

Quaternary Geology of the Nyu Hills, Oita Prefecture, Kyushu with Special Reference to the Palaeolithic Remains

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Quaternary Geology of the Nyu Hills, Oita Prefecture, Kyushu with Special Reference to the Palaeolithic Remains

By

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Abstract

From the geological and archaeological standpoint the Quaternary deposits of the Nyu Hills, Oita Prefecture have been studied at length. They are divided into the following formations in descending order:

Alluvium

Nyu-gawa formation

Jobaru formation

Kobaru-dai sand and gravel

Ozai formation

Tsurusaki formation

Crystalline schist

The lowest Tsurusaki formation bears an intermediate character between Tertiary and Quaternary on the basis of the geohistorical evidence. The Ozai formation and the Oka member of the Jobaru formation are the product of a cyclic sedimentation respectively in the Mindel/Riss and the Riss/Würm interglacial stage. The Kobaru-dai sand and gravel is veneer deposits of probably marine origin in the late Mindel/Riss interglacial or interstadial of the Riss glaciation. The Nyu-gawa formation is the river terrace deposits in the Würm glacial stage.

A few definite palaeolithic implements were found in the Ozai formation which represent the known oldest culture in Japan, being contemporaneous to the middle Acheulean. Most of the other implements came from the re-worked sediments ranging from the early to late Würm, and some of them are considered to be the secondary deposits from the older sediments.

Introduction

The several crude stone implements including the choppers collected by T. TOMIKU and S. NAKAMURA through surface sampling on the Nyu Hills, Oita district, brought about a severe dispute (1962). Since that time there have been two contrasting opinions about the age of those implements. The one school insists upon the antiquity of them and the other holds an idea that they originated in a later age. According to the former the implements are grouped into a few

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associations of different ages and the oldest one belongs to a certain older palaeolithic culture. While the latter emphasizes a possibility that the above mentioned implements are nothing but the degenerated types accompanied by the neolithic Jōmon culture. This is, of course, not only the most interesting but also the most basic archaeological problem in Japan. It can be solved only through the careful and synthetic procedure, which includes first the excavation to detect the provenance of the implements and second the general geological survey to check the geological age of the containing beds.

Apart from the archaeological problem this area is of geologically prime importance because it is a part of the standard area for the late Cainozoic stratigraphy in west Japan. A series of formations from the upper Miocene to late Quaternary succeeded one by one are distributed in this area without any large stratigraphical gaps between. Accordingly the establishment of the minute stratigraphy, especially of younger Quaternary one which has not been reported sufficiently, in this field is indispensable for the two-folded purposes, archaeological and geological. To approach these problems a serial excavations were carried out in the autumn of 1962, 1963, and 1964 by the Palaeological Society. We took part in the geological survey during these excavations and in another supplementary survey and this report is the result of our geological work. The geological reconnaissance has made clear the general stratigraphic relation of all the normal and primary sedimentary units in relation to the occurrence of the palaeolithic implements, although the stratigraphic positions of a few superficial and secondary deposits have not necessarily been made clear.

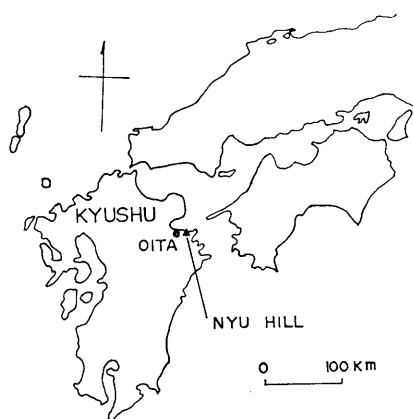


Fig. 1. Index map of the Nyu Hills.

Topography

The Nyu Hills*¹ are situated on the south coast of the Bay of Beppu, east Kyushu. It is bordered westward by the steep cliff along the Ono river, limited

*¹ 大分市丹生台地

from the coastal plain by a similar cliff [as the preceding one] northward, and abruptly lowered down to the alluvial plain of the Nyu river southeastward.

Topographically the Nyu Hills are classified into the composite coastal terraces where the highest part leans to the western edge. They consist of three major units, each of which in turn is subdivided into the upper and lower units respectively. The uppermost units (H_1 , Ozai plane,^{*1} 90 to 100 m high above sea level) is situated near the west border of the hill as mentioned above and represents the original depositional plane of the marine transgression, which has, however, suffered the severe dissection by the erosional agencies and does not preserve a real plane. The second one (H_2 , Nyu plane,^{*2} 78 to 85 m in altitude) is a fairly well preserved plane of erosion and deposition with its own veneer here and there and occupies east neighbour to the former. Remarkably wide and only slightly inclined plane with well-sorted sediments suggest the marine origin. The third (M_1 , Oka plane,^{*3} 45 to 50 m) and the fourth (M_2 , Jōbaru plane,^{*4} 35 to 40 m) represent respectively a depositional plane of the marine transgression and the pumice flow. They, especially the latter, are developed in the wide area occupying eastern and southern half of the hill and much flatter than the Nyu plane. Although the middle planes are deeply cut into by many ravines like as the Nyu plane, the heads of the ravines show the quite juvenile feature. The fifth (L_1 , Enmeiji plane,^{*5} 33 m) and the sixth (L_2 , Akagawa plane,^{*6} 25 m) represent the successive river terraces of younger age and are limited to the margin of the Nyu valley. At this hill the boundaries between the neighbouring planes are not sharply defined by the cliff but consist of the slopes, some of which are gentle and provided with thin deposits forming the transition planes.

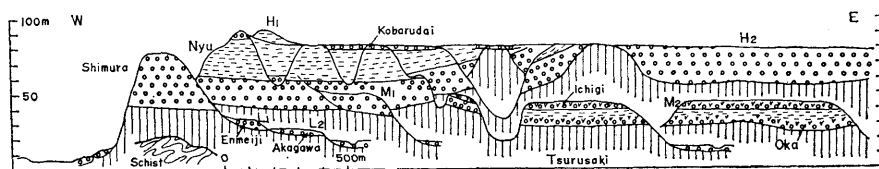


Fig. 2. Compiled geological section of the Nyu Hills showing the relation between the stratigraphy and the topography.

Stratigraphy

From a stratigraphical point of view we can distinguish several units comprising the hill. They are the basement rock of crystalline schists, three formations representing respectively a marine transgressive cycle, one veneer deposit of coarse material, and the fluvial deposits on river terraces. All the units except for the crystalline schist are included in Quaternary and their general stratigraphic relation is indicated in the following table.

*1 大在面, *2 丹生面, *3 岡面, *4 城原面, *5 延命寺面, *6 丹川面

Table 1. Stratigraphy at the Nyu Hill

Alluvium	soil orange loam secondary volcanic ash (brown to chocolate) alluvial silt, sand, and gravel
Nyu-gawa formation	Akagawa sand & gravel Enmeiji sand & gravel
Jobaru- formation	Ichigi tuff (including white loam) Oka mud
Kobaru-dai sand & gravel	
Ozai formation	Nyu mud (including the upper gravel) Shimura sand & gravel
Tsurusaki formation	Takajo alternation Maki sand & gravel
	crystalline schist

The lower Quaternary beds in the Oita district is called the Oita group, which overlies the upper Tertiary Sekinan group with a clinounconformity occupying the extensive area. It is divided into two formations on the basis of the geohistorical evidence including the sedimentary cycles, volcanic activities, and tectonism. The Takio formation comprises the lower part, and the Tsurusaki represents the upper and overlies the Takio in conformable relation at the area of the maximum subsidence which in this case coincides with the center of the deposition. The Takio formation is much more extensively distributed than the Tsurusaki which is limited in distribution southwestward and covers discontinuously the Takio. While it overlaps apparently on the ancient rocks eastward beyond the margin of the depositional area of the Takio. The major part of the Tsurusaki formation is distributed along the northern margin of the Tsurusaki Hills and at the whole area of the Nyu Hills, displaying an almost complete cycle of sedimentation which is graded upward from gravelly to pelitic and finally again to coarse. It is divided into two members: the Maki sand and gravel*¹ of the lower and the Takajō alternation*² of the middle and the upper. At the type section which is selected at the northwestern part of the Tsurusaki Hills the basal part of the Maki member consists of the alternation of coarse sands and gravels of a few meters with intercalation of coarse silt lenses. The overlying part is the alternation of sands, gravels, and silts which are predominated by pumiceous volcanic sand. Considerable lateral continuity of many gravel beds indicates that they were not deposited on the flood plain but in the marine environment, possibly deltaic. It is very interesting that the

*¹ 牧砂礫層, *² 高城互層

accumulation of rocks of different kinds is rather selective. Some of the gravel beds, on one hand, consist almost purely of the tightly cemented pebbles and granules of andesite and pumice, while on the other hand others are composed chiefly of the rounded cobbles and pebbles of ancient rocks with rather loose matrix. This may indicate the intermittent activity of the volcanoes. A fossil molar of *Stegodon orientalis* OWEN was discovered in the gravelly silt of this lower part and the marine molluscan shells including *Raeta pulchella* (ADAMS et REEVE), *Macoma* sp. and *Cerithium* (*Proclava*) *kochi* (PHILIPPI) and the leaves of *Cinnamomum* sp. are found sporadically in the sandy silt of the middle parts of the member. This assemblage is succeeded by one consisting of *Fulvia mutica* (REEVE), *Lucinoma annulata* (REEVE), and *Dentalium octangulatum hexagonum* GOULD. This succession indicates the gradual environmental change from the deltaic to the marine.

At one and a half kilometers east of the type section the member, rich in pumiceous sand, overlies the somewhat eroded Takio formation. Further east at the Nyu Hills the major part of the Maki member is hidden beneath the level of the alluvial plain and there are only a few outcrops. It is generally represented by the irregular alternation of sands and gravels with some intercalation of silty beds, being less sorted in this hill except for at northeastern extremity than that in the Tsurusaki Hills. At Jōbaru, the northeastern extremity of the hill, it is well sorted, regularly stratified, and composed predominantly of medium and coarse sands and subsequently of interbedded pebbly gravels. The pebbles in the gravel beds are superiorly rounded, sorted, and regularly arranged. Furthermore a diatomaceous white tuffite (2.1 m thick), yielding many fossils of marine mollusks and plant leaves, is intercalated near the upper limit of the member. These facts suggest that the member, at least at Jōbaru, might have deposited in the sea. The fossils contained in that tuffite are *Fulvia hilgendorfi* (SOWERBY), *Macoma incongrua* MARTENS, *Raeta pulchella* (ADAMS and REEVE), *Proclava pfefferi* (DUNKER), *Fagus* sp., *Zelkova* sp., and *Acer* sp.

Southward the member becomes thicker and more rudaceous. It overlies unconformably the crystalline schist there and consists almost wholly of poorly sorted gravels of subangular schist-pebbles with minor intercalations of poorly sorted sand and silt.

Takajō member at the type locality consists of the regular alternation of bluish-black silt of about 2 m thick and thin beds of tuffaceous sand in the lower half, and the upper half is also composed of thick alternation of pumiceous sands and gravels with intercalation of some silty beds. At Nyu Hills, especially in the west and the central area, the lower third of this member is much more pelitic and more extensively developed than at the type section and represented by the stratified gray silt beds yielding plant drifts and micaceous constituents together with a few sandy layers. The middle and upper parts of the member chiefly consist of the coarse pumiceous and volcanic sand and have subordinate gravels, coarse silts, diatomaceous stiff layers likewise at the type locality. In this pyroclastic sequence various features of disturbance in sedimentation accompanied by

the volcanism are observed at many localities. The pumices are of hornblende andesite petrographically. Although the area is bordered by the schist terrain by the south, the pebbles of schist are extremely rare throughout on the hill except for only its southern margin, where the lutaceous Takajō member directly overlaps the schist and contains a great deal of the schist grains. At the northern part of the hill some sandy silts and fine sands yield many fossils of marine mollusks characteristic to embayment facies such as *Fulvia mutica* (REEVE), *Cyclina sinensis* (GMELIN), *Raeta pulchella* (ADAMS and REEVE), *Proclava kochi* (PHILLIPI), *Batillaria multififormis* (LISCHKE), and *Philine japonica* LISCHKE.

The Tsurusaki formation on the Nyu Hills shows a gentle anticlinal structure with the axis trending NNW-SSE and accompanies the minor undulation on the northeast wing.

The upper part of the Pleistocene in Oita district is called the Kujū group. The several formations of that group are generally thin and flatlying and play a rôle in the formation of the terraces with their veneer deposits. Whereas those of the Oita group do not generally form the real elevated platform with their top horizons, but serve as the basement structures of the hilly areas like as the Tertiary and older formations do or at least represent the remains of the elevated peneplain at some localities. The Kujū group is subdivided into four formations: the Ozai, the Jōbaru, the Kobarudai, and the Nyugawa formations in ascending order.

The Ozai formation*¹ represents a complete cycle of the marine transgressive deposition, including lower gravels of remarkable thickness (25–30 m), middle gray mud (max. 22 m), and the upper gravel (max. 5.5 m). The first one is called the Shimura sand and gravel member*² and the second and the third are named together the Nyu mud member*³. The present distribution of this formation is restricted at the western half of the Nyu Hills, where the upper part of the formation has been eroded away by the level of 80 to 90 m in the major part and its uppermost horizon is only observed at a few relic highs about 90 to 100 m in altitude.

At the type locality of the formation, which is selected south of Shimura,*⁴ northwest part of the hill, the Shimura member covers unconformably the Tsurusaki by its basal cobble gravel (10 m) with intercalation of a sandy silt (2.5 m). The pebbles and cobbles are predominated first by hornblende andesite and subsequently by pyroxene andesite and schist, the latter of which comprises chiefly the coarser constituents. Above the basal gravel the irregular repetition of lenticular bodies or patches of sand and gravel (12 m) containing boulders is succeeded by the thin alternation of pebble-granule gravels and silty sands (4 m). At other localities this member also covers the various horizons of the Tsurusaki formation and consists of the sequence of sand and gravel similar to the type section and generally composed of cobble and boulder in the lower part and predominated by pebble and granule gravels or gravelly sand near the

*¹ 大在層, *² 志村砂礫層, *³ 丹生泥層, *⁴ 大分市大在志村

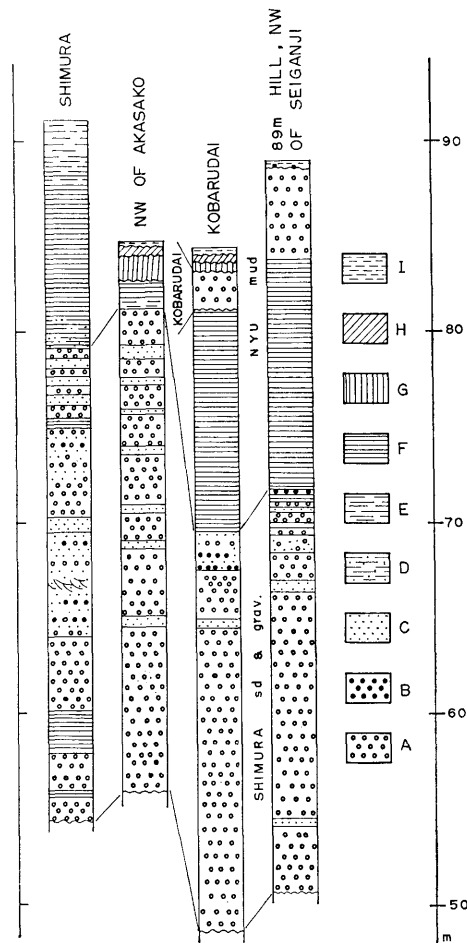


Fig. 3. Selected columnar sections of the Ozai formation at the Nyu Hills.

A: pebble, cobble, and boulder, B: granule, C: sand, D: silty sand~sandy silt, E: coarse silt, F: fine silt, G: pale gray clay (reworked), H: orange loam, I: surface soil.

upper limit. The pebbles and smaller grains of this member are extremely weathered, while the cobbles suffer only moderate weathering. The basal boundary of the formation is situated at the level of 50 to 60 m high at great many outcrops. At some localities, however, it shows a remarkable relief up to 25 m.

The Nyu mud member consists of an argillaceous sequence of tuffaceous silty sand, fossil-bearing bluish black silt, pale yellowish-ochre tuffaceous coarse silt, and granule-bearing pumiceous sand in ascending order and attains 22 m in total thickness at the type locality. The upper gravel of this member is preserved at 89 m hill north of Noma, where it consists of pebble gravel with intercalation of cobble lenses and dips southeastward in a form of the large cross-bedding. The greater part of the coarse material is andesite and rhyolite and severely weathered

likewise the finer grains and matrix. At many other localities the mud part of of the member is measured only 4 to 12 m thick and the upper gravel is utterly removed. The silt bed yields many molds of the marine mollusks such as *Anadara* (*Tegillarca*) *granosa* (LINNÉ), *Cyclina sinensis* (GMELIN), *Macoma incongrua* MARTENS, *Raeta pulchella* (ADAMS and REEVE), *Theora lata* (HINDS), *Umitakea japonica* (YOKOYAMA), *Proclava kochi* (PHILIPPI), *Neverita* (*Glossaulax*) *didyma* (ROEDING), and *Tritia japonica* (A. ADAMS). All the species are the typical elements of the fauna of the marine embayment in southern Japan.

The Ozai formation is almost horizontal structurally, but the detailed examination reveals that the formation has a very gentle synclinal structure with the maximum dip of 2 to 2.5 degrees measured at the muddy beds. It is interesting that the axis of the syncline of this formation lies on the anticlinal structure of the Tsurusaki formation.

The Kobarudai sand and gravel*¹ is a veneer deposit less than 4 m on the second higher terrace and distributed discontinuously at the south central part of the hill. It is almost composed of the gravel of weathered pebbles and contains sandy and silty patches here and there.

The Jōbaru formation*² occupies the extensive area from Jōbaru (northeast extremity) to Oka (southwest) forming the middle terraces of 35 to 50 m in altitude. It consists of the Oka mud member*³ in the lower half and the Ichigi tuff member*⁴ in the upper, which overlies the former with slight disconformity at Oka but apparently shows the overlapping feature in other areas. The type section of these members are selected respectively along the prefectural road from Okaguchi to Oka*⁵ and at the slope of the hill 200 m northwest of Ichigi bus-stop. At the type section the Oka mud member covers the Tsurusaki formation and consists of the basal gravel including boulders (3 m), pebble-bearing tuffaceous silt (1.3 m), pumiceous coarse sand containing the lenses of pure pumice pebbles and of rounded pebbles of the ancient rocks (3.8 m), dark gray mud rich in molluscan fossils, sand pipes, and plant drifts (5 m), yellowish pale gray tuffaceous silt sporadically containing mollusks (3.7 m), and finally pumiceous bed grading upward from pebble to coarse sand (4 m) in ascending order. The last bed is in turn overlain by the gravel of the Ichigi tuff member. The total thickness of the Oka mud member at the type locality attains about 21 m. The Ichigi tuff member at Oka comprises the fully sorted gravel of cobbles and pebbles (2 m), coarse sand (1 m), pumiceous white ash containing isolated pebbles (1.2 m), and pinky white fine ash (9.8 m). The pinky white ash is overlain by the stiff chocolate loam with distinct hornblende crystals. At the type locality of the Ichigi member the sequence of the Oka member is quite similar to that of Oka except for the position of the basal boundary which is at least 8 m lower at Ichigi than at Oka. The Ichigi member overlies the Oka mud with its basal gravel which is composed almost exclusively of the old rocks except crystalline schist and firmly cemented with the ferruginous material. This gravel

*¹ 小原台砂礫層, *² 城原層, *³ 岡泥層, *⁴ 一木凝灰岩 *⁵ 大分市丹生字岡

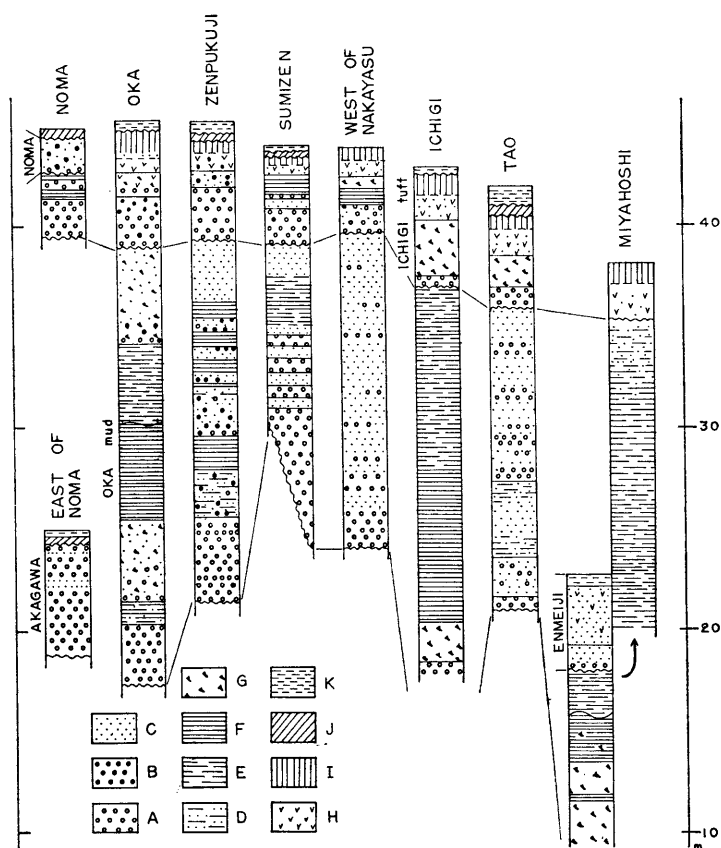


Fig. 4. Selected columnar sections of the Jōbaru formation at the Nyu Hills.

A: pebble, cobble, and boulder, B: granule, C: sand, D: silty sand~sandy silt, E: coarse silt, F: fine silt, G: pumice, H: ash, I: dark brown (chocolate) loam, J: orange loam, K: surface soil.

(0.5 to 0.6 m) is succeeded by the pumice flow of pale gray (2.5 to 3.0 m) and further by the white ash which contains granules and coarse sand grain of volcanic origin. The mud facies of the Oka member is restricted in distribution at three small areas, Oka, Ichigi, and Miyahoshi, along the southeastern margin of the Nyu Hills. It is perfectly replaced by the sandy or gravelly beds in other areas surrounding these three locations and abruptly disappears through thinning out northward. At the area between Oka and Ichigi the mud facies does not develop but is replaced by the fine sand beds.

At Miyahoshi*¹, eastern extremity of the hill, pumice bed with intercalation of gray silt layer crops out at the level of 11 m. The pumice bed is succeeded by the dark gray silt with abundant marine mollusks (2.2 m) and tuffaceous yellowish pale gray silt with few molluscan remains (2 m), which is unconformably covered by the Enmeiji member forming the narrow L₁ terrace. About 200 m north of

*¹ 大分市小在字宮法師

this locality the upward continuation of the Oka member is not truncated by the lower terrace. The massive pale brown and mud with reed-like plants (6 m) grades upward into massive fine sand (4 m). Further north the transitional sandy mud overlies the pebble gravel which is apparently contemporaneous with the mud facies at Miyahoshi and varies the thickness from 4 to 8 m. At the area between Ichigi and Miyahoshi the Oka member is also wholly represented by a sequence of sand and gravel. The pebbles of this formation are moderately weathered as a mass but include many fresh ones.

The fossils yielded in the dark gray mud of the Oka member are as following: *Striarca* (*Galactella*) *symmetrica* (REEVE), *Alvenius ojanus* (YOKOYAMA), *Clementia vatheleti* (MABILLE), *Veremolpa* cf. *micra* (PILSBRY), *Parataptes undulatus* (BORN), *Raeta pulchella* (ADAMS and REEVE), *Macoma* (*Psammacoma*) *awajiensis* (SOWERBY), *Laternula* (*Laternulina*) *flexuosa* (REEVE), *Dentalium octagulatatum hexagonum* GOULD, *Tritia japonica* (A. ADAMS), Echinoid 2 spp. (at Oka); *Anadara* (*Tegillarca*) *granosa* (LINNÉ), *Tritia japonica* (A. ADAMS) (at Miyahoshi).

At Isozaki*¹ coast, 3 km northeast of the Nyu Hills, the similar beds to the Oka mud member overlie the faulted and steeply inclined Tsurusaki formation with the basal gravel consisting of subangular pebbles and granules with sporadic boulders and cobbles (2 m). The basal gravel is succeeded by the fossil-bearing silty mud (3.5 m) which has the pumiceous layer at the lowest part, medium volcanic sand (4.5 m), and finally gravel (2 m). The total thickness is about a half of that at the type locality but is reasonably correlated to the Oka member on the base of the similarity in sequence of beds and its topographical relation. The molluscan fossils frequently occur in the mud as mold. They are *Anadara* (*Tegillarca*) *granosa* (LINNÉ), *Brachidontes senhousia* (BENSON), *Cyclina sinensis* (GMELIN), *Dosinia* (*Phacosoma*) *japonica* (REEVE), *Macoma* (*Psammacoma*) *awajiensis* (SOWERBY), *Theola lata* (HINDS), *Proclava kochi* (PHILIPPI), *Batillaria zonalis* (BRUGUIÈRE), and *Nassarius livescens* (PHILIPPI). The mud also yields the plant leaves such as *Irex* sp. and other broad leaves of entire margin indicating the warm climate.

The Nyugawa formation*² is the youngest Pleistocene beds in this area and wholly comprise the fluvial deposits on the river terraces at the type locality, which is selected at the north terraces of the upper stream of Nyugawa river, because its stratigraphic relation to the Ozai and the Jōbaru formations is readily clarified at this area. The Nyugawa formation is divided into the Enmeiji (older)*³ and Akagawa (younger) sand and gravel*⁴. The former rests unconformably on the upper part of the Tsurusaki formation to from the narrow and gently inclined terrace (30 to 35 m) extending from Enmeiji to the north. The large constituents of the gravel are exclusively siliceous shale, sanukitoid andesite, quartzite, and porphyrite, and schist contributes only small fractions except at the south terrace which border the schistose mountain. The Enmeiji

*¹ 大分市坂ノ市磯崎, *² 丹生川層, *³ 延命寺砂礫層, *⁴ 丹川砂礫層

member has the secondary loam of chocolate color at the top. The total thickness is less than a few meters. At Miyahoshi the Enmeiji member covers the Oka mud member unconformably as mentioned above. It consists of the basal subround pebble layer (0.2 to 0.3 m), fine sand (1.2 m), pale brown loamy silt with coarse sand mixture (2.3 m), and chocolate loamy bed with vertical cracks (1 m). The following fact should be noted that many sand pipes exist just below the unconformity plane.

The Akagawa sand and gravel occupies the narrower terrace and is thinner than the Enmeiji. It consists of the irregular bodies of subangular to subround pebbles with subordinate sandy intercalations.

The typical slope deposit north of Noma*¹ is called the Noma sandy gravel*², which lies the gentle slope cut across the Ozai formation and contacts with the Jōbaru formation with its lower end of the tongue. It consists of the irregular mixture of silt, sand, pebbles, and sporadic boulder and featured by the extremely poor sorting and the irregular orientation of the larger grains. This fact indicates it is a creep sediments, which has been water-washed in some extent. Some of the similar sediments apparently cut the lower terraces.

Correlation

A) Tephrochronology

The sedimentation of the late Caenozoic formations in central Kyushu is intimately related to the various kinds of volcanism as SHUTO pointed out in former reports (1953, 58, and 62). The Quaternary formations at the Nyu hill are not the exception to this general phenomena. For example the Maki and particularly Takajō members of the Tsurusaki formation are featured by the activities of biotite-hornblende andesite and the Oka member of the Jōbaru formation accompanies the volcanism of hornblende andesite. The tephrochronological key beds, however, extremely rare and incomplete in and on the later formations. Only four beds have been confirmed as keys.

orange loamolder alluvial plane
chocolate loam, white loam & pumice flowJōbaru plane

The pumice flow of the Ichigi tuff member quite resembles the non-welded or weakly welded part of the Aso welded tuff formation distributed southwest of Oita city. Concerning with the distribution in relation to the topography they are similar too. It is reasonably concluded that the Ichigi tuff is the marginal facies of the Aso welded tuff. At the Oita district the Aso welded tuff, however, comprises two members, either of which is represented by a grading sequence of the basal gravel, thin non-welded tuff, welded major part, non-welded pumice flow, and ash in ascending order. It is not clear which member the pumice flow of the Ichigi should be correlated to.

The white loam of the Nyu Hills is similar to the fine ash of the upper part

*¹ 大分市丹生字野間, *² 野間砂質礫層

of two members of the Aso welded tuff and the weathered part of the white loam resembles the so-called Yamé clay, which was verified to be contemporaneous to some of the Aso welded tuff in west Kyushu. The heavy mineral of the white loam is composed of the opaque mineral (chiefly magnetite) 50 percent, hornblende 25 to 30 percent, hypersthene 15 percent, and others 5 to 10 percent. This figure also resembles that of the Yamé clay.

The white loam grades upward to the chocolate loam with conspicuous hornblende crystals and vertical cracks, which is quite similar to the uppermost part of the Yamé clay. Its color varies from pale brown, dark brown, to reddish brown. The origin of this loam is a matter of question. The following observation at Notsuharu, 15 km southwest to Oita, however, is suggestive to this problem. At this locality the Aso welded tuff formation is overlain unconformably by the volcanic sequence of pale brown loam (1.0 m), pumice granule with lapilli of hornblende andesite (0.4 m), brown loamy soil (1.2 m), and black loam (0.6 m). The lower two units are considered to be the products of the San'in series of volcanism. The orange loam is quite young in origin but very incompletely preserved.

The above mentioned volcanic products could serve as the stratigraphic keys, if they were developed extensively. The limited preservation at the hill, however, markedly reduces their stratigraphical values. Furthermore some problematical volcanic materials distributed here and there make additional confusion. In conclusion the tephrochronological keys are very incomplete at the Nyu Hills, and this fact cause the difficulty in checking the stratigraphical position of the beds at the small outcrops.

B) Correlation

The determination of the geological age of these formations is one of the most difficult subjects because of shortage of the critical data in spite of the abundant occurrence of the fossils. Judging from the known range of *Stegodon orientalis* OWEN the Tsurusaki formation is not younger than the lower Narita group in Kwanto province and also not older than the Akashi group in Kinki province. While the Takio formation and its correlatives are safely correlated to the Akashi by their faunas and floras. Consequently the Tsurusaki which directly overlies the Takio is reasonably correlated to the Sanuki formation of the basal Narita Group. The Sanuki formation is preliminarily correlated to the Günz/Mindel interglacial.

The correlation of the formations of the Kujū group should be tried through the synthetic works on the sedimentation, geomorphology, fossils, and palaeoclimate. The Japanese geologists and palaeontologists generally accept the idea that the marine beds which form the terraces of the intermediate altitude (30 to 50 m) in west Japan are correlated to the Shimosueyoshi formation in Kwanto province which is in turn considered to be contemporaneous to the Riss/Würm interglacial. In the northern half of Kyushu the marine terraces comparable to the Shimosueyoshi are moderately developed at several locations and generally

covered by the Aso welded tuff formation. The stratigraphic relation between these two units is slightly unconformable at some localities and almost conformable at others. Anyhow there is not any large gap between them. The wood material came from the basal sediments of the Aso welded tuff at Yamé Hills, south Fukuoka Prefecture, reveals about 33,000 years BP by C^{14} test (GOHARA, 1963). Accordingly the Oka mud and Ichigi tuff members of the Jōbaru formation represent respectively the Riss/Würm interglacial warm stage and the middle part of the Würm glacial stage. Under this frame work of correlation the Ozai* and the Nyugawa formations may correspond respectively to the Mindel/Riss interglacial and to late Würm. We can not give the definite answer to the question whether the Kobarudai sand and gravel is corresponded to the inter-studial of the Riss glaciation or included in the Mindel/Riss interglacial. The Noma sandy gravel is not older than the Jōbaru formation and may be long ranged.

Table 2. Proposed correlation

Nyu Hill			Kwanto Province		Glaciation in Alps
Stratigraphy		Topogr.	Stratigraphy	Topography	
KUU GROUP	Orange loam Older Alluvium				
	Akagawa sd & grav.	Akagawa plane	Tachikawa loam Tachikawa sd & grav.	Tachikawa plane	Würm
	Enmeiji sd & grav.	Enmeiji p.			
	Ichigi tuff	Jobaru p.	Musashino loam Musashino & Yamate sd & grav.	Musashino p.	
	Oka mud	Oka p.	Shimosueyoshi loam Shimosueyoshi & Anegasaki F	Shimosueyoshi p.	Riss Würm
	Kobarudai sd & grav.	Nyu p.	Tama loam	Tama p.	Riss
	Nyu mud	Ozai p.	Jizodo F		Mindel Riss
	Shimura sd & grav.		Togane F		Mindel
	Takajo alt		Kasamori F		Günz Mindel
	Maki sd & grav.		Sanuki F Nagahama F		Günz
OITA GROUP	Takio Formation		Miura G		Donau Günz

* One of the junior authors, ONISHI recently established a new name for the seemingly aeolian sediment on the hill-top of Tsuijyama, the Tsuijyama aeolian bed, attributing it to the Riss glaciation.

Occurrence of the Stone Implements

The systematic archaeological research at the Nyu Hills was stimulated by the findings through the surface sampling on the Nyu plane, the second higher plane, after it was deeply plowed by the bulldozer. Reflecting this progress of the study great many stone implements were obtained through surface sampling and in consequence their geologic age can not be proved. Many implements, however, were also collected through the systematic excavations at several sites. The most prolific site was the area No. VII, west of Noma, where the trench was set up at the junction of the Oka plane and the Noma slope. Various kinds of the stone implements were obtained from the Noma sandy gravel and can be sorted into three associations. The origin of these implements may be (1) the crept and buried remains of the human being who lived on the ancient Noma slope or (2) reworked remains from the Shimura sand and gravel. We can not conclude this problem on the basis of the data at our disposal at present. If it is the case of (1), the implements are younger than the Oka mud, that is to say they are younger than the Riss/Würm interglacial.

Another large collection of the implements were come from the trenches on Nyu plane, northwest of Seiganji. The Nyu plane is generally covered by the white clay with sand mixture (0.2 to 0.4 m), orange loam, (0.1 to 0.3 m), and surface soil. Sometimes the brown sandy silt layer with dark spots is intercalated between the loam and clay. The orange loam yields the potteries of both the Yayoi and the Jōmon age and some stone implements and the underlying clay yields the mixed stone implements of a few palaeolithic associations including coup-de-poing, disk scraper, and flake tools. Although this clay looks like the white loam, especially the weathered part of the latter, the heavy mineral association of the clay is not similar to that of the white loam but to that of the Nyu mud, which is featured by the predominance of biotite with subordinate green hornblende, magnetite, and transparent glass. This fact indicates that this clay is a reworked layer of the Nyu mud. Its geological age should be younger than the formation of the Nyu plane, and may be, say, after the erosion-out of the white loam on the plane because there is no record of the white loam below and above this clay.

The finding at the 89 m high, northwest of Seiganji, is very important, although the collection consists of only one implement. The trench was dug into the upper gravel of the Nyu mud member. The implement was found at the level 35 cm below the boundary between that gravel and the reworked surface layer without any showing of the disturbance in the arrangement and compaction of the pebbles around the implement. This fact denies the possibility that the implement was forced into the gravel from outside in later age. The implement should be as old as the late Mindel/Riss interglacial.

Another recent finding at the cliff of Jūshin, southwest of Noma, adds a positive evidence for the existence of the older palaeolithic culture in Japan. It is a plagiolith made of andesite pebble. At this cliff the severely weathered massive

gravel lies under the dark brown soft loamy material (0.9 m) which may be reworked ash of Aso. The implement was obtained at the point 130 cm below the boundary between two units. The gravel consists dominantly of pebbles of schist and subordinately of andesites and quartzite with sporadic boulders and cobbles. The composition and the degree of weathering of the gravel is perfectly comparable to those of the Shimura sand and gravel in other areas but differs from those of the basal gravel of the Oka and Ichigi members. If this identification is correct the implement, which came from the middle horizon of the Shimura member, represents a culture of early Mindel/Riss interglacial stage and gives a meaning to the implements of older type collected in the shallow trenches and on the surface in the cut-crop area of the Shimura member.

In conclusion the stone implements collected at the Nyu Hills are sorted into three groups geologically (not the cultures archaeologically classified). They are (1) a group of the early Mindel/Riss interglacial stage, (2) of the late Mindel/Riss interglacial stage, and (3) of the Würm glacial stage.

Concluding Remarks

The Nyu Hills are constructed by five Quaternary formations on the schistose basement. The oldest of the five formations, the Tsurusaki, shows a intermediate character between the Tertiary and younger Quaternary ones concerning with the basin forming movements and post-depositional tectonic disturbance. The second older and the lower half of the fourth formation, the Ozai formation and the Oka member, represent a cycle of sedimentation accompanied by the eustatic rise of the sea level in the Mindel/Riss and the Riss/Würm interglacial stage respectively. The third formation is veneer sediments, which is considered to be marine in origin and represent the late Mindel/Riss interglacial or interstadial of the Riss glaciation. The members of the fifth formation represent the river terraces of the Nyugawa in Würm glacial stage.

A few definite palaeolithic remains were obtained from the Shimura and Nyu members of the Ozai formation. They represent, of course, the known oldest culture in Japan contemporaneous to the middle Acheulean. The majority of the implements, however, came from the reworked sediment ranging geologically from early to late Würm. These implements can be sorted into several associations and some of them are considered to be the secondary deposits from the older sediments.

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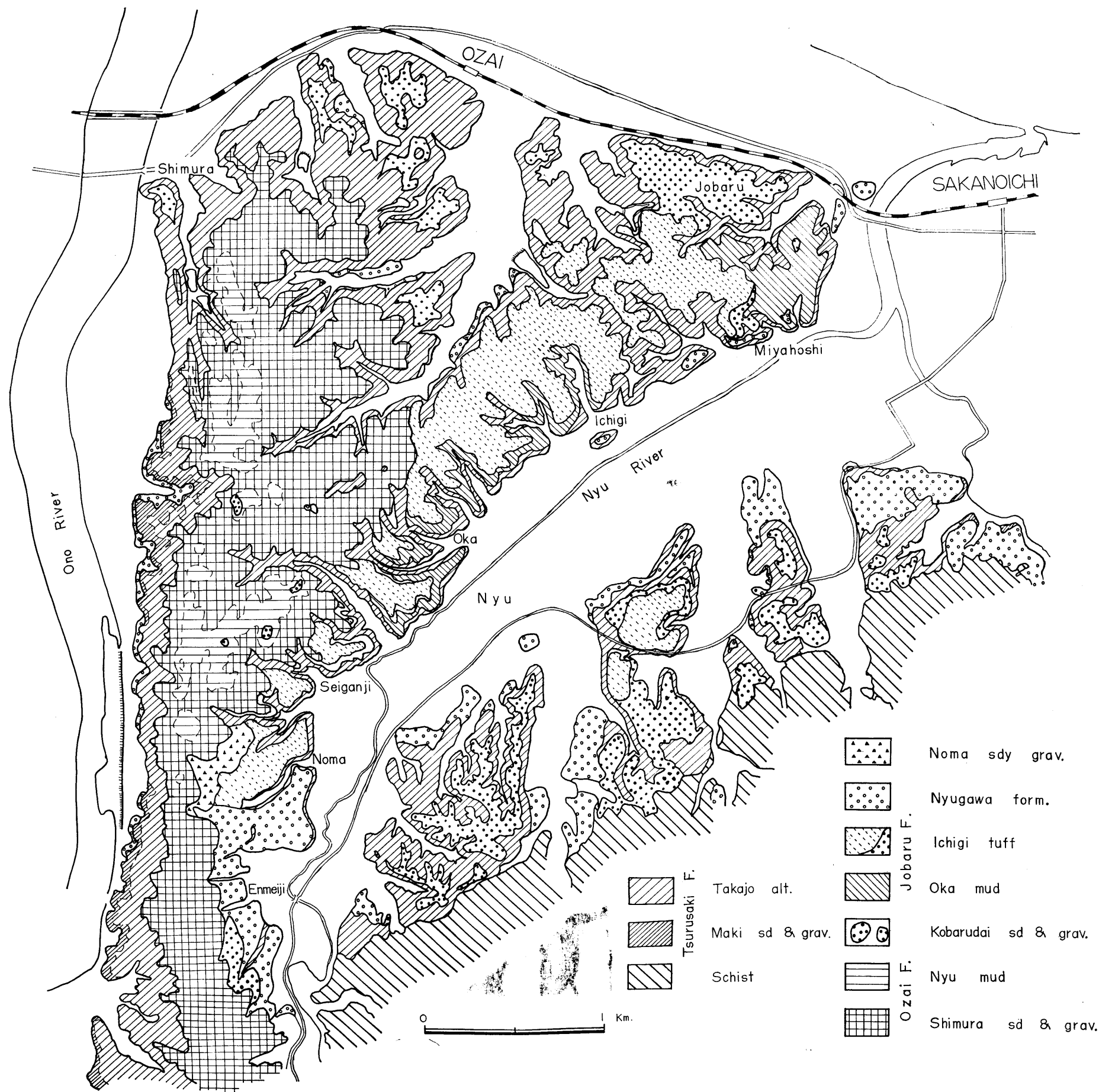
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|--|----------------------|
| | Noma sdy grav. |
| | Nyugawa form. |
| | Ichigi tuff |
| | Jobaru F. |
| | Oka mud |
| | Kobarudai sd & grav. |
| | Nyu mud |
| | Ozai F. |
| | Shimura sd & grav. |

- | | |
|--|-----------------|
| | Takajo alt. |
| | Maki sd & grav. |
| | Schist |
| | Tsurusaki F. |

0 1 Km.