A DRASTIC CHANGE OF LANDFORMS CAUSED BY A HUGE PYROCLASTIC FLOW IN THE HIDA DISTRICT, CENTRAL JAPAN

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Abstract Six huge pyroclastic flow eruptions from the Hida Mountains occurred in and around the Takayama Basin during the Plio-Pleistocene. These eruptions were related to the uplift of the Hida Mountains and it was expected that these would have markedly changed the landforms of the area. However, there is a scarcity of information on the details of this. In this study, we describe the landforms of the area before and after the eruption of the Kamitakara Pyroclastic Flow during the Middle Pleistocene in the southwest of the Hida Mountains. In the northeast of the Takayama Basin, the Uwano Mudflow Deposit and the Kiriyama Gravel Bed which show the flow path of the "paleo-Ausa River", are covered with the Kamitakara Pyroclastic Flow Deposit. We searched for corresponding deposits to these from the Takayama Basin to the Hida Mountains. There was a valley through which the "paleo-Azusa River" flowed from Kamikochi into the Takayama Basin before the eruption of the Kamitakara Pyroclastic Flow. The cross section of this valley was very wide. The "paleo-Azusa River" was later forced to change its path by the deposition of the Kamitakara Pyroclastic Flow.

Key words: Kamitakara Pyroclastic Flow, paleo-Azusa River, change of landforms, Hida district, Middle Pleistocene

1. Introduction

There are many volcanoes -for example the Yakedake Volcano, the Norikura Volcano, the Ontake Volcano and the Hakusan Volcano -in the Hida Mountains adjacent to the Takayama Basin, central Japan (Fig. 1). This indicates that volcanism has been very active in the area. Previous studies have shown that huge eruptions including six pyroclastic flows occurred in this area during the Plio-Pleistocene. Harayama (1999) pointed out that these volcanic activities are related to the uplift of the Hida Mountains after the Pliocene. However, the change of landforms by a large pyroclastic flow has not been documented well. Since the deposition of a large pyroclastic flow over the river valley formed a flattened surface, it is expected that pyroclastic flows would have changed the landforms widely. The

reconstruction of the landforms that existed before the pyroclastic flow eruptions, give new information on the uplift of the Hida Mountains before the Middle Pleistocene.

In this study, we outline the landforms existing before and after the eruption of the Kamitakara Pyroclastic Flow, which erupted at 0.58-0.69 Ma from the Kaisho source vent located in the southwest of the Hida Mountains to the northeast of the Takayama Basin. The distribution and stratigraphy of the Kiriyama Gravel Bed and the Uwano Mudflow Deposit, which are the key to reconstruct the landforms before the eruption of the Kamitakara Pyroclastic Flow, were investigated and those of the Kamitakara Pyroclastic Flow were also investigated to show the change of the landforms by it.

2. Study Area, Stratigraphy of the Early-Middle Pleistocene in the northeast Takayama Basin and "the paleo-Azusa River"

Figure 1 shows the schematic of the area studied. The Hotaka Mountains are located in the northeast of the Yakedake Volcano, and they consist of the Hotaka Andesite, which

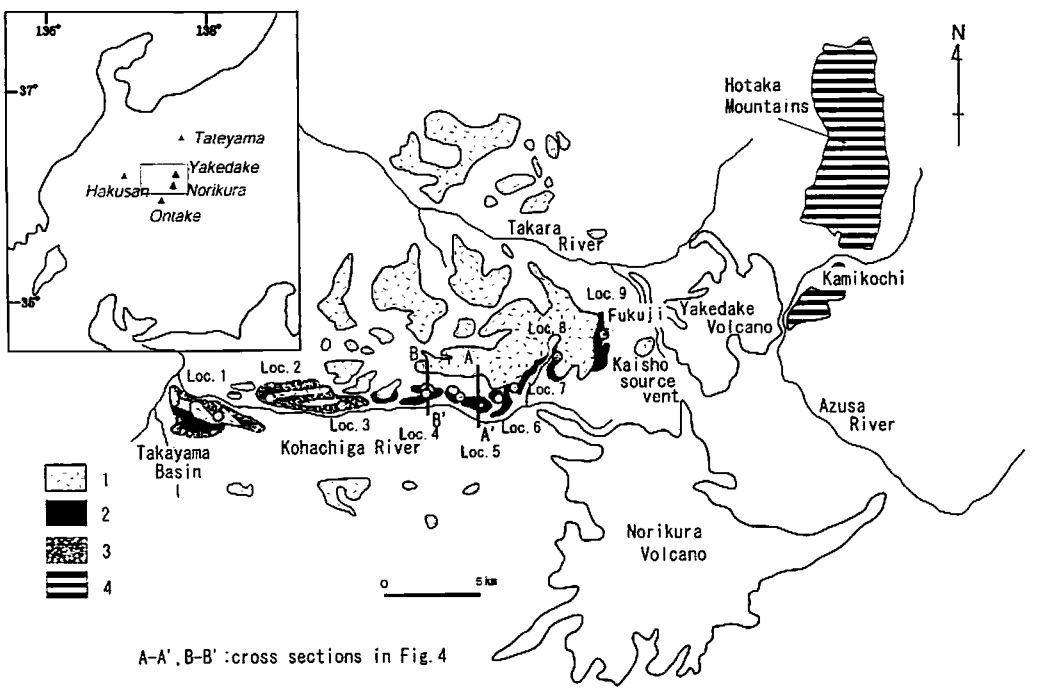

Fig. 1 Geological map and locality points.
1. Kamitakara Pyroclastic Flow Deposit
2. Uwano Mudflow Deposit
3. Kiriyama Gravel Bed
4. Hotaka Andesite

Locality points as following: Loc.1. Uwano, Loc.2. Kiriyama, Loc.3. Houriki, Loc.4. Itando, Loc.5. Miyougo, Loc.6. Sode, Loc.7. Hatahoko, Loc.8. Choshidani, Loc.9. Osobudani

characteristically contains large phenocryst of the plagioclase. The Azusa River flows through the Kamikochi area on the southeast of the Hotaka Mountains and changes the flow direction at the Yakedake Volcano, flows to the east, into the Matsumoto Basin. On the other hand, the Kohachiga River begins on the north side of the Norikura Volcano and flows to the west, into the Takayama Basin. In the north of the Kohachiga River, the Kamitakara Pyroclastic Flow Deposit (KPF) is distributed widely and forms the pyroclastic flow plateau called "Happonbara".

The eruption of KPF produced a huge pyroclastic flow deposit (>40 km^3) and a widespread fallout tephra (40 km^3) which cover from the central to the southern part of Northeast Japan up to 300 km from the source. The age of this eruption is estimated at 0.58-0.69 Ma by K-Ar dating and stratigraphic data from several areas (Suzuki 2000).

In the northeast of the Takayama Basin, the Kiriyama Gravel Bed (KGB) and the Uwano Mud Flow Deposit (UMD) are covered with KPF. The KGB contains round boulders of the Hotaka Andesite from the Hotaka Mountains, which existed to the north of ancient Kamikochi. Therefore, the KGB indicates that the river named "the paleo-Azusa River" (Ueki *et al.* 1998) flowed from Kamikochi into the Takayama Basin at one time (Harayama 1996). The KGB unconformably overlies the Nyukawa Pyroclastic Flow Deposit (1.76 Ma: Machida *et al.* 1997) and the age of the KGB is estimated to be the Early Pleistocene (Nagahashi 1995).

The UMD, which is distributed in the northeastern Takayama Basin, is one of the concealed volcanic deposits. The UMD is covered with the KPF and that conformably overlies the KGB. The UMD has been thought to be a hot pyroclastic flow that flowed from Kamikochi into the Takayama Basin through the paleo-Azusa River by which the KGB was deposited (Yamada *et al.* 1985). The UMD has stratification and current direction patterns from the east. Moreover, the UMD transformed part of the KGB into a state of high-temperature oxidation. Accordingly, the UMD is presumed to be a hot pyroclastic flow, which flowed down into the river from the east. Because of the distribution of the UMD is very limited, the eruption style and age of the pyroclastic flow is unknown. The distributions of theUMD and the KGB show the flow path of the paleo-Azusa River and allow reconstruction of the landforms existing before the eruption of the KPF.

Therefore, we searched for corresponding deposits to the UMD from the Takayama Basin to the Hida Mountains. The following petrological and stratigraphical characteristics of the UMD are used for identification: abundant biotite and quartz as phenocrysts: together with hornblende, oxy-hornblende and orthopyroxene as heavy minerals: a high refractive index of hornblende($n_z \fallingdotseq 1.700$). The UMD is stratigraphically overlain by the KPF, and it is underlain by the KGB.

3. The Geographical and Geological Features of the Uwano Mudflow Deposit (UMD) and the Kiriyama Gravel Bed (KGB)

Figure 1 presents a distribution of the KGB, the UMD and the KPF, and locality points. Geologic columns are shown in Fig.2. As a result of a geological survey, it was learnt that the above deposits are distributed between Choshidani and the Takayama Basin along the Kohachiga River. The followings are the characteristics of these formations: the KGB is a

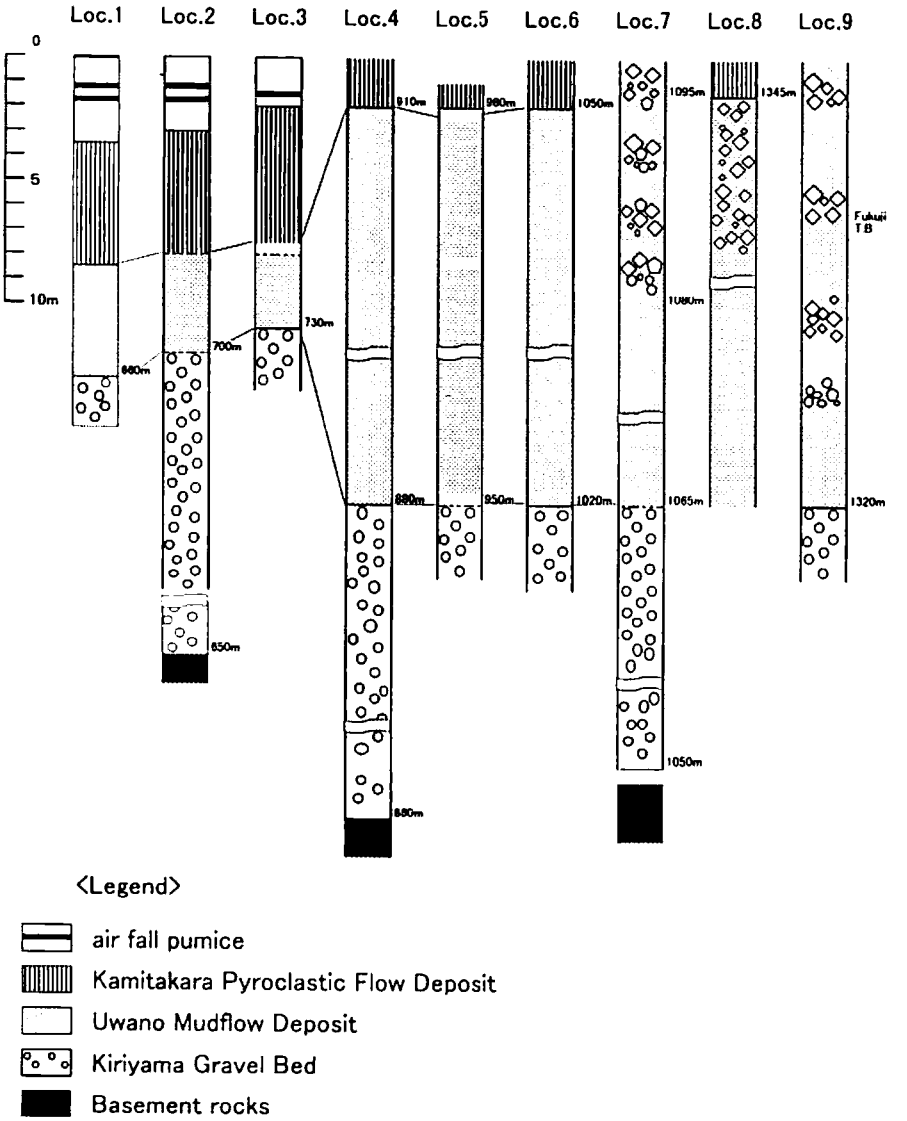

Fig. 2 Geological columnar sections of deposits.
Localities are shown in Fig 1.

fluvial gravel bed that includes very round gravel clasts more than 20 cm in diameter. The species of gravel clasts are andesite, sandstone, chert, slate and granite. The Hotaka andesite, which includes large phenocrysts of plagioclase, is especially conspicuous. The thickness of the KGB is 50 m at Loc.2 in the Takayama Basin, on the other hand it is 10-20 m at Loc.4 near mountains. The KGB shows a wide distribution in the cross-profile of valley, e.g., at Loc.4, the width in the cross-profile of valley is more than 750 m long.

Figure 3 presents the petrographic properties of the UMD. The UMD consists of dacite

volcanic breccia and coarse volcanic ash. The mineral assemblage of volcanic breccia and ash is abundant in quartz and biotite as phenocrysts. It also includes hornblende, oxy-hornblende and orthopyroxene as heavy minerals. The refractive indices of orthopyroxene is γ =1.710-1.717 and that of hornblende is n_2=1.695-1.708. The high refractive index of hornblende is a conspicuous petrographic property of this deposit.

While the thickness of the UMD is 3~6 m in the neighborhood of the Takayama Basin (Loc.1~3), it has increased to east and reaches 30 m at Miyougo (Loc.5). In the east of Loc.5, the UMD changes to show the characteristics of a pyroclastic flow deposit including poorly vesiculated pumice and welded parts.

At Loc.6, the KPF was found as a fill deposit in the valley that incised into the UMD and the KGB. This demonstrates that the depositional surface of the UMD had been terraced when the KPF flowed down. However, the interval between the two eruptions was not very long because there is no soil between the deposits.

At Loc.7, the UMD was observed continuously for 30 m vertically. The lower part of the UMD showed mudflow deposit facies, but the upper part changed to a slightly welded facies and started to include gray-white poorly vesiculated pumice and dacite volcanic blocks. The largest volcanic block was 1 m in diameter. At least, three inverse-graded flow units were found. As mentioned above, the UMD in this locality has the facies of a pyroclastic flow deposit. Therefore, in this paper, the pyroclastic flow which brought the UMD into the Takayama Basin, is given a new name - the "Hatahoko Pyroclastic Flow".

The boundary between the UMD and the KPF occurs at Loc.8, Choshidani, near the Kaisho source vent of the KPF. Though no soil was identified at this boundary, the top of the UMD was altered to a black colour by high-temperatures.

At Loc.9, the Fukuji Tuff Breccia (FTB: Harayama 1990) is distributed in the Fukuji-Osobudani area. This area lies to the west of the Hida Mountains. The FTB consists of the Osobudani Pumice Flow Deposit and the Chosidani Formation (Saito *et al.* 1984). The FTB is covered with the KPF, and the gravel bed beneath the FTB contains round boulders of the Hotaka Andesite. Consequently, this gravel bed is considered to be the KGB. The upper part of the FTB includes pumice flow deposits and lava (Hayarama, 1990). Although, Saito et al. (1984) suggested that the FTB was not the UMD, FTB and the UMD are considered to be the same volcanic formation based on the following evidence: 1. The UMD is almost the same as the FTB in petrographic character (Fig.3). 2. The UMD and the FTB occupy the same stratigraphic position ie., they are covered by the KPF and overlie the KGB.

As the UMD conformably overlies the KGB, it is thought that the Hatahoko Pyroclastic Flow (HPF) flowed directly down the river channel of the paleo-Azusa River by which the KGB was deposited. In most of the observation points, the HPF has the KGB at its base, so it was not found directly overlying the basement rock at the ridge level. This fact shows that the HPF flowed down from Choshidani along the paleo-Azusa River and it was deposited over the river valley to a depth of a few tens of meters but it was not distributed widely like the KPF because of high viscosity of HPF.

Tephra (Locality)	Phenocryst	Refractive index opx(γ) 1.700	1.710	1.720	ho(n_2) 1.670	1.680	1.690	1.700	1.710
Uwano MFD. (loc.1)	ho, opx, oxho ; qt, bi	—	—					—	
(loc.4)	ho, opx, oxho ; qt, bi	—	—					—	
(loc.5) matrix	ho, opx, oxho ; qt, bi	—	—					—	
(loc.5) pumice	ho, opx ; qt, bi		—					—	
(loc.7) matrix	ho, opx, oxho ; qt, bi	—						—	
(loc.7) pumice	ho, opx ; qt, bi		—					—	
Fukuji T. B. (loc.9) matrix	ho, opx ; qt, bi	—	—					—	
(loc.9) pumice	ho, opx ; qt, bi		—					—	

Fig. 3 Petrographic properties of Uwano Mudflow Deposit.
Uwano MFD.: Uwano Mudflow Deposit
Fukuji T.B.: Fukuji Tuff Breccia,
ho: hornblende, opx: orthopyroxene, oxho: oxy-hornblende,
bi: biotite, qt: quartz
Localities are shown in Fig. 1.

4. Discussion and Conclusions

We outline the landforms of the valley before the eruption of the Kamitakara Pyroclastic Flow, for the UMD and the KGB distributed to the Fukuji-Osobudani area, about 25 km east of the Takayama Basin, along the Kohachiga River. The cross section of the paleo-Azusa River valley is 2.5~5 times as wide as the Kohachiga River valley from the Norikura Volcano to the Takayama Basin (Fig.1 and Fig.4). In addition, the size of gravel clasts is 20 cm or more in diameter and these gravel clasts are very round, indicating that the paleo-Azusa River had a large drainage basin. The depth of the paleo-Azusa River valley is more than 300 m with steep walls, determined from the altitude difference of the KPF base (Fig.4). The UMD/HPF conformably overlies the KGB, which filled the valley of the paleo-Azusa River, and was confined to the valley of the paleo-Azusa River. Although the KPF existed in the erosional valley of the UMD, there is no soil between the UMD and the KPF (Fig.4). The interval between the two eruptions of the HPF and the KPF was not very long. At present, the KPF is distributed over the upper Choshidani area and interrupts the flow path of the paleo-Azusa River to Osobudani. In the Takayama Basin, the sediments higher than the KPF do not contain Hotaka Andesite gravel. This suggests that, the HPF brought the UMD down to the Takayama Basin along the paleo-Azusa River which connected Kamikochi to the Takayama Basin, and filled the valley. This was succeeded by the huge eruption of the KPF which covered the area widely, and forced the path of the paleo-Azusa River to change.

On the other hand, the Azusa River flows eastwards to the Matsumoto Basin at present, after changing its flow path by the development of the Yakedake Volcano. Because the Yakedake Volcano group began activity from 0.12 Ma (Oikawa *et al.* 2000), it is estimated that the present flow path of the Azusa River formed after 0.12 Ma. It is unknown where the paleo-Azusa River flowed between the eruption of the KPF (0.58-0.69 Ma) and the start of volcanic activity of the Yakedake Volcano group. This problem will be discussed in a future

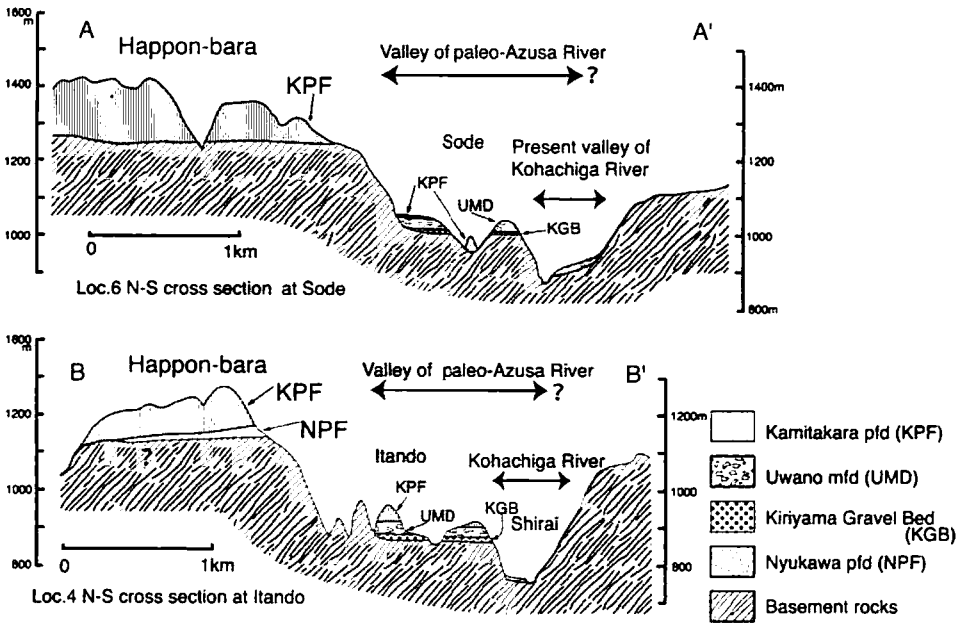

Fig. 4 Geological cross sections of the Kohachiga River(the paleo-Azusa River) valley.
The points of A-A', B-B' are shown in Fig1.

paper.

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