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Verifying the Function of Yayoi *"Ishibocho"* Tools from Tohoku District

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要旨：イネ科植物の刈り取りに使用された石器刃部には、コーン・グロスと称される特徴的な摩耗光沢が生じる。粘板岩などの石材におけるコーン・グロスの発達過程と特色を明らかにし、東北地方弥生時代のイネの収穫具である石庖丁の使用痕分析を行なった。福島、宮城、岩手、秋田各県から出土した 14 点の石庖丁の入念な顕微鏡観察により、実際の使用方法が復元された。石庖丁に認められる使用痕光沢の強度と分布を精緻に分析・図化した結果、石器紐孔に通した紐に指を掛け、右手親指でイネの茎を押さえ、穂の部分を摘み取っていく「穂摘み法」であったことが実証された。この方法により、石庖丁以外の様々な石器が収穫具として使用された場合の判定が可能であり、日本列島東北部の初期農耕社会における人間集団の文化的適応プロセスの比較研究に応用できる。

Introduction

From the perspective of the classical Processual Archaeology, human culture can be investigated as a means of extra-somatic means of adaptation to the environment (e.g., Binford 1962). The spread of rice agriculture during the Yayoi period to the northeastern parts of the Japanese Archipelago entails grave theoretical importance from the perspective. Adoption of rice cultivation included highly developed technological complexes such as on-site irrigation in environmentally mosaic-like mountainous terrains and not always broad river basins during the earlier half of the Yayoi period in northeastern Japan (Tohoku District). There had been adoption of complex agricultural technology including construction of rice paddies of small rectangle shape as well as the annual cycle of organized cultivation techniques. In addition, the various sets of cultural traits were also adopted such as ground stone artifacts for agricultural settlements. These stone artifacts consisted of representative axes and adzes, and are termed as "ground stone tools of Asian continental derivation". They constitute an integral part of human activities at the Yayoi settlements in most areas of the Archipelago. The *"Ishibocho"* tool whose function is investigated in the present article is a category of these ground tools.

Across the Tsugaru Strait which lies north of Aomori Prefecture, human groups in the Island of Hokkaido remained basically as hunting, gathering, and fishing society throughout the time periods which correspond to the Yayoi Age in main islands of Japan (Honshu, Shikoku, Kyushu). Such H/G/F culture is named as "Epi-Jomon Period" *(Zoku-Jomon jidai)*. Two contrastive life ways persisted between Hokkaido and the northern part of Honshu, although possibilities of incipient cultivation remain controversial. The Tsugaru Strait had not been a barrier against cultural transmission for most time periods from the Palaeolithic to the pre-modern period. As the folk knowledge saying goes until recent era, the Strait is "the salty river" ("*shoppee kawa*" in local dialects) in terms of cultural trait complex diffusion. During the Final Jomon period, the Kamegaoka culture flourished in both sides of the Strait preceding the Yayoi Age.

The beginning of rice cultivation in the Tohoku District dates back to the Early Yayoi period of Japan. The discovery of rice paddies of the Middle Yayoi period at the Tareyagani site in 1981 (Aomori Pref. Board of Education 1985), and those of the Early Yayoi period at the Sunazawa site in 1988 (Murakoshi et al. 1991), both located in Aomori Prefecture, confirmed the adoption of actual rice cultivation on the Tsugaru Peninsula which is situated at the northern edge of the Honshu Island. During the Middle Yayoi period, stable agricultural settlements were established in Tohoku District. Especially, Yayoi villages in the Sendai Plain in Miyagi Prefecture such as the Nakazaike-minami site (Sendai City Board of Education 1996) and the Takada B site (Sendai City Board of Education 2000) testified to developed agricultural life ways from recent excavations. Abundant wooden implements were also found.

The diffusion processes of the Yayoi cultural complex in Japanese archipelago has been a major theme of research

(e.g., Akazawa 1982 in English). For Tohoku District, Suto has continued research on the theme and a major achievement was published (Suto 1998). The regional variations of Yayoi period settlements in Tohoku District represent differential adaptive processes, and thus complex combinations of subsistence and cultural traits need to be investigated. During the Early Yayoi period, the typological similarity of the Ongagawa style potteries from a number of Tohoku sites (e.g., Suto 2000) exhibits a fine contrast with diversified subsistence and settlement strategies developed during the same period, including tendency for combined economy in some colder and/or mountainous areas of Tohoku. Takase (2004) synthesized researches on the transition from Jomon to Yayoi with special attention to social structure. In relational researches of economical aspects and typological aspects of artifacts, the study of tool function is essentially important. Reliable identification of tools which were actually utilized for agricultural purposes would shed light on the problem. Use wear studies would play an important role in this line of research.

The present paper focuses on the function of *Ishibocho* tools on the basis of high power microwear analysis. The name *Ishibocho* literally means “stone kitchen knife”. It is a historical name for Japanese archaeology, but from the viewpoint of actual function, it is rather misleading. The type was evidently used as rice reaping tools for annual harvest at paddies. Tools of the same category are widely found in continental China, Taiwan, and Korean Peninsula, during the Neolithic and the Bronze Age. The origin of Japanese *Ishibocho* was investigated in relation to Asian continent. However, the actual method of its use has not necessarily been fully investigated globally. The article verifies detailed method of use on the basis of distribution and intensity patterns of microwear traces on both faces of *Ishibocho* artifacts.

Experimental replication of the tools clarifies the developmental processes of a distinctive type of microwear polishes called “corn gloss”. The result will also contribute to differentiation of artifacts which were actually utilized as harvest tools from tools of various other functions. Throughout the Japanese Archipelago, various other types of stone tools were used for harvest. It is important to identify harvest tools and it is quite feasible to do so, based on the hard evidence described here.

The sample and the method

The phenomenon of “sickle gloss”, or “corn gloss” was recognized early in the history of stone tool function (Curwen 1930, 1935). The line of research was further synthesized to understand the strong polish on the edge of Neolithic sickle blades (retouched small blades) which were inserted to the haft for the purpose of harvest, and general characteristics of the “corn gloss” was described (Witthoft 1967). The corn gloss is so strong that it is often observable with the naked eye or with magnifying glasses. Keeley further integrated the corn gloss phenomena with elucidation of microwear polish in general. The polish was classified as a strong variety of “plant polishes” (Keeley 1980). According to Keeley, it exhibits the following characteristics (after Witthoft 1967, and Semenov 1964), (1) very smooth texture and highly reflective surface, (2) “fluid” appearances, (3) “embedded” striations, and (4) “comet shaped” pits.

Tohoku University Microwear Research Team (TUMRT) directed by the late Professor Chosuke Serizawa (Akoshima 2008) conducted a series of experiments in 1978 to 1980 to confirm the variation of microwear polish which was reported in Keeley (1977). Our team conducted a systematic program of replicative experiments for shale (siliceous hard shale), chert, and obsidian. It was confirmed that microwear polishes produced on these Japanese materials were almost identical with those on European flint (Kajiwara and Akoshima 1981). However, it was pointed out that the correlation between the polish types and the worked materials was not necessarily exclusive to one another, but the correlation was probabilistic (Serizawa, Kajiwara, Akoshima, 1982, Akoshima 1989). The classification scheme of Tohoku University team has since been widely adopted among Japanese researchers of high magnification use-wear analysis (e.g., Aoyama 1999, 2009, Harada 2005, Midoshima 2005, Yamada 2007, Takahashi 2007). The “corn gloss” is a part of “Type A” polish of Tohoku Univ. classification scheme (Akoshima 1996 for English explanation). The term “corn gloss” is used here for convenience to denote the polish type which was observed on the sample of *Ishibocho*.

The type A polish is not difficult to identify, compared to other types of polish. Their characteristics are very distinctive. The polish is produced as the result of surface texture alteration. It is the transformation of rock surface itself. It is neither an additive phenomenon of silica gel, nor remnant residues on the rock surface. The polish is the permanent change of stone surface structure, and thus it is not erasable by washing or cleaning.

The above mentioned characteristics of the corn gloss are ideal for identification of harvest tools of rice crop. Actually, crude flake tools were also used for rice harvest and they were identified on the basis of patterns of corn gloss (e.g., Harada 2003, Midoshima 2005). Reconstruction of the use method of *Ishibocho* tools was carried out by the same methodology as the case of flake tools in the Palaeolithic period.

A total of 14 *Ishibocho* tools from Tohoku District were selected for the present analysis. On the rice reaping knives, Suto conducted a detailed and meticulous study of

Tohoku District *Ishibocho* (Suto 2004). The samples which were microwear analyzed here were actually a part of his research objectives. It was highly labor intensive to observe the entire surface of the large specimens. The sample here is made up of 14 specimens as follows. (They are listed from south to north in Tohoku District).

The Tenjinsawa site, Soma City, Fukushima Prefecture, 2 specimens.

The Nishinoda site, Natori City, Miyagi Prefecture, 1 specimen.

The Shimonouchiura site, Sendai City, Miyagi Prefecture, 2 specimens.

The Nabeta locality, Tomizawa site, Sendai City, Miyagi Prefecture, 1 specimen.

The Izumizakimae locality, Tomizawa site, Sendai City, 1 specimen.

The Minamikoizumi site, Sendai City, Miyagi Prefecture, 4 specimens.

The Shikama burial mounds site, Shikama Town, Miyagi Prefecture, 1 specimen.

The Shimizushita site, Oshu City (Isawa Ku), Iwate Prefecture, 1 specimen.

The Yotsugoya site, Kosaka Town, Akita Prefecture, 1 specimen.

For the locational information and description of these sites, please refer to Suto (2004). For the characteristics of *Ishibocho* tools in Tohoku District, and description and illustration of the samples above, also see Suto (2004). On production processes of *Ishibocho*, Arai (2003) analyzed cases at Takada B and Tenjinsawa sites.

A metallurgical microscope that is Olympus BHM type with incident light attachment was used for the present analysis. Cleaning of specimens was done according to the following processes without using any brushes. 1) Hand wash with soap and ordinary water. 2) Application of ultrasonic cleaning of 150 W for 5 minutes, suspending the sample in the water tub. 3) Hand wash again with soap water. 4) Application of ultrasonic cleaning for 2 to 3 minutes. 5) Wipe with alcoholic cotton (Ethanol) during each observation session. This is to prevent finger grease from sticking on the surface which is often misleading as "pseudo-microwear polishes". Surface treatment such as vacuum coating was not necessary.

Observation was conducted at the magnification of 100 X. Polishes always extend to a certain area of specimen. Especially in the case of "corn gloss" on *Ishibocho,* the polished surface appears in wider areas, compared to such a case as scraping bone where the polish is localized to the contact edge. Observation was carried out with an X – Y movable stage of the microscope to cover the entire area of the sample with movements of several millimeters. When the corn gloss polish was found, the magnification of 200 X was used for observation of detailed texture of the surface. Both density of polish patches for the unit area and size and texture of these patches were combined to produce the distribution maps of each *Ishibocho,* according to the criteria described below.

Characteristics of corn gloss on slate

Characteristics of corn gloss polish on slate rock are basically identical with other rock types as flint or shale. Once it is developed to the stage of "weak" described below,

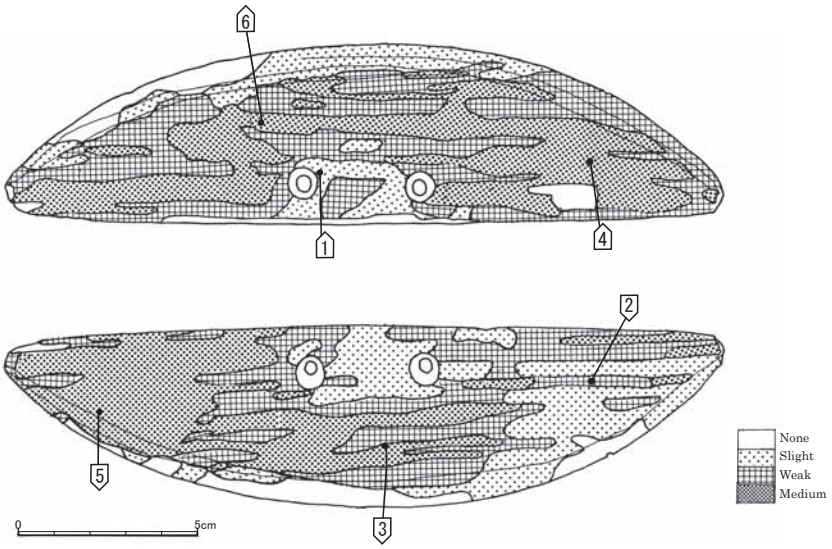

Figure 1. Distribution of corn gloss on Ishibocho (reaping knife) from Nishinoda, Miyagi Pref. (Numbers correspond to figure 2 microphotographs).

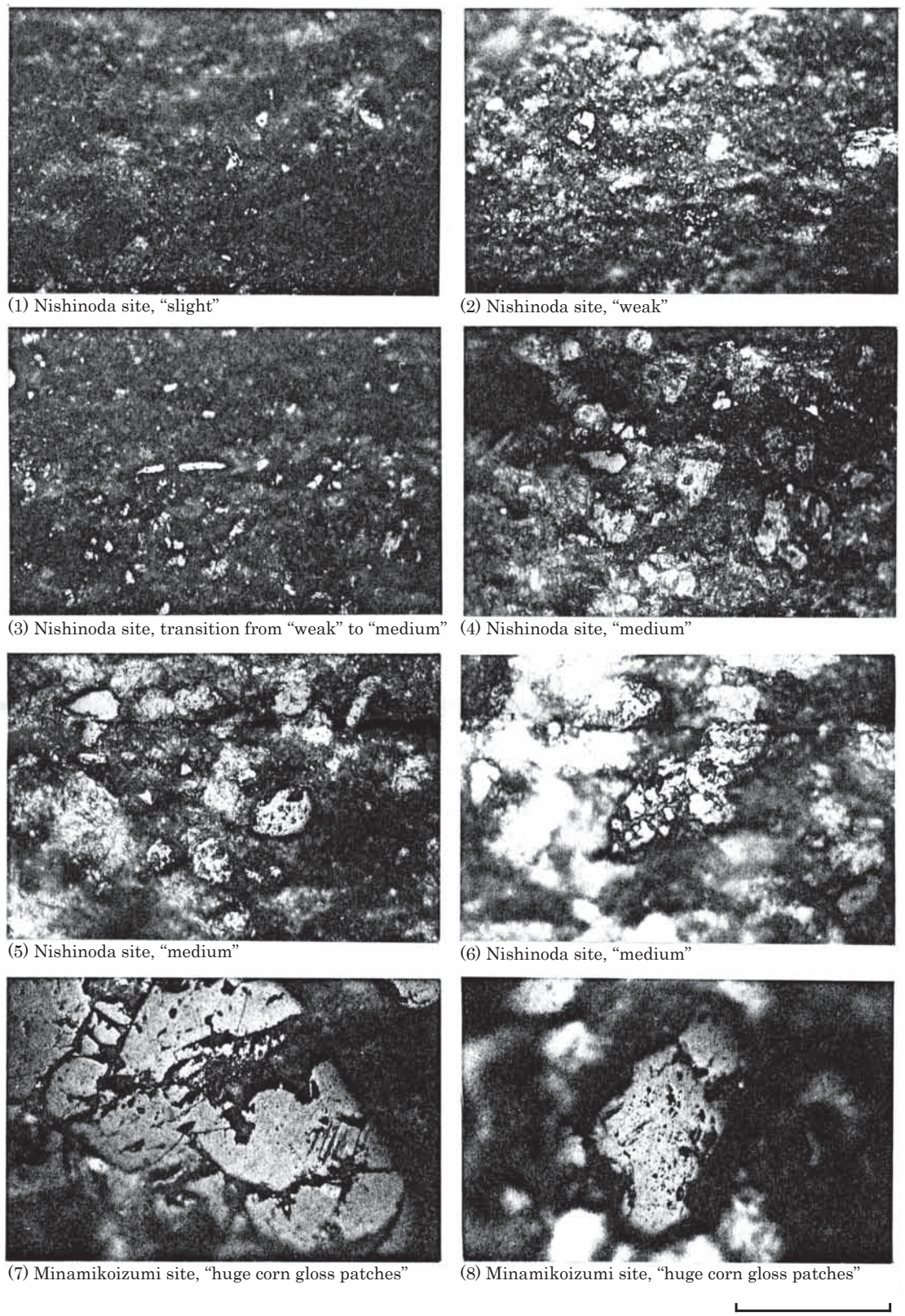

Figure 2. Corn gloss on reaping knives (The scale bar is 200 microns. 400 microns in case of (3)).

it is not difficult to differentiate between corn gloss and other types of polish. It is also possible to differentiate it from other micro-traces from manufacture, especially from grinding polishes, based on experimental results. An interesting example is a reaping knife discovered at the Iwanoiri site, Marumori Town, Miyagi Prefecture (Figure 5, no.3 in Suto (2004)). It is an unfinished *Ishibocho* as is known from half pierced depressions, but entire surface was fully shaped and ground. Two depressions were intended as string holes but not finished. Microwear observation of the specimen only exhibit grinding wears, but no corn gloss was found.

A notable difference between corn gloss polishes on slate type rocks from which many *Ishibocho* tools were made and those on other CCS rocks (crypto-crystalline silica) such as flint, chert, and siliceous shale, is the development of patch like polish structure in case of slate type sedimentary rocks. Let us take an example of reaping knife from the Nishinoda site (Figure 1). There are portions of different degrees of corn gloss development on a single specimen and their disposition is shown on the illustration. There are places from very incipient developmental stages to highly affected areas. The change of surface texture is gradual, and the degree of development is classified into "none", "slight", "weak", "medium", and "heavy". They are shown in figure 2(1) to 2(6) for the reaping knife from Nishinoda. Figure 2(7) and 2(8) are huge corn gloss patches on a reaping knife from the Minamikoizumi site, Sendai.

Appearance of unused surface is quite similar to other CCS rocks. Polishes from grinding during manufacture are often observed, but its granular rock structure looks almost identical with shale and chert. Corn gloss polishes first appear as tiny shiny points in the granular structure. Small shining points of less than 10 microns in diameter begin to appear with a sharp contrast to surrounding areas. Then, the shiny points grow into small patch like features. At the same time, the density of polished points and patches per unit area increases.

Development of gloss features brings a notable situation where various shiny points and patches coexist in the same portion, observable under magnifications. Polish patches of different sizes from minute to large coexist in the same area to be seen. In the case of chert and shale, "corn gloss" polishes begin to develop with appearances very similar to "wood polish". They begin to develop from the very edge of working blade and also from higher elevated portions of granular structure. Then they extend into surrounding areas gradually and the corn gloss finally covers overall affected area (cf. Kajiwara and Akoshima 1981, figure 1 (2) (3)). In the case of slate type sedimentary rocks, the process is not uniform gradual developments of polished portion, but ii is a collective formation of demarked patches of variable sizes.

A factor leading to non-uniform development of polished surface is probably the structure of granular components of the rock itself. Observation at high magnifications from 200 X to 400 X reveals differential appearances among patches and non-affected granules. Adjustment of focusing dials of the microscope also reveals that relatively elevated parts produce gloss patches in higher density.

In summary, the phenomenon of corn gloss development in case of slate type sedimentary rocks is defined as increase of the number of polish patches per unit area and enlargement of the size of polish patches. On the contrary, it is not a phenomenon of increasing brightness of each patch or the degree of smoothness of patch surfaces. Once the patches are formed, even if they are tiny, their texture is very smooth, their surface shape is flat, their surrounding edges are rounded, their brightness that is light contrast is strong, and patches are clearly demarked from their background. Their brightness is similar between large and small patches. It is not that more developed patches are brighter than others.

Distributions of corn gloss polishes over both faces of the reaping knife exhibit very informative patterns. The specimen from Nishinoda (Figure 1) represents a typical pattern of wear disposition brought from the method of use. The lithic raw material is composed of high density darker color parts and low density lighter color parts. The latter consists of sandy rock type. The stone constitutes thin laminar structure and the reaping knife was manufactured with its length in the direction of the laminar structure. The difference of stone quality is reflected in the degree of development of corn gloss polishes as is seen in the distribution map. The lighter color parts exhibit relatively heavier development of corn gloss. It is evident from the case that the variation of rock types generally affects the speed of polish development. Figure 2(3) is a microphotograph of the border part of two different laminar units. It is interesting that two different stages of polish development are seen in the same photo.

When the tool is placed with its convex blade edge down, areas of stronger polish extend toward the left part of the body of reaping knife. The polish distribution is not symmetrical between the left and the right. There is not much difference between either face of the implement. That is, the corn gloss is developed similarly on both surfaces of the tool and the left part of the body exhibit stronger polish on either face. This means that the implement was used in "turn around" method repeatedly. The polish is extraordinary weak around the two string holes on either face. The edge of the convex blade shows weaker polish relative to the body part. The units of grinding finish well accord with the difference of polish strength along the blade edge on either face. These distribution patterns are rather typical for most *Ishibocho* tools, as we will see below.

Developmental stages of corn gloss and striations

Developmental process of corn gloss is a continuous phenomenon, but here the degree of polish strength is classified into five stages, namely “none”, “slight”, “weak”, “medium”, and “heavy”, based on the following criteria.

“None”; the stage where no polish is detected under the magnification of 100 X.

“Slight”; the stage where the polish begins to form as tiny points in low density. The diameter of each polish patch generally does not exceed 10 microns. When they are observed under the magnification of 200 X to 400 X, their characteristic features as corn gloss barely begin to appear. In case of stone implements which exhibit only this stage of development, it is not always reliable to identify the polish as being corn gloss.

“Weak”; the stage where corn gloss patches exhibit sporadic distribution. When a frame of 1000 microns X 70 microns is set on the surface of the tool, several pieces of corn gloss patches of about 20 microns or larger in diameter are detected within the frame. The frame is measured using the scale in the eyepiece lens of the microscope. The size of the corn gloss patches does not reach 50 microns in length even for larger patches. However, the characteristic features as corn gloss polish are observable at the magnification of 100 X.

“Medium”; the stage where corn gloss patches exhibit grouped emergence. Within the same frame as above, 10 to 20 pieces of corn gloss patches of about 20 microns or larger in length are detected. Larger patches in this stage reach the size of 50 to 100 microns in length. Sometimes they exceed 100 microns in diameter.

“Heavy”; the stage where the corn gloss polish covers all over the observation area. This phenomenon is observed in the case of siliceous shale experiments. However, there was no implement of this stage in the present analysis. The most notable example of strong corn gloss for *Ishibocho* is shown in figure 2(7) (8). It is from the Minamikoizumi site. The huge patches reach the size of several hundred microns. They share the common characteristics as corn gloss in other samples in the paper. The stone raw material is not slate, but semischist .

Striations with corn gloss phenomena of *Ishibocho* need special cautionary attention, because their manufacture processes include broad application of grinding techniques. In the present analysis, only those striations which accompany with the surface of the corn gloss patches are denoted as use-wear striations. They are fused with smoothed flat surface of the patches themselves. They show a distinctive appearance as if the surface looked like swept with a brush, so to speak. The striations are extremely thin, shallow and parallel. They are observable only at high magnification of 400 X in most cases. This type of striation is considered to form as a part of surface structure of polished area. They generally indicate the direction of motion of the working edge of the tool. The same sort of striae is also seen on CCS rocks and they were called as “filled-in striations” (Keeley 1980, p.60). In the case of slate, striations are even more tiny and subtle. In the present specimens, only a limited number of reaping knives retain the traces. Existence and directional tendency could be recorded, but quantitative evaluation such as density was not possible. Those striations in the background area of polish patches were not included in the analysis, because they may have been the results of manufacture processes. Striations which are on top of polish patches but are not integrated with surface texture were not recorded as use-wear striae. Examples are shown in figure 2(7) on the right side corn gloss patch, running oblique together. They are “damage like grooves”.

Results

The results of microwear observation confirmed the so far supposed use method of this category of artifacts. Figure 4 shows microphotographs for intensity degree “medium” portions. They were taken at 200 X magnification. All the use-wear polishes detected in the analysis were type A of Tohoku University classification scheme (Kajiwara and Akoshima 1981). The areas around the string holes were also observed but no other types of polish were found.

The Tenjinsawa site (Figure 3 (1) (3))

Both implements show polish distributions mainly on the lower parts of the tool body. Both have stronger polish areas in the left half of the body. In the case of (1), there are differences in intensity of polish, according to the laminar structure of the stone material. Brighter color areas of sandy rock stripe structure exhibit relatively stronger polish. At the left part of face B (bottom), polish patches are found on the edge part. On specimen (3), there are differences between both faces, namely, face B shows stronger polish patterns.

The Shimonouchiura site (Figure 3 (2) (4))

Two faces of the implements show almost the same degree of polish intensity. This is the same pattern for two *Ishibocho* which were placed in a pit as grave goods. In the case of (2), the stripe pattern of “medium” and “weak” portions corresponds to the rock material lamination pattern. Both implements exhibit stronger corn gloss in the lower part of the body at the area adjacent to the edge. The edge parts themselves do not retain strong gloss on the other hand. The area surrounding the string holes show almost no polish patches. Detailed microphotographs are shown in Suto and Akoshima (1984). These two *Ishibocho* were repeatedly used probably for many years with edge re-grinding maintenance, before they were offered into the grave.

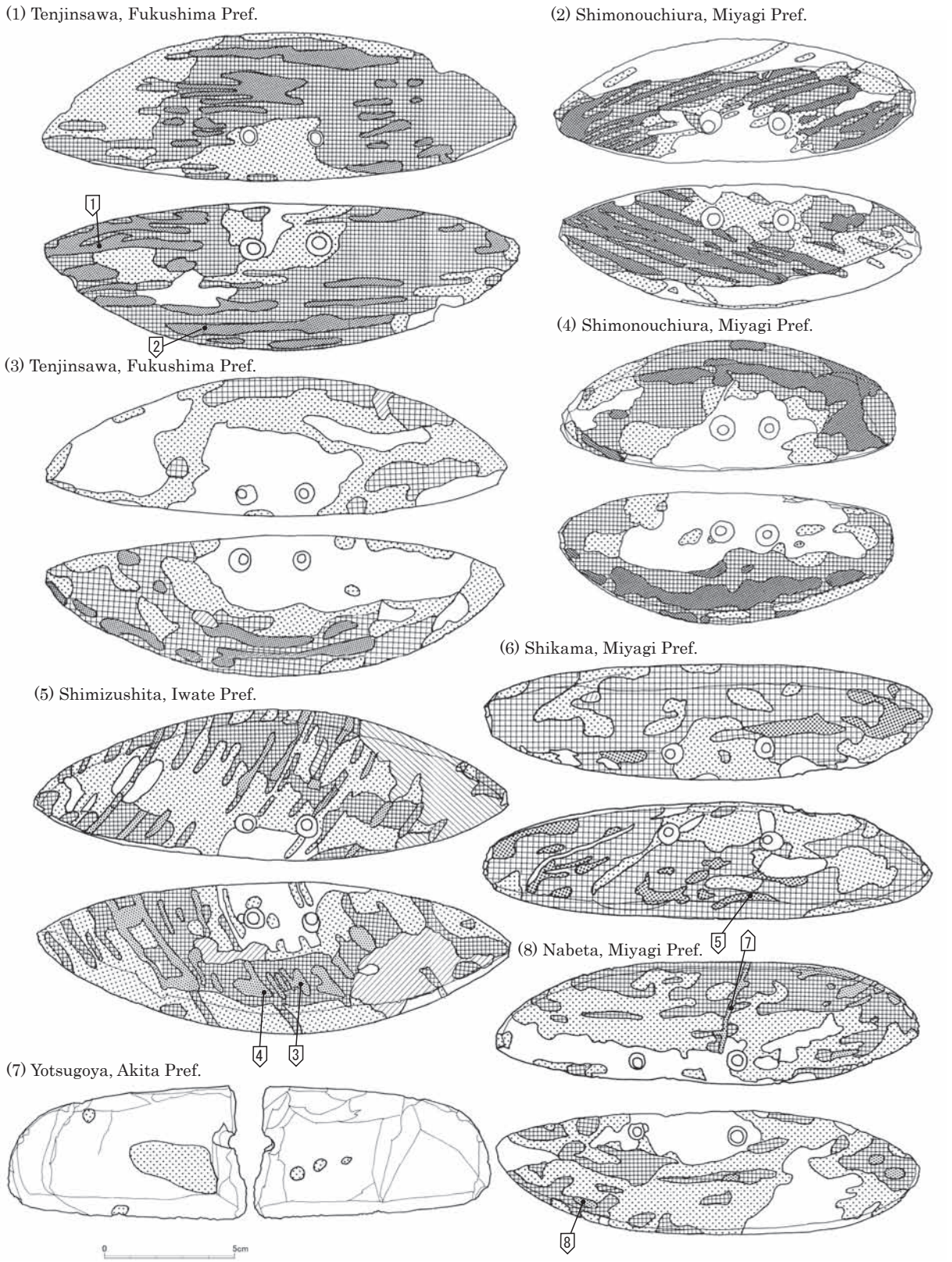

Figure 3. Distribution of corn gloss on reaping knives (Numbers correspond to figure 4 microphotographs).

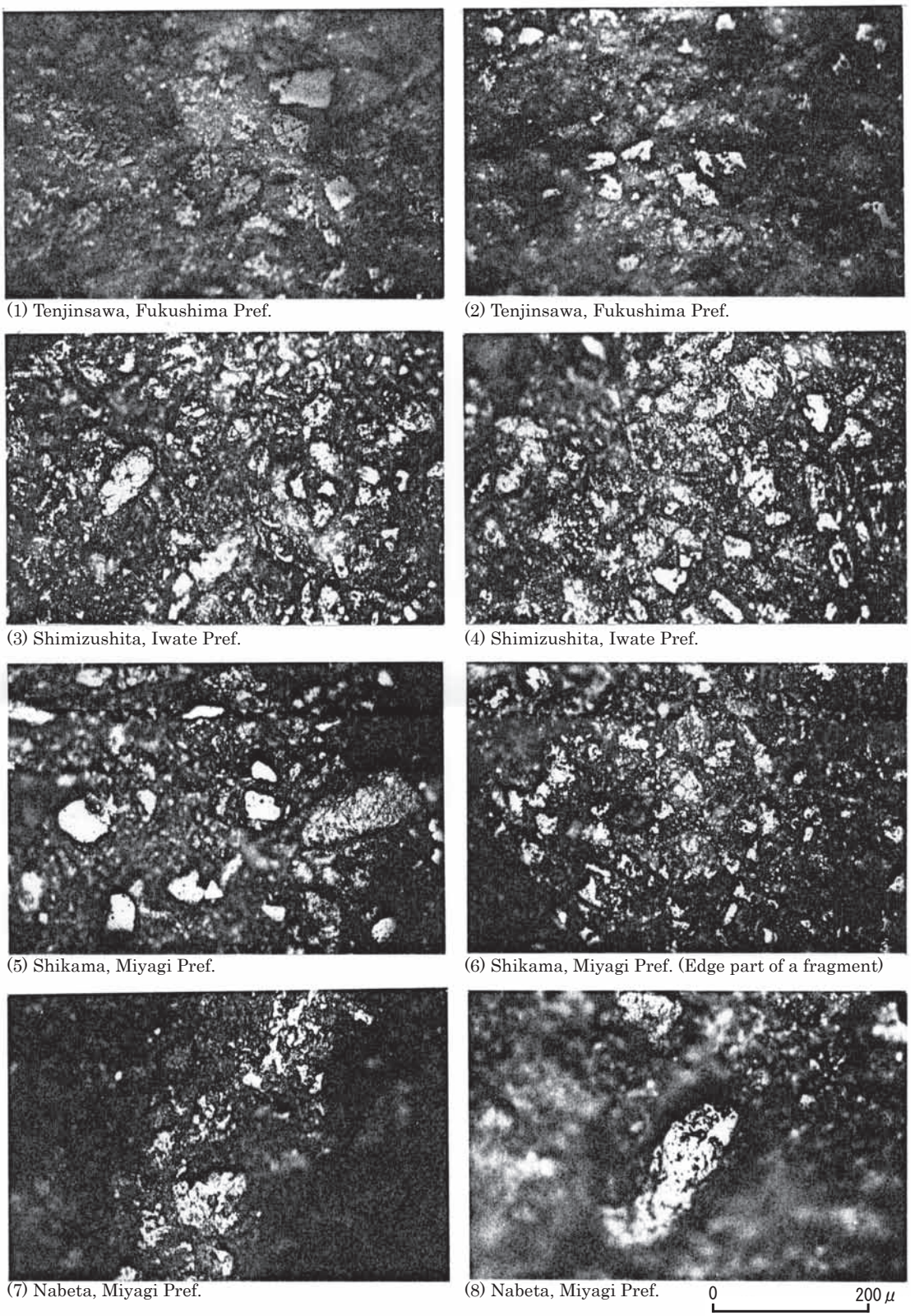

Figure 4. Corn gloss on reaping knives (Intensity is "medium" for all 8 microphotoraphs).

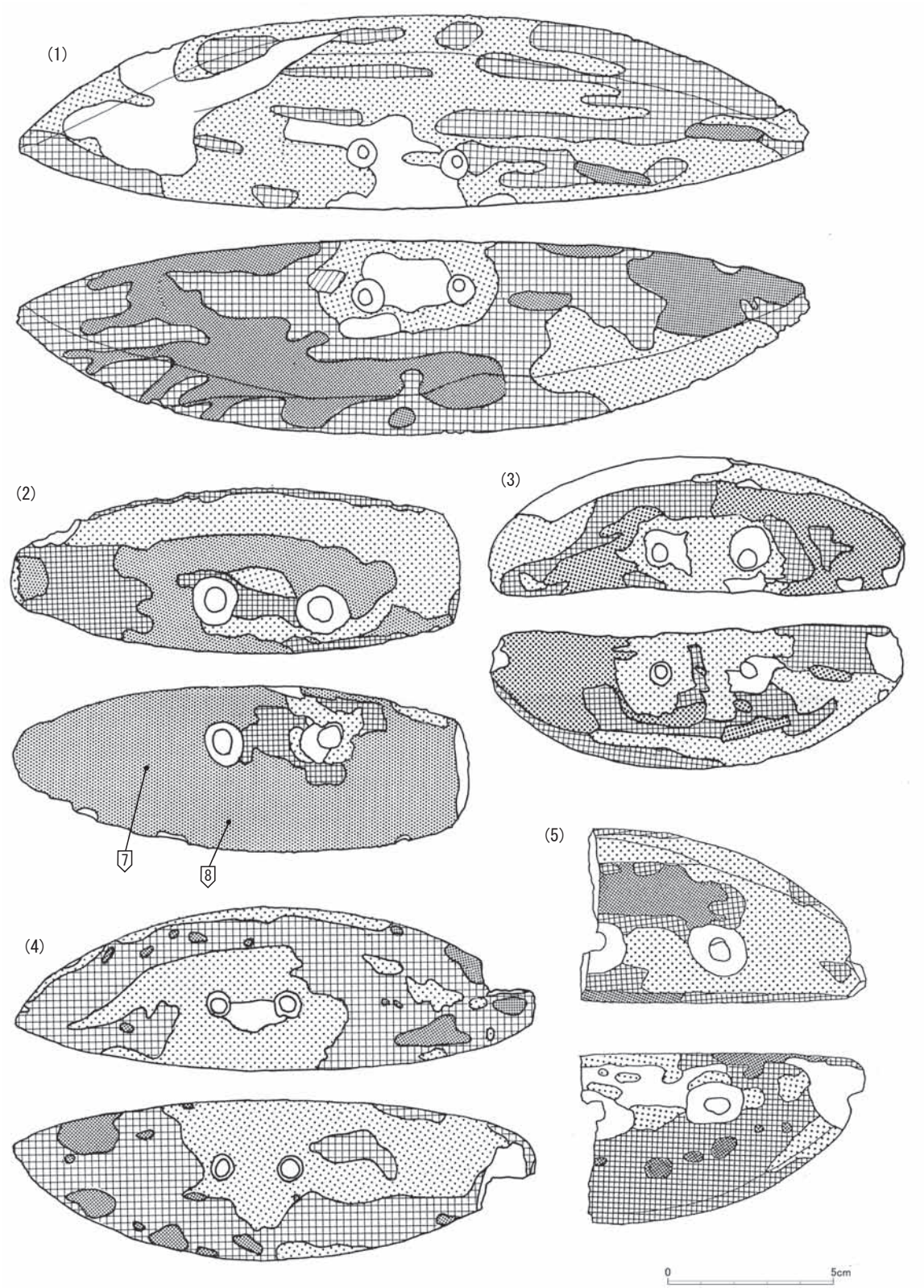

Figure 5. Distribution of corn gloss on reaping knives
((1), (2), (3), (4); Minamikoizumi, Miyagi Pref., numbers in
(2) correspond to fig. 2 microphotographs. (5); Izumizakimae, Miyagi Pref.).

The Nabeta locality of Tomizawa site (Figure 3 (8))

The implement does not show stronger polish generally, but the distributional pattern of corn gloss is recognized. The tendency of relatively strong polish area in the left half of the lower portion of tool body applies. The back side and its edge area of tool in the left half also show considerable corn gloss. The thin line below the left string hole is a linear area of peculiar rock material.

The Izumizakimae locality of Tomizawa site (Figure 5 (5))

This is a broken reaping knife, and it is not possible to compare between the left and the right part. However, the tendency of stronger corn gloss in the lower portion of the tool body is recognized. Relatively weak polishes along the working edge on face A (top) and the fact that it demarked the ridge of grinding finish line indicate the maintenance behavior of edge re-grinding. Detailed microphotographs are shown in Akoshima and Suto (1984).

The Minamikoizumi site (Figure 5 (1) (2) (3) (4))

Implement (1) shows stronger polish on face B (bottom), and it is more eminent in the left half of the lower portion of tool body. The back part also exhibit considerable corn gloss. The area around the string holes shows very little polish.

Implement (2) is made of semischist rock type. The corn gloss is extraordinary strong on face B. A wide area is covered with “medium” and partially even stronger polishes. It is noteworthy that there are groups of “huge corn gloss patches” as are seen in figure 1 (7) (8). The areas along the edge also retain developed polish parts on both faces of the specimen.

Implement (3) exhibits polished areas along the back side of the right half of tool body. However, the polish is stronger in the left half of the body. Along the edge of the right half, corn gloss is weaker on either face.

Implement (4) also shows the pattern of concentrating onto the left half of the tool body, but there are polished areas along the back side as well. The area along the edge exhibits polishes in the left half of the tool. The string holes of this *Ishibocho* are made asymmetrical to the tool shape. They are not in the central part, but the development of corn gloss is similar between two faces.

The Shikama burial mound site (Figure 3 (6))

Portions of developed polish distribute irregularly. The tendency to the left half of body and weakness along the edge is recognized. Stronger polished areas exist in the lower portion of central part of the tool body on face B. The “none” polish area in the left half of the body on face B is a peculiar step flaked part of the rock material.

The Shimizushita site (Figure 3 (5))

The corn gloss polish is eminent in the lower portion of the central part of the body. The degree of polish development over both faces very well corresponds to the stripe laminar structure of the raw material rock and the units of grinding finish ridges. Some parts of this implement are not observable due to a certain substance sticking to the surface.

The Yotsugoya site (Figure 3 (7))

This is a broken *Ishibocho*, and it is one of rare cases discovered in Akita Prefecture. Some corn gloss polishes are found in the left half of the tool body. They are of “slight” and “weak” stages of development.

Discussion

Consistent patterns of corn gloss distribution are observed on all the *Ishibocho* implements of the Yayoi period from Tohoku District. The microwear patterns indicate actual method of use in rice crop harvest activities. There is certain variability in the intensity of polishes, some variable appearances from raw material quality, and differences between two faces of the tool. However, the distributional pattern of corn gloss exhibits a strong tendency, from repeated use in the same manner, toward a general use-method of this type of curated technology (Binford 1979). The actual behavior of harvest is un-ambiguously reconstructed.

General patterns of use-wear on *Ishibocho* are summarized as follows.

(1) The corn gloss polish does not necessarily develop in a uniform pace and manner from the edge portion to the wider surface of the implement. The formation and resultant distribution of the corn gloss are influenced by at least three factors. They are the quality of lithic raw materials, or raw material characteristics of the particular portion in case of laminar rock structure, the degree of contact and intensity with the worked materials that were exclusively rice crops, and disappearance of corn gloss as the result of re-grinding of convex edge parts for rejuvenation of the sharp working edge.

(2) In case of rock types with laminar sedimentary structure, generally whitish portions of sand stone quality exhibit relatively stronger corn gloss development, relative to dark color portions.

(3) Two faces of *Ishibocho* do not show much difference in the degree of corn gloss development. Both faces are similarly affected with corn gloss phenomenon generally. In the meantime, the distribution patterns of polish on either face are consistent in that the left half of either face is more affected compared to the right half. There is no “ventral” or “dorsal” face for *Ishibocho* which is a ground finished stone tool, and the implement was repeatedly used by the “turn-over” method.

(4) When the implement is placed with its convex edge part down and its back up, the left half of the body exhibits

much stronger polish development, as mentioned above. This characteristic distribution is the most eminent pattern of polish.

(5) The polish is usually strongest on the lower part of the implement body. The edge part itself is rather weak. The corn gloss is often very faint along some portions of the working edge. In such cases, the contrast between the edge and the lower part of the body is sharp. The lines between grinding finish units in manufacture are often the border of polish strength. Thus, it is evident that the edge parts were frequently re-ground, leading to disappearance of corn gloss polish. The re-grinding behavior is well represented in one fragment of the edge part of *Ishibocho* from the Shikama tumulus (burial mound) site. A microphotograph is shown in figure 4(6). The broken edge still retains intense corn gloss polish.

(6) The back part side that is the opposite side of the edge often exhibits well developed polishes. However in those cases, the lower portions of the body in the left half generally exhibit even stronger polishes than the back part.

(7) The portion around two string holes does not show polished areas generally. Even in cases where the back side and the upper part of the body close to the back exhibit polish development, the string holes are surrounded by very intact areas where polish is faint or sometimes none. This pattern indicates that the area around two string holes is the place where direct contacts with rice crops were prevented, even when the *Ishibocho* was repeatedly utilized.

(8) Striations are not always evident even on the edge portion, but when they are existent it is a pattern that they

(1)

(2)

Figure 6. Reconstruction of use method of reaping knife.

run perpendicularly to the edge line. They are minute striations which are fused with the corn gloss surface texture on patches.

(9) From above observation results, it is very certain that the implement was used in a way where the motion was exerted perpendicular to the edge line, and the left part of the body was mainly in contact with the worked materials, with more pressure on one face of the two.

It is concluded with confidence that the actual method of the use of *Ishibocho* was like figure 6(1)(2). The method was picking off the ears with the right hand, the thumb being placed on the stalk below the ear. Some other fingers were in the ring of string which was tied through two string holes. The *Ishibocho* was turned over repeatedly, but the method of use remained the same, thus resulted in the symmetrical distribution of corn gloss polish on both sides.

The *Ishibocho* of the Yayoi period was an integral part of ground stone technology of the Asian continental derivation. It is a part of complex agricultural technology and also represents a category of "curated tools" in terms of the "organization of technology", in the sense of Binford (1983). Further investigation is necessary to identify other lithic tool categories which were also used for harvest activities, even where the typological *Ishibocho* and other ground tools of continental derivation are lacking in the lithic technology, but cultivation and harvest was a part of their annual life cycles in complex mosaic like adoption of new cultural traits relating to plant food production by human groups in northeastern parts of the Japanese Archipelago.

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References

Akazawa, T. 1982, Cultural Change in Prehistoric Japan: Receptivity to Rice Agriculture in the Japanese Archipelago. *Advances in World Archaeology,* vol.1, pp.151-211.

Akoshima, K. 1989, *Use-wear of Stone Tools.* Archaeological Library 56, New Science Co. (in Japanese)

Akoshima, K. 2008, Emergence of High-power Microwear Analysis in Japan, 1976 to 1983: Prof. Serizawa's Legacy and Beyond. *Papers on Archaeology, Ethnology, and History in memory of Professor Chosuke Serizawa*,* pp.189-207. Rokuichi Shobo.

Akoshima, K., and G. C. Frison 1996, Lithic Microwear Studies of the Mill Iron Site Tools. *The Mill Iron Site,* edited by G. C. Frison, pp. 71-86. University of New Mexico Press.

Akoshima, K., and T. Suto 1984, Use-wear on a Rice Reaper Excavated from Izumizaki-mae Locality, Tomizawa Rice Field Site. *Tomizawa Rice Field Site,* pp. 213-216. Sendai City Board of Education. (in Japanese)

Aomori Prefecture Board of Education 1985, *The Tareyanagi Site*.* Aomori Prefecture Buried Cultural Properties Research Report, no.88. (in Japanese)

Aoyama, K. 1999, *Ancient Maya State, Urbanism, Exchange, and Craft Specialization: Chipped Stone Evidence from the Copán Valley and the La Entrada Region, Honduras.* University of Pittsburgh Memoirs in Latin American Archaeology No. 12, Pittsburgh.

Aoyama, K. 2009, *Elite Craft Producers, Artists, and Warriors at Aguateca: Lithic Analysis.* Volume two of Monographs of the Aguateca Archaeological Project First Phase. The University of Utah Press, Salt Lake City, Utah

Arai, I. 2003, The Stone Reaping Knives of the Tohoku Region: Production Processes and Raw Material Selection. *Nihon Kokogaku, Journal of the Japanese Archaeological Association,* no. 15, pp. 1-10.

Binford, L. R. 1962, Archaeology as Anthropology. *American Antiquity,* vol. 28, pp.217-225.

Binford, L. R. 1979, Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research,* vol. 35, pp. 255-273.

Binford, L. R. 1983, *Working at Archaeology.* Academic Press.

Curwen, E. C. 1930, Prehistoric Flint Sickles. *Antiquity,* vol. 4, pp. 179-186.

Curwen, E. C. 1935, Agriculture and the Flint Sickle in Palestine. *Antiquity,* vol. 9, pp. 62-66.

Harada, M. 2003, Use-Wear Analysis of Lithic Farming Implements: Current Status and Limitations of the Studies on Harvesting Tools. *Kodai (Journal of the Archaeological Society of Waseda University),* no. 113, pp. 115-138. (in Japanese)

Harada, M. 2005, A Decade of the Society for Lithic Use-wear Studies*. *Newsletter of the Society for Lithic Use-wear Studies,* no.5, pp.1-2. (in Japanese)

Kajiwara, H., and K. Akoshima 1981, An Experimental Study of Microwear Polish on Shale Artifacts. *Kokogaku Zasshi,* vol. 67, no. 1, pp. 1-36. (in Japanese)

Keeley, L. H. 1977, The Functions of Palaeolithic Flint Tools. *Scientific American,* vol. 237, no. 5, pp. 108-126.

Keeley, L. H. 1980, *Experimental Determination of Stone Tool Uses.* University of Chicago Press.

Midoshima, T. 2005, *Sekki Shiyoukon no Kenkyu (A Study of Use-wear on Stone Tools*).* Doseisha. (in Japanese)

Murakoshi, K., et. al. 1991, *Excavation Report of the Sunazawa Site*.* Hirosaki City Board of Education. (in Japanese)

Semenov. S. 1964, *Prehistoric Technology,* translated by M. Thompson. Cory, Adams and Mackay.

Sendai City Board of Education 1996, *The Nakazaike-minami Site and others*.* Sendai City Cultural Properties Research Report, no.213. (in Japanese)

Sendai City Board of Education 2000, *The Takada B Site*.* Sendai City Cultural Properties Research Report, no.242. (in Japanese)

Serizawa, C., H. Kajiwara, K. Akoshima 1982, Experimental Study of Microwear Traces and Its Potentiality. *Kokogaku to Shizenkagaku,* (Archaeology and Natural Sciences*), no. 14, pp. 67-87. (in Japanese)

Suto, T. 1998, *A Study of Culture Change and Social Transformation in Prehistoric Period of Northeast Japan: from Jomon to Yayoi*.* Sanshudo. (in Japanese)

Suto, T. 2000, Tohoku District in the Yayoi Period. *The Miyagi Archaeology,* no.2, pp.1-24. (in Japanese)

Suto, T. 2004, Yayoi Period Polished Stone Reaping Knives of Northeastern Japan: A Marker of Early Agricultural Economy. *Bulletin of the Tohoku University Museum,* no. 3, pp. 17-67.

Suto, T., and K. Akoshima 1984, Rice Reapers excavated from the Shimonouchi-ura Site, SK2 Burial Pit. *Sendai City Cultural Property Research Report*,* no. 69, pp. 59-66. (in Japanese)

Suto, T. and K. Akoshima 1985, On Ishibocho in Tohoku District*. Paper presented at 51st meeting of The Japanese Archaeological Association, at Nihon University, p.19.

Takase, K. 2004, *Sociography of Yayoi Period in the NE Honshu Island.* Rokuichi Shobo. (in Japanese)

Takahashi, A. 2007, Use-wear Analysis of Tanged Scrapers*. *Kokogaku Danso,* pp.369-388. Rokuichi Shobo (in Japanese)

Witthoft, J. 1967, Glazed Polish on Flint Tools. *American Antiquity,* vol.32, pp.383-388.

Yamada, S. 2007, Chapter 2: The function of Stone Tools. *Seminar Palaeolithic Archaeology*,* edited by H. Sato, pp.32-49. Doseisha. (in Japanese)

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