

Midstream of Kiso river affected by Tensho mega-earthquake

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ABSTRACT

A flood struck the midstream area of Kiso River on August 9, Tensho 14 (1586). This flood has been called "Tensho river flood". The midstream alignment of Kiso River has been altered at a range of 20km length during Tensho river flood.

This paper presents the results of study on the activities of faults and the influence of ground changes derived from the Tensho mega-earthquake. Also, this paper presents the possibility that those watercourse changes of old Kiso River during Tensho period was due to the Tensho megaearthquake rather than the Tensho river flood.

Introduction

Kiso River, Nagara River and Ibi River, which is called "Kiso three-rivers", are flowing through the Nobi Plain including Nagoya city as shown in Fig.1. The Kiso three rivers repeated the largescale watercourse change, the alluvial action, etc. and then, the said three rivers had formed a vast Nobi alluvial plain.

When the alluvial lowlands in the Nobi Plain had been cultivated by people during the historic times, the flood damage occurred often at the area of midstream and down-stream of the Kiso three rivers. Those flood damages became to be recorded.

It is known that a historical flood which is called the Tensho river flood at Kiso River Had changed a part of Kiso River's watercourse. The Tensho river flood occurred in 1586, but it was not so large in scale to regard as the fundamental cause of the water-course change at Kiso River(Iida,1984). As for the watercourse change of Kiso River, the Tensho mega-earthquake, which occurred in about seven months before the Tensho river flood, should be paid attention rather than the influence by the Tensho river flood.

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Figure 1. Position of the Nobi Plain in the Japanese archipelago.

Old Kiso River's watercourse distinguished from the land use

A flood occurred in the midstream area of Kiso rive flowed through Nobi Plain on August 9th in 1586 (Tensho 14). It is called the Tensho river flood because it happened in the Tensho era (1573 - 1592). On that occasion of Tensho river flood, the watercourse of Kiso River had made a big change in the range of about 12 km.

The old watercourse of Kiso River before 1586 was estimated as shown in Fig.2 which was created based on a topographic map made in 1891 (K.S.R.C,2004). The old terrain was left in the topographic map made in the 1890s because the ground development in the 1890s had not progressed like present.

The old watercourse of Kiso River might flow to the northwest around Mt. Mii and connected to Nagara River in Sunomata while meandering large. It is clear that the private houses stand on the natural levee along the old watercourse of Kiso River and the old riverbed is used as paddy field.

Change of Kiso River's watercourse distinguished from old document and place name

The old watercourse of Kiso River before 1586 had branched complicatedly as shown in Fig.3(Nakajima,T.Nakajima,K.1963). Among those branches, two branches of the northern channel and southern channel were considered as the main watercourse of old Kiso River. The northern channel of old Kiso River was blocked during the Tensho river flood. As a result of the Tensho river flood, the flowing water of old Kiso River was concentrated into the southern

channel which has become today's main watercourse of Kiso River. Old Kiso River formed a border between Mino province and Owari province in Tensho era similar as the present Kiso River makes today's prefectural border between Gifu prefecture and Aichi prefecture. Therefore, the northern channel of old Kiso River has been called Sakai River which means the river of border.



Figure 2. Kiso passage before and after the Tensho river flood(1586).

The governor of Owari province might secure the maximum territory by setting the old border for Mino province along the northern channel, Sakai River, instead of along the southern channel. However, when the northern channel, Sakai River, was lost due to the Tensho river flood, Owari province was forced to reset the old border for Mino province to a new border along the southern channel of Kiso River which had penetrated into Haguri district and Nakajima district of Owari province. Therefore, the right bank of southern channel of Kiso River was occupied by Mino province after Tensho river flood and both of Haguri and Nakajima district has been divided into two provinces. As a result, the district names of Haguri and Nakajima have remained in the both of Mino and Owari province.

Judging from the above-mentioned transition of the place names, the watercourse of old and new Kiso River shown in Fig.2 will be reasonable in most.



Figure 3. Kiso passage of Tensho14(1891) previous.

Relation between watercourse and terrain inclination

The watercourse of Kiso River is freed from a ravine zone at the vicinity of Inuyama castle. Also, the complicated history of watercourse in the downstream of Kiso River can be recognized from Fig.2. In the Pleistocene epoch, deposition and erosion had been repeated on the Nobi Plain due to a change of the sea level. A wide Inuyama alluvial fan of about 12 km radius was formed in the Nobi Plain at the Postglacial Age after the Pleistocene. Kiso River gave a great influence on the terrain formation in the region shown in Fig.2. While Kiso River had left plural branches on the alluvial fan during the historic times, the mainstream had gathered into two watercourses to the west at the north side of the alluvial fan, which were the northern channel and southern channel of Kiso River.

The watercourse of the northern channel had been largely meandering, which existed before the Tensho river flood. Therefore, the catchment area along the northern channel seemed to have always been exposed to the crisis of the flood. In addition, the unstable status had been followed at the Kawashima area in the southern channel because multiple sandbars had been repeatedly formed after the Tensho river flood. Because the terrain inclination in the midstream basin was looser than the terrain inclination in the upper stream reaches and lower stream basin, the midstream basin of Kiso River including the Inuyama alluvial fan had been always unstable due to the repeated flood and sedimentation.

When the terrain inclination of the southern channel after Tensho river flood is studied, it is noteworthy that the watercourse of the southern channel extends in a straight line from Kasamatsu town hall to the southwest direction as shown in Fig.2. There is no meander in the watercourse at the above-mentioned straight part and the flow at this part seems to be more quantity and faster velocity. It has come to the inference that the main reason of watercourse alteration into the southern channel is due to a change in the terrain inclination.

Scale and cause of the Tensho mega-earthquake

The Tensho mega-earthquake was a massive earthquake occurred at the Chubu region in Japan on 18th January 1586 (= 29th November, Tensho 13). The Tensho mega-earthquake was also called Nagahama mega-earthquake in Shiga prefecture, Hakusan mega-earthquake in Ishikawa prefecture and Gifu prefecture, Kibune mega-earthquake in Toyama prefecture, Tenyu mega-earthquake in Mie prefecture, etc. The focal region and magnitude of the Tensho mega-earthquake has not been clear yet. Because, the Tensho era was the end of Warring States Period and the Shogun administration did not function to collect the information of calamity. Therefore, the old various records of the earthquake written by Samurais, monks, oracles, etc. were collected and presumed a distribution of seismic intensity etc. (see Fig.4) as below (Usami,1994).



Figure .4 Seismic intensity distribution diagram of Tensho earthquake.

The focal region of the Tensho mega-earthquake exerted on the wide range of Kinki, Hokuriku and Tokai regions, namely the present Fukui, Ishikawa, Aichi, Gifu, Toyama, Shiga, Kyoto, Nara and Tokushima prefectures. It has been reported a tremendous damage to these areas. By comparing the range of damage, the Tensho mega-earthquake is estimated to exceed the Nobi earthquake (M8.0 - 8.4 in Richter scale) in 1891.

There is a possibility that the plural faults moved simultaneously in the Tensho mega-earthquake. There are several views about the hypocenter fault of Tensho mega-earthquake as Shogawa fault in Hida province, or Adera fault in Mino province, or Yoro fault in Mino province and Ise Bay fault, or those plural faults.

Two historical seismic-activities of Yoro fault were confirmed by the geological investigation

performed in 1998(Nakamura et al.,1987). Since the latest seismic activity in the Yoro fault was after the15th century, it is possible to judge that this dislocation of Yoro fault was more likely to be one of hypocenter fault for Tensho mega-earthquake.

Relation between fault activity and the watercourse change

The Yoro fault is located at the western edge of Nobi Plain. This fault is regarded as one of the active faults related to the Tensho mega-earthquake (1891) as well as to the Tenpyo earthquake (745). This fault runs from north-northwest to south-southeast direction. The Yoro Mountains are located along the west side of Yoro fault, where are still rising. On the other hand, the Nobi Plain is located at the east side of Yoro fault, where is still sinking as shown in Fig.5 (Suzuki,Sugito,2010). The ground deformation of Nobi Plain, which is drawn into the Yoro fault, is called "Nobi tilting movement". It is recognized for the Kiso three rivers to be gathered near the Yoro fault because of the ground deformation by Nobi tilting movement.



Figure 5. Active fault and Kiso Three Rivers in Nobi Plain.

Judging from phenomena of (1) Inuyama alluvial fan formed by old Kiso River in the Postglacial, (2) meandering old watercourse before the Tensho river flood, (3) sandbars formed repeatedly in Kawashima area after the river floods and so on, the river inclination was loose and the watercourse was difficult to be fixed in the midstream of Kiso River. Since Yoro – Ise Bay faults had stimulated the ground sedimentation at Nobi Plain by the Tensho mega-earthquake, the southern channel of old Kiso River, which was oriented straight toward Yoro – Ise Bay faults, was assumed to become a dominant watercourse of old Kiso River.

In other words, the northern channel of old Kiso River had been just kept after the Tensho megaearthquake. However, the riverbeds and natural levees along old Kiso River had been significantly deformed by the successive aftershocks of mega-earthquake and by the Tensho river flood occurred 7 months later than the mega-earthquake. As a result of the abovementioned deformation, the southern channel of old Kiso River has become the main watercourse of Kiso River, which continues until today.

Conclusions

The following conclusions are obtained after consideration of the watercourse changes of old Kiso River by Tensho river flood and the cause of the Tensho mega-earthquake:

1) Since the Tensho river flood was a medium-sized flood, it is hard to think that it became the cause of a large-scale change of watercourse.

2) The watercourse of old Kiso River before Tensho river flood can be estimated from the transition of land use and place name. In response to the Tensho river flood, the northern channel of old Kiso River was blocked and the southern channel of old Kiso River became a main watercourse of Kiso River, until today.

3) Judging from phenomena of meandering Sakai River and sandbars in Kawashima area, the midstream of Kiso River is loose terrain gradient. However, the southern channel has become the main watercourse of Kiso River, has a bit steep gradient and flows to the southwest in a straight line.

4) Tensho mega-earthquake was an inland earthquake with the estimated Magnitude of about 8.0 in Richter scale, which was occurred in 1586 due to the movement of plural active-faults. Yoro fault was likely to be one of the source fault.

5) Yoro fault with influence on the flow path of the Kiso three rivers has advanced the Nobi tilting movement by the Tensho mega-earthquake. There is a possibility that the Nobi tilting movement has been expanded the southern channel of Kiso River.

6)As for the watercourse change of old Kiso River during Tensho era, the Tensho river flood was only a trigger, but the Tensho mega-earthquake occurred about 7 months before the river flood should be the fundamental cause of the watercourse change.

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