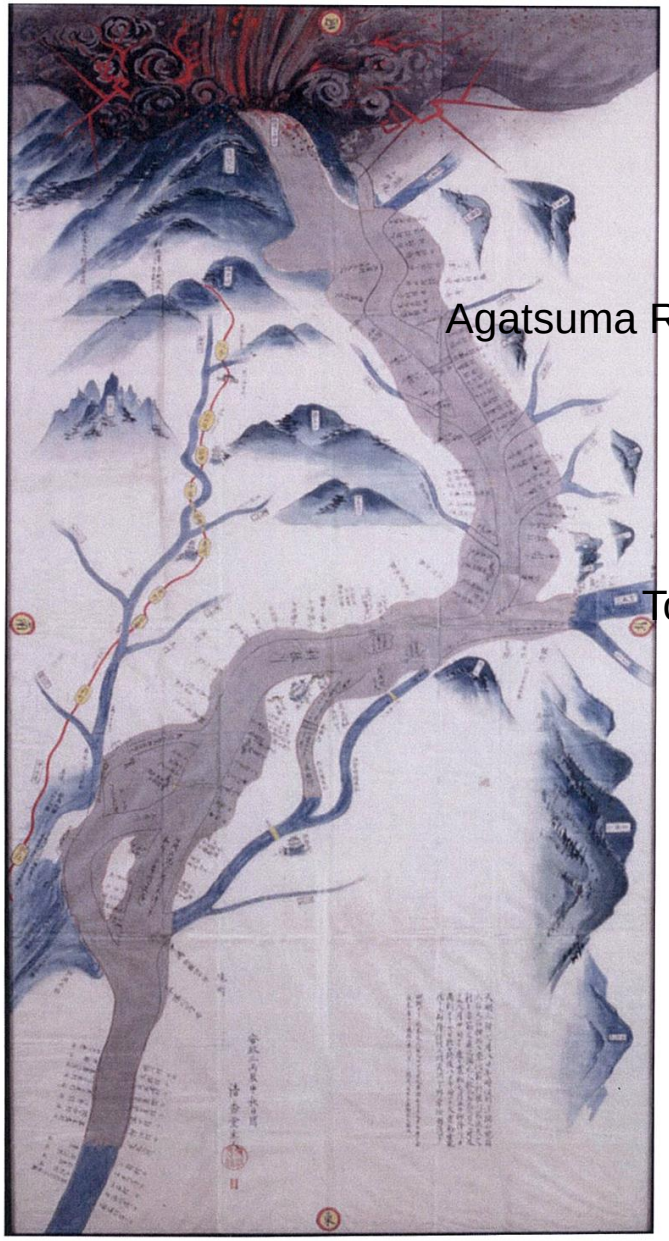


Fig. 2 Pyroclastic flows from Mt. Asama (Ref. 2)



口絵１　「浅間焼吾妻川利根川泥押絵図」（群馬県立歴史博物館所蔵、同フィルム提供）

Fig. 3 Sediment movement and aggradation of bed in Tone river in 1783 (Ref. 2)

火砕流概念図（カシミール3Dにて作成）
群馬・新潟・長野県境、白砂山上空20,000mより俯瞰

A pyroclastic flow reached Agatsuma River formed a natural dam which collapsed.

Subsequent Disasters

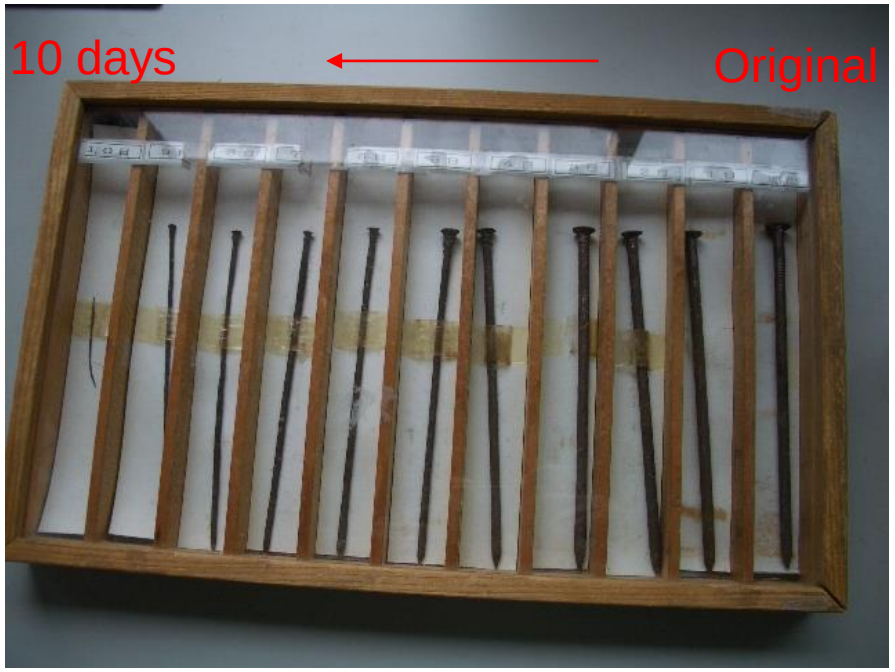
- The dam was eventually collapsed, and the subsequent huge hydraulic wave moved downstream with huge amount of sediment. It is recorded that about 700 dead bodies were found only at Yatotsuka village in Gunma Prefecture.
- The bed of Tone river aggraded by several meters by this event. Three years later in 1786, the largest flood in Edo era occurred, the reason for the disaster was the aggradation of river bed. The flood reached Edo (Tokyo), the depth of inundation in the lower area of Edo was recorded as 3～4.5 m.
- Tone river became devastated for more than 100 years after the eruption, and the floods occurred very frequently (60 times during 1783 and 1843).

A new dam

- The start of neutralization using milk of limestone（セメントミルクによる酸性水中和）allows to construct a new dam at Agatsuma river（吾妻川）, which is effective for the eruption of Mt. Asama as a sabo-dam（砂防ダム）for pyroclastic flow as well as flood control.
- Mitigation of disaster risk in Tone river（利根川）is extremely important, because lost of functions of Metropolitan Tokyo may seriously affect the global economics and politics.

Neutralization using milk of limestone

Construction of dam was impossible due to highly-acid water



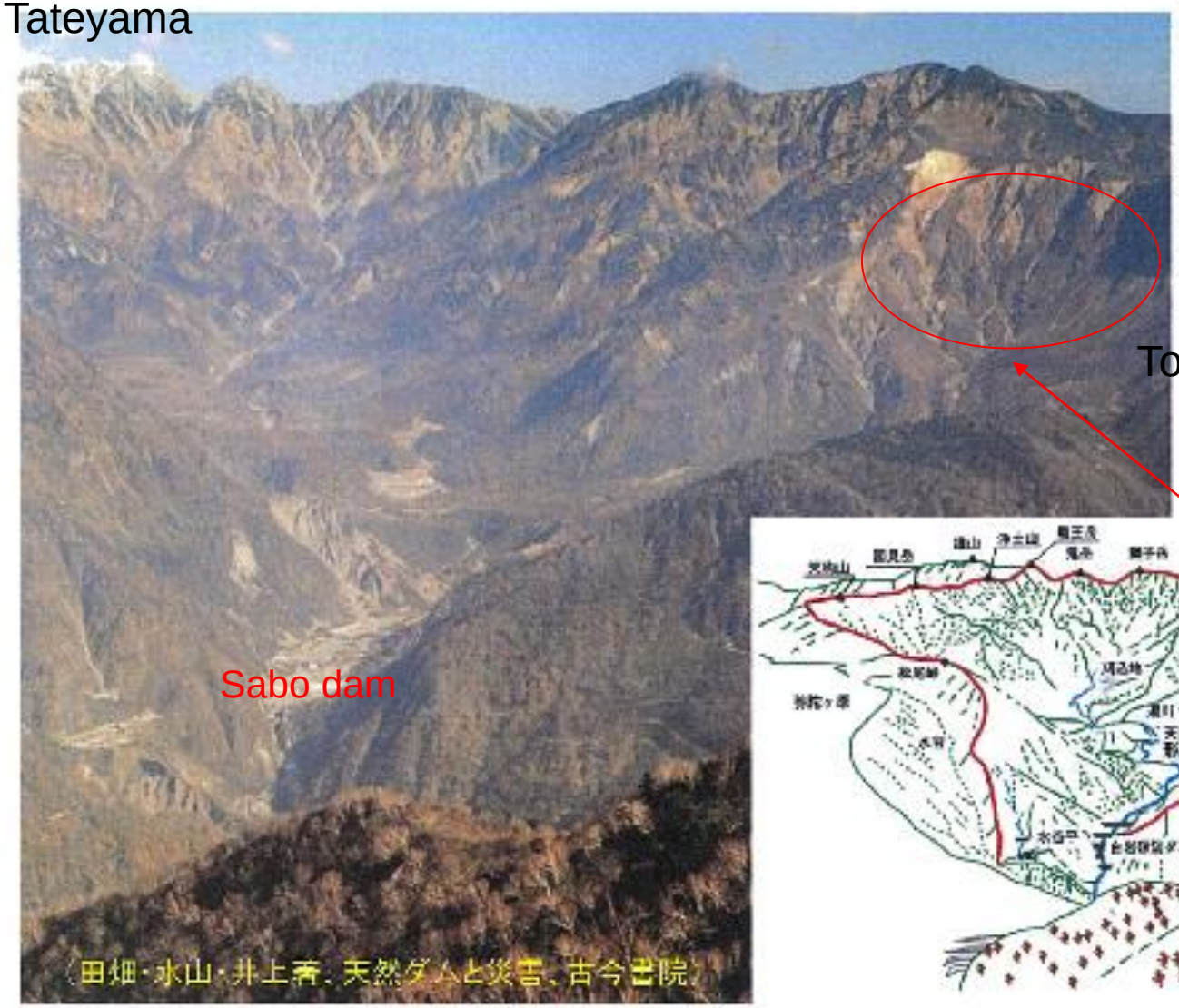
Dissolution of Iron and concrete

Debris Flow Induced by Earthquake and Subsequent Flooding at Tateyama Volcanic Caldera

- On Feb. 26, 1858, an earthquake (Hietsu earthquake, M.7.1～7.2) produced many land slides, among which a land slide termed Tonbi Kuzure in Tateyama volcanic caldera（立山カルデラ）was the largest.
- The land slide produced debris flow, and deposited in the caldera, the volume of which was estimated to be 0.41 billion cubic meters. The debris produced natural dams, the longest of which was 8 km, which stored snow-melt water.

飛越地震　安政五年二月二十六日（1858年4月9日）　M7.0～7.1内陸直下型地震

Mt. Tateyama



Tonbi-kuzure

Tateyama caldera

米の高値、打ちこわし、三日コロリ(コレラ)などが記載。災害が庶民の生活に様々な影響を与えていたことを示す。

Tateyama Caldera

The Japan Sea

Jyoganji River

Toyama

「安政5年常願寺川非常洪水山里変地之模様見取図」
里方図では2階の泥流による変地の模様色分けし、具体的数値で表している

Inundated Areas

Subsequent Disasters

- On April 23, 1858, another earthquake (M 5.7) occurred, which broke the natural dams, yielding flooding and debris flow（洪水と土石流） in the downstream. On June 7, 1858, another natural dam collapsed by static pressure of stored water, and severe flooding again occurred and attacked Toyama alluvial fan.
- Elevation of river bed in Jyoganji river（成願寺川） increased more than 20 m at some places, which made Jyoganji river devastated.

A Dutch Engineer

- A Dutch river engineer, Mr. J. deRijke, came to Japan in 1873 (5 years later of the opening of Japan in 1868). He performed many river training works in Japan to reduce disasters by flooding. Sabo works in Tateyama caldera and river training work in Jyoganji river also started in 1881 by the guidance of Mr. deRijke. He stayed in Japan for 30 years to advise Japanese river training works.

Land-slides and Natural Dams Produced by Heavy Rain in 2011

- Heavy rains occurred in 2011 at Kii Peninsula（紀伊半島）, which induced land-slide and produced natural dams.
- Land-slides produced 17 natural dams. Stored water was discharged by artificial channels（人工排水路）.
- The maximum amount of precipitation almost reached 2,000mm, which is a unusual new record and probably correlated with global warming.
- People lost are 92.

H23台風12号により紀伊半島に形成された天然ダム

国交省近畿地方整備局HPより

Concluding Remarks

- In the modern river training works during the past 130 years in Japan, only rains are considered as external force for planning and design. The reason may be that rains can be treated statistically, which looks scientific and rational.
- Historical review indicates that other factors such as volcanic eruption, earthquake, land-slide, heavy rains, etc. provided catastrophic disasters in the past in Japan, and therefore they cannot be neglected, and are very important in planning and managing rivers.