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Archaeological Analysis of Dry Cultivated Field Soils with Regard to Soil Micromorphology

Miyaji Atsuko [1]

1. Introduction

The study of prehistoric and early historic food production economies in Japan has long focused primarily on rice cultivation. Such is the case not only in archaeology but also in history and folklore. However, such a narrow focus may lead to incorrect conclusions about these early subsistence economies. This paper takes a different approach toward these issues and attempts to clearly demonstrate that a broader, more generalized analysis of early agriculture, including dry cultivated fields (or dry fields), is necessary to understand the total subsistence economy of early agrarian societies in Japan.

Shigemitsu Kimura points out that dry field farming from ancient to medieval times began to be discussed after the 1970s (Kimura: 1996). He points to a 1973 article by Yoshihiko Amino entitled "Formation and Structure of Manors" (Amino: 1973) as an example of the development of this topic.

Excavation of plant remains aside from rice from sites has been documented since early the early days of Japanese archaeology, and the importance of plants other than rice after the Yayoi period has been recognized. However, rice and paddy field sites were the main points of interest in studies of early farming practices and subsistence economy. There has been little discussion of dry field farming or of the locations and dispositions of such fields at archaeological sites. One of the reasons for this oversight is that accurate investigation of such fields was considered too difficult a task. However, increased investigation of wetland sites has gradually added to the data set for non-rice agricultural products.

Recently more reliable samples have accumulated for microscopic identification through means such as SEM observation. Furthermore, the number of examples of dry field remains has increased as well. In addition, I have made some attempt to apply soil micromorphology

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Keyword: soil micromorphology（土壌微細形態）, dry cultivated field（はたけ）, cultivation soil（耕作土）, food production economy（食料生産経済）

techniques to this archaeological material as yet another method for dry-field sediment analysis.

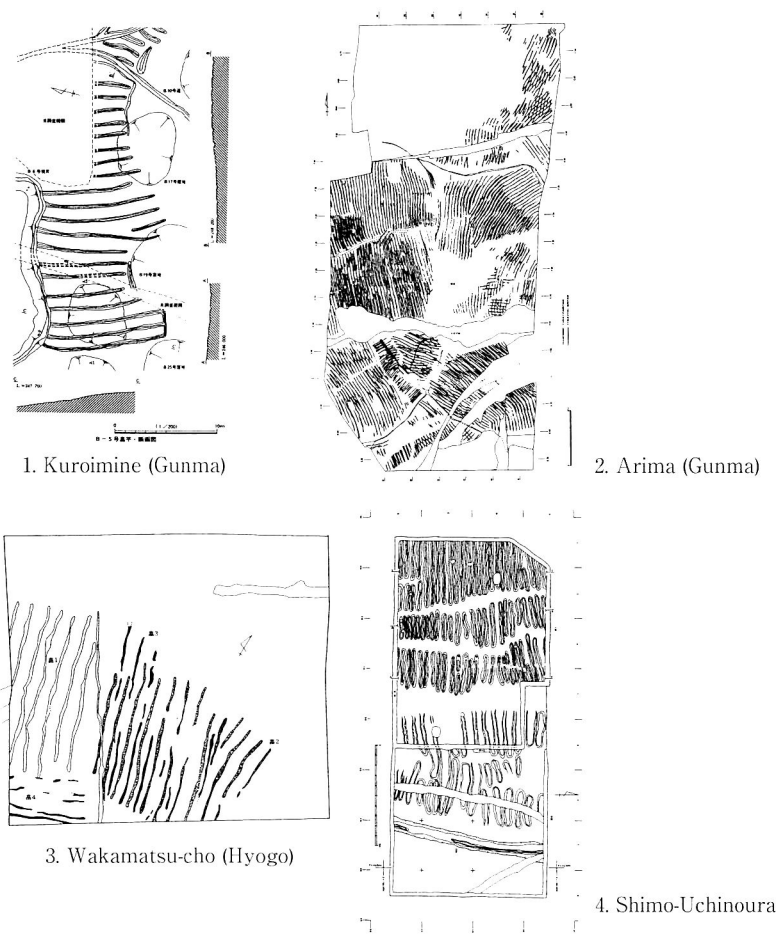
The purpose of this study is to examine cultivated dry-fields from the viewpoints of 1) form, 2) structure, 3) geographical convenience, 4) location relative to nearby settlements, and 5) the micro-structure of the cultivated soils. A distinguishing feature of this study is the application of soil micromorphology to Japanese archaeological contexts. My hope is that this paper will add support to the importance of the continued archaeological study of ancient dry fields in Japan.

2. Classification of Dry Cultivated Fields

1) Arrangement of Ridges and Furrows

First, I will describe the ridge and furrow arrangement of cultivated field remains from archaeological sites. Yoshiyuki Kuraku (2000) divides the arrangements of furrows into three types. Here I will use this as a base and add some complimentary types.

A. Furrows or ditches between furrows arranged in parallel lines. Furrow is black in color



1. Kuroimine (Gunma)

2. Arima (Gunma)

3. Wakamatsu-cho (Hyogo)

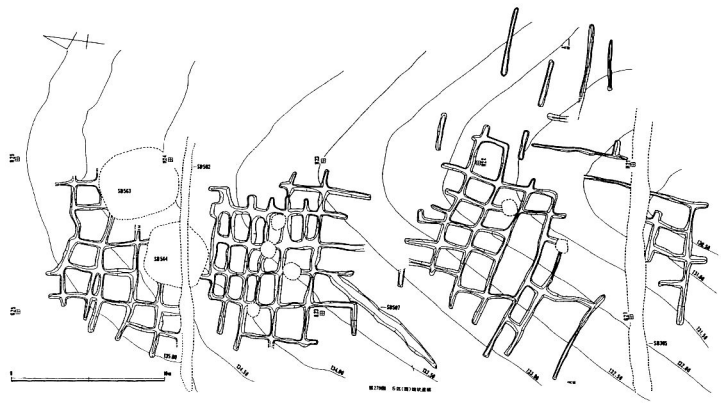
4. Shimo-Uchinoura

Fig. 1 A: Furrow or ditch between furrows in parallel
(Fig. 1-3: Japanese Archaeology Association (2000))

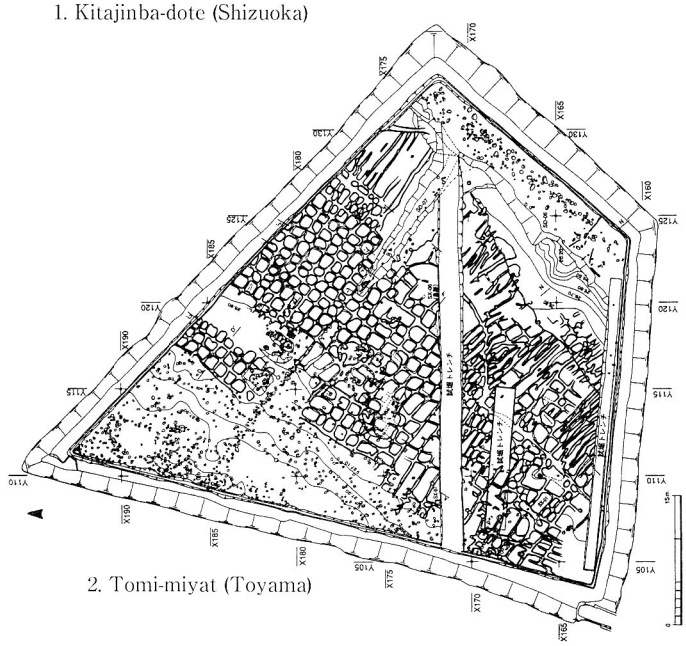
depending on circumstances. (Fig. 1)

Examples: Kuroimine site in Gunma (Fig. 1-1), Megurumi Site in Shizuoka, Wakamatsu-cho site in Hyogo (Fig. 1-3), Shimono-uchiura site in Miyagi (Fig. 1-4)

B. Ditches intersect at 1-2 meter intervals, each plot surrounded by ditches. (Fig. 2)



1. Kitajinba-dote (Shizuoka)



2. Tomi-miyat (Toyama)

Fig.2 B: Division supplement

Examples: Kitajinba-dote in Shizuoka (Fig.2-1), Tsurumaki-Uenokubo in Kanagawa, Tomi-miya-ta in Toyama (Fig.2-2).

C. Hemispherical and circular, shallow-flat based pits 20-30cm in diameter possibly represent-ing stick cultivation (Fig. 3)

Examples: Nodake-tamatabaru, Umusa-hurushima, Shikina-shimautaki in Okinawa, Uenohara,

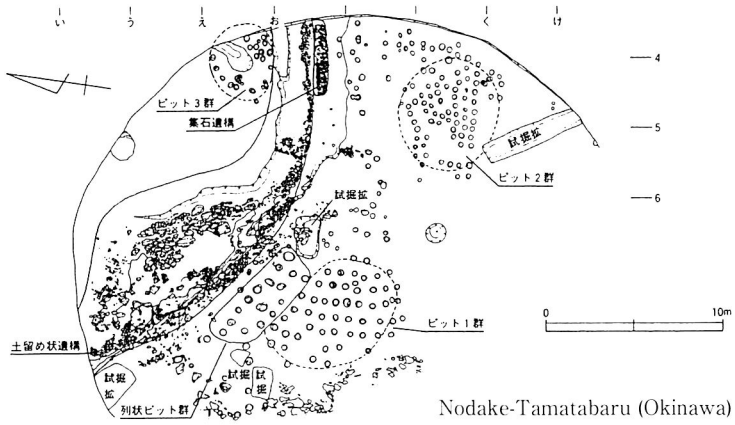


Fig.3 C: Circular pit

Fukikami, Yamanonaka, Miyao Yamashita-horigashira in Kagoshima, Makinohara-no.2, Tenjinkawachi-no.1 in Miyazaki, and Nobaru in Kumamoto.

2) Form of Ridges and Furrows

Next, I will describe the form of the ridges and furrows. Ken Noto (1991) has presented a classification of ridge form (Fig. 4) that I will follow with some complimentary additions.

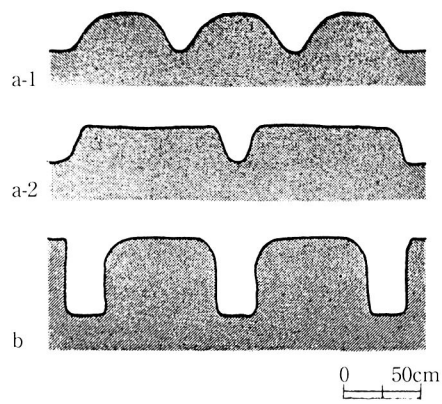


Fig.4 from of furrow (Noto: 1991)

a. Dry Ground Types

The ridge cross-section resembles an inverted plate. Subdivision is possible depending on ridge width.

a-1 Ridge resmbles an inverted shallow bowl. Ridge widths range form 20-40cm. Crops are planted in a single line.

Examples: Arima site F ward FA layer lower part.

a-2 Planting surface flat. Average ridge width is 1.2m. Crops are planted in several rows on the ridge top.

Examples: Kuroimine B ward no.5 field.

b. Wet ground type

The planting surfaces are prepared by digging surrounding ditches. Furrows are deep and piling up material excavated from the furrows creates the planting surface. Ridges are semi-cylindrical in shape. The fields of this form (b type) have been found in wetland environments.

Clay was piled up to form a dry cultivation ground. This type is like a primative form of raised field known as "Horiage-ta" or "Shimbata" in the later Medieval and modern periods.

Examples: Kumanodo no.I no. 3 field, Ashida-kaito III ward D furrow

c. Seedbed type

Planting surfaces are strips of about 3.6 × .08m with planting rows in parallel lines. This type may represent a small domestic garden for an individual household because they tended to be small and quite close to the residential space. Based on the results of phytolith analysis, it has also been suggested that that this type of field may have been used as a bed for growing rice seedlings.

Examples: Kuroimine B ward 36 field, Nichigumi

Both sites were buried by a pumice layer from Mt. Haruna (FP layer). It is believed that this layer was deposited in early summer.

3) Regional and Temporal Variation

Work by Terasawa indicates the spread of cereals such as wheat and millet, and of legume crops as well as rice in eastern Japan during the Late Yayoi period (Terasawa: 1986). This study suggests that the difference of cereals reflects the degree of dependence on rice. The most common assertion is that rice was the basis of agricultural production among cereals in northern Kyushu during the late Middle Yayoi. Even thouth foxtail millet and common millet were excavated with rice from Middle Yayoi deposits in the Seto inland sea and the Kinki regions; rice was the primary cereal in the Late Yayoi period. However, in eastern Japan, alternative crops such as wheat and beans dominate over rice in assemblages dating into the later Yayoi period. Recently reports of plant remains from archaeological sites are increasing and the observation of this trend is gaining support.

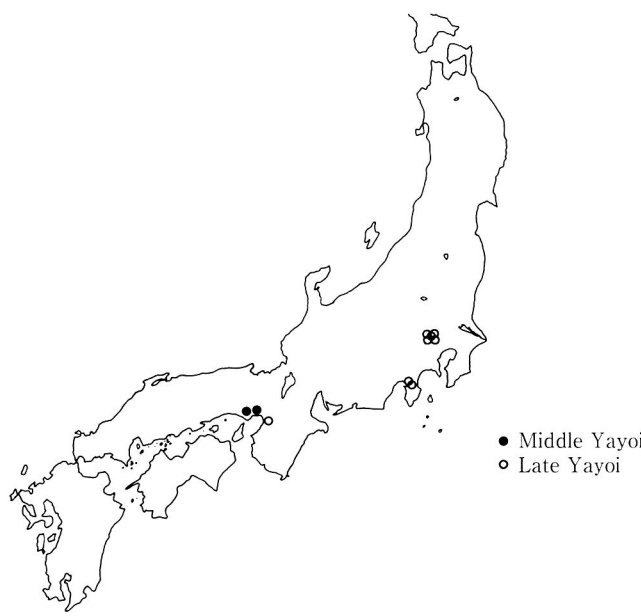


Fig.5 Distribution of Hatake (field) in Yayoi period (Miyaji: 2000)

In addition, dry fields have been observed in eastern Japan dating after

the late Middle and into the Late Yayoi period (Miyaji: 2000) (Fig. 5).

Compared with the Yayoi period, dry field agriculture appears to increase explosively in the Kofun, Heian, and early modern periods. There are many sites with dry field remains that have been found in Osaka dating to the Asuka（飛鳥） and Heian（平安） periods. In addition, there is now an abundance of evidence from Akita, Yamagata, Miyagi, and Nigata. I believe that these data may reflect official governmental agricultural policies regarding the encouragement of dry land farming. According to a study by Kimura, an ordinance was passed encouraging dry land farming in 715, during the Nara（奈良） period (Kimura: 1992).

The above-mentioned codes were passed as part of the Nara period jori（条里） system, which, along with similar agricultural policies enacted during the early Edo（江戸） period are well known in Japanese history.

On the other hand, careful examination of historical government agricultural programs has suggested that they were passed in "times of stagnation," but feudal tenure systems were different from "ho（保）" and "Betsumyo（別名）" which appeared suddenly after the middle eleventh century. The feudal tenure system was established based on developments which begain in the Eisho（永承） period.

In fact, there was extensive dry-field cultivation in the medieval period. Kimura points out that regulated exploitation of fields belonging to provincial governors as part of a public system was not yet established and that "a strong desire for possession of lands for agricultural use was a basis of the life of farmers who were often in confrontation. Fights were frequent from the eleventh to the twelfth centuries, and fields became the target of full-scale plundering (Kimura: 1992, 1996). Analysis of these documents can probably lead to implications about the archaeological record. Such considerations invite further empirical investigation.

4) Plant Remains and Pollen

The products of dry field farming are largely confirmed through opal phytolith and pollen analysis. There are very few macrobotanical remains of cultivated crops, but some examples of such remains are as follows:

SaikachikuboVI in Iwate (Heian period)

A seed (possibly Barley), small carbonized twigs recovered in abundance from furrows (likely ash from burned field plants)

Koizumi-Otsukagoshi in Gunma (Mt. Asama eruption of 1783 (Tenmei 3)

Furrows, a soy bean, and peels of taro

Nakamura in Gunma

A soy bean and holes for taro

Minori in Hyogo (Heian ~ Kamakura)

Wheat and legume remains

Kumamoto University yard 9909 in Kumamoto (the 18c latter half)

Barley and legume remains

3. Analysis of Soil Micromorphology

1) Methods and Materials

For the present study, I have applied new methods (in Japanese archaeology) for analysis of soils in the field, a practice that has long been difficult using conventional methods. Soil micromorphological studies are usually regarded as lying in the realm of soil science (Macphail: 1991). Soil micromorphology is an analytic technique of soils and materials included in the soil matrix using a microscope. It uses foil and a polarized light microscope is and similar to lithic taxonomy in geology.

This technology has been known in geology since the 19th century, and has been used in soil science since the 1930s. It was first applied archaeologically in the 1950s, but it has not been until the last 10 years that samples have accumulated enough to form concrete results. This technique for observing soil microstructure has been shown to be very effective in analysis of conditions of sedimentation.

Soil micromorphology has long been closely related to the study of soil formation processes. This method has been applied to a wide range of disciplines in soil science such as soil physics, soil chemistry, and even soil biology. Applications go beyond agriculture into ecology, geology, and now, it is becoming an important technique in archaeology.

Specific description of important aspects of soil micromophology are as follows:

1) All levels of soil characteristics such as quartz content, structural arrangement, and pedological features can be described.
2) Data can be obtained for reconstruction of events and processes in soil formation history.
3) Classification can be made for specific purposes.
4) All soil categories such as order, suborder, great group, and soil series can be compared.
5) Minerology, soil chemistry and soil physics can be conducted with the aid of additional samples as the need arrises

(Bullock et al.: 1985)

The samples were collected using a 6 × 8 × 20cm stainless steel frame called a "Kubiena box" (after the inventor (Kubiena: 1938)). Such a device is useful for collecting samples without losing the structure of the sediments. Water was removed from the samples by using a vacuum freeze-drying machine after being frozen in the frame using liquid nitrogen. The sample was then impregnated with a mixture of liquid POLIRITE T-241 polyester resin for 10 days using a vacuum impregnation machine.

The hardened sediment sample was then glued to a 10 × 23cm slide glass using epoxy resin and polished on one side. It was first cut to a thickness of about 500 μm and then after cut uniformly to a thickness of about 30 μm with continued abraision. After this process was completed, it was observed with the naked eye to examine sedimentary layers in cross-section, and then examined under a low-power binocular light microscope, or, where necessary, using a rock microscope with downward illumination and transverse illumination. Digital images of the thin sections were captured and downloaded to a computer for analysis.

The results of this analysis were successful in showing some of the important locational and micro-environmental information and are discussed below.

2) Results

I would like to point to a method of analysis as-yet untried in Japan, though well proven in other parts of the world. I believe that the development of farming technology in Japan can be better understood through the application of thin-section soil micro-morphological analysis. One example of this is from an A-a-1 type field located in Fukiya-Mikado, in Gunma. A description of the results of analysis from this site are as follows.

(1) Fukiya-Mikado, Gunma Prefecture: Type A-a-1 (Miyaji, Hirayama and Momohara, in Print)

Fukiya-Mikado located in Komochi village, Kitaguma county, Gunma Prefecture (Miyaji, Hirayama and Momohara: in print) (See Chapter 2). An Hr-FP layer dating to the mid-6th century AD and an Hr-FA layer dating to the early 6th century AD are well preserved, cover an area with a radius of about 9km, and are the result of eruptions of Mt. Haruna. Nearby subsoils were covered in a thick FP layer up to several meters thick.

This locality is well known as the Kuroimine village settlement dating to the late Kofun period that was buried under a large quantity of pumice. Due to the nearly instant burial of the cultivated soils, the site makes an excellent case study for evaluating the structure of ancient fields.

Sample 1 is a soil section collected from a track under a pure FP stratum in part of Fukiya-Mikado (Plate 1). The field is of type A-a-1 as mentioned above. The ground mass consists of

brown to dark brown (PPL). Fine sand, mineral inclusions, and carbide grains. Most of the carbide grains had diameters of about 1-3mm. In addition, this sample contained other minerals and inclusions such as finely crushed obsidian and feldspar. There were also many linear and jagged cavities in the soil. The largest of these cavities was around 1mm in diameter and 10-30mm in length. It is likely that these cavities were produced by the actions of animals and plant roots in the soil and that their presence indicates fertile soil activity.

Sample 2 is from a portion of the subsoil that was not within the scope of the lower part of the pure FP stratum (Plate 2). The soil grain constituting this ped was originally dense and the development was weak. From the sub-angular blocky structure, peculiar to undisturbed soils, it is believed that the soil in sample 2 has not been subject to alteration since formation. In addition, I believe that the absence of extensive cavities in the sample 2 soil indicate little bio-turbation suggesting that the soil was not particularly firtile.

When comparing the microstructure of sample 1 to modern dry field soils, many commonalities are observed. The quantity of cavities, constitution of the soil grain, and the soil matrix are all readily comparable with modern cultivated soils. For comparison to sample 2, sub-angular blocky structure is a hallmark of uncultivated soils.

Sample 3 was collected from the Umamichi track

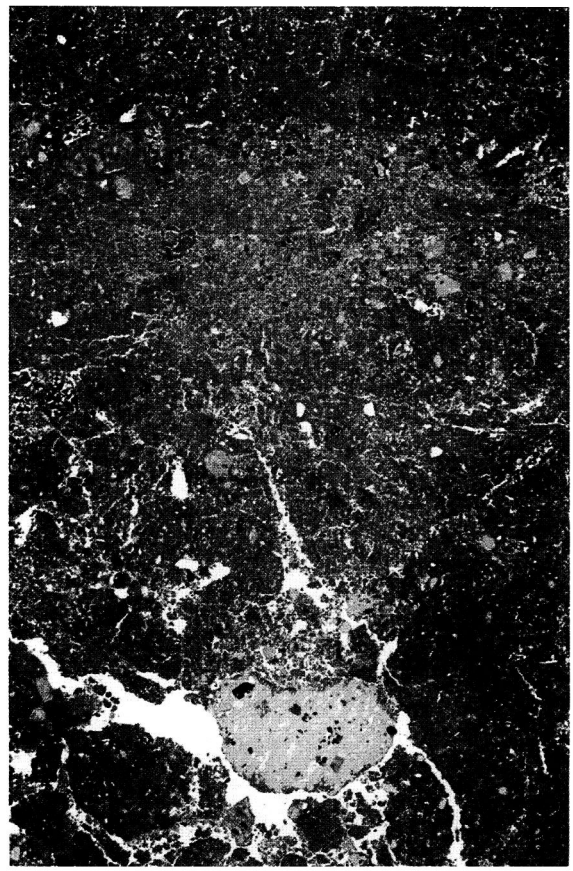


Photo. 1 Cultivate soil, Fukiya-Mikado

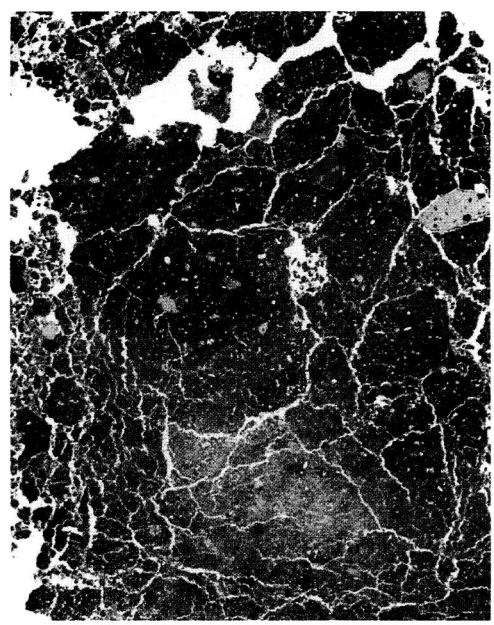


Photo. 2 Un-Cultivate soil

(Plate 3). The deposit consists of brown to dark brown (PPL) fine sand. A wide range of particle sizes down from fine sand were observed and the ped contained ovate and jagged voids. The largest cavity was less-than or equal to 1mm and lengths ranged from 2 or 3 to 10mm.

Volcanic mineral deposits were not crushed in sample 3. I believe this suggests that sample 3 soils were not disturbed by human activity. However, phosphate contents are high suggesting that the presence of animal excrement (Bakels: 1997). Richard I. Macphail of the University College of London has been conducting experiments with identifying feces and urine in cultivated soils at the Buttser Iron Age experimental farm. Further chemical analysis of the soils of sample 3 need to be conducted to compare to Macphail's work.

(2) Nogi, Aomori Prefecture: Type A-a-1 (Miyaji, Matsui, Hirayama: 2000a)

The Nogi site in Aomori has evidence of Towada A volcanic ashes in its buried parallel furrows. This volcanic deposit dates to the first half of the 10th century A.D. The sample was collected from the cross-section of a furrow and processed into a thin section (Plate 4). The upper half of the section contains carbonized organic matter in an area of massive particles dark reddish-brown

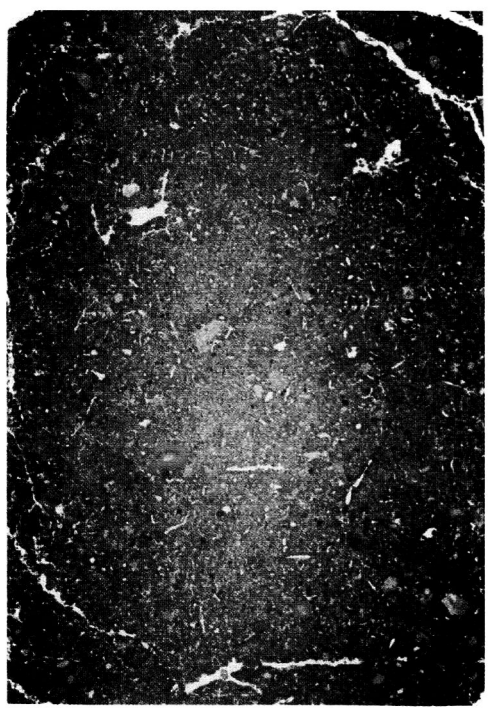


Photo. 3 Soil include Feces

Photo. 4 Cultivate soil, Nogi

in color and about 10cm in thickness. The massive dark reddish-brown particles in a may partially represent fires caused by volcanic eruptions and is partially a result of argillite deposits directly from the eruption. The particle size ranges from 1mm to 5mm and have non-homogenous shapes including spherical, ovate and asymmetric.

The argillite deposit appears to have been the result of human activity rather than natural accumulation. In addition, small cracks 2-3mm in width and around 3-10mm long are concentrated in the lower part of the sample. Further, course, nearly perpendicular voids and long, narrow, tube-like cavities resulting from animal and root activity. Hard mineral deposits line these cavities suggesting that the soil had a stable water content. Soil-dwelling fauna such as earthworms and cicada larva are often active in such soil conditions.

A circular area with weak color about 3cm in diameter seen in the center of the sample may be interpreted as resulting from the activity of soil-dwelling animals. Such activity suggests soil fertility and it is likely that this soil was rich for cultivation. An accumulation carbonized spheres about 2mm in diameter and homogenous size and shape may be the remains of carbonized plant seeds.

4. Discussion

Early dry field farming in the Japanese archipelago was largely restricted to western Japan spreading east several centuries later than rice. The center of dry land agriculture seems to have shifted from the western lowland areas to plateaus in eastern Japan.

Dry field agriculture appears to have begun in the Kinki district sometime in the Middle Yayoi and developed considerably in the Tokaido area near the end of the Yayoi period to the earliest stages of the Kofun period. As well as providing an alternative to rice agriculture, an organized production mechanism was established to some extent and this in turn helped to allow larger permanent settlements.

Furthermore, plants other than rice are likely to have been grown near settlements in the Yayoi period. During the Kofun period, farming activity intensified and appears to have come under the management of some kind of organizing group. This transition from residential farming to collective farming is observed in the organization of cultivated fields uncovered in Gunma prefecture. Crops other than rice were cultivated to augment the main rice diet. As such, fields for cultivation of non-rice crops likely began as residential vegetable gardens.

5. Conclusion

Throughout this paper I have argued 1) form/consitution of fields was regulated by geographical conditions rather than other factors, 2) Location relative to settlements was affected by the social production mechanism in a given period, and 3) micromorphology of cultivated soils clarify the intensity and organization of production in a field. I also have clarified the possibility for identification of plant remains in ancient field soils.

We can employ the results of this study to aid us in examination of dry cultivated fields and the subsistence economy. The considerations in this paper invite further empirical investigation. The social and economic implications of dry field farming remains from archaeological context awaits further study.

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Abstract

A study about food production economy of the prehistory to ancient times has long been developed by focusing on rice cultivation not only in archeology but also in various fields such as document history and folklore. But such situation may lead to incorrect conclusions on food production economy. This paper takes a different approach toward these issues and makes it clear that the generalize analysis include dry field farming is necessary to understand economic structure of an agrarian society generally.

I consider cultivated field land from the viewpoint of 1) form, 2) constitution, 3) geographical convenience, 4) locational relation to settlement, 5) micro structure of cultivation soil. A key distinguishing feature of this study is applying soil micromorphology to archeological context. This paper provides significance of archaeological inspection of cultivated field and future subject.

Dry field farming developed mainly in western Japan in the early stage and spread to east approximately one or two stage later than rice. And the center seems to have shifted gradually from low land zone of western Japan to the plateau of eastern Japan.

The dry field farming cultivated land began to be seen in Kinki from the Middle Yayoi, and developed a lot in northern Tokai from the end of Yayoi to the beginning Kofun period, which are can be seen of impact for intensive agriculture. Along with options of rice cultivation, the economic bases were organized after production mechanism was established to some extent and larger permanent group began there living.

In addition, in relation to settlement, other plant except rice were seen to be cultivated near the settlement in Yayoi period. In Kokum period, farming activity were intensified and managed as production by some group. This transition can be guessed from the condition such as cultivated land remains in Gunma. Crops cultivation except rice in Yayoi period played supporting role of rice cultivation and started just like the private vegetable garden, and was built in production mechanism by some group.

The main positive contribution of this paper has been, 1) form / constitution of field being regulated instead of geographical condition by another factor, 2) locational relation to settlement are affected by the production mechanism each periods, and 3) micromorphological peculiar of cultivated soil.

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畑土壌の考古学的研究－土壌微細形態分析から－（日本語要旨）

宮路淳子

日本語趣旨

先史・古代の食料生産経済についての研究は、考古学に限らず文献史学，民俗学などさまざまな分野で，これまでイネを中心に据えてすすめられてきた。遺跡からのコメ以外の植物遺体の出土は早くから報告され，弥生時代以降の植物食の重要性は認められていたが，食料生産経済に関してはイネと水田跡が取り上げられることが多く，畑作物とその生産地が論じられる機会は少なかった。そのことには，畑作物・耕作地の検出が困難とされていたことにも一因がある。

しかし低湿地遺跡の調査が増加し，水洗選別・フローテーション法が調査に取り入れられるようになってきたことを背景として，出土種子の同定個体数は確実に増えてきている。今後はSEMの導入による観察によって，より確実な同定試料が蓄積されると期待できる。そして，畑作耕作地の調査例も増えつつある。

筆者は，農耕社会の経済構造を総合的に理解するためには，イネだけでなく他の畑作物も含めた総合的解析が必要だと考える。そこで今回は，畑を取り上げ，1）形態，2）構成，3）立地，4）集落との位置関係，5）耕作土の微細構造，の５つの観点から分析する。

特に筆者は，はたけ土壌を分析する新しい方法として，土壌微細形態学の考古学への応用を試みる。歴史的に微細形態学は土壌生成と密接な関係をもってきたが，今日では土壌物理，土壌化学，さらに土壌生物学をも含む土壌学の広範な場面での適用が増大してきている。農学において広く使われているばかりでなく，生態学，地質学それに考古学に対する応用も重視されつつある。

微細形態学の記載は，次のような特性をもつ。

1）石英粒子のレベル，より高次の構造配列のレベル，またはある過程によって生じたフィーチャーのレベルなど，あらゆるレベルでの土壌の特徴について詳細に記録できる

2）土壌中での出来事とその過程を再構築するためのデータが得られる

3）一般的かつ特別な目的なための土壌分類を可能とする

4）土壌分類体系中の一つの目，亜目，大群，または土壌統のような下位のレベルであっても，一つのカテゴリー内の異なる土壌の特性を比較できる

5）必要に応じてさらなる鉱物的・化学的・物理的分析法を選ぶための基礎となる

（Bullock et.al: 1985）

本稿では，これまでに調査された畑遺構を再整理・分類し，土壌微細形態の分析結果を併せて報告することにより，はたけ遺構の考古学的検証の意義および畑作研究の到達点と今後の課題を示す。

畑作植物の出土比からは，畑作物は早い段階には西日本に中心を持ち，イネの伝播よりも一段階あるいは二段階ほど遅れて東へ広がっていったように見える。そしてその中心も，西日本の低地帯

から東日本の台地上へと移っていったようである。畑作耕作地が近畿で弥生中期後半頃から見え始め，弥生末～古墳初頭に東海以北に多くなることは，農業の集約化を考える面でも重要である。コメ栽培の取捨選択とともに，生産機構がある程度確立して経済基盤が整備されたところへ，より大きく恒常的な集団が生活をはじめた状況を反映しているのではないだろうか。

また集落との関わりでは，弥生時代にはイネ以外の植物は，集落の縁辺で栽培されていた状況が見られる。これが古墳時代以降には，農耕活動は集約化され，集団としての生産活動として管理されるようになっていく。この様子は，考古学的には群馬県での耕作地遺跡などの状況から推察でき，また奈良時代以降については文献史料からも裏付けられる。弥生時代のイネ以外の畑作物栽培は，イネ栽培の補助的な役割を担いつつ，家庭菜園的な位置づけで開始され，やがて時代が下るにつれて集団の生産機構のなかに組み込まれていったと考えることができる。

今回の論考では，1）耕作地の形態・構成は立地条件ではなく別の要因によって規制されている場合があること，2）集落との位置関係は，生産機構と併せて考察していく必要があること，3）畑耕作土には，マトリックスの中での孔隙率，土壌動物の活動痕，対する非耕作土には顕著な亜角塊状構造など，それぞれ特有の微細形態があると考えられる，などの点を明らかにした。