Ogasawara (The Bonin Islands) - Landform Classification of Chichijima and Some Geomorphic Problems

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Oğasawara (The Bonin Islands)—Landform Classification of Chichijima and Some Geomorphic Problems

Yoshio NAKAMURA, Yamato KASAI and Norio HASEGAWA

An islet in the ocean is interesting in a geomorphological sense, in that, generally speaking, most subaerial processes are directly concerned with the present sea level as the absolute base level of erosion. Since the writers are especially interested in dissection features of isolated hills or uplands, a small island or an islet is an ideal site to comprehend the morphological meaning of the subaerial dissection of the landform surface. We must note, however, the difference in the morphological environment between an islet in the ocean and isolated hills or uplands surrounded by lowland plains. That is, the former has developed in a more complex fashion in that it has suffered additional erosion from wave action.

In the Ogasawara Islands, a subtropical climate affects most geomorphic processes as a significant factor in addition to the locational factor of insularity, but in this paper the writers will pay little attention to the climatic effect on landform evolution, except for certain semi-arid landscapes on some islands in this region.

This report is the second concerning the results obtained from field research between August 28th and September 13th, 1970, as sponsored by Tokyo Metropolitan Government. As the first report has already been published (Hasegawa et al., 1972), only an abridged geographical outline of the Ogasawara Shoto is presented in the present paper.

1 Problem setting and methods of landform classification

The Ogasawara Islands are, with some exceptions, composed chiefly of Paleogene bronzite-andesite and nummulitic tuff, and are situated in the eastern part of the Shichitô-Mariana Ridge (Mogi, 1970). Geomorphologically, these islands are characteristically rugged in appearance, and their shorelines are everywhere surrounded by vertical sea cliffs, many more than 100 m. in height. In spite of the small size of each island, clear, 4 to 5 step staircase landforms, which are elevated, though densely dissected surfaces, are seen. Mukojima and some parts of Hahajima are of relatively low relief, but, as a whole, all other islands reveal very rugged topography.

In attempting to classify the landforms of Chichijima, as well as of certain other islands in this region, the standard method of landform classification used in Japan seems to be unsuited to this island because of the small size of each landform unit. On the topographical map (1:50,000) the components of the whole island are categorized only as "steep slopes" and as "gentle slopes on the flanks and tops of hills". On maps of 1: 5,000 or 1: 10,000, a "flat surface" category appears, to be sure, but its general applicability to the landform surfaces of Japan is more limited than the same expression at a scale of 1:50,000. Additionally, it must be noted that, generally speaking, the horizontal extension of a landform unit points to a stable condition in geomorphic evolution, and that a vertical one suggests an unstable or an active situation as influenced by gravity. On this island, according to the relatively large relief (about 300 m in order), various processes of geomorphic development have operated elsewhere in three dimensions.

Consequently in the landform classification of this paper, the point to be emphasized is that the classification or subdivision of landforms is based on the present distribution of erosive agencies, as only erosional processes act in diversity, though on a small scale. Thus, the following topics have been used in the discussion: (1) valley forms, (2) the shapes of hill side slopes and their distribution based on field observations and photo-interpretation, and (3) boring data from Futami Bay. Base maps used for this work are at a scale of 1: 5,000.

As to the general landform classification of these islands, previous reports by Professor Asami (1970a, b, etc.) are virtually complete. Therefore, in this paper only slight evidence can be added to such results.

2 The landform classification of Chichijima

1) *Sea cliffs and related steep slopes*

Chichijima has two kinds of coastal cliffs; those affected by present wave cutting, and those formed in former periods and whose footslopes are today covered with detrital sediments of talus. Present scarps tend to develop continuously along straight coast lines in the southern and eastern parts of Chichijima, but on the contrary, other coasts show combinations of present cliffs in small capes, and of previous cliffs at the bottoms of embayments where recent shorelines have combined each cape with sandy beaches or beach ridges. At Location 10, on the western slope of Mt. Mikazuki, a series of extensive taluses covers the footslopes like a frontal apron. Upon these taluses the leafy ginkokai shrub[1] (*Leucaena glauca Benth.*) grows luxuriantly, having been planted by the Japanese Army to camouflage gun positions in the period of World War II. Foot

1) Leafy ginkokai grows in impenetrable walls, and was introduced from central Africa (Sampson, 1968).

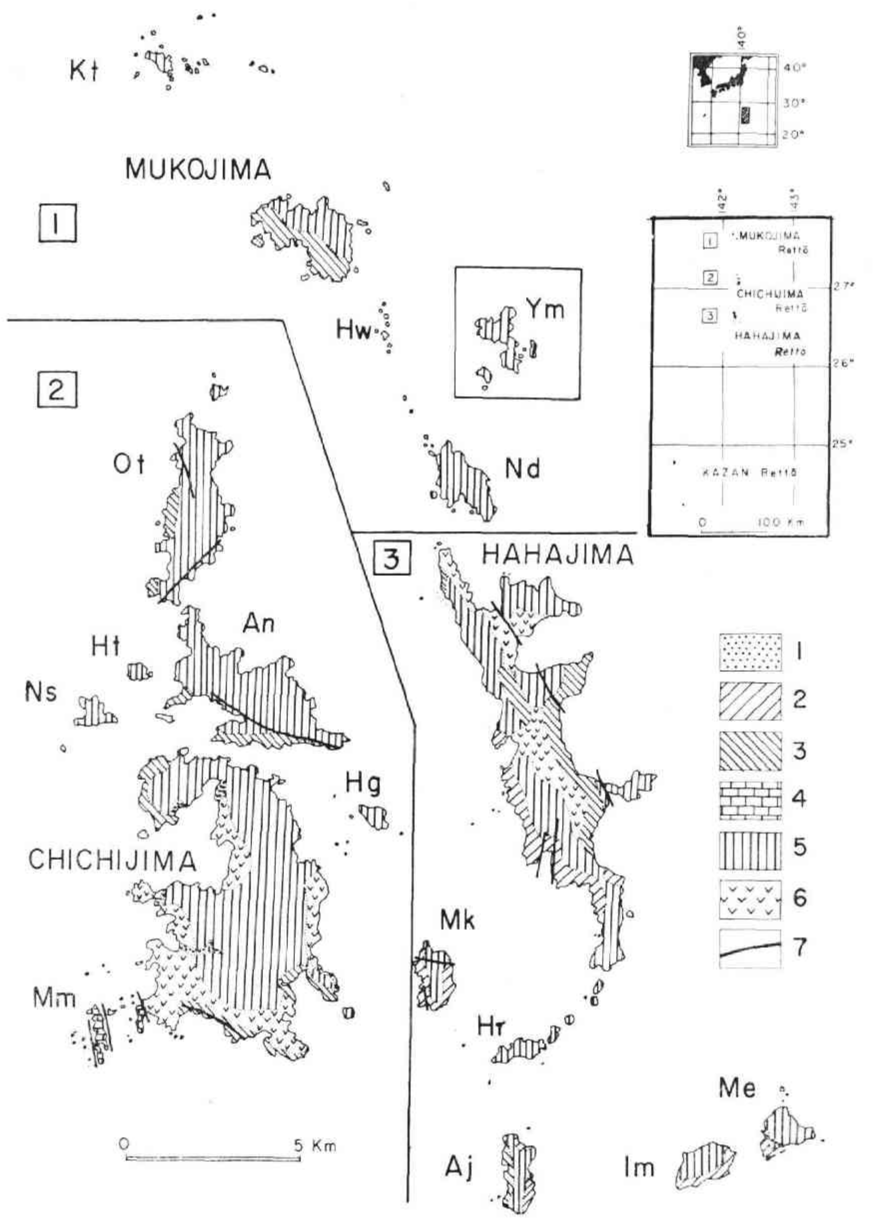


Fig. 1 Index map and geology of the islands

1 Mukojima Rettô Hw: Harinoiwa Nd: Nakôdojima Kt: Kitanoshima Ym: Yomejima

2 Chichijima Rettô An: Anijima Hg: Higashijima Ht: Hyôtanjima Mm: Minamijima Ns: Nishijima Ot: Otôtojima

3 Hahajima Rettô Aj: Anejima Hr: Hirajima Im: Imôtojima Me: Meijima Mk: Mukaijima

1 unconsolidated gravel (alluvium) 2 tuffaceous sandstone and mudstone
3 tuffaceous breccia 4 limestone 5 agglomerate and lava 6 andesitic lava
7 fault line (after Asami, Tokyo Prefecture 1969, 1970)

slope talus is being cut by present wave action, and in places new wave-cut benches are being formed. Although the talus formation preceeded the growth of the leafy ginkokai, it cannot be said that the talus was built before the shrub was planted, since this plant can easily grow thick in a few months. Furthermore it can be seen that at many locations talus composed of debris is still mobile, even under such thick vegetation. Such an unstable condition of the scree is already seen at Locations 2, 3 and 4, along the northern foot of Mt. Mikazuki. At Location 2, a cable line coil, 5 cm. in diameter, laid by the Japanese Navy Signal Corps before 1945, has been pushed away and in places is cut by the sliding blocks of debris. Similar evidence is found at Location 3, where former stone or concrete pylons, 0.5～0.8 m. in height, turned, rotated and tumbled from their positions. Judging from the dippings of some stone pylons, the landslides occurred northwestward. Most of the pylons dip in NE-SE directions indicating that their roots were dragged towards the NW-SW (Fig. 3). Some electric poles have also been cut and split by giant blocks after having been overturned; and at Location 2, the lower trunks of some tall trees [Terihaboku (*Calophyllum inophyllum*)] have been bent downslope. At Location 1, there are many blocks which have been crushed or split after their tumbling down from upslope. Hence, it appears that the landsurface is still susceptible to mass movement. At this location, we found a huge block with many scars forming parallel stripes on its surface. These stripes were perhaps carved by means of violent oscillation between the sliding blocks. From such evidence we can deduce that the landslide has operated continuously but very slowly, at least since 1945.

A large collapse has recently occurred near the top of Mt. Mikazuki, where many blocks of debris have been produced. At the foot of a sea cliff (Location 38), blocks of limestone, each more than 3 m. in diameter, have piled up to form a talus slope, which has been covered also by shrubs of leafy ginkokai.

The crest line of a knife ridge at Location 39 which divides the active sea cliff on the southern side and the inactive valley slope on the northern side is a remarkable feature in the landscape of this area. Here is found a contrasting landscape in that the almost vertical wall of this sea cliff is bare of vegetation and is covered with reddish latosols. On the crest line is a narrow path for wild goats (*Pfad*), while on the other side, a gentle concave slope is densely covered with only moderately tall but very thick subtropical jungle. The latter landscape, lying on the northern side of the crest line, today suffers a kind of active piracy of the drainage basin of the valley by the retreating sea cliff. Such piracy suggests that decreases in the area of the drainage basin have occurred not from an adjacent basin but from the sea.

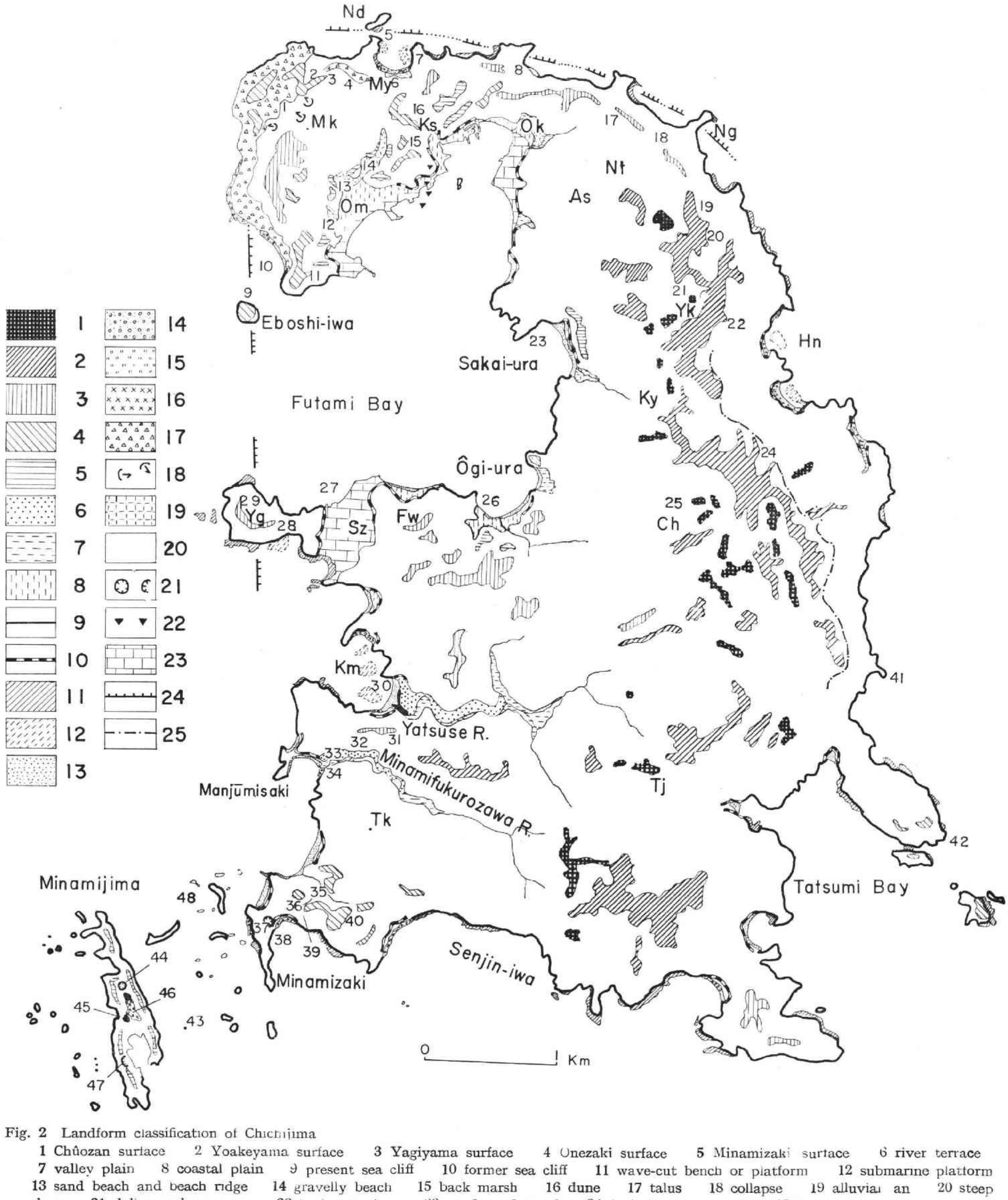


Fig. 2 Landform classification of Chichijima
1 Chûozan surface 2 Yoakeyama surface 3 Yagiyama surface 4 Onezaki surface 5 Minamizaki surface 6 river terrace 7 valley plain 8 coastal plain 9 present sea cliff 10 former sea cliff 11 wave-cut bench or platform 12 submarine platform 13 sand beach and beach ridge 14 gravelly beach 15 back marsh 16 dune 17 talus 18 collapse 19 alluvial an 20 steep slope 21 doline and sea cave 22 boring station 23 artificial flatland 24 fault line (supposed) 25 break of slope
As Asahiyama Ch Chûozan Fw Furiwakeyama Hn Hatsuneura Km Kominatohama Ks Kiyose Ky Kasayama Mk Mikazukiyama My Miyanohama Nd Nakadôrijima Ng Nagasaki Nt Nyûtôzan Ok Okumura Om Omura Sz Suzaki Tj Tsutsujiyama Tk Takayama Yg Yagiyama Yk Yoakeyama

2) *Wave abrasion platforms*

Almost everywhere at the feet of sea cliffs, wave-cut platforms or abrasion benches have developed. Near Higashijima at Rôsokuiwa, for example, many small reefs and stacks are present around the island below sea level, which suggests a former extension of the island. Great numbers of small stacks in this area also indicate powerful wave abrasion which has produced many stacks that are separated from the island masses of Chichijima and Hahajima. Wave-cut platforms have developed along the shorelines at the bases of cliffs like fringing reefs, not of coral, but of bedrock breccia or tuff. Examples can be seen from Tatsumizaki, Kujirazaki and Mitsuiwazaki as far as Nagasaki (Fig. 2). The distribution of these small stacks and reefs suggests that very recently great volumes of the landmass have been eroded into the sea.

At Miyanohama as high as the tidal range on the opposite sides of the baymouth, a broad platform has developed 30–50 m from the strand line (Location 5). At Suzaki (Location 27), similar platforms were found cut into boninite, where micro-relief is complicated by small mounds and depressions (many of which are pot holes) formed because of differing resistibility to wave abrasion.

At the head of one bay at Location 23 (Sakaiura), another type of wave action, a kind of indirect abrasion, is observed. Here there is an embayment with a sandy beach[2] at its bottom, but in some places, where the exposed base is abraded by breaking waves filled with coarse sand, bedrock has formed cliffs or capes. The landscape of these locations appears round, mild and moderate, as a result of the intervention of masses of sand which have filled the space between the agencies of energy transmission for wave-breaking and rock-abrading.

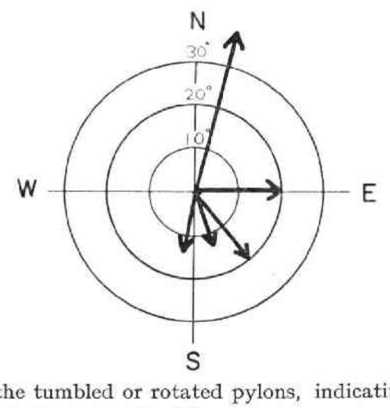


Fig. 3 Dip and strike of the tumbled or rotated pylons, indicating the directions of debris slides at the northern footslope of Mt. Mikazuki.

2) Most beaches in this island consist of two kinds of materials; sand particles derived from the bedrock, and white or yellowish grey coral dusts of various diameters.

On the other hand, where waves break directly against cliffs, as indeed on most of these shores, the landscape appears rather angular, straight and sharpened, as described above.

When one looks down on the sea from certain heights near the strand, submarine benches in dark colors in contrast to the light colors of the sandy sea bottom are clearly visible. Examples are seen in views from Location 22 to Hatsuneura, from Location 31 to Kominatohama, and from Location 28 to the Suzaki coast.

At Location 46 (near Sameike of the island of Minamijima), the upper part of the bench has been temporarily covered with thin layers of beach sand, but periodically wave action is in operation to wipe these away.

3) *Shore beaches*

(a) Sandy beaches

At such locations as Kominatohama, Location 30, at Miyanohama, Ôgiura, Location 26, and at Sakaiura, and Hatsuneura, sandy beaches with widths of about 20 m. at most, and in the shape of arcs with seaward concavity, have developed. Although these are situated in the bay heads, beach sands are very coarse and subangular. An exception is at Kominatohama where the largest river, the Yatsuse-gawa, joins the bay. Generally, grains of beach sand are supplied from the places near the sea cliff where debris is produced by weathering and wave cutting. This debris is then transported by coastal currents but the distance is so short that the particles cannot be sufficiently rounded, and in addition, there are few rivers supplying fine materials to the beach. Coarse sand, including coral dust, moves about according to the oscillating movements of the breaking waves.

At Kominatohama and at the mouth of the Minamifukurozawa, beach sands close to the mouth of river have formed a lagoon as well as a back-marsh. At Location 33, the stream disappears under the beach sand, but gushes out again about 10 m. further downstream, and laps over the overlying sand layers (Fig. 4 and Photo 1). Here, it is significant that the stream of the Minamifukurozawa flows directly on boninite bedrock, over which the sand covering is so thin that the stream can emerge again at the point of intersection along the lines between the water table and seaward-sloping plane of the beach. At Kominatohama (Location 30), in contrast, the Yatsuse river has deeply cut into the bedrock, so that the river mouth has been dammed with an enormous volume of sand. Accordingly, the concealed water or the stream cannot emerge until it flows below sea level into the sea. At Location 6, a small back-marsh has formed behind the narrow beach-ridge, resulting from the same relationship between drainage on

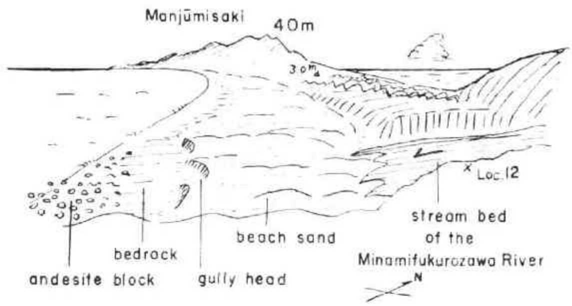


Fig. 4 Concealed stream gushing out at Location 14 (See Photo 1)

the land and disturbance by beach development, although there is no river joining the bay.

(b) Rocky beaches

Cobble stones and boulders make up rocky beaches at the mouths or sides of bays, for examples, at Location 7 and at Location 34, while sand-beaches are situated at the bottoms of embayments. Such boulders are generally angular and poorly sorted. How and why these have been distributed at different locations, as contrasted to sandy beaches, is not yet clear. In an attempted answer to this question, it might be surmised that at the mouths or sides of the bay bedrock has been exposed by a process of positive wave-cutting, so that much debris has been produced to supply the material for a rocky beach. However, such rock material could not be found.

4) Alluvial and coastal plains

The most wide and flat section at Ōmura (Locations 12–14) is not a typical alluvial plain but is a kind of coastal plain formed at the head of Futami Bay, and consisting of varying layers of sand, clay and gravel. Judging from boring data (Figs. 5 and 6), a few submarine valleys as rugged topography on the bedrock are traceable. Depressions in the relief are filled with coral sand or clay. This submarine topography still preserves the initial relief which was established during a former period when the sea level was considerably lower. It can be seen that even below a surface as flat as the Ōmura area, certain rugged relief may be buried by recent marine and fluvial sediments.

Small alluvial fans have developed at a few locations where the Ogasawara Branch Office of the Tokyo Metropolitan Government, the Telephone Service, the Public Lodging House and other installations are located (Locations 13 and 14).

A part of the lowland near Suzaki (Location 27) is an artificial flat land empoldered by the Japanese Navy to serve an air base in the War period[3]. The other parts of this section are elevated wave-cut benches.

At Kominatohama, a set of beach ridges and lagoons suggests that here, though in small scale, a coastal plain has arisen but that its growth is yet in an early stage.

5) *Fluvial terraces*

Fluvial terraces could be found only in the following areas. First, along the Yatsuse river, where a terraced surface about 2 m. higher than the present stream bed at the mouth of the river (Location 30) has developed. This terrace is composed entirely of coarse sand — fine sand, gravel or bedrock not being observed. At another location (Location 32) about 1.5 m. above the present bed of the Minamifukurozawa river, another terrace has developed. This latter has cut into the bedrock and is covered with a thin layer of gravel.

The height of these terraces relative to the stream beds decreases upstream and diminishes to zero within 1 km of the stream mouths. Farther upstream, flood plains of 1 to 2 km in length have begun to develop.

6) *Coastal terraces*

The only terraced surface that has been accompanied by some extension of area is observed at Ônezaki, where latosols of more than 1.5 m. thick have been formed. The Ônezaki surface is representative of terrace surfaces at this elevation — averaging 60–80 m. above sea level. Some flat-topped ridges related to this surface have also been recognized in the Minamizaki area (Locations 35 and 40), where many abandoned sugar cane fields have gone to seed[4]. The gentle slope at the top of Eboshi-iwa (72 m, Location 9) is similar to this level in height, and of special interest to writers, the slope declines eastwards, suggesting an eastward tilting movement. At the northern and northwestern feet of Mt. Mikazuki, a flat, leveled surface at a similar elevation is recognized, but the true surface of the terrace cannot be observed because of the widespread cover of debris blocks supplied from recent landslides in this area.

Hill top levels with remarkably accordant height indicate the presence of the former terrace surface even if today there is no areal extension. At Location 12 at about 30 m. elevation, at Location 16 at about 40 m., and Location 36 at about

3) At the corner of the base, a wrecked aeroplane of the former Japanese Navy is still visible. Another corner has been turned into a training course for drivers.

4) The former sugar cane fields were bordered or partitioned by rows of pine trees. A present path, following an ancient path, goes between these rows like a corridor on the flat surface.

40 m., former levels of the probable abrasion platform can be recognized and perhaps reconstituted, as no sediment but latosol derived from weathered bedrock remains as cover.

It is noteworthy that in Chichijima surfaces at 30–40 m. elevation are densely dissected as described above, while in Hahajima and in Mukojima these are well-preserved in the form of flat terraces or undulating slopes (Photo 2 and 3). These differences in dissection features will be a point of discussion in chapter 4.

7) *Erosion surfaces*

The staircase morphology of Chichijima reflects some erosion surfaces at different levels (Asami 1970b). Here, the writers would classify them into three levels, as follows:

(a) The Chûozan level (290–320 m.) indicates an erosion surface, the flat tops of which are deduced to be at almost the same height as Mt. Chûozan 321 m., the highest peak on this island. Certain other peaks such as Mt. Yoake 307.5 m., Mt. Tsutsuji 302 m., and Mt. Kasa 290 m., belong to this same level. There is no broad flat surface at this level. The aforementioned mountain tops are crests or ridges that protrude from the surrounding slopes as monadnocks. On the crests of these mountains, bare tor-like rocks have been exposed to subaerial weathering (Locations 21 and 25). Tor-like knolls are seen elsewhere not only on the higher peaks but also on the ridges of hills at about 150–100 m. in height (Locations 8, 15, 17, 29).

(b) The Yoakeyama level (200–250 m.) represents an undulating surface of minor relief that is spreading along the mid-slopes of a series of mountains, from Mt. Chûo to Mt. Yoake. This surface is very flat and is the most widespread erosion surface on the island. Appropriate to the gently undulating topography, some shallow-concave valleys (*Muldental*) have also developed at this level (Locations 19, 20). A distinctive break in the slope profile is observed near Hatsuneura (Location 24, Photo 7). Above the break line, gentle slopes based at the Yoake level have been formed, and below are steep slopes or cliffs undergoing marine erosion.

On the surfaces at this level, latosol is distributed only on flat sections and in less sloping portions. Especially without vegetation cover, bedrock of boninite has been exposed by the process of mechanical weathering. At Location 18, a typical pillow structure is observed in spite of the fact that the location has not been attacked by present wave cutting but only by subaerial weathering (Photo 4).

(c) The Yagiyama[5] level (about 150 m.) with rounded features is recognized

5) Mt. Yagiyama is also called "Yagyûsan" by the islanders.

on the accordant ridges. Included at this level are undulating surfaces developing at the northern feet of Mt. Asahi, near Mt. Furiwake, at Komagari, on Mt. Yagiyama and on the western and southern slopes of Mt. Takayama. Surfaces of this level are distributed most widely throughout Chichijima, though in patches because of strong dissection. Especially on the eastern part of Anijima a broad and continuous surface at this level has developed, similar to the uppermost coastal terrace (Photo 6). The main ridge of Otôtojima also belongs to this level in elevation.

3 Some observations of other landforms

1) Karst

As Minamijima and the southern part of Chichijima consist of limestone (Fig. 1), much karst topography has formed. A doline, filled with the water of On-yô-ike, and a *Karrenfeld* on the surrounding hills are examples. Besides these, so-called "submerged karst" has been reported by Asami (1970b). This is a special landscape in which a group of small limestone islets has formed a discontinuous ring above sea level whose basement is united below sea level, and only the higher parts of the doline wall appear above the sea. Kannukijima is such a topographic feature (Location 48, Photo 5). Furthermore, a limestone cave (Location 47) and a "bridge and tunnel" (Location 45, Photo 8) seem to have been brought about through a combination of marine erosion and the karst-forming process.

The writers have found, in addition, the following four landscapes:

(a) A doline near Minamizaki about 100 m. in diameter and 20 m. in depth, Location 37, at the southwestern end of Chichijima. (b) a "growing doline" in the northern part of Minamijima, Location 44, which is a conical depression only 15 m. in diameter and 2 m. deep, and (c) a "mushroom stack" about 3 m. above the sea level and 5 m. in diameter (Location 43, Photo 10). This latter stack is modified in its upper portion by corrosion because it is composed of limestone, and is cut by wave action in its lower portion. The upper half of this feature, a small *Karren*, has a honeycomb structure in its horizontal section and a columnar alignment in its vertical section. The lower half, separated by a clear boundary, is surrounded by steep, almost vertical or partly overhanging but very smooth, bluffs caused by strong wave-cutting. This latter case, in the writers' judgement, is the minimal topography on which karst and marine erosion act together, but on each different part of a landmass (such as a stack), without being interrupted by any intermediate process such as stream erosion or mass wasting.

(d) "Artificial stalactites" were found at Location 22, in a ruin of a Japanese fort constructed of concrete blocks. On its ceiling many hanging materials, most of which were 5–10 cm. long and 2–3 cm. in diameter at their roots, were discovered. These came to a sharp point at the nadir (Photo 11). The fort was constructed of cement, a variety of limestone, so it can be concluded that these sticks must have been formed by the process of karst-formation subsequent to 1945. They are here called "artificial stalactites" because they were originally formed by artificial construction though subsequent processes were natural.

2) *Crustal movement*

The eastward sloping surface at the top of Eboshi-iwa (77.5 m.) is a part of the terrace surface correlated to the Ônezaki level. Such a slope cannot have been formed from only an initially flat level surface because a valley with a scale large enough to have formed such a broad valley-side slope could hardly have developed here. This surface slopes to the east at a gradient of 7° on the upper part, and at 18° on the lower part. The crest line of Yagiyama also dips eastward at a gradient of about 10° (Photo 12). These facts lead to the conclusion that since the Ônezaki terrace was established, outside a boundary line drawn from Yagiyama to Ônezaki from the main part of Chichijima, a tilting movement dipping eastward has occurred.

In addition, the writers presume that the landslide near Mt. Mikazuki may have occurred under the influence of this block movement. The reason for this presumption is that the landslide area is situated just along the northern extension of this supposed structural line (Fig. 2).

3) *Landscapes indicating a former fault-line*

Facing the northern coast of Chichijima, there are several small peninsulas which are similar in form and each has typically a set of peaks about 70 m. in height, with a col of about 30 m. in height lying between the head of the peninsula

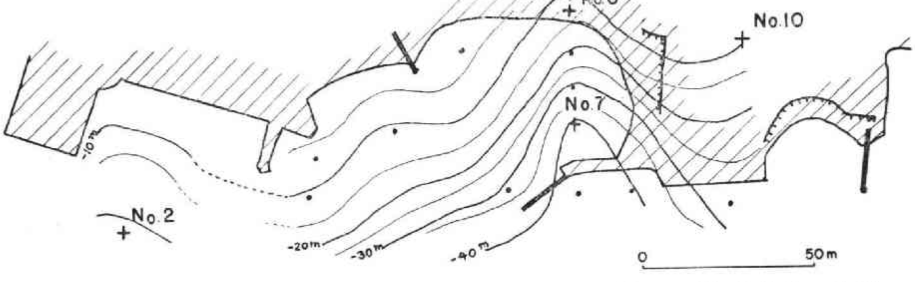


Fig. 5 Submarine topography of the northern part of Futami Bay. No. 2, 6, 7 and 10 are boring stations in Fig. 6.

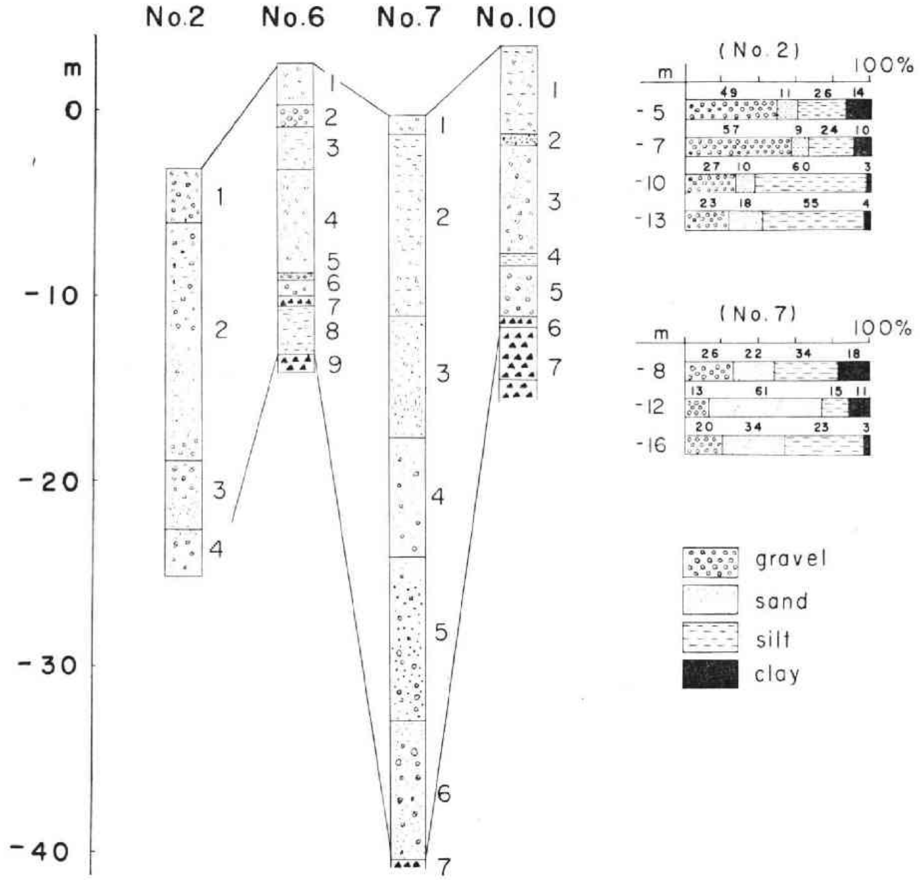


Fig. 6 Boring data of Futami Bay

No. 2 1. coral fragments with gravel (dark grey) –3.18–3.21 m.... a lot of coral fragments; 40–50% of them with granules 10–20 mm. in diameter, N* = 2–3 (*N-ratio is an indicator measured from the frequency of hammer striking to penetrate a unit depth in the earth.)

–5.68 m... silty, with some coral mud

2. coral fragments with silty sand (grey)

–8.88 –13.93 m... a lot of coral fragments with some layers of silty sand (calcareous), 10–15 cm. thick, high amount of contained water

–14.03 m. .. without coral fragment

–19.03 –21.03 m... N-ratio increases to 4 in proportion to the increase of coral fragments.

3. sand with coral fragments containing shells (light grey)

–18.0 –19.5 m.... a lot of shells, larger grains of sand; sand with shells and coral flakes; a few pebbles 10 mm. in diameter; silty content decreases; acidic sand and gravel increase.

4. sand with coral fragments containing shells (light grey), sand with shells, involving a few coral flakes; with finer grains of sand

and the main island. Such features are called "Kern buts and Kern cols", and are exemplified by Nakadôrijima, with hills at 76.8 m. and 66.4 m.; and by Nagasaki at 42.8 m. A fault line is assumed on the location connecting these cols (Fig. 2). Nakadôrijima has become separated from Chichijima as a result of wave action on both sides of the former col, which eroded out the bridge between this Kern but (the present Nakadôrijima) and Chichijima.

4) *Submaıine valleys in Futami Bay*

A submarine valley, which is 42.5 m. below sea level and about 20 m. in width, extends in a N40°W direction near the Kuroshio-pier (Fig. 5). The longitudinal gradient of the valley floor is 45° about 30 m. offshore, and it becomes gentler further away from shore. Three types of deposits on the bedrock may be classified: a) deposits composed chiefly of coral remains, b) fine sands, mainly silica, and c) coarse sand and gravel consisting of colored mineral particles, interspersed with bivalve shells and clay. Sandy or muddy materials of crushed corals form a matrix for the larger coral fragments (Nihon Kôei, 1970).

4 Some sketches of Hahajima and Mukojima

1) *Hahajima*

The southern half of Hahajima, consisting of Oligocene nummulitic tuff, is mostly in undulating topography with small relief. Everywhere on the flat and gentle slopes latosol has formed, but there is little on the steep slopes. In the northern half, the boninite area, steep and rugged landforms have developed, including gigantic sea cliffs of about 400 m. in height.

No. 6

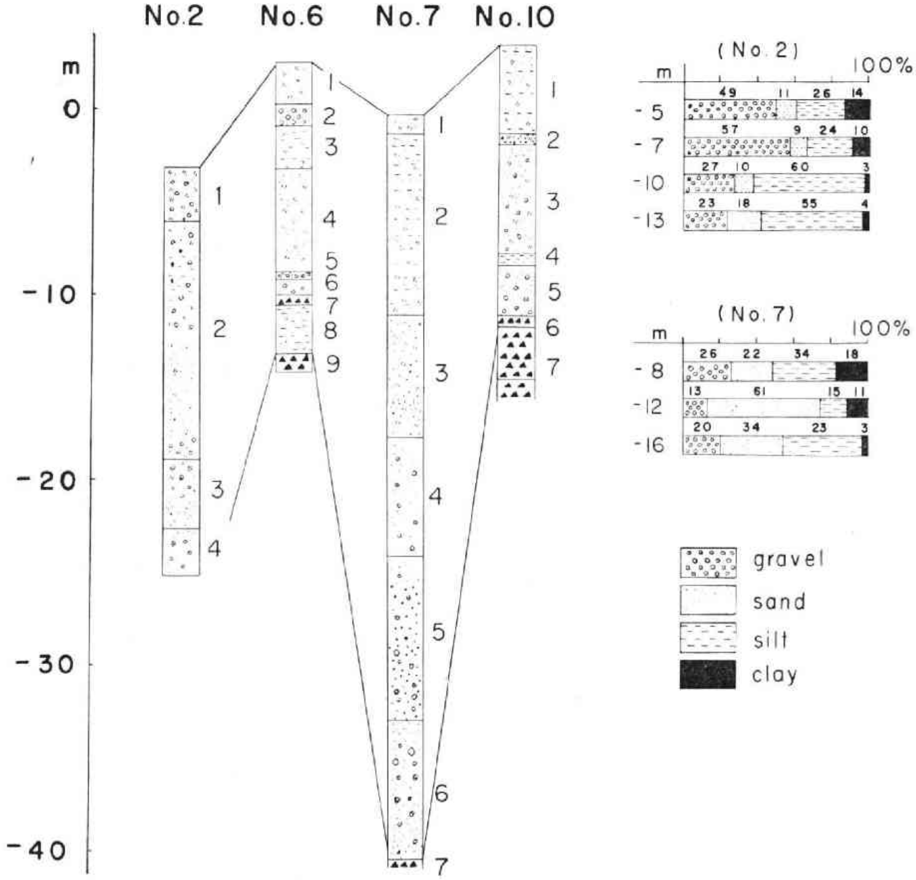
1. sand with coral (light grey) 2. gravel (dark grey) 3. sandy clay with coral (grey)
4. sand with coral (grey) N-ratio of 1.–4.=3–15
5. gravel (dark grey) N=88 6. sand and gravel (〃) 7. agglomerate (〃) boulders
8. sandy loam with coral (dark brown), N=10 9. agglomerate (〃), N>100

No. 7

1. sand with coral (dark grey) 2. clayey sand with coral and loam (grey) 3. medium and fine sand with coral; sandy loam (grey) 4. sand and gravel (dark grey)
5. sand and gravel (dark green); coarse sand (5<N<20)
 –28m.... gravel 10–20%, 10–15 mm. in maximum diameter
6. sand and gravel (dark grey); mixed with a few shells, N=20
 –34m....angular gravel 15–20%, 10–20 mm. in diameter
7. agglomerate, N>100

No. 10

1. silty sand with coral (grey) .. poldered earth 2. medium sand with coral flakes (dark grey) 3. sand and gravel with coral (〃); –6.5 m. .. boulders 4. clayey sand (〃) 5. gravel 30–40% (〃); 0.5–3 mm. in diameter 6. agglomerate 7. bedrock, N>50



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–8.88 –13.93 m. . . a lot of coral fragments with some layers of silty sand (calcareous), 10–15 cm. thick, high amount of contained water
–14.03 m. . . without coral fragment
–19.03 –21.03 m. . . N-ratio increases to 4 in proportion to the increase of coral fragments.

3. sand with coral fragments containing shells (light grey)
–18.0 –19.5 m. . . . a lot of shells, larger grains of sand; sand with shells and coral flakes; a few pebbles 10 mm. in diameter; silty content decreases; acidic sand and gravel increase.

4. sand with coral fragments containing shells (light grey), sand with shells, involving a few coral flakes; with finer grains of sand

and the main island. Such features are called "Kern buts and Kern cols", and are exemplified by Nakadôrijima, with hills at 76.8 m. and 66.4 m.; and by Nagasaki at 42.8 m. A fault line is assumed on the location connecting these cols (Fig. 2). Nakadôrijima has become separated from Chichijima as a result of wave action on both sides of the former col, which eroded out the bridge between this Kern but (the present Nakadôrijima) and Chichijima.

4) *Submaıine valleys in Futami Bay*

A submarine valley, which is 42.5 m. below sea level and about 20 m. in width, extends in a N40°W direction near the Kuroshio-pier (Fig. 5). The longitudinal gradient of the valley floor is 45° about 30 m. offshore, and it becomes gentler further away from shore. Three types of deposits on the bedrock may be classified: a) deposits composed chiefly of coral remains, b) fine sands, mainly silica, and c) coarse sand and gravel consisting of colored mineral particles, interspersed with bivalve shells and clay. Sandy or muddy materials of crushed corals form a matrix for the larger coral fragments (Nihon Kôei, 1970).

4 Some sketches of Hahajima and Mukojima

1) *Hahajima*

The southern half of Hahajima, consisting of Oligocene nummulitic tuff, is mostly in undulating topography with small relief. Everywhere on the flat and gentle slopes latosol has formed, but there is little on the steep slopes. In the northern half, the boninite area, steep and rugged landforms have developed, including gigantic sea cliffs of about 400 m. in height.

No. 6

1. sand with coral (light grey) 2. gravel (dark grey) 3. sandy clay with coral (grey)
4. sand with coral (grey) N-ratio of 1.–4.=3–15
5. gravel (dark grey) N=88 6. sand and gravel (〃) 7. agglomerate (〃) boulders
8. sandy loam with coral (dark brown), N=10 9. agglomerate (〃), N>100

No. 7

1. sand with coral (dark grey) 2. clayey sand with coral and loam (grey) 3. medium and fine sand with coral; sandy loam (grey) 4. sand and gravel (dark grey)
5. sand and gravel (dark green); coarse sand (5<N<20)
–28m.... gravel 10–20%, 10–15 mm. in maximum diameter
6. sand and gravel (dark grey); mixed with a few shells, N=20
–34m....angular gravel 15–20%, 10–20 mm. in diameter
7. agglomerate, N>100

No. 10

1. silty sand with coral (grey) .. poldered earth 2. medium sand with coral flakes (dark grey) 3. sand and gravel with coral (〃); –6.5 m. .. boulders 4. clayey sand (〃) 5. gravel 30–40% (〃); 0.5–3 mm. in diameter 6. agglomerate 7. bedrock, N>50

2) *Mukojima*

This northernmost island among the Ogasawara islands has a local relief of about 80 m. and is composed of tuffaceous breccia and agglomerate of Oligocene. These are manifested as gentle slopes over the whole island and are surrounded by steep bluffs. Three steps are distinguished among the landforms, at the 80 m., 50 m. and 30 m. levels, and the last is very flat, a typical elevated abrasion platform. Along the valley bottoms shrubs have densely grown, but on the upslopes or flat surfaces there are only palms with a sparse covering of grass[6]. The landscape of Mukojima seems to be that of Savanna, which may have been introduced because of the following factors:

(a) These islands lie in the subtropical Ogasawara Anticline which is relatively more arid than the moderate climate of Mainland Japan.

(b) There is no remarkable elevation on this island, so that there is no certainty of precipitation from orographic effect. In contrast, Chichijima, Hahajima and other islands which have mountains of more than 300 m. are provided with much precipitation.

(c) Overgrazing by wild goats cannot be overlooked in the vegetation landscape. Grass and certain bushes appear as in late autumn. Even in the beginning of September, these are of yellow-brown color and are in a blighted state.

The most important factor in the geomorphic processes of this island is the lack of water. This has had a decisive influence on the dissection features of the area. In the case of Mukojima, the gentle features of the upper surfaces, with a contrasting landscape of vegetation, suggests that mass-wasting is a major factor in geomorphic processes, rather than stream erosion. Thus, this island has been subjected to surface-flattening by mass-wasting, and by areal reduction at its rim through violent wave-cutting.

3) *Harinoiwa*

About 2 km. southeast of Mukojima, Harinoiwa rises above the sea. Harinoiwa (needle rocks in Japanese) has a very striking landscape (Photo 13). Each "needle" was produced by powerful wave cutting which perhaps fragmented the original island into the "needles" of the present. It can be seen that, even though a supposed island was subdivided into the present stacks, the accordant height of their tops still remains to indicate the level of the former surface of the island. This evidence supports the concept proposed by one of the writers that wave-cutting, as well as the lateral erosion of streams, has actually resulted in the

6) "The plant communities in Mukojima are broadly divided into two groups: the *Livistonia chinensis var. boninensis-Pandanus boninensis* community in the valleys, and the *Paspalum orbiculare* community in the hills" (Hasegawa et al., 1972).

areal reduction of the landmass, and not in the lowering of the elevation of the landform surface (Nakamura, 1969).

5 Conclusion

1) On Chichijima, three steps in erosion surface levelling are recognized; the Chûozan level at 290–320 m., the Yoakeyama level at 200–250 m. and the Yagiyama level at 150 m. Moreover, there are also two levels of coastal terraces, the Ônezaki at 50 m. and the lower level at about 30 m. These are immediately correlative to the terrace surfaces on Hahajima and Mukojima, although a certain number of steps are lacking. The staircase morphology of the Ogasawara islands suggests intermittent upheavals for each island. The landform classification of Chichijima is indicated in Fig. 2 in order to clarify the distribution of erosive agencies on this island.

2) Karst landscapes on Minamijima and on the southern part of Chichijima, the interesting manifestations of coastal morphology, the latosol forming process under a subtropical climate, former and recent crustal movements, and other specific phenomena on these islands, are only briefly described in this report, as the occasion demands more of landform classification.

3) At present, Chichijima as well as Hahajima and Mukojima are undergoing the violent and powerful action of wave-cutting in all coastal areas. Accordingly, the development of each landform surface, in terms of areal extension, depends upon how the location of a given surface is preserved from wave action. Fluvial topography, minor relief or flat plains for example, are located in such places as the heads of bays where subaerial landforms have been protected from wave action by beach ridges. The retreat of sea cliffs has resulted in the areal reduction of drainage basins, under such geomorphic environment bringing about the enfeebling of the fluvial process. Relatively speaking, fluvial erosion is less important in these islands than such other geomorphic processes as mass-wasting, karst-formation, and particularly mechanical and chemical weathering.

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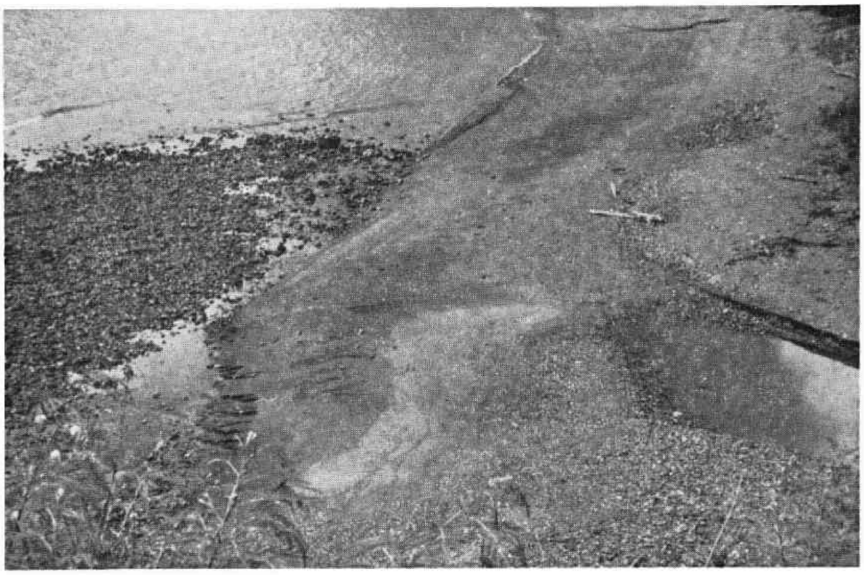

Photo 1 Concealed stream — gushing out at the mouth of the Minamifukurozawa river, Location 14; cf. Fig. 4

Photo 2 The southern part of Hahajima; undulating surfaces developing on the Oligocene tuffaceous sandstones, 110–80 m. above sea level, may be seen at the right.

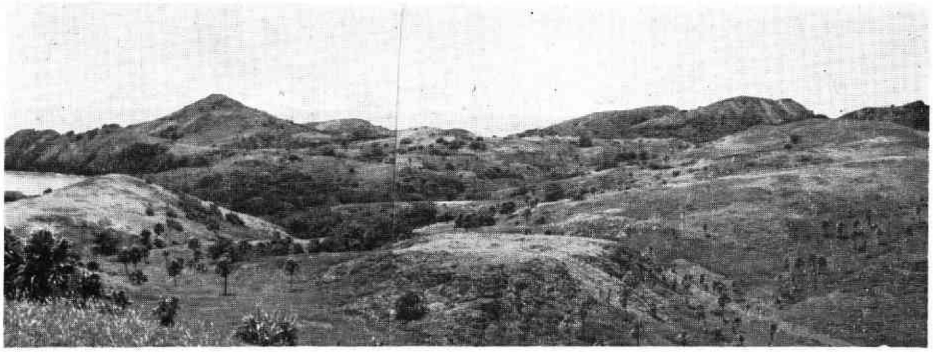

Photo 3 A typical landscape of Mukojima; flat and rounded crests and Savanna-like scenery. The peak on the left is about 70 m., and the right is 81 m. above sea level.

Photo 4
Pillow structure of boninite,
Location 18

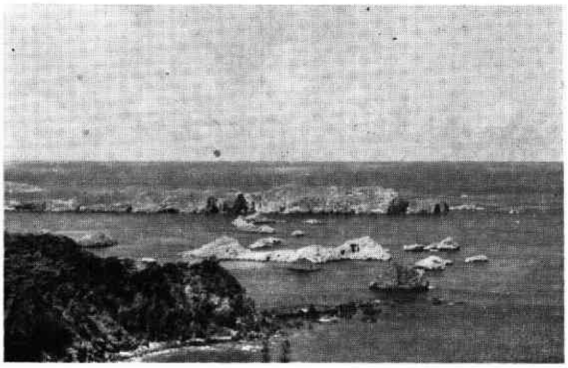

Photo 5
A submerged karst landform,
Tatejima, Location 48

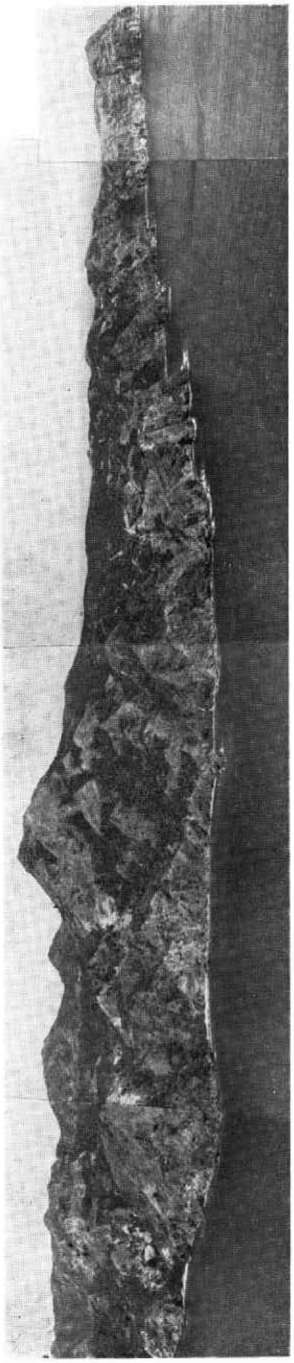

Photo 6 The eastern half of Anijima; an extensive erosion surface about 130 m. high.

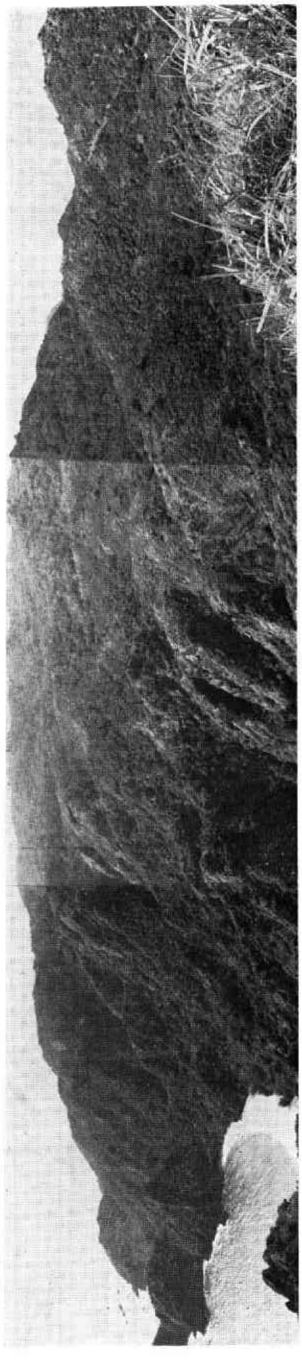

Photo 7 A break line of hill slopes near Hatsuneura

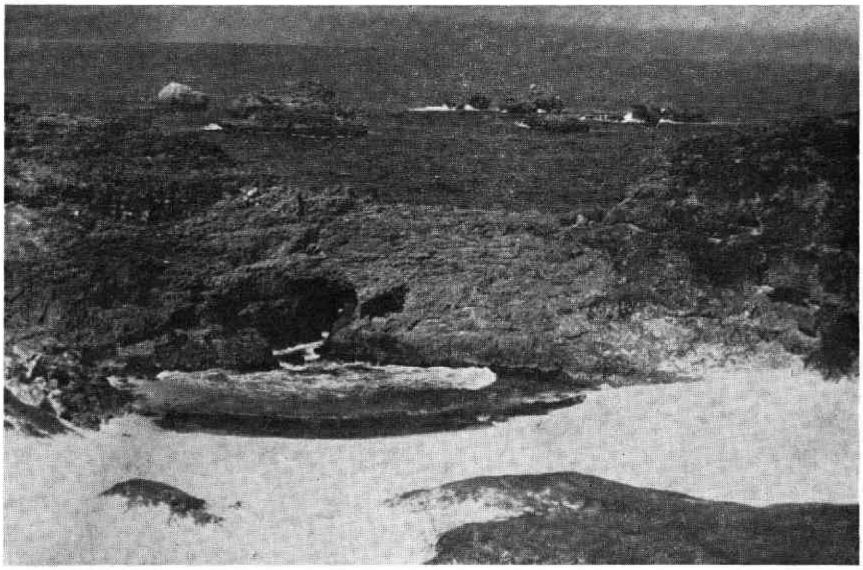

Photo 8 A small bay on Minamijima with a wave-cut tunnel, beach and so on, Location 45

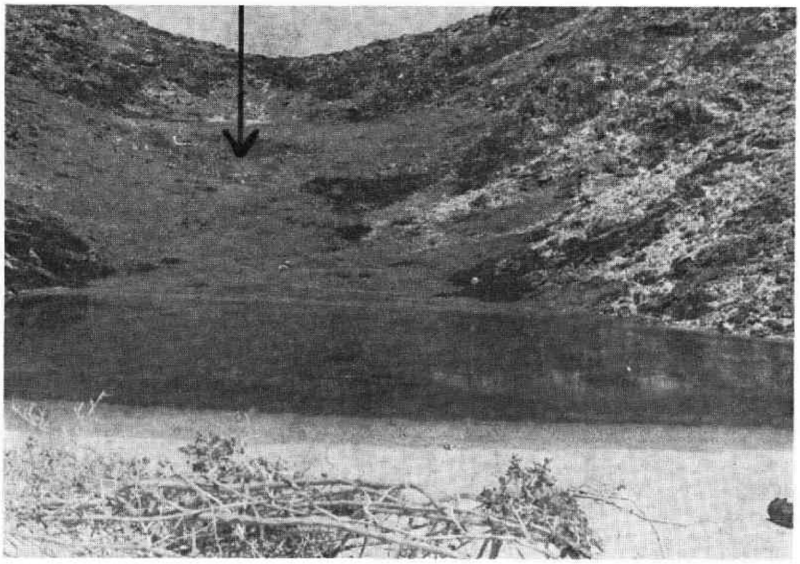

Photo 9 A growing doline at Minamijima, Location 44

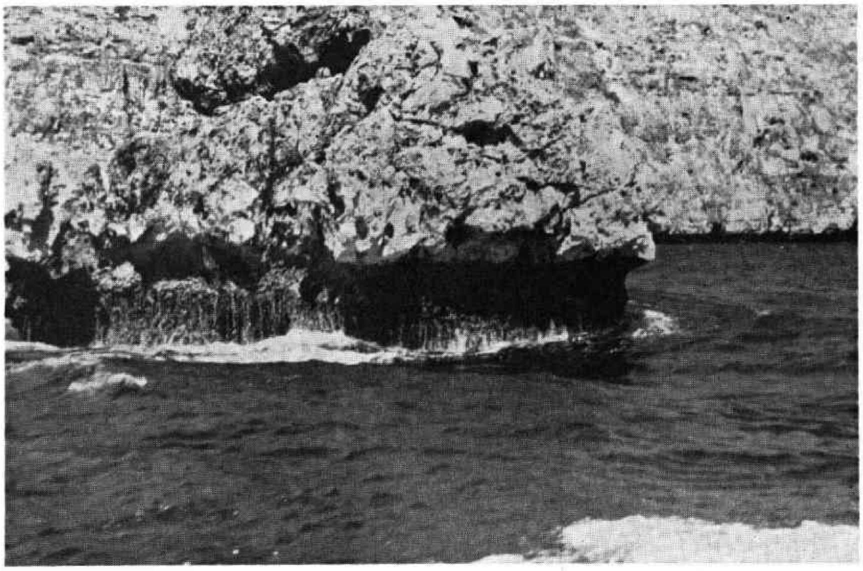

Photo 10 Mushroom stack; the upper part suffers corrosion as part of the karst forming process, and the lower is affected by wave-cutting (vigorous marine erosion).

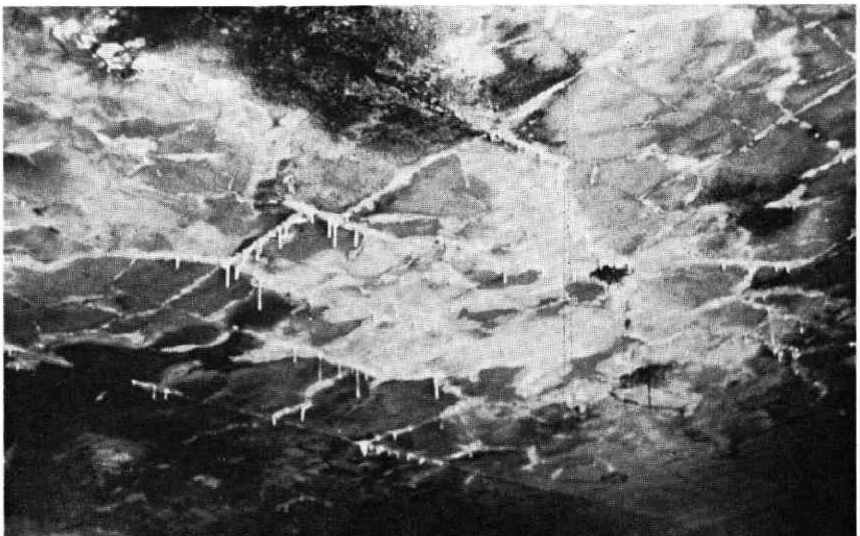

Photo 11 "Artificial stalactites" on the ceiling of a concrete building, formerly a Japanese army base, Location 22

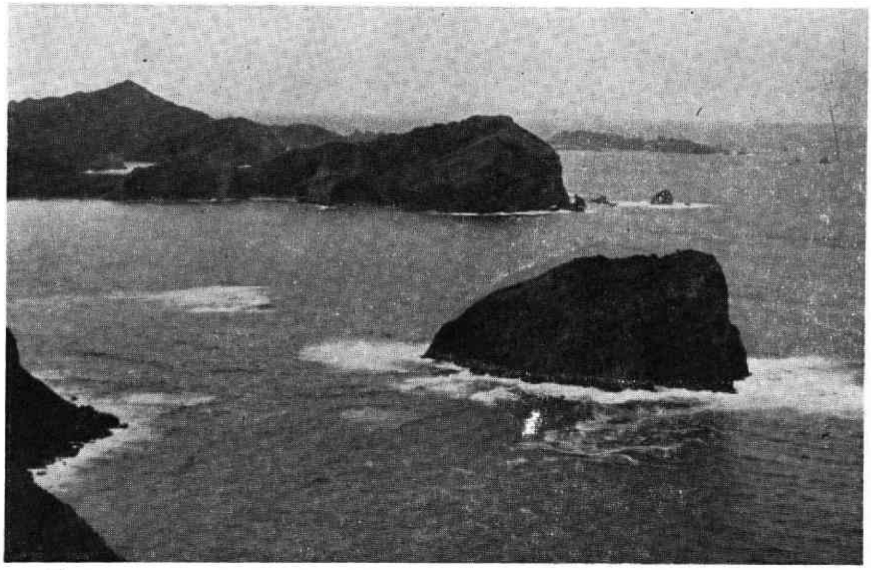

Photo 12 Landscape showing the tilting movement to the east; the crest surfaces of Eboshi-iwa and Yagiyama dipping slightly eastward

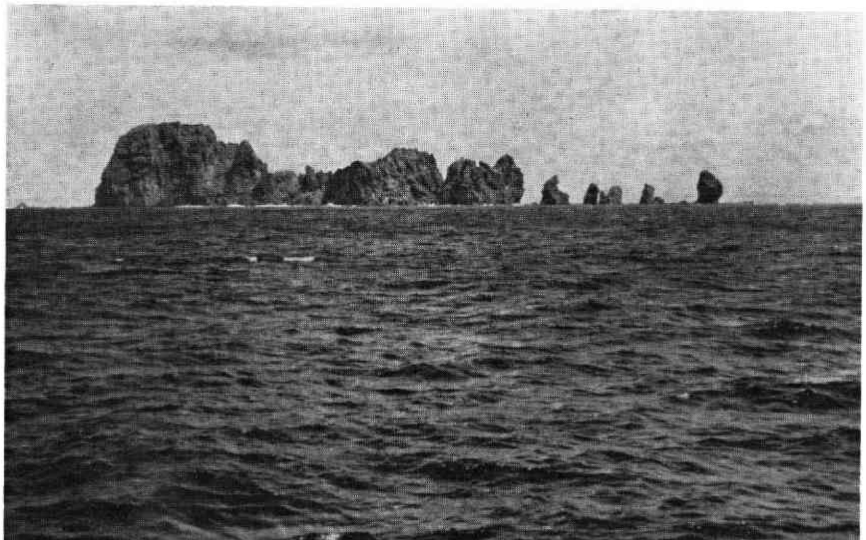

Photo 13 Harinoiwa, a scene of strong wave erosion