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Abstract

Fluvial facies of the lowermost to lower Pleistocene Osaka Group distributed in the southern part of the Uji Hills were investigated. Six sedimentary facies are distinguished in the sequence of the surveyed area. They are talus deposits (Facies 1), alluvial cone gravels (Facies 2), intramountain swamp silts and poured-in gravels (Facies 3), sinuous channel-fill river sands and gravels (Facies 4), sheet flood gravels and sands of the typical braided river systems (Facies 5), and backmarsh silts and inverse-graded fine-grained sands (Facies 6). Among them, Facies 1, 2 and 3 are considered to represent intramountainous small sedimentary basins. Facies 4, 5 and 6 represent larger scale alluvial fan systems formed by the river which ran through the mountainous ranges northeast of the surveyed area. Three cycles of major coarsening-upward sequence up to 80 m thick, composed of Facies 3 or 6, 4 and 5 in ascending order, are recognized in the sediments of the surveyed area. It is considered that this vertical facies change provides a good sedimentary model of the sequence of an intramountain basin which started from swamp or pond deposition and grew into a majada fan lobe.

Introduction

Large- and small-scale lateral and vertical facies changes of an alluvial fan reflect the tectonic and climatic history of the area (Collinson, 1986; Einsele, 1992; Heward, 1978a, b). Ethridge (1985) gave five types of idealized vertical sequences in alluvial fan deposits. However, there can be many other depositional and tectonic scenarios which may also explain the various vertical and lateral facies successions of recent and ancient fluvial systems.

The Osaka Group, distributed in the Kinki district, Southwest Japan, has become one of the standard sequence for viewing stratigraphy of the Plio-Pleistocene in Japan (Itihara *et al.*, 1984). It is composed of a clastic accumulation of gravels, sands, and muds of various fluvial and marine bay systems, and provides many subjects for sedimentary facies analysis and sequence stratigraphy of intramountain basin deposits in an island arc.

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Big outcrops occasionally appear by exploitation of pebbles and grits, and land readjustment for urbanization in foothills around Osaka and Kyoto. This paper outlines the vertical sedimentary facies change in the early Pleistocene alluvial fan deposits well observable in the Uji Hills, southwest of Kyoto, and discusses the process of the alluvial fan sedimentation.

Geologic Outline of the Osaka Group

Fig. 1 shows the main distribution of the Osaka Group. The Group attains in thickness to about 300 to 500 m in the hill areas, but to 1,200 m or even more at the depocenter of the sedimentary basin (Fig. 2).

A number of volcanic ash layers are intercalated in the Osaka Group and serve as keys for correlation (YOKOYAMA, 1969). The ages of these volcanic ash layers and marine muddy sediments in the Group are determined or estimated by fission-track ages and paleomagnetic polarities (YOSHIKAWA, 1984). The Group yields many fossils such as plant remains, pollens, diatoms, and occasionally elephants (ITIHARA *et al.*, 1984).

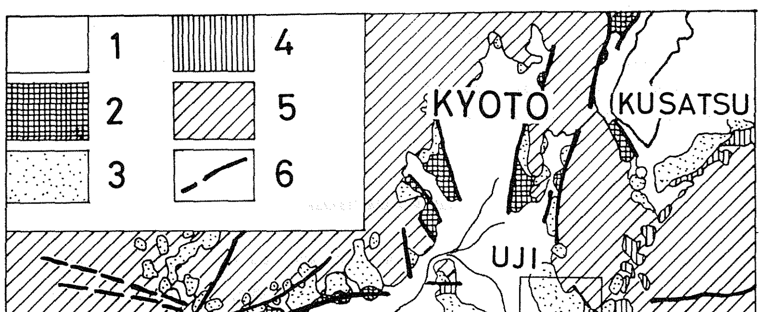

Fig. 1. Geologic outline of the Osaka Group (after NAKAZAWA *et al.* eds., 1987). 1: Recent and terrace deposits, 2: Upper Osaka Group, 3: Lower Osaka Group, 4: Lowermost Osaka Group, 5: Pre-Neogene basement rocks, 6: faults.

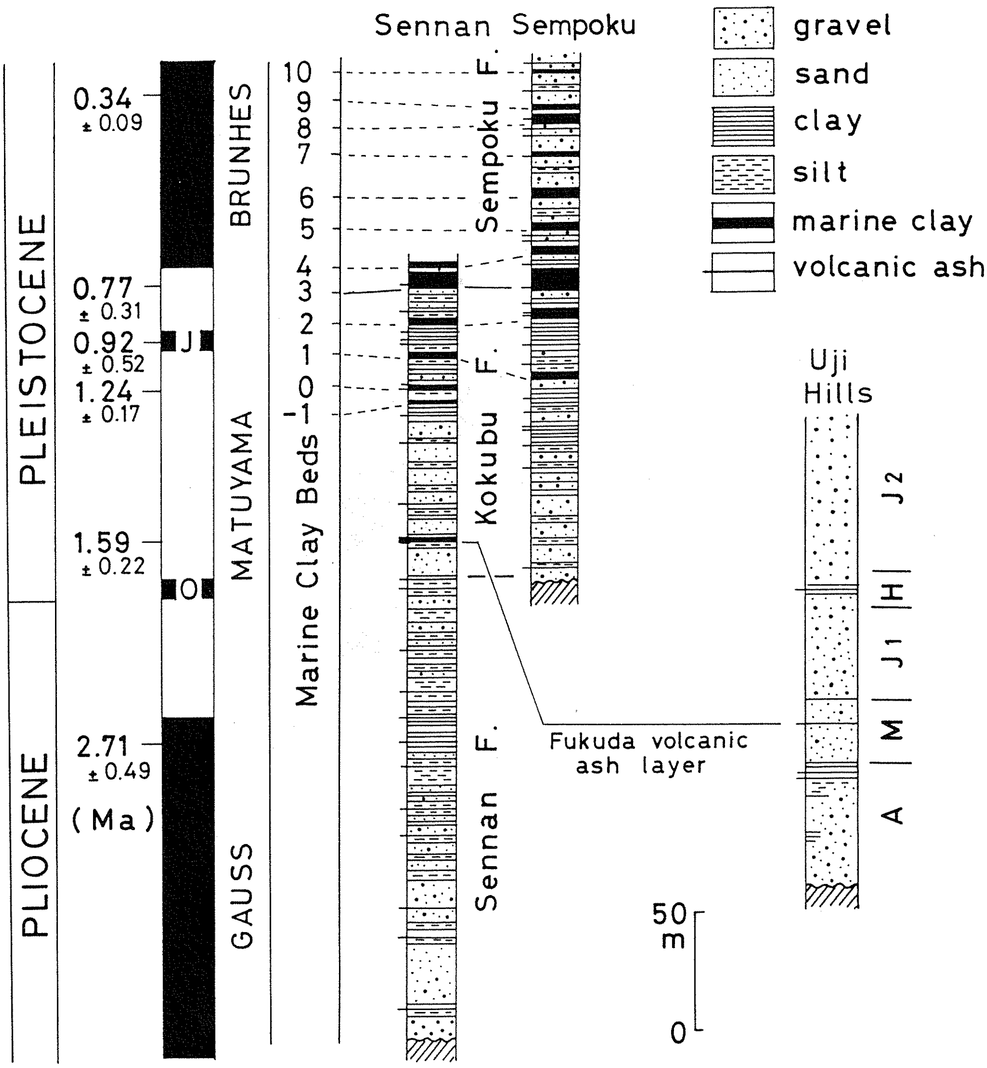

Fig. 2. Stratigraphic outline of the Osaka Group (based on NAKAZAWA *et al.* eds., 1987, and ITIHARA *et al.*, 1991). Uji Hills; A: Aodani clay and gravel bed, M: Myojogahara sand bed, J_1: Joyo gravel bed I, H: Hase clay bed, J_2: Joyo gravel bed II.

However, it is almost barren in alluvial fan facies.

The Group is divided into two parts based on depositional facies and systems. The lower half is composed mainly of alluvial fan, fluvial channel and interchannel, and other fluviatile deposits forming a basin-filling aggradational sedimentary body as a whole. On the other hand, the upper half consists of parasequences characterized by the intercalation of bay floor mud layers and other coastal marine deposits among fluviatile sandy and gravelly sediments.

In the southern part of Uji Hills, an alluvial fan system was built up by a river, named Paleo-Seta river (IIDA, 1980) which discharged in the northeastern margin of the sedimentary basin of the Osaka Group. It occupies an area of about 125 km^2. A geologic map of the area of the fan deposits is shown in Fig. 3. These deposits, named "Joyo gravelly beds" are correlated roughly to the lower part of the Lower Part of Osaka Group, and divided stratigraphically into eight members; Aodani clay and gravel bed (A), Myojogahara sand bed (M), Joyo gravel bed I (J_1), Hase clay bed (H), and lower,

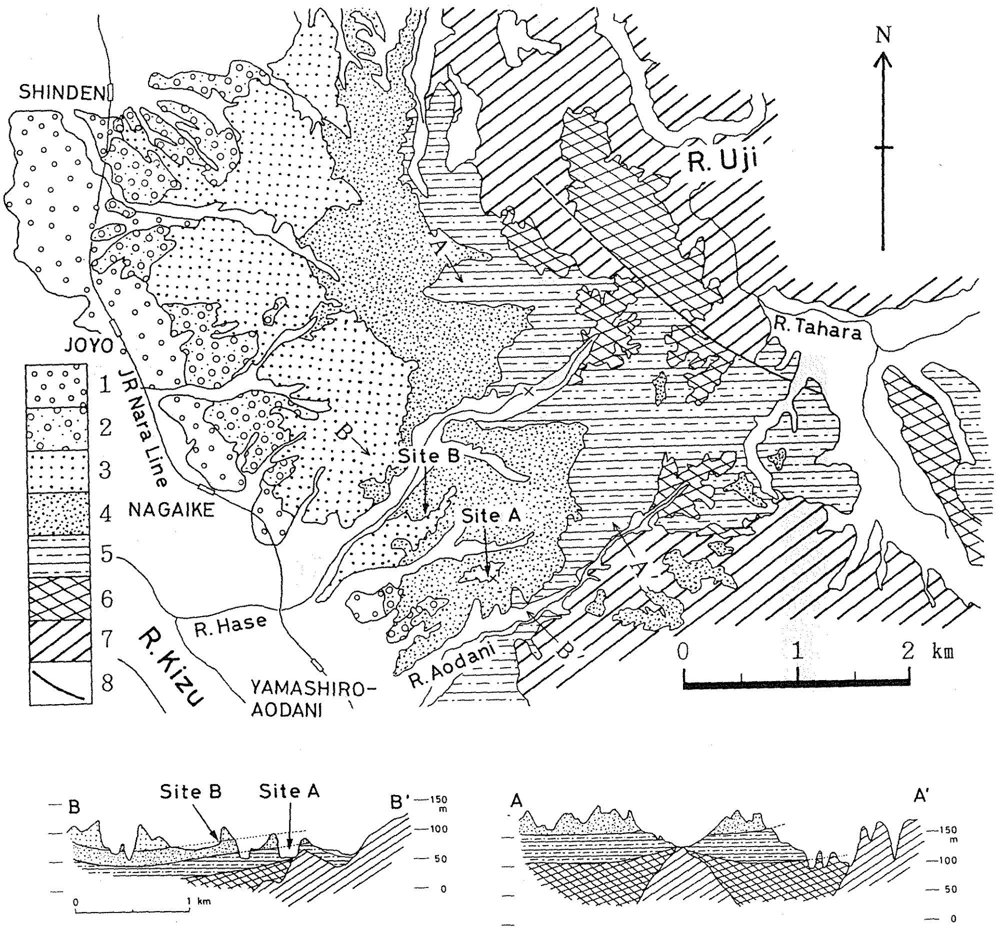

Fig. 3. Geologic map of the southern part of Uji Hills (JOYO GRAVEL RESEARCH GROUP, 1992). 1: Terrace deposits, 2: Uji gravel bed, 3: Joyo gravel bed II, 4: Joyo gravel bed I, 5: Myojogahara sand bed, 6: Aodani clay and gravel bed, 7: Basement rocks, 8: Faults.

middle and upper part of the Joyo gravel bed II (J_2) in ascending order (Joyo Gravel Research Group, 1992).

Sedimentary Facies Succession

Six sedimentary facies are recognized in the fan systems as shown in Fig. 4 (Joyo Gravel Research Group, 1992). A detailed geologic map around Sites A and B is shown in Fig. 5. Sequence of these facies is observed well in many quarries, especially around Sites A and B in the southern part of the paleo-fan area (Fig. 6). Basement rocks which had formed buried peaks are also observed in the southern part of these sites.

Facies 1 is talus deposits formed at the flanks of the mountains and is observed only at the margin of the distribution of the "Joyo gravelly beds". It consists mainly of massive gravelly beds. Pebbles of these gravel beds are composed mainly of weakly metamorphosed white and black chert and gray shale hornfels derived from adjacent basement rocks.

Facies 2 is gravelly flood and debris flow deposits also observed only locally. This facies comprises the main part of the Aodani clay and gravel bed. Poorly-sorted angular gravel layers with thin intercalation of silts and sands are dominant in this facies.

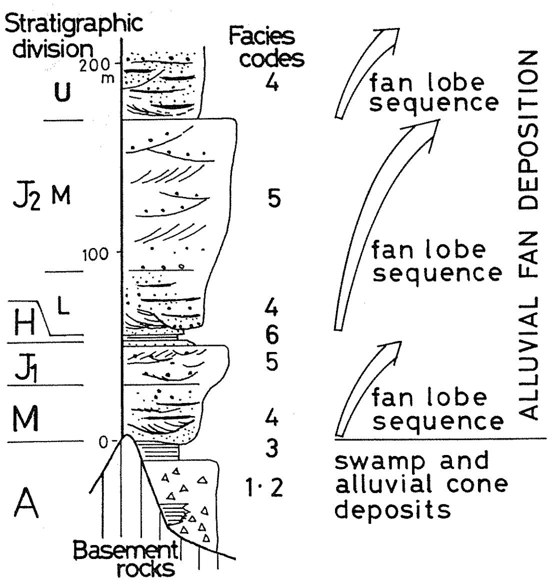

Fig. 4. Lobe sequence of the early Pleistocene alluvial fan system in the Uji Hills (modified from Joyo Gravel Research Group, 1992). J_2: Joyo gravel bed II, H: Hase clay bed, J_1: Joyo gravel bed I, M: Myojogahara sand bed, A: Aodani clay and gravel bed. For facies codes see text.

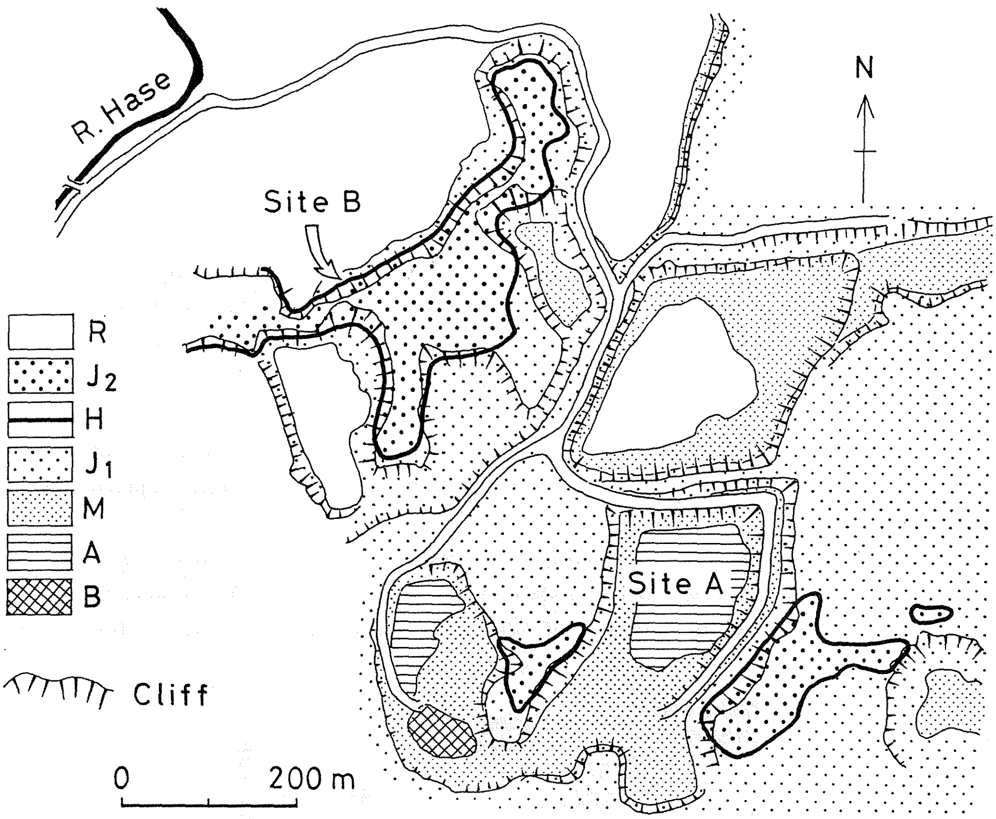

Fig. 5. Geologic map around Sites A and B (after Joyo Gravel Research Group, 1991). R: Recent materials including bioclastic detritus by exploitation, B: Pre-Neogene basement rocks. Other stratigraphic codes are same as Fig. 4.

Crude trough cross-stratifications are developed in gravel layers. Composition of the gravels is similar to that of Facies 1.

Facies 3 is intramountainous swamp deposits, composed mainly of poorly-sorted dark blue mud layers and thin intercalation of angular gravel layers. Composition of the gravels is also similar to that of Facies. 1. Mud is generally massive or crudely laminated. Plant leaves and seed remains are abundant in the peaty dark brownish clay layers. Autochthonous root remains are also found in the layers.

Facies 4 is sinuous channel-fill deposits, composed mainly of subrounded gravels, sand and silt layers, and each channel-fill deposit shows as a whole fining-upward sequence. Channel-fill deposits of Facies 4 are well observed in cuts and walls of a large quarry of site A (Fig. 6, Plate 1 A). The channels have a NW-SE trend there. Channel-fill deposits are divided into three subfacies as follows:

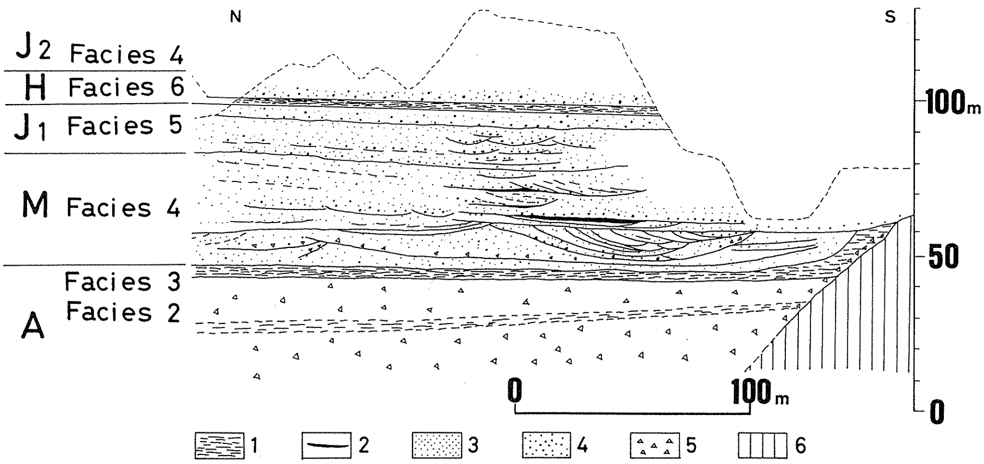

Fig. 6. Geologic sketch of Site A (after JOYO GRAVEL RESEARCH GROUP, 1992). 1: clay, 2: intercalation of finegrained sand and silt, 3: sand, 4: gravel, 5: angular gravel, 6: basement rocks. Stratigraphic codes are same as Fig. 4.

1. ***Large bar deposits formed in active channels with sinuousity.*** Large-scale channel-fill cross stratification cosets are constituted of gravels and sands, attaining to as much as 10 m in depth and 100 m in width. Epsillon- and lamda-cross stratification indicating laterally accreted sedimentation is dominant in these deposits. Lag clasts derived from adjacent basement rocks are observed at the base of some channel deposits. Trough cross-stratification is well developed also, generally in many cross-stratified coset beds. Ripple cross lamination, which can be observed commonly in the upper part of laterally accreted sandy sinuous river deposits, is rare in the subfacies. This can be assigned to high energy of the stream and erosion.

2. ***Dune deposits formed in semi-abandoned channel.*** These deposits occur rather rarely. Lenticular-shaped layers of sands and granule-sized gravels are well developed in these deposits, and generally fill the somewhat concave surface of gravel bars in the channels. Features of the stratification and sedimentary structure in the layers are variable. They have deposited on the floor of a half-filled and semi-abandoned low-sinuosity channels as well.

3. ***Abandoned channel-fill deposits.*** Strata of this subfacies are composed of markedly fine-grained sediments, namely very fine sands and silts. They are intercalated in coarser sediments of the above two subfacies, and form coset bodies of lenticular geometry which range from a few to 20 cm in thickness and 10 to 30 m in width. Inverse grading is common in the sets. Slightly inclined parallel lamination is well developed also in the sets. That is, they also show laterally accreted low angle cross stratification.

Facies 5 represents unstable braided stream deposits. This facies is composed mainly of gravels, sandy gravels and coarse-grained sands, and is marked off from facies 4 by absence of silty layer intercalations. Rare occurrence of large cross-stratifiction in gravelly beds is a feature of Facies 5 also. Composition of gravels is similar to that of Facies 4, though the size of clast is larger in general than that of Facies 4. Concave-up lense- or wedge-shaped planar cross-stratification is common, showing development of channels and bars in the stream system. Massive well sorted sand units in concave-up lenses bounded by lower scour surface are also observed at some places. 2–3 m wide channel scour structure filled by sandy layers are well observed in large outcrops. In short, sedimentary features of Facies 5 reflect varying discharge as is highlighted by an intimate association of gravel layers with well-laminated or massive sand layers.

Facies 6 represents deposits on an abandoned alluvial fan lobe surface with relief of several ten centimeters and marshland or swamp deposits, forming a fining-upward sequence of several meters thick together with the underlying uppermost part of Joyo gravel I and overlying main part of the Hase clay bed. Sequence of this facies is well observed at a site of southern part of the fan area. This sequence consists of a set of inversely graded beds (Plate 1 B), a few centimeters to a few tens centimeters thick, showing appearance of mud-sand alternation, and disorderly bioturbated massive mud, in ascending order (Plate 1 C).

Site of deposition of the inversely graded beds in the "Joyo gravelly beds" should be assigned to the slope and top of the bars of sandy sinuous rivers rather than to flat floodplains. There they develop mostly on the face of the fossil bars and form laterally accreted depositional bodies. On the other hand, they are fairly bioturbated and thin on the top of bars. Moreover, parallel-laminated medium-grained sands accumulate thick on the flat fluvial floor (Fig. 7). The bioturbated and vegetated floodplain and marshland facies developed widely at a later stage, after the local depression was molded and topography was flattened by the lateral accretional deposition of the inversely graded beds.

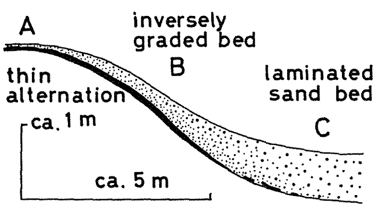

Fig. 7. Depositional model showing a lateral accretional inversely graded bed. Main river flow direction is perpendicular to the figure. For explanation, see text.

How the Alluvial Fan Lobes Originated and Developed

Facies 3, 4, 5 and 6 form three cycles of major coarsening-upward sequence up to 80 m thick from the Aodani clay and gravel bed to the top of the Joyo gravel bed II as shown in Fig. 4. Facies succession described above displays a good model of alluvial fan construction. It started by deposition of Facies 3. That is, the river discharged on a flat plain of buried swamp shown by depositional surface of Facies 3 at the beginning of the fan lobe formation. As the slope of the river was gentle, the river system of deep channel with some sinuosity developed at an early stage of the fan lobe. Then the slope became steeper because of the filling up of the channel and aggradational deposition. Hence, typical braided river deposits and/or sheet flood deposits of Facies 5 of Joyo gravel bed I developed in the later stage of the fan lobe construction. Similar process of fan construction was repeated twice by deposition of Facies 4 and 5 of Joyo gravel bed II. Upward facies change from braided river to sinuous river was only displayed in the last stage of the fan life.

In general, many alluvial fans may arise from talus or alluvial cone and develop through high-slope fan with braided streams, low slope fan, and lastly alluvial plain deposits with a meandering stream system. As shown above, however, real process of the Joyo paleo-fan construction is quite different from such a model. That is to say, the swamp-fill deposits were overlain first by the sinuous stream deposits, though coarser-grained than in usual case, and then by the braided stream deposits, forming a coarsening-upward fan lobe sequence. This is natural because of initiation of the fan construction by sediment supply into swamp water. On the contrary, the reason why the first cycle ended abruptly and the second cycle began is a problem to be clarified.

The second cycle starts from swamp and small basin plain of molding. The third cycle lacks both swamp and floodplain sediments but started from braided stream deposits with slightly and partly sinuous feature. At any rate, coarsening-upward three cycles of deposition of the Joyo alluvial fan are apparent. Turning out and wandering of the lobe may be a possible reason of these cycles, as was suggested by JOYO GRAVEL RESEARCH GROUP(1992). Climatic change and/or eustacy may be a more fundamental background of this process but has not being clarified yet.

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References

COLLINSON, J. D. (1986): Alluvial sediments. in READING, H. G., (ed.) *Sedimentary environment and facies.* Blackwell, Oxford, 20–62.

EINSELE, G. (1992): *Sedimentary Basins. Evolution, Process and Sediment Budget.* Springer-Verlag. Berlin.

ETHRIDGE, F. G. (1985): Modern alluvial fans and fan deltas. in FLORES, R. M., ETHRIDGE, P. G., MIALL, A. D., GALLOWAY, W. E., FONCH, T. D. (eds.) *Recognition of fluvial systems and their resource potential.* Soc. Econ. Paleontl. Mineralog. Short Course 19, 101–126. cited in EINSELE, G. 1992. *Sedimentary Basins, Evolution, Facies and Sediment Budget.* Springer-Verlag. Berlin. 40–41.

HEWARD, A. P. (1978a): Alluvial fan and lacustrine sediments from the Stephanian A and B (La Magdalena, Cinera-Matallana and Sabero) coalfields, northern Spain. *Sedimentology*, **25**, 451–488.

HEWARD, A. P. (1978b): Alluvial fan sequence and megasequence models: with examples from Westphalian D-Stephalian B coalfields, northern Spain. in MIALL, A. D., (ed.) 1978. *Fluvial sedimentology.* Mem. Can. Soc. Petroleum Geol., no. 5, 669–702.

IIDA, Y. (1980): Paleogeography of the western part of the Shigaraki Plateau, Kinki district, Japan — relict landform of Pliocene valley deduced from the Ofuku gravels — *Jour. Geol. Soc. Japan*, **86**, 741–753. [in Japanese with English abstr.]

ITIHARA, M., KAMEI T., YOSHIKAWA, S. and NASU, T. (1984): Late Neogene and Quaternary stratigraphy of Kinki district, Japan. in ITIHARA, M. and KAMEI, T. (eds.), *Proc. of 1st Intern. Coll. on Quaternary stratigraphy of Asia and Pacific area, Osaka, 1986.* 74–83.

__________, YOSHIKAWA, S., MITAMURA, M., MIZUNO, K. and HAYASHI, T. (1991): 1:125,000 Quaternary geological map of Osaka and adjacent areas, Kinki, Japan. *Urban Kubota* No. 30. [in Japanese]

JOYO GRAVEL RESEARCH GROUP (1991): Inversely graded beds of the Osaka Group in the Uji Hills, Central Japan. *Jour. Sediment. Soc. Japan*, No. 35, 91–100. [in Japanese with English abstr.]

JOYO GRAVEL RESEARCH GROUP (1992): Sedimentary process of the early Pleistocene alluvial fans in the Uji Hills, Central Japan. *Chikyu Kagaku*, **46**, 57–68. [in Japanese with English abstr.]

NAKAZAWA, K., ICHIKAWA, K. and ITIHARA, M. eds. (1987): Kinki district: Geology of Japan 6. *Kyoritsu Shuppan*, Tokyo, 297 p. [in Japanese]

YOKOYAMA, T. (1969): Tephrochronology and paleogeography of the Plio-Pleistocene in the Eastern Setouchi Geologic Province, Southwest Japan. *Mem. Fac. Sci. Kyoto Univ.* **36**. 19–85.

YOSHIKAWA, S. (1984): Volcanic ash layers in the Osaka and Kobiwako Groups, Kinki district, Japan. *Jour. Geosci. Osaka City Univ.*, **27**, 1–40.

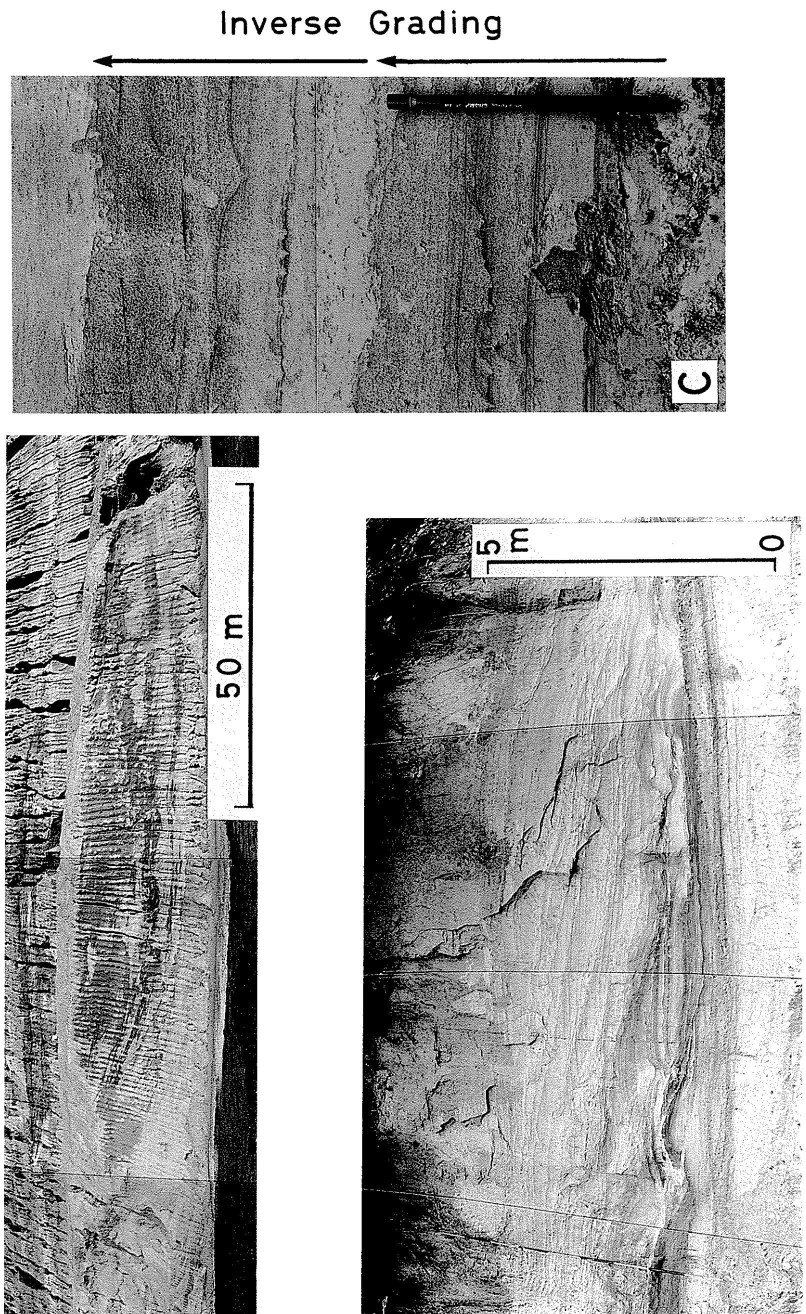
PLATE

Plate 1

A. Photograph of the channel-fill deposites of Facies 4 showing lower-middle right side part of the geological sketch of Fig. 6 (Site A).

B. Occurence of inversely graded beds (Site B) forming a fining upward sequence with the underlying uppermost part of the Joyo Gravel I and overlying massive part of the Hase clay bed.

C. A detailed picture of inverse grading (Site B).


Inverse Grading
C
A
50 m
B
5 m
0